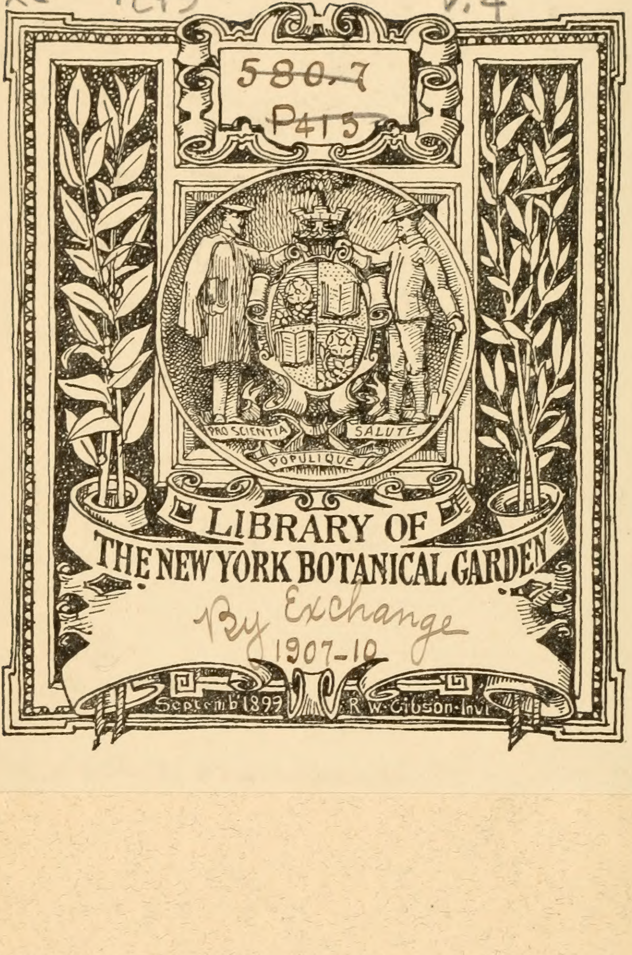
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ANNALS

OF THE

ROYAL BOTANIC GARDENS,

PERADENIYA.

EDITED BY

J. C. WILLIS, Sc.D., F.L.S.

VOLUME IV.

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Some Evidence against the Theory of the Origin of Species by Natural Selection of Infinitesimal Variations, and in favour of Origin by Mutation.

BY

J. C. WILLIS.

IT may seem somewhat superfluous to bring up at this period evidence against the theory of natural selection of infinitesimal variations, but as the opposition theory of origin of species by mutation is by no means generally accepted, it may be well to produce a fairly trenchant argument which was suggested to me by my work upon the Flora of Ritigala.* It must be made clear at the start that the evidence is not so absolutely in favour of mutation as it is against selection of infinitesimal variations, but at present the mutation theory is the only one in the field which can be invoked to explain the facts.†

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* Willis, Flora of Ritigala, an isolated Mountain. Ann. Perad. III., 1906, p. 271.

† For the benefit of Ceylon readers, who can hardly be expected to be up to date in a matter of this kind, the following notes will make the object of this paper a little more clear. No one at this period of time can doubt that an evolution of species has gone on, and it is Darwin's great service to have proved this. But there is now much dispute going on as to the way in which this evolution took place. The current theory, and that accepted by most of the disciples of Darwin—though he himself never, so far as can be made out, adhered unreservedly to it—is that the changes necessary to give rise to a new species take place by the natural selection of infinitesimal variations. To take a simple illustration, the fruits of a certain plant were measured, and it was found that 568 of them showed lengths represented below, the lengths being given in the upper column, the number of fruits showing them in the lower :—

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	1	5	11	17	27	37	62	74	83	79	51	43	32	18	13	5	5	3	1

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part I., May, 1907.]

An argument that has already been used* in favour of this theory of origin of species by mutation, and a point which has always been a great difficulty upon the theory of natural selection of infinitesimal variations, is the apparently useless nature of the differences that divide so many species and varieties. Thus, to take the simple instance that comes almost first to hand in the flora of Western Europe, in the genus Ranunculus, the species *R. bulbosus* differs from *R. repens* mainly in the fact that the former has the sepals reflexed, while the latter has them spreading. Now it is practically almost impossible to suppose that these differences can have any important bearing upon the success in life of the two species. Very similar results are to be attained by comparing almost any species of any genus. Almost always the points of distinction are such as seem to have no importance in the life of the species. The mere fact that the two Ranunculi above quoted live in almost identical habitats, side by side, would of itself seem to form a most cogent argument against the characters having arisen by natural selection of minute variations.

When we consider the enormous amount of work that up to about 1895 was put into the study of adaptations, the fact that

The numbers are very fairly evenly grouped about the mean length. Now it is generally supposed that evolution takes place by there existing a great number of offspring showing similar variation in a character that may be of value in the struggle for existence. Those that have it best marked will survive, those that have it poorly marked will go under, and so generation by generation the character will increase, till at last by progress in this and other characters we may get a plant so distinct that it will be a new species.

The other theory is that of mutation, on which the new characters are supposed to arise at one step, as in fact they often do in the production of new garden varieties. Once they have appeared the new characters are hereditary, and the new form does not go back to the old one. Evidence has been accumulating in favour of this view for some time now, but that set forth in this paper seems to afford a final argument for it. Be it specially noted that on the theory of natural selection of the infinitesimal variations every part must be shown to have some use, while on that of mutation this is not necessary, though of course variations that are actually harmful may be killed out in the struggle for existence.

The position of matters at the present time is very fairly and lucidly stated in a book, "Recent Progress in Variation, Heredity, and Evolution" (London, John Murray, 7*s.* 6*d.*) by R. H. Lock, formerly Scientific Assistant at Peradeniya.

* Willis, Flowering Plants and Ferns, 2nd. ed., p. 118.

adaptations were found in almost every structure, very often without any evidence whatever, and the extremely ingenious and fanciful nature of the explanations of these adaptations, we should expect that by this time some explanation at least of some of the innumerable differences that characterize species would have been brought forward, but as yet this has only been done in very rare cases, and in the vast majority of instances we are entirely in the dark as to any meaning that there may be in them.

Now, upon the theory of natural selection of infinitesimal variations, it is evident that any structure whatsoever must be capable of being shown to be or to have been—

(1) Of some actual use now; or
(2) Of some use in the past, in its present or in a different, and perhaps larger (less aborted) form; or
(3) Correlated with some useful structure, whether visible or not.

But in the vast majority of specific differences none of these things can be shown to hold, and considering the ingenuity that has been already devoted to this question, it seems very doubtful if it ever will or ever can be done. This alone, when one thinks it over, would seem to be almost sufficient argument against the origin of species by natural selection of infinitesimal variations, and affords a very good argument also in favour of their origin by mutation, for on this theory there is no *need* for the new variations to be actually useful. Can it, for instance, be supposed that the hereditary fasciation of the cockscomb is of any use to that form? Or, again, take the case of the Podostemaceæ, which have flowers (standing vertically and not horizontally) of the most pronounced dorsiventrality, though insects do not visit them, and the dorsiventral structure is a decided disadvantage, so far as we can tell. As I have pointed out elsewhere,* we cannot suppose

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* Willis, Morphology and Ecology of the Podostemaceæ. Ann. Perad. I., 1902, p. 434.

it to be an adaptation in this case, but a structure which has been forced upon the flowers either by direct mutation or by correlation.

My own work in botany was formerly to a large extent the study of adaptations, in which, as a student from 1886 to 1890, I was trained to believe, and, in general, the result was that I found some other suitable explanation of a much less fanciful kind. For instance, gynodiœcism, formerly explained as an adaptation to cross-fertilization, turned out to be a very variable and to some extent non-hereditary character, and I was entirely unable to regard it as an adaptation, its value to the plant being extremely problematical. Or, again, the case of the dorsiventral flowers of the wind-pollinated Podostemaceæ, above described, may be quoted, or the production of cleistogamic flowers.* Apart from the great difficulty (in many cases of adaptation or supposed adaptation) of imagining of what use the first stages, which are necessary on the theory of selection of infinitesimal variations, can be, a simpler and more reasonable explanation can in very many cases be found.

The general line of argument so far followed has nearly always been answered by the not very good reply (were it not that the theory of infinitesimal variations holds the field) that we do not know where the species originated, and that the characters in question may have been useful somewhere, or at some time. Most British species, for example, range over a vast area in Europe and Asia, and one cannot therefore feel sure that this reply is not good. And it is to this reply that the evidence of local endemic species seems to afford a final rejoinder.

Let us begin with the case of Ritigala. There are several species on the summit, which are confined to it, *i.e.*, to an area of at most 2–5 acres. Now, as Ritigala is not peculiar among the Ceylon mountains in height or other qualities, and as geological evidence seems to show that its elevation has not

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* Willis, Linn. Soc. Journ. 30, 1893, p. 295.

appreciably altered, while the monsoons which now blow over the Island must have blown as at present for a vast period of time, no sane individual will pretend that these species are the last survivals of species, which were formerly widespread. If they were so, there is no reason why they should not be found upon some of the other hills of the island, whereas in actual fact, as I shall show in a subsequent paper, nearly every isolated mountain in Ceylon has its own particular species endemic to it, so that, if we suppose all these to be survivals, we shall be hard put to it to explain the former condition of so small an island.

It must therefore be admitted that the species peculiar to the summit of Ritigala must have been evolved upon that summit, or near to it, and consequently, so far as the reply of the infinitesimal variationists above-mentioned is concerned, the argument that the characters may have been useful "somewhere" has the bottom knocked out of it, for, if the characters were ever useful, they must have been useful *on the summit of Ritigala*, and nowhere else. Not only so, but the argument as to the "some time" is almost equally useless, for there is no evidence to prove that the conditions on the summit of Ritigala have altered within any reasonable period, in fact within the period during which most, if not all, of our existing species have evolved. If the characters themselves were not actually useful, they must (on the theory of infinitesimal variation) have been correlated with useful variations.

Now let us examine the endemics of Ritigala, beginning with *Coleus elongatus*, Trimen. There are four species of Coleus in Ceylon, but this species is by far most nearly allied to *C. barbatus*, Benth., which, be it carefully noted, also occurs at the summit of Ritigala. From the other two species it differs very much in the inflorescence, in the size of the leaves, and in the habitat, as well as in those points in which it differs from *C. barbatus*. No one can for a moment, however, maintain that these forms are merely varieties; they are very distinct and well separated species ; in fact *C. elongatus* is almost, if not quite, sub-generically distinct.

We may best put the points of difference between these species in the form of a double column, thus :—

*Coleus barbatus.**	*Coleus elongatus.*†
Stem cylindrical, but tending to quadrangular in inflorescence.	Stem quadrangular.
Stem pubescent with long hairs.	Stem pubescent with short hairs.
Leaves oblong-oval, 1–2 inches.	Leaves ovate-triangular, 1–2 inches.
Leaves closely pubescent.	Leaves finely pubescent.
Leaves rather thick.	Leaves rather thin.
Petioles rather short.	Petioles rather longer, and slenderer.
Inflorescence a raceme of condensed cymes, each about 5-flowered, forming false whorls of ten flowers at each node.	Inflorescence a raceme of one-sided cymes, looking like racemes, about 1½ in. long, one at each side of each node.
Flowers large.	Flowers small.
Bracts large.	Bracts small.
Calyx with long hairs.	Calyx with short hairs.
Calyx of one large ovate upper tooth and four small lower teeth.	Calyx of five almost exactly equal teeth, upper teeth not larger
Corolla rich purple or white.	Corolla pale purple.
——	——
Grows on rocky places.	Trails over rocks.

In all other characters the two species closely agree, but they are at once widely separated by the different type of inflorescence and by the calyx, and *Coleus elongatus* is unquestionably a good species.

Now, with regard to this species *Coleus elongatus*, growing solely on Ritigala summit, there are several points to be brought forward. In the first place, I would simply ask, is the climate or are any other conditions so different upon the summit of Ritigala that any one can pretend that it is an advantage to the plant to have its calyx equally toothed

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* Bot. Mag. t. 2318.

† Trimen, Journ. Bot 27, 1889, p. 165. Figure in "Ceylon Flora," No. 74.

instead of having one large tooth and four small ones, or to have its flowers in (apparent) racemes instead of in true cymes ? The same may be asked with regard to any of the other characters,* so that if any or all of these characters are correlated with advantageous characters, these latter must be purely internal.

In the second place, *Coleus elongatus* is much too different a species from the other species of this genus, whether in Ceylon, India, or elsewhere, to have been evolved rapidly by means of continuous variations. The process must have taken a very long time, for the differences are about sufficient to mark a sub-genus. Now, it is hardly to be supposed that the ancestors of the existing plants can have been upon Ritigala long enough for this to have taken place. No other species with a calyx or with an inflorescence like those of *C. elongatus* occurs in India or Ceylon.

In the third place, the species is too entirely different from the other species of Coleus, whether we take *C. barbatus* or one of the others, for evolution by means of continuous variations to have been *possible*. To take some of the characters, especially those that are most prominent, how is the one type of inflorescence going to develop into the other by any possible continuous variation ? The mind cannot conceive of such a process, unless it be by discontinuous variation. Still more, how is a calyx with one big tooth on top and four small ones below going to develop into one with five equal teeth ? The study of infinitesimal variation shows that the maximum change to be expected in one generation would be a mere fraction of the width of a tooth, and how is this to prove of sufficient advantage or disadvantage to be of any material import in the struggle for existence ? The question is equally hard if we suppose a common ancestor, for what kind of calyx or inflorescence will be intermediate ?

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* Some of these would even seem to be disadvantageous, *e.g.*, the thin leaves in a dry exposed situation, and the small flowers of pale colour.

In the fourth place, the area of the summit of Ritigala is very restricted, at the most being but a few acres. Not only so, but the exposed rocks, upon which alone do the two species of Coleus grow, do not occupy more than about a quarter of an acre at most. Now, will any one pretend that the struggle for existence is so keen upon so small an area that it can make much difference to a Coleus what kind of calyx it has, or what sort of inflorescence ? It might be possible to advance this opinion if even the quarter of an acre were densely covered with the plants, but in actual fact there are probably not a dozen plants of either species on the whole summit of Ritigala, and these are too widely separated for there to be much competition between them. To get such wide differences between the species, on the theory of natural selection of infinitesimal variations, we should have to have had a strenuous competition between very many of them, and no one can pretend that this is, or ever has been, the case on Ritigala. Even if the whole area were bare rock, and were covered with these species alone to the exclusion of others, the competition would be comparatively small. But this cannot be allowed for the Coleus, for there are also endemic species of Trichomanes, which lives in shady places, Bulbophyllum, which lives epiphytically, and Cyperus, living in open grassy places, to say nothing of quite a number of endemic varieties. Can it be honestly said that any of the characters of this species are of any use to it in the struggle for existence ?

Lastly, comes the difficulty that the species from which *C. elongatus* is with almost absolute certainty descended, *C. barbatus*, is also to be found living upon the summit of Ritigala, and as numerously as *C. elongatus*. Now, if we suppose that the characters of the latter were so advantageous to it in the very small struggle for existence that went on upon the top of Ritigala, we must surely suppose also that *C. barbatus* would succumb in that struggle, but instead of that it remains as numerous as *C. elongatus*. This would therefore indicate that there was no serious struggle for existence, and consequently that the characters of *C. elongatus* were not derived by means of the accumulation of infinitesimal variation.

We can hardly suppose that the two species have descended from a common ancestor, now extinct, for they must have done this on the top of Ritigala, and yet now *C. barbatus* is widespread through Ceylon and South India, and we can hardly imagine that it would so easily spread from Ritigala, while *C. elongatus* did not. If both were well suited to Ritigala, why should one spread and not the other? Or, again, what kind of inflorescence, or of calyx, was intermediate between those of the existing species? Further, *C. spicatus*, endemic in South India, is also closely allied to *C. barbatus*, and must have come from a common ancestor.

It follows, then, beyond the possibility of contradiction, as it seems to me, that the very pronounced characters of *C. elongatus* were not produced by the accumulation of infinitesimal variations, but must have arisen by mutation or discontinuous variation. How, or why, they arose is another question, to which some experiments that I have put in hand may possibly supply an answer.

The other endemic species found upon the summit of Ritigala supply lines of argument exactly similar, but as there was but little material of any of them, too little to make a full description, we may leave this mountain and pass on to the consideration of some of the other Ceylon endemics of restricted areas. In order to avoid any suspicion of choosing examples, we may simply turn over the pages of Trimen's "Flora of Ceylon" and take them all as they come to hand.

Ranunculus sagittifolius, confined to the high mountain region about Nuwara Eliya, differs widely from the only other Ceylon Buttercup, *R. Wallichianus* (South Indian also), which occurs side by side with it, though in drier and sunnier places, but is closely allied to *R. reniformis* of the mountains of the Western Indian Peninsula, differing mainly in the petals, which are 5 in the Ceylon species, 12–15 in the Indian one.

These two species must have had a common not very remote ancestor, and as the main differences are in number, the variation must have been discontinuous.

The same kind of arguments may be used here as in the case of *Coleus elongatus.* Are we to suppose the conditions of life so different in the Ceylon and Indian mountains that a 5-petalled flower will suit the one, a 12-petalled the other ? Or how is the one to pass into the other, or both to arise from a common ancestor, except by discontinuous variation ?

The next genus in which local endemics occur is Acrotrema, and these differ mainly in the shapes of the leaves. Can it be supposed that the simple obovate-lanceolate leaf of *A. intermedium* fits it for the Kitulgala district, while the pinnate leaf with linear-lanceolate segments of *A. Thwaitesii* fits that species for the Dolosbage district, but a few miles away, a trifle higher up, and in a similar climate ? The only species of this genus that is at all common is *A. uniflorum*, which occurs in a great variety of forms, "almost every district producing a local form" (Trimen). *A. lyratum*, characterized by very long peduncles, is found only on the summit of Nillowekanda, an isolated precipitous rock in the Hinidum pattu ; its nearest relative appears to be some form of *A. uniflorum*, found in the district, but not actually recorded for Nillowekanda. Now, is it to be supposed that the long peduncles are any advantage, or that the struggle for existence on the summit of Nillowekanda is so keen that they can have been evolved there by infinitesimal variation ?

Or, again, in Schumacheria, why should the oval or rotundate leaves of *S. alnifolia* be suited to Ambegamuwa, &c., while the lanceolate-oblong leaves of *S. angustifolia* are suited to the Kukul korale ?

Why, again, should *Dillenia retusa*, with its obtuse leaves and small flowers, be found alongside of *D. indica*, with its acute leaves and large flowers ? Both are common in the low-country of Western Ceylon, while in Western India *D. indica* occurs with *D. bracteata*, a still nearer relative of *D. retusa*.

Now, why should the common ancestor in one country give rise to A and B, in the other country to A and C? In the Eastern Peninsula, again, live *D. ovata* and *D. meliosmæfolia*, as well as *D. indica*, and these species are closely allied. Why should they be better suited to the Eastern Peninsula, while *D. bracteata* suits Mysore and *D. retusa* Ceylon?

In Unona, again, what advantage can the deep constriction between the seeds of *U. elegans* be to it, as compared with the slight constriction of *U. zeylanica?*

Or what advantage can the two ovules of *Polyalthia Moonii* and *P. persicifolia* be against the one of the other species? *P. rufescens*, another species with two ovules, and closely allied to both, occupies the Cochin District of South India, and why should there be three species in so similar a country, especially as the Ceylon species live in the same district? And how did the one form get to the other, or both arise from a common ancestor, except by mutation?

Similar queries might be asked 800 times for the 800 endemics comprised in the Ceylon flora, but these few must suffice, as we do not wish to labour the point.

Now, where the endemics are confined to a small local area, and are not accompanied by their nearest related species, it is still possible to say, though the argument is but a weak one, that they may have been evolved to suit the local conditions, but how is this argument to apply when the two grow close together, as in fact is very commonly the case in Ceylon, and was for instance the case with the Coleus species on the top of Ritigala?

For if the endemic species had developed its peculiarities to suit the local conditions, one would expect that the other species would not suit them. But it not infrequently happens, as in the case of the Dillenias mentioned above, that there is one common and widespread species, accompanied here and there by a local species confined to one district. To take an example from the families already considered, in Uvaria there are two nearly allied species, *U. Narum* and

U. macropoda, both having red pendulous carpels, but the former having them on stalks 1 inch long, the latter on stalks 6–7 inches long. These two species are otherwise most closely allied, and both grow together. Now, can we suppose that the long stalks of the carpels of *U. macropoda* are so great an advantage that they should have been developed without suppressing at the same time *U. Narum?* Or, if preferred, the argument may be put the other way, and it may be asked why *U. macropoda* was not suppressed. This will get over the difficulty of origin from a common ancestor, the length of the stalks in which may have been intermediate.

If, instead of taking the endemics at random, we pick those that occupy only particular hill tops, we obtain as striking proofs of our general thesis as that given by *Coleus elongatus*, but the point seems to be sufficiently made out.

If the characters that distinguish the endemic species of Ceylon, which number about 800, were characters really valuable to them, we should expect in general that they would be common within the island. On the other hand, they are usually remarkable for their rarity and for being confined to one locality in the forest, or to one mountain top or group of high mountains. Thus, to take at random the first 55 met with in Trimen's "Flora," 37 are very rare, and only 18 at all common; while of the non-endemic species in the same genera only 8 are rare, while 19 are common.

Or, again, take the endemic genera. Here, at any rate, the evolution having gone far enough to give rise to genera, one would expect to find commonness the rule, but in actual fact the Ceylon endemic genera are usually rare.

The Ceylon endemics, then, are in general a group of some 800 species, of which about two-thirds or more are rare, confined to one or a very few localities. In particular they affect mountain tops and places in the south-western forests. Every isolated mountain top has some, *e.g.*, Ritigala, the Pedurutalagala group of mountains, Adam's Peak, Hinidumakanda, and, as recent investigations made by myself would appear to show, Namunakuli in the south-east. This being so, one must suppose that they have been evolved by mutations rather than by natural selection of infinitesimal variations, and this would also explain why most of them are so rare, the mutations not having proved specially useful, and why they affect mountain tops, the conditions there being perhaps sufficiently different to cause a tendency towards mutation. In general they have characters which are, so far as one can conceive, useless in the struggle for existence; they occur in places where that struggle cannot have been very keen, or between very large numbers; they often occur alongside of their most nearly allied species, and very often the differences in character are such as can hardly conceivably have arisen by the selection of infinitesimal variations.

But, now, to the whole of this argument it may be objected that though mutation may serve very well to explain things in the notoriously peculiar case of Ceylon, which though not an oceanic island has nearly 30 per cent. of endemic species, it will not serve for other countries. Let us therefore consider some of these. We may begin with Mauritius, and take a few examples from Baker's " Flora." The bulk of the endemics first mentioned in the list are not accompanied by any widespread species, and we may therefore pass them by, only asking why their peculiarities should fit them specially for Mauritius. In Calophyllum we come to the first instance of an endemic species, *C. parviflorum*, living beside the almost cosmopolitan species of the Eastern Tropics, *C. Inophyllum*. The two are very much alike, but the latter has a globose fruit, the former an oblong-rostrate one. The latter lives in the beach forests, the former more inland. Now, is it to be supposed that the shape of the fruit can have any effect upon the life of the species sufficient to account for its being evolved by natural selection of infinitesimal differences, though it may be correlated with some internal character fitting it for life more inland?

Why should the awned carpels of *Sida glutinosa* fit it for life alongside of the nearly allied cosmopolitan *S. humilis?*

Why should the double allowance of stamens in *Toddalia lanceolata* fit it to live alongside of *T. aculeata ?*

Or, to turn to the flora of New Zealand, why should the stemless form, and spatulate leaves, of *Cardamine depressa* fit it to inhabit the same places as the stemmed *C. hirsuta* with pinnate leaves? Or, why should the subcordate leaves of *Hypericum gramineum* fit it to live alongside of the oblong-leafed *H. japonicum ?*

Examples like these might be multiplied to any extent by taking other floras, but these must suffice for the present.

But to the whole of the line of argument adopted in the last paragraphs it may be objected that the two species quoted are not, so to speak, parent and child, but both descended from a common ancestor. To this I would reply, how can the existence of numerous endemic species, all closely allied to one common species, and all separated by some distance from one another, be explained on any but the parent and child theory? Take the Indian flora as an example.* To begin again at the beginning, in the genus Clematis, § Cheiropsis, we have *C. montana* common all along the Himalaya, while *C. napaulensis*, *C. barbellata*, and *C. acutangula* are confined to particular sections. We have *Anemone rivularis* common throughout the Himalaya, and various local allied species. And many more examples of the same kind might be quoted, but this must be reserved for a later paper. The general principle on which India and Ceylon have been peopled with the many species which they contain would seem to be that one very common species has spread widely, and, so to speak, shed local endemic species at different points, or else that one species has spread, changing at almost every point into a local endemic species, which has again changed on reaching new localities.

This must suffice as a preliminary statement of the position taken up, which is that the evidence of endemic species

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* This theory explains some of the puzzles of geographical distribution with ease, as I shall show in a subsequent paper.

completely disproves the theory of origin of species by natural selection of infinitesimal variations, and gives strong evidence in favour of origin by mutation. The evidence cannot, I think, be disputed for the case of the endemics of the summit of Ritigala. It is equally good for the endemics of Ceylon, Mauritius, or New Zealand, and this being so, analogy of the characters that divide species all over the world (for, of course, the systematists have worked at specific distinction regardless of any theory of the origin of species) shows that this must be a perfectly general rule, and consequently that the theory of infinitesimal variations as the foundation of the origin of species must be given up.

The theory of mutation, on the other hand, will explain all the cases that have been brought forward, though why mutation should proceed in this apparently casual manner must for the present remain a puzzle. It is possible, if not probable, that a group of allied species represents so many more or less stable positions of equilibrium in cell-division, and it is at least entirely doubtful if any given species is specially adapted for the circumstances in which it is found. This adaptation, though of course certain for whole groups of plants, such as water plants or parasites, must be proved for each instance.

We shall follow this paper with others dealing in detail with the many interesting points here raised.

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EDITED BY

J. C. WILLIS, Sc.D., F.L.S.

DIRECTOR.

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Further Evidence against the Origin of Species by Infinitesimal Variations.

BY

J. C. WILLIS.

On thinking over the argument given in my last paper on page 8 of this volume (" In the fourth place, &c."), further reasons against the possibility of the origin of species by infinitesimal variation have occurred to me, which may be briefly given here.

A point that has so far escaped attention, to my knowledge, is that *while the characters that distinguish species and genera are largely characters of the floral organs, the struggle for existence is almost entirely among the seedlings and young plants, in which these organs are not yet present.*

Once the plant has reached the stage of flowering, there is, in the enormous majority of cases, no struggle for existence worth mentioning between it and the other members of its species, at any rate no such struggle as will kill out, say 75 per cent., and enable those with any given character strongly marked to survive. I very much doubt whether any evidence could be brought forward to prove that even 25 per cent. were killed out at this stage, and that being so, it is evident that the gain in any one character must be almost indefinitely less, on the old theory, than it is conceivable that it might be if all but those with that character strongly marked were to go under.

To take an example, is it conceivable that in Dillenia it can make any difference to the seedlings whether their leaves are acute or obtuse, or the petioles 1 or 1½ inch long, and yet these are the only characters that can show till the plants are at least ten years old, by which time all that are going to die out will have done so, and the survivors will have grown into

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small trees. Not only so, but, as already pointed out in the previous paper, the two species of Dillenia grow side by side, and are equally common.

The Dipterocarpaceæ, so common in Ceylon, afford a still better case. Dipterocarpus itself is divided into subgenera on characters of the fruiting calyx, and can it for one moment be imagined that there is any struggle for existence between trees 40 years old, in which it matters whether the calyx is smooth or 5-ribbed. These trees are very much alike in their vegetative characters, and their flowers do not appear for a very long time, by which time the struggle for existence between members of the same species must be long over.

Innumerable examples of this kind might be quoted from the flora of Ceylon or any tropical country, but these will suffice to indicate the point in view. If the characters of the species were characters of the seeds, one might perhaps say that these had such an effect upon the seedlings that they enabled them to survive, but in most cases the characters are not so, but of petals or sepals, of size of flower, and what not, that cannot be supposed to have any effect upon the capability of the seed to germinate or to preserve its life ; in most cases they cannot even have an effect in causing more seed to be set.

Further, in most cases allied species live near together, and why should this be the case, if infinitesimal variation is the rule ? Why, if one species with a stalk to the carpel of 4 inches long is living in a given place, should it break up into two with stalks 1 inch and 7 inches long, from the point of view of advantage to the species ? This fact, that nearly allied species usually live very closely together, is a strong general argument against advantage having anything to do with the origin of species.

Another strong argument against infinitesimal variations is that for selection among them to produce any great effect, it should be between a large number. But in actual fact any given plant can only have, on the average, six like itself around it, and the competition can therefore only be between seven, of which one, being very commonly the parent, will often have the advantage from the start. Now between seven the competition may be very strenuous, but it is evident that the range of variability can on the average be only a very small one, and consequently that progress can only be much slower than is often (consciously or unconsciously) supposed. In the majority of cases there cannot be any competition between two plants separated by a considerable distance, unless, later in life, for the services of insects to pollinate their flowers. Wind, of course, might affect those on one side of a crowd more than others, but any such agent cannot as a rule have any very great effect.

I find that I was wrong in stating Coleus spicatus to be endemic in South India, for Bentham says that it also occurs in Africa. On the other hand, the argument about Coleus barbatus gains greatly in force from the fact that this species also occurs in tropical Africa.

I have received many letters dealing with my former paper, and the usual tenor of them is that a good case has now been made out for mutation, and that if we can now prove that one species can mutate into another, all will be finished. But no one has seriously tried to pick a hole in my argument, and I take this opportunity of repeating that it is *impossible* to get this species by continuous variation, and that from analogy all the rest follows.

There are several other arguments that might be brought forward, but want of time compels me to leave them for another paper.

Revisions of Ceylon Fungi.

BY

T. PETCH.

INTRODUCTION : General and Historical.

THE earliest records of tropical fungi were based on the miscellaneous collections made by various pioneer expeditions chiefly at the beginning of the last century. Though the botanists who took part in these explorations devoted their attention mainly to the phanerogams of the regions visited, they occasionally gathered a few fungi, and these as a rule were deposited in some museum in Europe where they remained for long periods (sometimes 60 years) before anyone was sufficiently interested in fungi to undertake their examination. It will be at once understood—at least, by anyone who has had to examine the miscellaneous gatherings of the average " Fungus Foray "—that these early collections will be composed in great part of the commonest species, though with the usual " beginner's luck," they may include some of the greatest rarities. In general, it is I think clear that the collector who merely gathers fungi *en passant* should obtain (not necessarily exclusively) the commonest species of the district through which he travels. We may expect, therefore, that the thousands of fungi recorded for the Tropics should include most of the common species.

It is also to be noted that these pioneer collections are almost entirely composed of such fungi as could be preserved, at least as far as their shape is concerned, in the same way as flowering plants, or could be dried without decay. From this has grown the idea that the more durable fungi, *e.g.*, *Lentini* and *Polypori*,

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are far more abundant in the Tropics than in other regions. "The genera characterized by a tough, leathery pileus that dries up and becomes rigid and persistent are more numerous in the tropics than the fleshy putrescent genera" (Massee). "The fleshy Hymenomycetal fungi belong almost exclusively to temperate regions: as warmer countries are approached, they are only found at high elevations, whilst their representatives near the sea level belong to genera in which the substance is tough and leathery, and the proportion of water in their composition is comparatively small. Hence we find that nearly all the fungi of the agaric type to be met with constantly in the Tropics belong to such genera as *Marasmius*, *Schizophyllum*, *Lentinus*, and the almost woody *Lenzites*" (Cooke).

But it by no means follows that this is actually the case. The preponderance of these fungi in existing collections is merely an accident of collection. If we take Berkeley and Broome's account of the fungi of Ceylon, we find that, among the basidiomycetes, the number of species which readily decay exceeds that of the tough or woody species which can be easily dried and preserved; and it is highly probable that this will be found to be true of other countries also. When the question is considered on the spot, it does not seem probable that the *Polypori* and *Lentini* should outnumber the putrescent agarics: the evanescent fructification of the latter is far better adapted for the propagation of the species than the tough and woody sporophores of the *Polypori*, which are subject to the attacks of innumerable insects during their comparatively prolonged period of exposure, though this is much shorter than in temperate climates. It is rare to find Fomes showing its "annual" growths: the sporophore does not last long enough. Very frequently also the sporophore never reaches maturity, but stops growing when the rain suddenly ceases, and is then eaten by insects. The idea that the leathery hymenomycetes are the more fitted for a tropical climate ignores such questions as humidity and rainfall, and the existence of the essentially tropical genera, *Gleoporus* and *Laschia*.

Another argument in favour of the accepted view that the tougher fungi predominate is supposed to be found in the large number of fungi of that class which have already been recorded ; if the more perishable basidiomycetes are really in the majority, there must be an enormous number of them. This brings us at once to the conviction which forces itself on everybody who attempts to interpret tropical fungi in the light of these old descriptions ; the majority of them do not represent distinct species, and do not describe anything as it exists naturally. So impossible is it to fit our common fungi to any of the descriptions, that in some cases the mycologist in the Tropics utterly refuses to attempt the task of evolving order out of the present chaos ; or, in the alternative, he decides that everything is a new species. The mycologist who accepts the old descriptions as correct will find ample opportunity in any country he cares to visit in describing the mutations which have been evolved during the last sixty years ! The early descriptions were based on dried specimens : in many cases these had been lying about in museums for fifty years ; so that even if all were distinct species the descriptions, except in a few instances, could not fail to be incorrect. But besides this the describers had no idea of the changes of colour and form which might occur in the forcing climates of the Tropics during certain seasons of the year, and they have accordingly, though quite correctly from their limited point of view, made endless species out of mere forms of common things. And to arrive at this conclusion we need postulate no more than that the fungi which spring from the same mycelium are the same species.

The fungi of Ceylon exhibit this multiplication of descriptions in a marked degree, though the work was done under most favourable conditions ; the majority were collected and provisionally sorted out by botanists of considerable experience in mycology, and they were accompanied by hundreds of accurate paintings. If under such circumstances the results are in many cases worse than useless, what value is to be placed on work which is based only on a collection of dried specimens? The "description" seldom describes the fungus. The species which when dried retain their form and colour, *e.g.*, *Polystictus sanguineus*, Fr., are so few in number, that they do not alter the general conclusion. Indeed the constant occurrence of *P. sanguineus* and *P. xanthopus* in tropical collections strengthens the view that other species should also be common to all tropical countries.

Ceylon appears to have been out of the track of the earlier fungus collectors, probably because its flowering plants had to a large extent been collected before botanists turned their attention to fungi. Fries' Epicrisis (1836–38) gives only one Ceylon record, though there may be others happily buried in his frequent phrase "in India orientali." The species recorded is *Fomes levissimus*, Fr., and Saccardo adds that it was collected by Wahlenberg; this addition is probably erroneous, as there is no record that Wahlenberg visited Ceylon, and his other specimens were gathered in South Africa. In any case it has not been collected since, either in Ceylon or elsewhere.

In 1777, 1780, and 1781, J. G. König collected in Ceylon, and included a few fungi in his collection. These remained undescribed until 1842, when Berkeley published a "Notice of Fungi in the British Museum" (Ann. Nat. Hist. X., 1842), and described fourteen Ceylon species. Part of König's collection apparently reached Paris, for Leveille in 1844 (Champignons Exotiques. Ann. Sci. Nat. Ser. 3. Tom. 2) referred to two of his specimens, and in 1846 ("Descriptions des Champignons de l'herbier du Museum du Paris," Ann. Sci. Nat. Ser. 3. T. 5), described two new species from it. Altogether we know of sixteen species which were collected by König; whether his collection included other species I have at present no means of ascertaining, as I have not got Berkeley's paper. These species are chiefly Polypori, probably picked up haphazard; yet not one of the sixteen has been *recorded* again from Ceylon. The only species re-identified up to the present is *Xylaria escharoidea*, Berk.; and it is found that this was named *Xylaria Gardneri* by Berkeley on Gardner's and Thwaites' specimens, while it has been named *Xylaria nigripes*, Klotzsch; *X. piperiformis*, Berk.; *X. mutabilis*, Currey; and *X. flagelliformis*, Currey, on specimens from other parts of the Tropics. His *Polyporus agariceus*, Berk., is *Favolus agariceus* Lev., and is almost certainly *Polyporus arcularius* Fr., or at least the Ceylon species which was given that name by Berkeley and Broome in the "Fungi of Ceylon"; it is also the *Favolus cillario*, Mont. (probably an error for *ciliaris*) of Beccari's Ceylon collection.

After König, nothing seems to have been done until Gardner's arrival in 1843. J. G. Watson left a good drawing of *Colus Gardneri*, gathered in 1835, but he does not seem to have thought the other Peradeniya fungi worthy of record. Gardner had previously collected fungi in Brazil, and would doubtless have sent a large number of species home had he lived longer. As it was, his time was fully occupied with phanerogamic botany, and his consignments to Berkeley only include about 120 numbers. Some of the new species of these were described in Hooker's Journal of Botany VI. (1847), while other descriptions were included with those of Thwaites' collections. His collection resembles that of König, in that it includes many polypori, but it also contains the larger agarics with a few gasteromycetes and pyrenomycetes; in short, he gathered the most obvious fungi, and those which it is possible to identify are the most conspicuous, common forms. Many of these were assigned, quite erroneously, to European species, *e.g.*, that named *Tricholoma nudum* resembles *T. nudum* only in colour, and is an *Entoloma*. There are however, many common forms which practically occur throughout the year at Peradeniya, but which cannot be traced in Berkeley's descriptions, *e.g.*, there is apparently no description of our commonest *Lentinus* among those of the eleven *Lentini* collected by Gardner. It is possible, of course, that the conditions then were different, but certainly no one collecting fungi at the present day could miss this *Lentinus*. Judging from the rest of the work, it is most probable that this species was collected, but wrongly described.

The comparison with other collections is instructive. Gardner sent 123 numbers, and we know what names were given to 108 of these, but they do not include a single one of König's species. Again, Thwaites collected carefully over the same ground for nearly twenty years and sent home altogether about 1,500 numbers, yet, according to the records, he failed to find 48 of Gardner's species, though they must all have been fairly common, conspicuous fungi. Gardner's fungi were accompanied by numerous figures, but unfortunately at his death his herbarium and figures were sold and are now at the British Museum, where they cannot for some years be examined by any one who has seen the fungi growing. For this reason, it is not always possible to decide with strict accuracy what his species were, and thus several fairly obvious synonyms must be withheld. But it is quite clear, that Thwaites did gather the same species, and that Berkeley redescribed them under other names.

One of the most striking instances is that of the termite nest agaric, *Volvaria eurhiza.* Gardner sent two immature examples of this, which Berkeley named *Armillaria eurhiza* and *Lentinus cartilagineus ;* there is probably a third name for the same species sent by Gardner, but at present this is doubtful. Now this is quite a common agaric at Peradeniya and elsewhere, in fact it is found (in Ceylon) wherever there are termites, and it is the chief edible agaric. But neither name is given in the list of Thwaites' specimens. It might be suggested that Thwaites did not send what had already been named, but against this we have the fact that Gardner's herbarium was not available, and the rest of Thwaites' collection shows no evidence of any such selection. However, on examining Thwaites' specimens and drawings, it is found that he did collect it and send it to Berkeley, but that it was renamed *Collybia sparsibarbis.* Now this species occurs either with or without a ring, a fact which accounts for the two names given to Gardner's specimens ; and the presumption is that there is another name representing the ringed form in Thwaites' collection, but so far it has not been unearthed. These three names were given on the assumption that the spores were white. Are we to suppose that neither Gardner nor Thwaites discovered it when mature ? If they did, there are yet other names for this species in the Ceylon list. The most likely supposition is that the mature agaric is included under the records of *Pluteus cervinus*, but, on the other hand, there is actually a Ceylon *Pluteus* closely allied to that species. For the present, therefore, we must suppose that neither Gardner nor Thwaites discovered that the spores were pink, though they probably often ate the fungus. The synonymy of this species can be carried beyond the Ceylon lists. Holtermann collected it in Ceylon, Borneo, and Malaya, and called it *Pluteus Rajap;* while Penzig and Saccardo obtained it from Java, and named it *Flammula Janseana* and *Pholiota Janseana.* Again, judging from Beccari's figure—which is all there ever was to judge from—Cesati's *Tricholoma subgambosum* from Borneo is another name for the same species. This serves to show that although the lists do not support the contention that the various collectors should obtain in general the common species, yet when the actual fungi can be determined, this view is fully upheld. The same species is gathered by five collectors, and is " described " under seven names. This example gives in addition a good illustration of the truth that it is often easier to trace the identity of a fungus by a touch of " local colour " than from pages of description. This agaric is edible and grows from termite nests. The descriptions of this species and the reasons for considering the various names as synonyms have been given in Vol. III. of the Annals of Peradeniya.

As another instance of the difficulties imposed by these early lists, we may take another common fungus, a *Clavaria*, to which we have for sometime been endeavouring to attach a name. It occurs in myriads at Peradeniya on the footpaths where the sand and gravel has been washed away, and it is equally common on the footpaths of tea estates all over the Island. It is to be expected, therefore, that anyone who collected *Clavariae* would include this species. Now Gardner only gathered one *Clavaria*, *C. miniata*, which grew in sandy soil, and the description of this does not agree with our footpath species. Thwaites collected thirteen species of *Clavaria*, but he did not get Gardner's species ; seven of the thirteen are said to be European species, and none of the descriptions fits our present form. Yet it is quite incredible that *C. miniata* should not be among these thirteen, if it is the species common on the footpaths. *C. miniata* is the required size and colour, but it is said to be palmate and to grow on sandy soil, whereas our species is practically filiform and grows only on compacted clay. The only filiform ground-living species in Thwaites' collection is one of his earliest numbers (67) and has been split up into two species, *C. argillacea*, Fr., and *C. inaequalis*, Fr., though it does not seem to be either, the original specimens being apparently red and threadlike. The only way out of the difficulty is to assume that Gardner's species is wrongly described, and that Thwaites' specimens of the same were attributed to European species. But it would have removed all doubt if the collectors had labelled their specimens "common on footpaths."

Another example may be taken from the group which is supposed to be always easily recognizable in dried specimens, viz., *Fomes*. We have a very common *Fomes* which particularly favours *Mangifera indica* and *Poinciana regia*, and is so common amongst old clumps of bamboos that the Sinhalese call this particular form of it the bamboo fungus, "Una Bimmal." It occurs in innumerable shapes, but it is generally stalked, though the stalk may vary from a scarcely perceptible one, ten centimetres in diameter and about two centimetres high, to a thin elegant structure ten centimetres high and five millimetres in diameter. The pileus may consist of an irregular mass of confluent lobes forming a sheet thirty centimetres in diameter, or it may be a regular reniform or circular pileus only five centimetres in diameter; and the stalk may be central or lateral. But it is always readily identified by its dark chestnut lacquered stalk, and slightly paler, lacquered, concentrically sulcate, and radially puckered pileus. This corresponds to *Fomes lucidus* of Europe, and it is evidently what Fries refers to under that name when he says it is common all over the Tropics, though it seems to differ from *lucidus* in some respects, and is probably a parallel, rather than an identical, species. Yet there is no Ceylon record of *Fomes lucidus*, or anything approaching it.

Thwaites arrived in Ceylon in 1849, and for some time did very little in connection with his favourite cryptogams. He appears to have sent small consignments to Berkeley from time to time, a list of sixteen Ceylon species being published in the Kew Gardens Miscellany, 1854, p. 229, while other Ceylon records are scattered through Berkeley's lists. Dr. Harvey who visited Ceylon in 1853 collected three species. But from about 1865 to 1869 Thwaites appears to have put all the Gardens' staff to collecting fungi, with the result that over 1,200 numbers were sent to Berkeley, accompanied by several hundred accurate watercolour drawings. These were described by Berkeley and Broome in the Transactions of the Linnean Society, Vol. 27, and in the Journal of the Linnean Society, Vols. 11, 14, 15. These lists were evidently intended to form a complete account of the fungi of Ceylon to that date, but many of the earlier records, even of Thwaites' specimens, have been omitted. The total number is 1,211.

It has already been stated that Thwaites apparently did not collect fifty per cent. of Gardner's species, but this is chiefly due to Berkeley's failure to recognize what he had named before. Even in cases where he suggests that a new species may be identical with an earlier form, one only wonders, on comparing the descriptions, where the resemblance is to be found. For example, he suggests that *Lepiota continua*, which Gardner collected but Thwaites did not, may be a wartless form of *Lepiota oncopoda* which only Thwaites collected. Now, we know *L. oncopoda*, and any suggestion as to what *L. continua* was is useful, but the former is fleshy and has gills attenuated behind, and is covered with large warts, while the latter is membranaceous, smooth, and has gills "reticulated behind," whatever that may mean in a *Lepiota*.

The genus *Lentinus* is represented in Thwaites' collection by twenty-five species. The group has not yet been completely made out because some of the type specimens referred to are Gardner's, and cannot be examined on the spot, but so far it is evident that one of these *Lentini* is a *Clitopilus*, and another (*L. cartilagineus*) is the termite nest *Volvaria*. Four other names refer to one species only, and this is a *Clitocybe*. This leaves nineteen *Lentini*, and, of these, two names at least refer to one species which elsewhere in the list does duty as a *Pleurotus*, while another species is represented under at least eight names. So that at present our twenty-five *Lentini* reduce to eleven, and in all probability they will be reduced still further when the remainder have been identified. And yet *Lentini* are considered to be always recognizable. No wonder that "the tough, leathery fungi predominate" in the imagination of descriptive mycologists.

Again, Gardner collected three species of *Pleurotus;* Thwaites collected nine in the Gardens; yet they have no species in common. But we find from the drawings and specimens, that one of Thwaites' species is a *Lentinus;* and that two other names are synonyms and indicate the only *Pleurotus* which Gardner collected in the Peradeniya Gardens, though his gathering was attributed to a European species.

Our commonest Lepiota, *L. Zeylanica*, Berk., was originally described from specimens sent by Gardner. Berkeley did not recognize it in Thwaites' consignment, but renamed it *theloides* When it was afterwards discovered to be identical with Gardner's species, Berkeley and Broome split up Thwaites' gathering into *zeylanica*, *subclypeolaria*, and *rubicata*, on characters which prove to be common to all the Ceylon forms which at all agree with the descriptions of these three. *Subclypeolaria* is a Cuban species, possibly quite different from *zeylanica ;* no conclusion can be drawn from the fact that a Ceylon species was considered identical, and the description is too brief to be of service. As illustrating the confusion over this species ; the figure which Berkeley and Broome cite as *rubicata* is marked by them *zeylanica ;* and the figure marked *theloides* and subsequently referred to *zeylanica* exactly matches those marked *L. inebriata.* The last-named differs only in the colour change of the gills, and is probably a " weather form."

Thwaites' *Marasmii* include, according to Berkeley and Broome, 44 species, all but two of which were gathered in the Peradeniya Gardens. Of these, we have only fourteen figures and fifteen named gatherings. The number of figures is instructive, for it indicates to some degree how many species Thwaites thought he had collected ; he did not trouble, except in a few cases, to make another drawing of what he considered the same species, unless it showed wide variation ; and consequently when Berkeley and Broome split up one gathering into two or more species we have only the figure of one. Before attempting to identify these forty-four species, it was thought advisable to roughly classify them by means of the descriptions into *Collybiarii* and *Mycenarii*, but this proves quite impossible, as the necessary characters are not given. Comparing Thwaites' numbers, we find that his 38, 100, 102, and 752 were each split up into two species ; his 101 into four *Marasmii* and a *Collybia ;* his 204 into five *Marasmii* and a *Collybia ;* and his 807 into three *Marasmii :* it is readily understood, therefore, why we have so few figures. Now, the genus is not particularly abundant in the Gardens at the present day ; we have no " fairy ring " species to compare with *M. oreades ;* our common species among grass is *Heliomyces caryotæ* which does not grow on *Caryota*, and seems no more than a good *Marasmius.* On the other hand, specimens, if not species, of *Mycenarii* are fairly common on dead leaves and twigs. Up to the present about six of these have been connected with

Berkeley's descriptions, but our commonest form still defies identification. It is, like all our common species, highly variable ; the pileus varies from four to fifteen millimetres in diameter, and the stalk from two to eight centimetres in length. The stalk is almost black, shining, and strigose at the base, often springing from a yellowish mycelium on the leaves or twigs. In this all the specimens are alike, but the sulcate pileus may be rough or smooth between the sulcæ, corresponding with the presence or absence of veins between the gills, and the gills may or may not have a red brown edge. But Berkeley and Broome rely on size, and the presence of veins connecting the gills, for the separation of their species, and neither is valid in the present case. They never discovered that the edge of the gills of any Ceylon species was coloured. Throughout the whole of their *Marasmii*, one realizes that their limits of allowable variation were too close, and in some cases they use characters which are quite valueless. For instance, a twisted stalk separates *M. florideus* from *M. hemibaphus ;* and *M. semipellucidus* "differs from other species with which it might be confounded in the upper part of the stem being pale and pellucid." But all the stalks of our thin stalked species twist hopelessly in drying, and there is not one of them in which the upper part of the stalk is not at first pale and pellucid. At present we can only be certain that young specimens of our common species were named *M. proletarius*, B. & C., though they are redbrown in the figure whereas to suit the name they should be white ; that it is the part of Thwaites 807 which was attributed to *M. hœmatocephalus*, Mont, and also the part of the same number which was called *M. fulviceps*, Berk. As Gardner collected the original specimens of *fulviceps*, one is tempted to adopt the latter name, but this species is, according to the description, not sulcate !

The four *Marasmii* in Thwaites 101 are *hypochroides*, *coniatus*, *semipellucidus*, and *atrorubens*. There is a figure of the first only. All are about the same colour, with a sulcate, campanulate pileus. *Hypochroides* is distinguished by its size ; *coniatus* is covered with dust-like particles, which is not a fit character on which to separate a gathering after the specimens have been dried, poisoned, pressed, and kept for five years ; *semipellucidus* has a stalk pellucid above, which is quite a valueless character ; and *atrorubens*, according to description of the original Surinam specimen, has a velvety stem. It is worthy of note that the original description of *atrorubens* was founded on a single specimen picked out of a gathering of *M. hœmatocephalus*. It will probably be found that the last name will cover a large number of the redbrown sulcate *Marasmii* which have been described from the Tropics, but as far as Ceylon is concerned, Berkeley and Broome have confused matters by referring to this species Thwaites 752, the figure of which shows a purple pileus.

Our largest *Pluteus* appears to have been split into as many species as *Lentinus exilis*. Its names include *cervinus*, *nanus*, *phlebophorus*, and several new ones, depending chiefly on stature, abnormalities, and weathered forms. One of these, *P. spilopus*, has been rediscovered in England, but the description of the English form says that the pileus is radiately rugulose, a character not found in the Ceylon specimens, and omits the scabrous centre (recalling *Armillaria mellea*) which is a constant feature of all forms of our species. It does not grow on wood, as a rule, but in dense clusters near the base of stumps on earth which is bound together by fine white mycelium. Berkeley and Broome state throughout that it grows on dead wood, but the figures show that it does not.

The following illustration will show how prolonged is the process of identification in many cases, and how " unscientific " is the clue which sometimes leads to it. Early in 1906, I gathered a white-spored agaric from an old stump in the Gardens. It was distinguished from all previous species by the viscid sub-diaphanous pileus, distinct from the solid fibrous stalk, and the large spherical spores, but above all by the peculiar characters of the gills. There seemed to be no division of the *Leucosporœ* into which it could be fitted without violent strain. Nothing in Berkeley and Broome's descriptions fitted it, and the figures, being only in profile and longitudinal section, could not be expected to reveal the gill characters. Successive crops were gathered for more than a year from the same stump, and the extent of its variation in colour and form was fairly well determined, but still there was no clue that it was one of Berkeley and Broome's species. Now among their Ceylon species is one named *Collybia magisterium*, so called because its spores " look like a *magisterium*." As I had a vague idea that a magisterium was a piece of chemical apparatus, I always passed over this description with a resolve to examine these peculiar spores when I had time, the more readily as I had nothing apparently to fit the description or figure of the species ; but on learning later that the magisterium was really a " Philosopher's stone," I became so eager to know what shape that might be that I examined the herbarium specimens at once, hoping thereby to find a clue to some efficient substitute for the once wide-spread pagoda tree. The spores, except for the apiculus, were exactly spherical, and the same large size (up to 20 μ) as in the species I had been so long in doubt about. A further examination of the herbarium specimens shows that there is no doubt as to their identity ; the peculiar characters of the gills can still be made out in the dry state if one knows what to look for. The species was named at least three times, viz., *Collybia apalosarca*, *Collybia euphylla* and *Collybia magisterium*, though none of the descriptions mentions any of the naked-eye characters which make the species so distinct. Nothing is said about the viscid character of the pileus ; one is erroneously said to be striate to the centre ; another is said to have a hollow stalk ; and the gills are misdescribed in all. The descriptions were drawn up from the figures only, and the latter are not views which would illustrate the distinctive characters. The result supports the author who writes of " the curse of establishing species from figures." In the case of *Collybia euphylla*, we have the specimen and drawing, Thwaites 1201, from which the species was described, but Berkeley and Broome included with it Thwaites 731, which is apparently quite a different species with long thin stalks and small spores, and which was clearly not taken into account in drawing up the description. In all probability "*Collybia apalosarca*" is related to *Oudemansiella*, though it is difficult in the absence of figures to grasp the description of the gills of that genus. In this case the division of the gills is a variable feature, and it is not comparable with that of *Schizophyllum*.

These misdescriptions have as a matter of course been copied into the "Sylloge Fungorum" for the guidance of other mycologists, and as a rule some one finds species to fit them. Although the man on the spot knows that the majority of them did not originally describe any natural production whatever, and cannot assign any fungus to a description without the help of the original specimen and drawing, yet he finds that they are apparently quite intelligible to mycologists who are not hampered by such assistance, nor by fresh specimens from the original locality. As a rule, the mycologist who rediscovers a Ceylon agaric in another country merely lists the name: when he adds details of the fungus, they prove that he has made a mistake. *Collybia apalosarca* is certainly not identifiable from its "description;" yet it is included in a recent list of African fungi. But the compiler adds that the spores are oval and 9 × 8 , a fact which at once proves that the identification is incorrect. The same list includes *Pluteus balanatus*, B. & Br.: the specimen on which this was founded is quite immature, Berkeley and Broome did not see the spores, and there is no evidence that it was a *Pluteus*: they say that the gills are pink, but in the figure they are pale ochraceous. Another Ceylon species in the same list is *Pluteus glyphidatus*, B. & Br., but the redescription omits the characteristic features of that species, and adds details which do not fit it. I have no intention of declaring that Ceylon and Africa cannot have species common to both; but I confidently assert such a determination based on the existing descriptions must in the majority of cases be incorrect.

Thwaites' illustrations (executed by Wm. de Alwis) and the greater part of his specimens are still at Peradeniya, and these form the basis on which future work must be founded. His species are certainly described under several names, and when this synonymy has been determined the basidiomycetes at least will be reduced to about one half their present number. Berkeley and Broome seem to have uniformly disregarded Thwaites' remarks as to the identity of different gatherings, but in most cases Thwaites' view is correct: they also show a decided preference for splitting up one of Thwaites' gatherings into three or four species. It will not be possible to work back to Gardner's species for several years, except in very obvious cases. It may safely be said, however, that the determinations of Ceylon fungi as European forms are in most cases unreliable, and therefore theories of distribution, or lists of the edible fungi of different countries, based merely on the records of "Saccardo," are valueless.

Examples of such determinations are *Psathryella disseminata*, *Psalliota campestris*, *Ps. arvensis*, *Ps. sylvatica*, *Pleurotus dryinus*, *Lepiota procera*, *Amanita vaginata*, *Nectria cinnabarina*, *Tricholoma nudum*, *Clitocybe candicans*, *Pluteus cervinus*, *Flammula sapinea*. This statement is only made of those cases in which fresh specimens have been examined and compared with the original specimens and drawings.

The descriptions of Ceylon fungi seem to have suffered considerably in the transcription into "Saccardo." Thus *Pleurotus polychromus*, which is $\frac{3}{4}$–1 inch, is said in "Saccardo" to be 18–25 cms., and conversely *Psalliota pedilia*, with a stem 1 inch thick, is said to have a stem 2 mm. thick. The transcriber had evidently very hazy views of the metric system. *Lepiota dolichaula* is said to have a stalk "apice nigricante," which presumably corresponds to Berkeley's phrase: "the deep pit in which the apex of the stalk is sunk." *Xylaria melanaxis*, Ces., is said to grow "in truncis," though the original record makes no mention of that fact.

Berkeley's Ceylon species and genera have been written about on several occasions, and the names have been subjected to the usual changes, sometimes after an examination of his specimens, but more often without. In consequence, the reduction of his species to synonyms, after an examination of the original specimens and drawings, and a comparison of these with fresh specimens, introduces rather curious results. For example, Berkeley "described" the same fungus three times as *Psalliota trachodes*, *Ps. pedilia*, and *Ps. poderes.* Saccardo leaves the first in *Psalliota*, but puts the other two in *Chitonia*, while Hennings later leaves the first two in *Psalliota* and *Chitonia* respectively, but institutes a new genus, *Chitoniella*, for the third. Yet there is only one species! In connection with this name changing, it may be pointed out that, even in accordance with the rules of botanical nomenclature, it is hardly fair, when Berkeley wrote *Agaricus* (*Lepiota*) *rubicatus* B. & Br., to obtain an advertisement by writing *Lepiota rubicata.*

König's collections were made before the establishment of a Botanical Garden in Ceylon, and they cannot now be localized. Gardner practically collected only at Peradeniya and Nuwara Eliya, and the greater part of Thwaites' specimens are from the same localities: so that the "Fungi of Ceylon," as compiled by Berkeley and Broome, represents little more than the fungus flora of the Peradeniya Gardens.

During the time that Thwaites was amassing his collection Beccari visited Ceylon on his way to Borneo (1865). He landed at Galle, and travelled along the beaten track to Colombo, Kandy, and Nuwara Eliya, a route which had been traversed by all his predecessors. The fungi which he collected on the way were described by Cesati in 1878. Apparently he had not submitted even his Peradeniya specimens to Thwaites, who was then collecting vigorously, for out of eighty-eight species which he collected in Ceylon, fifty-two have not been recorded by any one else, and twenty-six of these are new. Nineteen species are definitely stated to have been taken in the Peradeniya Gardens: of these, seven only were found by Thwaites or Gardner, and of the remaining twelve, six are new species: he only gathers one *Clavaria* in the Gardens, and that, according to the description, is not our common species.

Since Thwaites' time work on Ceylon fungi has consisted merely of repeated shuffles of his specimens: there have been practically no additions to the herbarium or to the list of species. The late Professor Marshall Ward, who came out to investigate the coffee leaf disease caused by *Hemileia vastatrix*, worked out the development of the perithecium of *Meliola*, but did not trouble about the species. Nietner (1872) writing on the coffee disease mentions one new species ; and some specimens of *Diplodia* apparently on seeds sent from Ceylon have been described by F. Tassi (1899). Between these dates a few of Thwaites' specimens found unnamed in Berkeley's herbarium have been described (in Grevillea) by Cooke and Massee. Holtermann worked in Ceylon during 1895, and his results here and elsewhere have been published under the title "Mykologische Untersuchungen aus den Tropen" (1898), but they afford very little from a systematic or distributional standpoint. He states that during his fourteen months' stay in the Tropics (Ceylon, Java, Borneo), he *saw* four hundred European species of fungi ! It is to be regretted that he did not examine them and establish their identity.

At the present time, if the name of a Ceylon fungus is required, the *modus operandi* is as follows. In the first place it must be compared with Berkeley's descriptions of Thwaites' species and the original specimens and drawings, in order to find out what Berkeley then named it, and *how many times he named it*. Then a search must be made through the descriptions of Gardner's species to see whether it was named in 1846. If the specimen happens to be a *Polyporus*, there must be a further reference to König's species. This process generally gives ultimately several names for each species, and the synonymy can in some cases be further lengthened by considering Cesati's descriptions of the specimens collected by Beccari. All doubtful cases are reserved, and no decision arrived at until a large number of specimens have been examined. In this way the synonymy of the species, *as far as Ceylon is concerned*, may be definitely determined, though progress is extremely slow. But this gives no idea whatever of the number of times it has been named on specimens from other countries. It seems to me that the only possible way in which any definite knowledge can be evolved out of the present chaos is that the mycologists of each tropical country should work out their species in a similar manner, and that when this has been done they should interchange specimens and coloured drawings of at any rate their common forms. But if the original collections were not returned to the sender there is no possibility of ever arriving at a definite conclusion, and the existing records are merely so much waste paper. Certainly the present practice of consigning basidiomycetes to Europe is a waste of time. The describers not only fail to recognize a species : in many cases they do not hit upon the right genus. The descriptions are unrecognizable, and the "species" on which they are founded are often only damaged or abnormal forms of common things. The latter is especially the case when, as so often happens even at the present day, the actual collecting is entrusted to coolies. The mycologist must collect his own specimens and know them under all conditions.

It may be urged that the conclusions arrived at only hold good for basidiomycetes, and that the work which has been done on tropical pyrenomycetes, for example, represents substantial progress. Those who hold this opinion would change it if they had to examine these fungi on the spot. This group, parasite or saprophytic, is predominant in disease investigations, and it is remarkably difficult to collect specimens which show the characters of the ripe fungus. As a rule, specimens must be kept under cultivation before ripe spores are obtained : the natural production of ripe spores appears to be a very transitory process. Are we to expect that the species collected at random by collectors who have no opportunity of revisiting a locality will in all cases be in a fit condition for an exact determination ? Cesati remarks, *re* Beccari's discomycetes: "Paucissimi fungilli ex hoc ordine extantes in collectione Beccariana vix tute determinandi, quia eorum fructificatio omnino deest vel nimis saltem se exhibet imperfectam," and this is true of most collections of this class made at the present day. *Xylaria nigripes* affords an instance of this condition in the *Pyrenomycetes :* the ascus form, which is yellowish gray, may be watched for weeks, but all specimens examined contain immature spores until the stage is reached in which the whole fungus is blackened by the extruded ripe spores. And the original inexact description of *X. nigripes* has burdened the species with at least half a dozen synonyms.

There are very few groups which can be accurately worked out from dried specimens. Probably the *Uredineæ* and *Ustilagineæ* afford favourable material for such work, but even in these groups the results are not altogether trustworthy. For example, it has been found that the description of *Ustilago Shiraiana*, Henn., on bamboo, does not agree with the fresh specimens. Here Ceylon affords another example: the unmistakable *Ustilago Treubii*, Solms., which forms the well-known obconic galls on the stem of *Polygonum chinense* is said to have smooth spores, 4 μ in diameter, (Dietel, Engler-Prantl, Pflanzenfamilien, pt. 160, p. 11): but the abundant Ceylon specimens have spores 7–9 μ in diameter, closely and regularly reticulated. Are we to suppose that our fungus is another species producing exactly the same extraordinary effect?

The following are a few of the duplicate names which have been given to Ceylon species, in addition to those already mentioned. They are cited here merely in support of the statements of this article, and will be discussed later. It is not to be deduced that they are synonyms:—

Lepiota dolichaula, B. & Br. *Lepiota procera*, Scop.

Lepiota oncopoda, B. & Br. *L. pseudogranulosa*, B. & Br. (in part).

Lepiota œnopoda, B. & Br. *L. adorea*, B. & Br.

Psalliota subæruginosa, B. & Br. *Lepiota macrocola*, B. & Br.

Clitocybe candicans, P. *Lentinus apalus*, B. & Br. This is a pink-spored agaric.

Marasmius calvus, B. & Br. *Collybia multijuga*, B. & Br. (in part).

Lentinus percomis, B. & Br. *L. lecomtei*, Fr. *Pleurotus polychromus*, B. & Br.

Lentinus exilis, Klotsch. *L. velatus*, B. & Br. *L. multiformis*, B. & Br. *L. infundibuliformis*, B. & Br. *L. cretaceus*, B. & Br. *L. manipularis*, B. & Br. *L. lobatus*, B. & Br. *L.*

subnudus, Berk. The figure of *Lentinus scleroticola*, Murray. from Samoa exactly represents a dried, half-expanded *L. exilis*, but the latter has only a pseudosclerotium. Massee's photograph of *L. cyathus* is also *L. exilis*. In all probability all these are *L. tuber-regium*, Fr.

Pleurotus angustatus, B. & Br. *P. dryinus*, P. *P. flabellatus*, B. & Br.

Entoloma microcarpum, B. & Br. *E. intermixtum*, B. & Br.

Armillaria rhodomala, B. & Br. *Flammula sapinea*, Fr. *F. dilepis*, B. & Br.

Psalliota crocopepla, B. & Br. *Ps. lasiophrys*, B. & Br.

Psalliota actinorachis, B. & Br. *Lepiota biornata*, B. & Br.

Panæolus cyanascens, B. & Br. *P. caliginosus*, Jungh. *P. papilionaceus*, Bull.

Hygrophorus roseostriatus, B. & Br. *H. glandulæformis*, B. & Br. *H. bicolor*, B. & Br.

Favolus tessellatus, Mont. *Favolus scaber*, B. & Br. *F. ruficeps*, B. & Br.

Favolus brasiliensis, Fr. *F. multiplex*, Lev.

Peziza sarmentorum, B. & Br. *P. crenulata*, B. & Br.

Marasmius crispatus, B. & Br. *Cantharellus elegans*, B. & Br.

Poria ravenalæ, B. & Br. *P. fuligo*, B. & Br. *P. nigra*, Berk.

Diatrype gyrosa, Schw. *Nectria gyrosa*, B. & Br.

Lentinus stenophyllus, Berk. *L. giganteus*, Berk. *L. obnubilus*, Berk. *L. maculatus*, Berk. This is a *Clitocybe*.

Physarum lividum var. *conglobatum*, Rost. *Didymium cinereum*, Fr. *Physarum nutans*, P. *Tilmadoche reniformis*, Mass. *Didymium echinosporum*, Mass. This is *Physarum nicaraguense*, Macbride.

A large *Psalliota* which occurs in troops at Peradeniya appears to be recorded under at least a dozen names. Specimens which correspond with the named figures have been gathered from time to time, but up to the present it has not been found possible to separate them by any constant character.

Berkeley's genus *Endocalyx* contained two species, *E. Thwaitesii* and *E. psilostoma*: these are identical. To the same genus belongs *Melanconium melanoxanthum*, B. & Br., and *Phæodiscula gonospora*, Penz. & Sacc., with its sub-species *atrata*, *atratula*, and *minutella*. Apparently *Graphiola macrospora*, Penz. & Sacc., *Melanconium profundum*, Penz. & Sacc., and *M. Yatay*, Speg., are other species of *Endocalyx :* indeed these last seven names appear to be all synonyms of *M. melanoxanthum.* A paper on this genus is in course of preparation.

Peziza ruberrima, B. & Br., is, *fide* Massee, a collapsed *Lycogala : Aschersonia mellea*, B. & Br., is a small agaric (*Pleurotus ?*) : "*Tricholoma nudum*" is a pink-spored agaric : *Lepiota alphitochroa*, B. & Br., is a *Psalliota*, identical with *Psilocybe canorubra*, B. & Br. : *Bovista velutina*, B. & Br., is an unopened geaster : "*Lycoperdon atropurpureum*" is *L. gemmatum*, Batsch : *Hydnocystis Thwaitesii* is a *Genea : Sclerocystis coremioides*, B. & Br. (new species and genus), is a very common minute sclerotium : the sheet which is supposed to contain *Lycoperdon pusillum*, Bull., and *L. conspurcatum*, B. & Br., contains nothing but (unrecorded) *L. purpurascens*, Berk. : "*Psathyrella disseminata*" is a very common *Psathyra*, and has apparently been described as *Psathyrella* under several other names : *Tuber Zeylanicum* is a sclerotium, probably the same as *Sclerocystis coremioides.* Many species are founded on specimens which Berkeley and Broome calmly state are immature, *e.g.*, *Dothidea Barringtoniæ*, *Sphæria acanthigera*, *Sphæria chloronema*, but this has not prevented a later shuffle into other genera : *Volvaria geaster* is so immamature that it was not recognized as an agaric until it was cut open.

The so-called *Eurotium diplocystis*, B. & Br., resembles a small group of immature puffballs with the mycelium attached, and is probably the same as the specimens named *Paurocotylis :* it is certainly not *Eurotium.* *Helotium melleum*, B. & Br., from Ceylon is (*fide* Massee) a corticolous lichen : there is however a totally different *Helotium melleum*, B. & Br., from Scotland.

Pluteus balanatus, *Psalliota pedilia*, *Lepiota adorea*, *Lepiota biornata*, *Tricholoma charisterum*, *Lepiota macrocola*, *Armillaria rhodomala*, *Coprinus setulosus*, *Coprinus castaneus*, *Pleurotus polychromus*, *Lentinus velatus*, *Polyporus olivaceo-fuscus*, *Lycoperdon phlebophorum*, *Hypocrea artocreas* were all described from immature specimens; *Lepiota œnocephala*, *Psalliota lasiophrys*, and *Psalliota celidota* were described from drawings of weathered and decaying specimens; and *Psalliota chrysocycla*, *Hygrophorus bicolor*, and *Hygrophorus elegantissimus* owe some of their distinguishing characters to the fact that they have been "caught" by the dry weather. *Leotia brunneola* was founded on a drawing only: the specimen was gelatinous, and when put out in the sun to dry was lost: there is no evidence that it was a *Leotia*.

In some cases the names of host plants have been wrongly transcribed from Thwaites' sheets, and in others synonyms have not been recognized. *Triphragmium Thwaitesii* on *Hedera vahlii* differs only slightly from *T. clavellosum* on *Paratrope terebinthacea*: it may be questioned whether Berkeley would have separated these two had he known that the names of the host plants were synonymous. Similarly, Cooke separated *Ravenelia Hobsoni*, Cke., on an undetermined host plant, from *R. stictica*, B. & Br., on *Pongamia glabra*: but the undetermined host proves to be *Pongamia glabra*, and the fungus on it *R. stictica*. More recently, Dietel instituted *Ravenelia zeylanica* for a form on *Gleditschia* which Berkeley included with *R. sessilis*, Berk., on *Albizzia Lebbek*, but the supposed leaves of *Gleditschia* are really *Albizzia Lebbek*, and the fungus was correctly named by Berkeley.

Thwaites' specimen 426 is labelled *Pterygota alata*, which is a synonym of *Sterculia Thwaitesii*, Mast., but Berkeley and Broome name it *Rhytisma maculosum*, B. & Br., on *Sterculia alata*, Roxb., which is not a Ceylon plant. Thwaites' 518 is correctly labelled *Memecylon umbellatum*, but Berkeley and Broome call it *Chionanthus zeylanicus*, and name the fungus on it *Sphæria chionanthi*, B. & Br. Thwaites' 423 consists of fungi on leaves labelled "*Ficus parasitica*": it has been separated into *Dothidea rhytismoides*, Cd., "on *Hugonia mystax*," *D. microcentra*, B. & Br., "on leaves apparently of *Artocarpus*," and *D. aspidea*, B. & Br. "on *Ficus repens*."

Though Thwaites was deeply interested in cryptogamic botany he seems to have relinquished the study of fungi altogether after the publication of Berkeley and Broome's list. Yet he was sufficiently aware of the importance of following up their work to stipulate that the drawings and specimens should be returned to Ceylon, and he knew too much about fungi, and travelled too widely over the Island, to imagine that he had collected everything. The sudden cessation of all mycological work suggests that he realized the value of what had been published. It is to be regretted that he has left practically no comments on Berkeley and Broome's work: notes of dissent are attached to a few specimens, but that is all. Possibly he found the work of annotating the whole list too great a task to be undertaken at an advanced age.

In a review of a previous paper on "The Fungi of Termite Nests," in which it was necessary to reduce to synonyms six names, the reviewer remarks: "Auf die von den verschiedenen Autoren gegebenen und vielfach von einander abweichenden Beschreibungen ist kein Gewicht zu legen, wenn man den Umstand berücksichtigt, dass der Pilz infolge seines unterirdischen Wachstums sowohl in Form und Grösse sehr variiert." I fear that in the majority of cases this flattering unction must be withheld. The plain fact is that a mycologist is not able to describe a dried agaric with any measureable degree of accuracy. Moreover, when he comes to deal with tropical species he denies them even the limited amount of variation which he grants in the case of temperate forms. Every minute difference is considered specific. A *Lentinus* in wet weather has a smooth whitish pileus, and is named *exilis*: with diminishing rainfall it has a scaly pileus, and becomes *cretaceus*; some specimens retain the livid colour of the immature form, and are separated as *multiformis*: and the arrested fructification with gills just developing is named *velatus*. Are there no examples of a fungus with a variable, smooth or scaly, pileus in temperate regions, and is it necessary to bestow a name on obviously immature specimens? Again, another *Lentinus* is at first violet, and then changes to yellow, and yet another changes from violet to dark brown: but the describer of dried specimens makes at least two species of each, and puts them in different genera.

Other colour changes (beyond those of the gills) account for the naming of a young form as *Armillaria* and the mature stage as *Flammula*.

Even in structure there is wide variation. We have species which may or may not be umbonate, and the difference occurs in two connate-stalked specimens, but the gathering is carefully sorted out into two distinct species. Variations in the veil or the scaliness of the stem are thought sufficient distinction: well, we take a mass of leaf mould bearing expanded and unexpanded specimens of *Lepiota pyrrhœs*, which has a stem clothed with red-brown scales below the ring, and allow the unopened examples to develop in a saturated atmosphere under a bell glass: the scales then remain on the veil, and the veil separates from the stem leaving a wide central circular opening through which the stem passes: finally, the veil disappears, and the stem is smooth, shining, and ringless: then it is *russoceps*. Similar variations occur in our commonest *Psalliota*, with the result that it is about a dozen species. The published accounts of the fungi of Ceylon demonstrate that an agaric, at least, cannot be described from a dried specimen, and that the average describer has not the slightest idea of the general biology of the species with which he attempts to deal.

Descriptions of Ceylon fungi will be published from time to time as it becomes necessary to work out the various species. In all cases, these will be based on a large number of specimens, and where possible the fungi will have been watched through all their stages. It is evident that, with about 1,300 old "species" to be verified in addition to those which have not been recorded, it will not be possible to present these contributions as summaries of definite groups: they will merely consist of those species which have come to hand, and even these will not be recorded until it is reasonably certain that all their Ceylon synonyms have been ascertained. In some groups our information is fairly complete. Thanks to Mr. Lister's critical examination of the mycetozoa of Ceylon in the Kew and South Kensington herbaria, Thwaites' seventy-four species have been accurately determined: seven of these are not mycetozoa, and the remainder fall into fifty-two species : the list of Ceylon mycetozoa with recent additions contains one hundred and three species. Similarly, all the previously recorded Ceylon phalloids have been re-discovered, with some additional species. But in other groups, our information about the fungi of Ceylon must necessarily be doled out in fragments : and it will entail a considerable reduction in the names already existing. The results fully bear out the contention that all collectors in Ceylon included in their collections the common species, and that these have been re-described each time under new names ; and that in any one collection, the same species is described under different names and in different genera.

1.—Lepiota dolichaula, B. & Br.

"*Lepiota dolichaula*, B. & Br. : pileo carnoso expanso umbonato, centro glabro, alias punctate squamuloso, margine lacero-appendiculato, carne alba immutabili : stipite elongato stricto (base excepta), subæquali, apice penetrante, flocculoso punctato cavo ; annulo amplissimo deflexo lacero ; lamellis latis ventricosis remotissimis.—Thwaites, Ceylon, No. 694." (Linn. Trans. 27, p. 150.)

The pileus is almost plane except for the well-defined umbo and the decurved margin. The umbo is pale or dark brown, minutely tomentose ; elsewhere the pileus is white, covered with minute, brown, widely-separated, dot-like warts ; between the warts it is thickly covered with minute, white granules, or almost glabrous. It varies from 14–19 cm. in diameter, and the white, loose flesh is about 1·5 cm. thick near the centre. The margin is appendiculate and decurved, but only half covers the ends of the gills.

The gills are ventricose, up to 2·5 cm. wide, rounded or truncate at the outer ends, which are widely exposed, free, somewhat distant. They turn yellow in drying, and are pinkish where eaten by insects.

The stem is 29–42 cm. long, about 1·5 cm. in diameter, attenuated upwards, with a well-defined bulb 2–3 cm. in diameter at the base ; white, mealy or glabrous, sunk into the pileus for about a centimetre, hollow, lined with shining white fibres, brittle : the inner layers are pinkish, and when the outer white layer is split, the stem shows pinkish spots and streaks.

The ring is at about one-fifth the height from the top. It is movable, with a sheathing collar about 5 mm. deep, joined below to a free rigid horizontal portion about 5 mm. wide, which passes into a looser, ample, dependent curtain. It is scaly beneath.

The spores are white, oval, thick-walled, 12–17 × 8–10 μ.

In the Peradeniya list, "edible" appears against this species in Trimen's handwriting. There appears, however, to be some doubt on this point: the natives say they do not eat it.

Berkeley's description of the stalk as "flocculoso punctato" is based on an attempt by the artist to depict the splittings in the outer layer of the stalk. Saccardo says the stalk is blackish at the apex, but this is a mistranslation.

The species is fairly common (and conspicuous) on the lawns at Peradeniya, but, according to the lists, it was not collected by Gardner. However, as in many other cases, when this species is caught half-expanded by the dry weather, the pileus splits into shaggy scales, and I have no doubt that the *Lepiota procera*, Scop., of Gardner's collection was really *L. dolichaula.*

Lepiota altissima, Mass., from India appears to differ only in the size of the spores (8 × 5): it might be worth while also to inquire whether the large Amanitas and Lepiotas collected by Hooker at Darjeeling and elsewhere in India are not the same species.

2.—Lepiota oncopoda, B. & Br.

Pileus at first cylindric, top obtuse, finally almost plane, broadly umbonate, up to 12 cm. in diameter, white, covered with white superficial conical warts, which are large in the centre and diminish to mere scales towards the margin, densely mealy between the warts: flesh thick, but soft: margin appendiculate, striate when old or when the warts, &c., are brushed off.

Stalk, up to 12 cm. long, gouty below, the swollen part occupying one-third to one-half the whole length, up to 2 cm. in diameter, equal above and 4–7 mm. in diameter: the swollen part is solid, the narrow upper part is stuffed: clothed like the pileus with large conical warts and meal up to the ring; above the ring slightly mealy.

Ring variable, sometimes with a close-fitting movable collar, 8 mm. long, and an ample dependent curtain warted on the under side, sometimes remaining altogether on the margin of the pileus, white.

Gills free, sometimes narrow, sometimes ventricose, ·4–1 cm. broad, attenuated behind, rather distant, white.

Spores broadly elliptical, with an almost terminal apiculus, white, 8–13 × 6–8 μ.

On decaying wood.

The large warts of this species are easily rubbed off, and the stem when handled becomes smooth and yellowish: this accounts for Berkeley and Broome's statement that the stem is "clothed, especially above, with little superficial warts." The specimens were probably gathered by a cooly, and the paintings show that all the warts have been rubbed off the lower part of the stem. As in *Armillaria asprata* and *Psalliota crocopepla*, the warts make the young specimen resemble a *Lycoperdon*. Berkeley and Broome state that it grows on the ground, but the figures show the wood attached to the base.

The type figure and specimen of *Lepiota pseudogranulosa*, B. & Br., undoubtedly represent a small specimen of *Lepiota oncopoda*, though the description says that the spores are only 5 μ long. An examination of the type specimen, however, shows that the spores reach 13 × 8 μ: there are some spherical warted spores (? of *Sterigmatocystis nigra*, van Tiegh.), 5 μ in diameter, mixed with them. Thwaites' 823* was said to be a variety of *L. pseudogranulosa*, but it differs altogether from that species, and was not taken into account in drawing up the description. The description of *L. pseudogranulosa* says that the pileus is "estriatus," but the figure shows a striate margin.

Berkeley and Broome suggest that *Lepiota continua*, Berk., collected by Gardner in 1844, may be a wartless form of *L. oncopoda*. According to the description, *L. continua* differs in having a membranous, glabrous pileus, and gills reticulated behind : it agrees in being white, margin sulcate, stalk pulverulent and thickened below.

3.—Lepiota œnopoda, B. & Br.

Pileus at first acorn-shaped, then conico-campanulate with an abrupt prominent nipple-shaped umbo, finally plane with the umbo arising perpendicularly, about 3 cm. in diameter, white, umbo sometimes slightly brown, covered except the umbo with minute white scales, silky beneath the scales or when these have been washed off : margin strongly plicato-striate, the plications extending half way to the umbo or further : flesh thin.

Stalk 4–6 cm. long, 3–6 mm. in diameter, attenuated upwards, sunk into the hollow umbo, white at first, then pinkish with a powdery bloom, red when old, hollow, the cavity lined with white shining fibrils, flesh pinkish. Ring white, firm, movable, without free margin.

Gills white, then pinkish, rather broad, somewhat distant, equal, free, rising behind into the hollow umbo.

Spores oval, somewhat pointed at one extremity, 7–10 × 4–6 μ.

On the bark of living jak trees.

The figure of *Lepiota œnopoda* shows an old specimen with a red stalk and a partially collapsed, conico-campanulate pileus : it is larger than any specimens recently collected. *Lepiota adorea*, B. & Br., is a young specimen in which the margin of the pileus is just separating from the stalk. Berkeley and Broome state that *œnopoda* grew on dead wood, and *adorea* on the ground. They form one of Thwaites' gatherings, and were probably all collected at the same time : undoubtedly both grew on wood.

4.—Volvaria terastia, B. & Br.

Pileus 11–20 cm. in diameter, broadly campanulate, then almost plane, obtusely umbonate, viscid when first expanded ; centre blackish brown with adpressed tomentum, elsewhere dark purple-brown, gray, or brownish gray, covered with radially-arranged adpressed silky fibrils; cuticle extending beyond the gills, margin slightly fimbriate: flesh white, solid, 1 cm. or more thick over the inner edge of the gills, thinning out regularly to the margin.

Stalk 8–15 cm. long, 3–4 cm. in diameter at the base, narrowing at first rapidly and then more gradually to the apex, where it is 1–2 cm. in diameter, usually gray with adpressed fibrils, sometimes white, solid.

Volva up to 8 cm. high when expanded, and 6 cm. in diameter, erect, rigid, about 6 mm. thick at the base, 2 mm. thick above, pale or dark brown below, rough and blackish brown above, the surface split into irregular blackish patches of varying size and shape isolated by white or brownish lines, 2–3 mm. broad: internal surface white, marked with distant yellow-brown patches. A thick base 1–2 cm. high is common to both stem and volva.

Gills free, not crowded, white, then pink, up to 1·5 cm. broad, nearly equal, lower edge almost straight, outer ends rounded or truncate, inner ends rounded above and below, leaving a wide space round the stem, margin entire or crenate.

Spores deep Indian red in mass, inclining to chocolate where moistened by contact with the pileus, subglobose with a terminal apiculus, 5–6 μ, pale brown under a high magnification.

Among grass: often connate in clusters of three or four. Said to be edible, and known to the Sinhalese as Puwakbada Bimmal.

This magnificent species was figured by Berkeley and Broome in the "Transactions of the Linnean Society," Vol. 27, Pl. 34, but the colour of the pileus is not quite correct, and the stem and interior of the volva are too dark. The exterior of the volva as depicted in the figure is somewhat imaginary, the brown, white-bordered areolæ being separated by dark wavy sutural lines. No such lines have been observed in the numerous specimens gathered during the last two years, and they are not marked on our figure of this species. The original painting, however, was not returned to Peradeniya, and it is therefore impossible to say whether these sutural lines were inserted by the artist or by the lithographer. The figure would be a fair representation of a piece of tortoise-shell, but it misrepresents the volva of *Volvaria terastia*. In very wet weather the surface of the volva does not split into areolæ.

5.—Volvaria diplasia, B. & Br.

Pileus 8–11 cm. in diameter, broadly conico-campanulate, sometimes obtusely umbonate, golden yellow or almost white, centre smooth, elsewhere densely covered with spreading fascicles of short silky hairs, cuticle extending beyond the gills : flesh thick, white.

Stalk about 10 cm. long, attenuated upwards, 1·3–1·5 cm. in diameter at the base, ·8–1 cm. in diameter at the apex, white, shining, somewhat brittle, solid.

Volva 3–4 cm. high, substance thin and tough, usually closely sheathing the stem, white or pale brown and smooth externally, white with scattered yellow spots internally.

Gills white, then pink, widely free, edge entire or serrate, ventricose, rounded at both ends.

Spores deep Indian red in mass, elliptic, $6–8 \times 4–5\ \mu$.

On decaying wood ; sometimes on dead stumps at a height of 9 feet from the ground.

In general stature and the structure of the pileus this species resembles *V. terastia*, but it apparently differs in its constantly thinner stalk, lax volva, and elliptic spores, as well as in its habit of growing on wood. In one specimen which developed beneath a decaying log, the half of the pileus exposed to the light was golden yellow, while the half in comparative darkness was pure white.

6.—Volvaria geaster, B. & Br.

The figure of this species bears the following note in Thwaites' handwriting : "Immature, and unfortunately no more specimens could be found. It had much the appearance of a *Geaster*, which I thought it was until I cut it through." From the colour and striate margin of the pileus, and the pointed lower extremity of the volva, this appears to be an immature specimen of the species which Berkeley and Broome referred to *Amanita vaginata.*

7.—Entoloma amethysteum (B. & Br.), Petch.

This fairly common species was sent to England by Gardner (No. 31) and Thwaites (No. 203). Gardner's specimens were named *Tricholoma nudum*, Bull.: Thwaites' were divided into *Tricholoma nudum*, Bull., *Clitocybe iopepla*, B. & Br., and *Clitocybe laccata*, Scop., var., *amethystea*, B. & Br. It occurs in large numbers on rubbish heaps at Peradeniya during wet weather, often densely cæspitose.

Pileus when young broadly conico-campanulate, margin regular, incurved, becoming repand and irregularly lobed when full grown, umbonate, smooth, margin striate when moist, flesh thin: up to 9 cm. in diameter.

Stalk up to 8 cm. long, 1 cm. in diameter, smooth, sometimes split longitudinally and fibrillose, tomentose at the base, solid, equal or slightly attenuated upwards, often irregular.

Gills narrow, rather crowded, attenuated outwards, sinuate, edge irregularly lobed.

Spores, pink, ovate or subglobose 5–6 × 3–4 μ.

The whole fungus, internally and externally, is at first amethyst: in old specimens the centre of the pileus turns brown, and the stalk is streaked with brown: the pileus becomes ashy-white when dried.

Two of Berkeley and Broome's species, *Tricholoma rubrocyaneum*, B. & Br., and *Tricholoma charisterum*, B. & Br., bear much resemblance to immature *Entoloma amethysteum*, but in both cases the stalk is represented as white in the paintings, and in this respect they differ from all the numerous immature specimens of the latter which I have seen.

8.—Flammula dilepis, B. & Br.

This species is especially common on old coconut stumps. The colour of the immature specimens differs completely from that of the full-grown form, and, although the gills are yellow, it was named *Armillaria rhodomala* by Berkeley and Broome (Thwaites 1,212). The mature form (Thw. 401) was named *Flammula sapinea*, Fr., from which it differs, *inter alia*, by its warted spores : Berkeley and Broome say that the specimens are " on dead wood, evidently of some conifer. Possibly from imported deal," but there is no note by Thwaites to this effect on the specimens. Thwaites 878, *Flammula dilepis*, B. & Br., has rather longer stalks than usual : like the specimens referred to *Flammula sapinea*, it is the dry weather form, which is not often met with. Another species, *Flammula oxylepis*, B. & Br., is said by Saccardo (not by Berkeley and Broome) to be " affinis *Fl. sapineæ* " ; the description would fit *Flammula dilepis*, but we have neither specimen nor figure : half of the gathering of *Flammula oxylepis* (Thw. 909) was separated as *Lepiota micropholis*, B. & Br., but as the type gathering and figure of the latter species is a different number (Thw. 906), this does not give any clue : it seems incredible that Thwaites should include under the same number a *Lepiota* which grows on the ground and a *Flammula* which grows on wood, and in all probability Thwaites 909 was only one species. Again, judging from Thwaites' figure, the Ceylon species attributed to *Naucoria furfuracea*, P., is also *Flammula dilepis*, but in this case the specimens (Thw. 1,182 : Thw. 93) were not returned. The only *Flammula* collected by Gardner is *Fl. holocrocina*, Berk. ; it is said to have narrow gills and, if this is correct, it is a different species, though it may be wondered why Gardner did not collect the commonest species.

At present it is certain that *Flammula dilepis*, B. & Br., was also named *Armillaria rhodomala*, B. & Br., and *Flammula sapinea*, Fr., but it is probable that there are other synonyms in the Ceylon list.

In young specimens the pileus is reddish purple with a pale yellow, incurved margin, covered with minute scales almost to the edge. The stem is streaked with reddish purple, darker towards the base, becoming yellow upwards. The ring is composed of triangular fragments of the veil, most of which remains attached to the margin of the pileus. The gills are pale yellow. The flesh of the pileus and stem is yellow, or white towards the base of the stem.

Mature examples have a pileus up to 8 cm. in diameter, broadly convex, then almost plane, undulating, or depressed, sometimes obtusely umbonate, pale yellow, centre rough with minute, erect, red-brown or purplish scales, elsewhere covered with scattered adpressed scales, or smooth ; margin appendiculate ; flesh yellow, thick over the stalk.

Stalk up to 6·5 cm. long, 6–11 mm. in diameter, striate or coarsely fibrillose, yellow, or yellow above and brown below, or streaked with purple-brown, hollow, expanding into the flesh of the pileus, yellow internally, base slightly tomentose.

The ring is represented by a few fibrils on the stem.

Gills pale yellow, becoming ferruginous from the spores, distant, broad (up to 1 cm.), edge irregular, broadly adnate with a decurrent tooth.

Spores ferruginous, elliptic, minutely warted 5–7 × 3·5–4 μ.

Common on coconut stumps, densely clustered, sometimes connate at the base. Specimens with or without an umbo occur in the same cluster. In comparatively dry weather, or in the sandy coconut districts, the pileus remains broadly campanulate and yellow, but in wet weather it is repand or plane, and the sodden specimens are deep red-brown, sometimes yellow in the centre, with a striate margin ; it is most often collected in this state. The specimens developed in drier weather retain the purple tint in the scales, and are often streaked with purple at the base of the stem.

Berkeley and Broome's specimens of *Armillaria rhodomala*, *Flammula sapinea*, and *Flammula dilepis* have been examined, and fresh specimens have been compared with these and the original paintings.

9.—Psalliota alphitochroa (B. & Br.), Petch.

Pileus 2–5 cm. in diameter, conico-campanulate, then plane, or repand, centre obtuse or depressed ; grayish-white, densely covered with minute, powdery scales or warts ; the centre covered by a smooth, glabrous, somewhat livid patch, continuous in the young specimens, broken into separate scales, or fissured, or recurved and cup-shaped in mature specimens : margin striate, appendiculate : flesh thin, red-brown when cut.

Stem 3–4 cm. high, 3–7 mm. in diameter, white, clothed with minute scales like the pileus, mealy above the ring, equal, hollow, stuffed with white fibres, base bulbous : becoming reddish when handled, red or red-brown when cut. Veil very fragile, sometimes remaining entirely attached to the margin of the pileus.

Gills, free, rather crowded, about 4 mm. broad, equal or somewhat ventricose, attenuated at both ends, pink, then purple-brown.

Spores, purple-brown, broadly elliptica 1,5–5½ × 3½ μ. On the ground, among grass.

As in *Chitoniella poderes*, the central patch on the pileus is the whole of the cuticle of the young specimen : it ceases to grow when the agaric is quite small.

This species was named *Lepiota alphitochroa* by Berkeley and Broome (Thwaites 771), though the colour of the gills should have prevented this mistake : the section in the drawing shows the gills dull red. Another gathering (Thwaites 842) was named *Psilocybe canorubra*, B. & Br. : the specimens were rather smaller, but they agree in all points with *Lepiota alphitochroa.*

10.—Psalliota crocopepla, B. & Br.

Pileus 2–8 cm. in diameter, broadly conical, entirely orange or orange-red or brick red, covered with revolute scales or with spine-like erect scales in clusters ; margin strongly appendiculate ; flesh white, thin.

Stem 4–7 cm. high, 3–6 mm. in diameter ; equal, but clothed below the veil with a dense covering of orange or orange-red down which increases in diameter up to the veil, thus making the stem appear obconic ; white or slightly reddish, mealy, and longitudinally striate above the veil ; stuffed, then hollow ; white internally ; sometimes white and glabrous at the base ; " ring " fibrillose, forming a sharply-sloping upper edge to the covering of down. The down turns crimson when bruised.

Gills for a long time white, then purple with a whitish edge, free, ventricose.

Spores purple-brown, ovate, with a large, blunt, sublateral apiculus, 6–7 × 4 μ.

Fairly common among grass at Peradeniya, but generally solitary.

Psalliota lasiophrys, B. & Br., is based on an old specimen of this species, somewhat weather-worn. The original specimens and paintings of both species have been examined.

11.—Psalliota subæruginosa, B. & Br.

Densely cæspitose : pileus hemispherical, obtuse, 2·5–3 cm. broad, or expanded, 4·5 cm. in diameter, sometimes slightly umbonate, pale yellow, or with the centre dull dark green, becoming pale green then yellow outwards : the greater part of the pileus is always yellow : minutely tomentose, the outer layer cracked into squarish areolæ and showing paler yellow or white between : margin somewhat incurved at first, appendiculate.

Gills for a long time white, then purple-brown, crowded, free, attenuated behind.

Stalk up to 9 cm. long, 2–6 mm. thick, equal, shining, white, yellowish at the base, with a few loose fibrils, variously twisted, becoming reddish when handled, stuffed then hollow. The flesh of stalk and pileus turns reddish when cut. Ring near the top of the stem, usually directed upwards, lax, persistent, white or yellow, or white with a yellow edge. Spores pale purple-brown, oval, 5–6 × 3 μ.

Berkeley incorrectly states that it is " viscidulo," and has adnexed gills, and for this reason Saccardo lists it under *Stropharia*. No specimens were sent to Berkeley, but the figures (two sets) show free gills in each case, and expanded, almost plane, pilei, with moderately long stalks. Recent large gatherings show that the immature form with long, drawn-up stalks is Berkeley's *Lepiota macrocola*. Apparently Thwaites collected this with the specimens which Berkeley called *Psalliota*, for he has marked it " ? var. of 756."

The figure of *Lepiota macrocola* shows three specimens out of a dense cluster of twelve, the others being represented by broken, cæspitose stalks : only one of the three specimens is umbonate, though Berkeley and Broome give this as a character : the gills are of course free ; only one of the three pilei is shown in colour, and this has no trace of green in the centre. The group corresponds exactly with recent gatherings of *Psalliota subæruginosa*, in which the pilei vary from yellow with a green centre to pure yellow. The original specimens have been examined.

12.—Panæolus cyanascens, B. & Br.

Pileus up to 3 cm. in diameter, hemispherical, ashy white, smooth, covered with glistening particles, sometimes slightly ochraceous in the centre ; margin entire, with a bluish tinge, marked with raised radial ribs : young specimens viscid when moist : flesh thin, white, turning blue when cut.

Stalk 6–10 cm. long, 2–3 mm. in diameter, straight, equal, white and shining, sprinkled with minute white particles, becoming brownish when old, tomentose at the base, hollow : in longitudinal section it is divided from the pileus by a deep blue line.

Gills adnate, broad (6 mm.), ascending, edge entire, gray, becoming blackened with the spores.

Spores intense black in mass, subglobose 14 × 11–12μ, or oval 13–14 × 7–8μ, apiculate at both ends (lemon-shaped).

The whole fungus turns deep blue when bruised. Gregarious, sometimes connate at the base.

Berkeley's description, drawn up from the figures, says "Albidus, cyanescens," "stalk deeply tinged below with blue" : these colours on the figures show where the specimens have been bruised.

The herbarium specimen "746 September, November, 1868," is labelled *Panæolus cyanascens* and *P. papilionaceus :* the spores all agree with the measurements given above, and apparently the sheet contains one species only : one specimen resembles *papilionaceus*, but its spores do not exceed 14μ. "*Panæolus caliginosus*, Jungh.," was gathered (*fide* B. & Br.) in September, 1868, with "*papilionaceus*" : there is no labelled specimen in the herbarium, but the figures represent old sodden specimens of *cyanascens*. slightly stained blue in parts : Berkeley and Broome give the size of the spores as 9 μ, but, according to Saccardo, *caliginosus* should have spores 16–18 × 10 μ. Two specimens on another sheet, gathered in January, are apparently not recorded by Berkeley : they are labelled *P. papilionaceus* and *P. cyanascens*, but are much larger (17 cm. high) than the other specimens : their spores are 17–19 × 13–15 μ : this is probably another species altogether. Berkeley says that the spores of *P. papilionaceus* from Ceylon " vary from ·0007 to ·0001 (inch) long " : he probably intended ·0007 to ·001 inch, which would be 17–25 μ : we have no herbarium specimens with spores of this size. It appears from this that Berkeley and Broome's specimens of *papilionaceus*, *cyanascens*, and *caliginosus* were all *cyanascens* as Thwaites supposed, and that the records of the other two for Ceylon were incorrect. The change of colour which occurs on handling fresh specimens of *cyanascens* should have prevented any mistake. Old specimens of *cyanascens* have recently been gathered, which agree exactly with the drawings marked *caliginosus*, Jungh. : these have a brownish pileus and stem when sodden, but the pileus becomes ashy white in drying. In such specimens the colour change takes place very slowly.

13.—Boletus portentosus, B. & Br.

Pileus 18–22 cm. in diameter, smooth, greenish olive, becoming blackish olive in the centre, undulating or broadly convex. centre depressed ; flesh 3 cm. thick, pale yellow, spongy, slowly turning blue in the lower half when cut.

Stalk 9 cm. high, about 6 cm. in diameter at the base, narrowing to 4 cm. in diameter at the apex, lacunose, dark brown covered with a greenish-yellow bloom, tapering abruptly to a point at the base, solid ; flesh pale yellow and spongy.

Pore surface greenish yellow, edges of the pores brown. Pores about ·6 mm. in diameter, greenish yellow in section, bright yellow when young, 7 mm. deep, not decurrent.

Spores greenish olive, broadly elliptical, 8–9 × 5–7 μ.

Berkeley and Broome incorrectly state that the colour of the flesh is unchangeable, and that it is brownish beneath the cuticle.

Polyporus olivaceofuscus, B. & Br., was founded on a single immature specimen of which no drawing was made: the layer of pores in the dry specimen is scarcely a millimetre deep. Berkeley and Broome state that the pileus is "pulverulento-tomentoso," but there is no sign of this now. Sections of the immature pores prove conclusively that the fungus is an immature *Boletus*, and in general outline and the relatively enormous stalk it agrees with *B. portentosus*: the colour given, "*olivaceofuscus*," is nearer that of *B. portentosus* than the "*brunneus*" which Berkeley and Broome give for the latter. I have no doubt that *Polyporus olivaceofuscus* is an immature example of *Boletus portentosus*.

14.—Endothia gyrosa (Schw.), Fuck.

This was recorded as *Diatrype gyrosa*, Schw., by Berkeley and Broome in "Fungi of Ceylon." It occurs fairly commonly at Hakgala in the bark of trees. The Ceylon specimens are red-brown externally, 4–5 mm. in diameter, erumpent, roughly hemispherical, and tuberculate, with projecting, cylindric, or slightly tapering ostiola, ·4–1 mm. long and ·15 mm. in diameter. Internally the stromata are orange-red and friable, the colouring matter being readily soluble in alcohol. The perithecia are black, ·25–·5 mm. in diameter, and are embedded in the stroma at all depths. The interior of an ostiolum is also black. I have not seen any specimens in which the perithecia were discernible from the exterior, except such as had been eaten by insects. The asci are fusiform, 40–50 × 7 μ, eight-spored; spores uniseptate, oval, not constricted, hyaline, 9–10 × 4–4·5 μ: no paraphyses.

The Ceylon specimens appear to differ from those of Europe to a slight extent in colour, and in the larger size of the asci and spores. According to "Saccardo," the spores are spuriously one-septate, but they seem to be truly one-septate in the Ceylon specimens. The projecting ostiola are easily broken off, leaving black spots on the stroma · Berkeley and

Broome's *Nectria gyrosa*, with black ostiola, consists of small specimens of *Endothia gyrosa*, with the projecting ostiola for for the most part broken off.

15.—Fleischeria javanica, Penz. & Sacc.

This species was described by Penzig and Saccardo in "Icones Fungorum Javanicorum," p. 59, and is up to the present the only member of the genus. It occurs in Ceylon at Hakgala and Nuwara Eliya, where it is found on the moss-covered trunks of living trees. The Ceylon specimens differ in a few particulars, but are apparently the same species: they enable us to add a description of the conidial stage which was apparently not observed by the above-named authors. Specimens in the conidial stage were sent to Berkeley by Thwaites forty years ago (Thwaites No. 255), and were said to be a stylosporous stage of a *Nectria*.

The stromata are at first hemispherical, up to 5 mm. in diameter and 2–3 mm. high, bright orange, rough with minute, close-set, rounded elevations, in the centre of each of which is a slightly paler ostiolum. The substance is hard and pale yellow throughout. The pycnidia are small, pear-shaped, and widely separated: they are lined with basidia about 15 μ long and 1·5 μ in diameter, which bear single terminal conidia. The conidia are yellowish, elliptic with sharply pointed ends, 9–14 × 3·5 μ: they are extruded in an orange-coloured globule when ripe.

The conidial stage is thus the same as *Aschersonia*.

The rounded elevations of the stroma grow out and become more or less globose, so that the fungus appears at first sight to be a crowded group of nectrias on a well developed stroma. At the same time the colour changes to reddish brown. The mouths of the perithecia are dark red and somewhat translucent, and project slightly. Each of the globose swellings bears several perithecia embedded in it. The asci are narrow, fusoid, with a tapering stalk, up to 180 × 7 μ. The spores are at first filiform, and break up into oblong spores with rounded ends: my specimens are not quite mature and the largest ascospore measures 10 × 2·5 μ.

The Java specimens are said to be larger, 8–10 mm., and the length of the ascus is less. The base of the stroma is flattened and attached to the bark only in the centre. Penzig and Saccardo figure a white base with a black ring surrounding a central white spot : in my specimens the central point of attachment is whitish, but the remainder of the base is orange or blackish. Except in these points, the specimens agree with the description and figure of *Fleischeria javanica*. There are no remains of scale insects beneath the stromata. Apparently *Fleischeria* differs from *Hypocrella* only in the larger, denser stroma.

16.—Sphæropsis undulata, B. & C.

This was described by Berkeley and Curtis from specimens collected in Cuba : " Stromate nigro suborbiculari undulato, apicibus peritheciorum papilloso : sporulis obovatis, magnis, hyalinis, 30–33 μ longis." Berkeley and Broome recorded a species from Ceylon under the same name, but gave the spore measurement as 12·5–15 × 7·5–10 μ. Subsequently Beccari collected specimens in Sarawak which were doubtfully named *Sphœropsis undulata*, B. & C., by Cesati. The description of the Sarawak specimens is " Perithecia cæspitose aggregata *Cucurbitarima* simulantia, nigra, vertice depresso : humectata carnosa fiunt. Asci et paraphyses nulla. Sporidia ovalia, exosporio crasso, fuscella, simplicia : guttula ampla centrali, raro binis, 7 × 4."

Saccardo refers the Cuban specimen to *Dothiorella*, since the spores are hyaline, under the name *D. undulata*, and notes at the same time that the Ceylon specimen with spores about half the size seem different : he also places Beccari's species in *Haplosporella*, under the name *H. Cesatii*. He does not however re-name the Ceylon species, although its spores apparently are intermediate between those of the specimens from Sarawak and Cuba. When however Cesati's unit (2 μ) is allowed for, the spore measurements of the Ceylon and Sarawak specimens agree. Thus the Ceylon species appears to be the same as that from Sarawak, and will stand as *Haplosporella Cesatii*, Sacc. The fact that Cesati's unit was 2 μ appears to have been generally overlooked.

The perithecia are produced in circular flattened clusters, about 1–2 mm. in diameter, often crowded together over a large area. In fresh specimens the apex of the perithecium is rounded. The perithecia are spherical or elongated, and open by an irregularly circular pore or a longitudinal fissure : they are ·5–·75 mm. in diameter when spherical, and up to 1·75 × ·75 mm. when elongated.

The irregularity of the stromata in the dried specimens is due in great part to the irregular dehiscence of the perithecia. The spores are thick-walled, continuous, oval, blackish olivaceous, 13–18 × 8–10 μ. The perithecia and stromata are carbonaceous : the stromata bursts through the bark and appears superficial.

In the report of the Mycologist, Royal Botanic Gardens, Ceylon, 1905, this species was referred to as *Sphæropsis undulata*, B. & C., on the supposition that the herbarium specimens, with which the recently collected specimens were compared, had been correctly named by Berkeley and Broome.

17.—Asterina congesta, Cooke.

The leaves of *Santalum album* at Peradeniya are usually covered with a black mycelium which sometimes injures them to such an extent that the trees are defoliated. A similar fungus on *Santalum album* in India was described by Cooke (Grev. VIII., p. 95) as *Asterina congesta.* His description is "Epiphylla : peritheciis discoideis, atrobrunneis, 100–150 μ in diameter, rimoso-dehiscentibus, densissime congestis : mycelio tenui, brunneo, sparso ; ascis ovatis : sporidiis ellipticis brunneis, medio hyalino-cinctis demum uniseptatis, 20 × 10."

The fungus on *Santalum* at Peradeniya grows on both sides of the leaf but is usually most abundant on the under surface. It begins in small circular patches which ultimately coalesce and cover almost the whole surface. To the naked eye the mycelium is black : when magnified it appears brown, forming a network of small mesh, and passing into a rather plentiful hyaline mycelium. The hyphæ are about 5–7 μ in diameter, irregularly swollen and bent at intervals, and are furnished with scanty appressoria which are short, blunt, curved, one-celled, about 7 × 5 μ. The perithecia have the usual stellate appearance of *Asterina:* they are minute, crowded, flattened, about 80 μ in diameter, and rupture at the apex. The spores are elliptic or pear-shaped, 19–28 × 12–14 μ, blackish brown with a pale zone in the middle. I have examined a large quantity of material, but have not been able to find any septate spores, nor any asci: the immature spores are borne singly on short basidia.

It appears therefore that the Ceylon fungus is a *Capnodiastrum.* Cooke's description of the spore of his *Asterina* agrees with the usual spore of *Capnodiastrum* except that he states that it is finally one-septate. The Ceylon species will be known as *Capnodiastrum congestum,* as it is most probably the same fungus as that examined by Cooke. An exact statement on this point must depend on an examination of Cooke's type specimen, which is probably in England.

18.—Aschersonia mellea, B. & Br.

" 798. *Aschersonia mellea*, B. & Br. Pulvinata, mellea, glabra, cellulis demersis, sporis sub-ellipticis nucleatis (No. 730). On dead bark. South of the Island, July, 1868. A line or more across." (Journ. Linn. Soc. XIV., p. 89.)

Thwaites' specimen No. 730, bearing the inscription " South of the Island. July, 1868," consists of two pieces of bark bearing forty-six examples of this supposed *Aschersonia*, and two detached specimens. They are yellow brown, pulvinate, glabrous, faintly ridged, irregularly oval. The two detached specimens are inverted, and bear gills. Those on the bark are attached only at one edge, and sections show that they are all a small sessile, excentric agaric (*Pleurotus ?*) in various stages of development. The largest specimen is 5 × 3 mm.

19.—Sphærobolus rubidus, B. & Br.

" 731. Sphærobolus rubidus, B. & Br. Peridio exteriore rubro, ore irregulari: sporangio rubro (Thwaites No. 312). On Elephant's dung. Spores oblong, ·0003 inch long."

This has recently been collected on elephant dung at Hakgala. The unexpanded fungus is globose, *white*, slightly tomentose, about 1·25 mm. in diameter. It opens with from four to six, almost upright, small teeth which are reddish yellow internally. The open fungus is somewhat urceolate. The peridiolum is oval, shining, and red-brown : it is about one millimetre long and ·75 mm. in diameter. The spores in the ejected peridiola are oblong oval, hyaline, 5–5·5 × 3 μ.

It differs from *Sphærobolus stellatus*, Tode, in the colour of the fresh peridiola and the size and shape of the spores.

20.—Matula poroniæformis (B. & Br.), Mass.

The genus *Michenera* was established by Berkeley and Curtis in 1869, being founded on a species from Cuba which they named *M. artocreas*. In describing the fungi of Ceylon Berkeley and Broome discovered among Thwaites' specimens another species which they considered a member of the same genus as the Cuban specimen, but without assigning any reason, they changed the generic name to *Artocreas*, naming the Ceylon species *Artocreas poroniiformis*, and the Cuban *Artocreas Micheneri*. They afterwards state (Journ. Linn. Soc. XV., p. 83) that *Artocreas* is synonymous with *Michenera*, but they do not give any reason for the change.

Ever since, the position of the genus has been doubtful. Berkeley and Broome placed it after *Corticium*, and Saccardo follows them in including it among the *Thelephoreæ*. Massee (Journ. R. Micr. Soc., April, 1888, p. 173) states that *M. poroniiformis* falls between *Nidulariæ* and *Hymenogastreæ*, and places it in a new family *Matuleæ*, evidently differing from those who have considered its structure similar to that of the Cuban species. Patouillard (Bull. Soc. Myc., 1891, p. 42) refers *Michenera* to the *Uredineæ*, after an examination of *Michenera artocreas*. Hennings (Engler-Prantl., Pflanzenfamilien, pt. 170, p. 120) follows Saccardo's arrangement, including both species under *Michenera* and putting the genus among the *Thelephoreæ ;* he gives copies of Patouillard's figures, which show that the arrangement of the spores in *M. artocreas* is quite different from that which obtains in *M. poroniæformis*.

Thwaites' specimens, some of which are in the Peradeniya herbarium, were collected at Hakgala, elevation 5,600 feet. I have recently received fresh specimens from the same locality, where it grows on dead branches of *Cinnamomum camphora* still attached to the living tree. It seems probable that the fungus is parasitic. These specimens agree in all respects with those collected forty years ago.

The fungus bursts through the cortex of the undecayed twigs as a minute white cushion which slowly acquires a spherical form. In the earlier stages it is surrounded by erect scales of the outer bark in the form of an irregular, deeply-divided cup : these break away as the fructification expands. When the sphere is about 3 millimetres in diameter it appears white or brownish white : this colour is due to an outer coating of minute adherent scales, and under slight magnification the underlying tissue, as seen between the scales, has a watery translucent appearance. When dry the whole is white, but in the growing state it is a gelatinous sphere covered with minute white scales. A median section of the young sphere shows that it is multilocular. In the centre is a group of chambers, usually five or six in cross section, filled with spores : these chambers are irregularly hexagonal in section, and vary from ·5 × ·4 mm. to ·75 × ·6 mm. This group is surrounded by other chambers which do not contain spores : these latter form a single layer of large chambers, about ·75 mm. across, in the upper part of the sphere, and a double layer of smaller chambers at its base. These outer chambers contain thick-walled hyphæ, 4–5 μ in diameter, whose walls are gelatinized so that the translucent mass completely fills the chamber. The outer wall of the sphere and the walls which separate the chambers are about 50 μ thick. Under a low magnification, the cross section shows a central white patch surrounded by a broad translucent ring with a somewhat crenate outer edge : across this ring, the white side walls of the outer chambers join on to the central white patch like the spokes of a wheel.

Dehiscence takes place at the apex. If the branch is not horizontal, it occurs at the highest point, and the resulting cup appears to rise obliquely. Apparently the walls separating the upper chambers are gelatinized, the outer wall is perforated at the top, and the fructification expands into a cup-shaped structure. There is no formation of new chambers after the dehiscence, and no abscission of a distinct cap. The exterior of the mature fructification is identical with that of the immature sphere. The cup is 3–6 mm. in diameter, and about 3 mm. high : it is filled with tissue internally and has the appearance of a *Peziza* with a depressed disc. The outer wall extends vertically above the disc, sometimes for a distance of a millimetre, and forms an erect rim. The disc is gelatinous and brownish when moist, but white and areolated with slightly raised swellings when dry : these surface swellings correspond to the remaining chambers of the original sphere.

When dry the fructification is quite hard. A longitudinal section shows a thick outer wall which forms the cup, and, within the semicircle formed by this, a mass of loose spores. Generally an unopened spore chamber can be found towards the base, and if the specimen is not too old the vertical walls of the opened chambers can be traced.

But that the wall of the cup should be thick is quite contrary to the evidence obtained from the unopened sphere. If the section is soaked in water, however, the explanation is clear : the wall of the cup then swells out, and shows that it consists of the outer layer of chambers which have contracted into a dense pseudoparenchymatous layer on drying. It is this which causes the dried specimen to be harder than would be expected. If a longitudinal section is allowed to dry on the slide, the cup straightens out until the outer wall is almost a straight line.

The fate of the original chambers of the sphere may be briefly summarized. The uppermost chambers of the translucent outer layer disappear : the remaining chambers of this layer contract in drying and form the hard outer wall of the cup ; the uppermost of the spore-bearing chambers open at the top (? their walls are gelatinized) and set free the spores, while those below remain closed for a longer time.

The spores are hyaline, spherical, thick-walled, and measure 18–20 μ in diameter. They are borne *singly on short side branches* of indefinitely long hyphæ which arise from the walls of the cavities. These side branches are up to 15μ in length and are given off on alternate sides of, and perpendicularly to, the main hyphæ. The mass of spores and hyphæ completely fills the chamber. When all the spores have been dispersed the inside of the cup turns brown.

Berkeley says it is "erumpens; receptaculo hemisphærico, pallide rufo; hymenium albido; sporis globosis. On bark. Looking just like an imperfect *Crucibulum*. Spores globose, ·0009 inch in diameter." The "pale red" is probably due to drying, or an alteration in colour by the preservative used: "albido" is correct for the dry disc, but not for the fresh specimens. The measurement of the spores, 22·5 μ is too large: they barely reach 20 μ in the type specimens. Saccardo (Sylloge Fungorum) gives 24–28 μ.

Massee's description of the family *Matuleœ* and the genus *Matula* gives a better idea of the species. "*Matuleœ*. Peridium primo clausum, dein apertum. Globa multilocularis, dissepimentis crassis, non scissilibus peridioque continuis. Cellulæ vel loculi ad parietes hymeniferi, basidiis cylindricis vel subclavatis 1–2 sporis. *Matula*, Mass. Peridium sessile, prima ætate globosum, mox cylindricum, regularite apice dehiscens. Gleba multilocularis, loculis rotundato-irregularibus. Sporæ globosæ." The dissepiments can hardly be styled thick, and they finally deliquesce with the spore-bearing hyphæ into a gelatinous mass. I cannot find any trace of specialized basidia: the subclavate structures seen in the section are the first stages of the developing spores. The regular rim of the cup is probably accounted for by the originally gelatinous nature of the tissue which forms it.

The characters of the genus *Michenera* (*fide* Saccardo) are "Placentæformis, disco ceraceo. Sporæ magnæ, limoniformes, longe pedicellatæ": and Patouillard's figures bear out the description. But practically none of these characters is to be found in *Michenera poroniœformis*. *Michenera artocreas*, the original species, appears to have been collected several times in various parts of America; if it has been correctly described and figured, it is evident that the Ceylon species is not in any way related to it, and that Massee's name *Matula* must stand for the latter.

Rick (Ann. Myc., Vol. 2, p. 243) has described a new species of *Michenera* from Brazil under the name *M. Rompelii.* It is "erumpens, pezizæformis usque ad $\frac{3}{4}$ cm. lata, oblique sessilis, extus straminea, subpruinosa, intus albida : hymenio humefacto turgido, subgelatinoso, butyraceo. Sporæ usque ad 20 μ in diameter ; globosæ, ento- et exosporio lucem egregie refringente." Except that the fungus is "extus straminea," this description exactly fits *M. poroniæformis.*

The Geographical Distribution of the Dilleniaceæ, as illustrating the Treatment of this Subject on the Theory of Mutation.

BY

J. C. WILLIS.

MY choice of an order was determined by the fact that this was the first order in Hooker's Flora of British India with other than world-wide distribution.

In previous papers* I have given arguments in favour of the mutation theory that seem to me sufficient justification for accepting it as a working hypothesis, and testing whether it breaks down when applied to the actual facts of any subject. For absolute proof we require of course to show in a few cases at any rate that actual mutation has occurred. I have a number of experiments on hand, in which, by growing plants under different climates, under radio-activity, on the clinostat, and in other ways, I am endeavouring to produce mutation, but these must in any case occupy some years, and it will be worth while testing the theory, as that of evolution itself was tested, by working out various problems assuming it to be true. The one which has most interested me is that of geographical distribution, but there are many other directions in which the acceptance of mutation will produce far-reaching results.

If we examine the local distribution of the Dilleniaceæ in the East, we find that in the larger genera—and this is the case with any of the larger genera, of any order that I have examined—there is a general tendency for there to be several *local* endemic species, connected by one or two widely ranging common

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* Willis, Some Evidence against the Theory of the Origin of Species by Natural Selection of Infinitesimal Variations, and in favour of Origin by Mutation. Ann. Perad., IV., 1907, p. 1. Further Evidence, &c., Ann. Perad., IV., 1907, p. 17.

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species, which most commonly occur also beside, or near to, the local endemics.

If we take the genera of this family in order, from Hooker's Flora, the first is Delima, and in this there is one very widely ranging species, *D. sarmentosa*, occurring in Ceylon, and from Assam to Singapore, the Malay Archipelago, the Philippines, and South China, while the other species, *D. lævis*, has only been once collected, at Malacca. Now, if we accept the theory of infinitesimal variations, we must either admit that *D. sarmentosa* was evolved near Malacca, and afterwards spread enormously, while *D. lævis* has not spread, or else that there has been a vast amount of destruction, reducing *D. lævis* to one locality, or destroying the other species that were evolved with it, or make some other bold assumption. It is, however, very nearly allied indeed to *D. sarmentosa*, differing mainly in the size and number of veins of the leaf, and in the size of the flower, and if anything, one would expect that it would be a successful species, and spread as widely as *D. sarmentosa*. But it has not spread, while *D. sarmentosa* is very widespread and very common. But if we accept the theory of mutation, the explanation is comparatively simple ; we have only to suppose that *D. sarmentosa* spread freely through the country, and mutated off *D. lævis* at Malacca. This is a far simpler explanation than that which can be given upon the theory of infinitesimal variations, besides being a good deal more probable ; we have absolutely no warrant to assume that there has been much, or indeed any, destruction, nor to assume that *D. sarmentosa* was evolved at or near Malacca. The small spread of *D. lævis* is easily accounted for on the mutation theory, for it may have been quite recently evolved, and not having a very efficient distribution mechanism would not travel very far except in a great length of time.*

The other species of the genus Delima is South American, *D. aspera*, in French and Dutch Guiana. So far as I am aware, there are no species yet recorded from Africa, and should it transpire that there are none, we shall be met by a very difficult problem to the infinitesimal variationist, but one which is

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* Ridley, on Dispersal of Seeds by Wind. Ann. Bot., XIX, 1905, p. 351.

quite simple to the mutationist, who has only to suppose polyphyly to have occurred.* But more probably, Delima should be united to Tetracera.

The next genus is Tetracera, of which there are five or six species in the East, and others in Africa and South America. *T. lævis* is found in Ceylon and Malabar, and in Java and Borneo, *T. Assa* from Chittagong to Singapore, and in Java and the Philippines, *T. Euryandra* from Penang to Singapore, and in the Moluccas and New Caledonia, *T. macrophylla* from Penang to Singapore and Sumatra, *T. grandis* in Perak, and a doubtful species in Penang.

On the theory of mutation, as on any other theory, the first question to arise is, How did *T. lævis* get to Ceylon and Malabar, as well as to the further east ? On any theory this question is most easily solved if we imagine that the ancient continent, on whose existence perhaps most people are now agreed, Brazilia-ethiopica, had land connections, complete, or nearly so, to both Ceylon and Malaya, though of course it is *possible*, but with difficulty and with the assumption of a vast amount of destruction for which we have no warrant, to explain the facts of distribution with only a land connection to Ceylon. But the Malayan region contains so many more genera of the southern type than does Ceylon, that it is easier to explain by assuming land connection to Malaya also.

Assuming, then, that *T. lævis* entered Ceylon and Malaya from the south, we have only to assume that it mutated off *T. Assa* and *T. Euryandra*, or one of these (which then gave rise to the other) at an early period, which would allow them also to spread widely, while one of them gave rise to the other three species. The general morphology of Tetracera shows that it is a comparatively primitive genus, and this would account for its species being in general comparatively widespread, as well as for other species being found also in Africa and in South America.

The third genus is Acrotrema ; there are seven species in Ceylon, besides *A. costatum* from Moulmein to Singapore, and *A. Arnottianum* in Malabar and Travancore. The land

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* Willis, Morphology and Ecology of the Podostemaceæ. Ann. Perad., I., 1902, p. 446.

connections above surmised will account for the presence of the species in Malaya, and interest centres in the Ceylon forms. One of them, *A. uniflorum*, is fairly widespread, while the other six are all rare, though they all occur near to localities of *A. uniflorum*, which is "extremely variable, almost every district producing a local form" (Trimen). With regard to one of them, *A. dissectum*, Trimen remarks: "The plant at Hiniduma was growing along with *A. uniflorum*, var. *sylvaticum*, and many of the specimens are believed by Thwaites to be hybrids between the two species, the various forms of the leaves making a complete connecting chain." No one who has examined the flowers of this species, and has had experience of the really extraordinary lack of insect visitors to small plants in the tropics, will suppose that hybridization has really occurred here; it is far more likely that various mutations are still living side by side, illustrating the transition from one species to the other. I am at present conducting some experiments with a form of *A. uniflorum*, endeavouring to persuade it to mutate.

Another species of interest is *A. lyratum*, which is characterized by very long peduncles. This occurs solely on the summit of Nillowekanda, an isolated precipitous rock in the Hinidum pattu, and, as I have pointed out in my previous paper, it is impossible to suppose that the long peduncles can have been evolved on Nillowekanda by infinitesimal variations.

The easiest way by far to explain the distribution of Acrotrema is to suppose that *A. uniflorum*, which we know to be very variable, travelled about the south-west of the Island, and *shed* the other species by mutation in different places, while it, or one of its mutants, got as far as Travancore, where it gave rise to *A. Arnottianum*.

The next genus, Schumacheria, differs from Acrotrema mainly in being shrubby, and is confined to Ceylon, where it may be supposed to have arisen from Acrotrema by mutation.

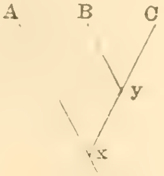
The fifth genus is Wormia, of which there are seven species. *W. triquetra* is confined to Ceylon, while there are six species further east, and again the distribution is most easily explained by imagining a land connection to Malaya. *W. triquetra* belongs to the subgenus Euwormia, to which also belong *W. pulchella* in Perak, Malacca, and Sumatra, *W. meliosmæfolia* in Malacca, *W. Scortechinii* in Perak, and *W. Kunstleri* in Perak. All the last three may be supposed to have split off from *W. pulchella*, which might also give rise to the subgenus Capellia, of which there are two species, *W. suffruticosa* from Malacca to Sumatra and Borneo, and *W. oblonga* in the Malay Peninsula and Sumatra.

Finally, we come to Dillenia. In the subgenus Eudillenia we have *D. indica* common from Ceylon through the Western Peninsula, the Himalaya, Assam, the Eastern Peninsula, Java, Sumatra, Borneo, &c., while most of the other species are local, *D. retusa* in Ceylon, *D. bracteata* in Mysore, *D. ovata* in Penang and Perak, and through Cochin-China to Borneo. These are quite simply explained by mutation ; let *D. indica* enter from the south and split off the others. *D. ovata* was perhaps the first, or the best adapted, for it has spread comparatively widely.

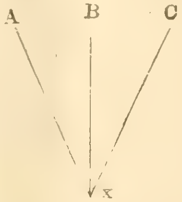
In the subgenus Colbertia we have one or two groups of species, and I am not quite sure to which one or two of the species belong. It matters little, however, for the purpose of this paper. The widely spreading species of the subgenus are *D. aurea* and *D. pentagyna*, the former running from Nepal to Bhotan in the Himalaya and through the Eastern Peninsula to the Andamans, Java, and Cochin-China, the latter from Oude to Assam and Pegu and Cochin-China, and down the Western Peninsula, but not in Ceylon. Now the species nearly related to the former appear to be *D. pulcherrima* in Pegu, *D. scabrella* in Assam, and *D. parviflora* in Tenasserim Pegu and the Andamans, while species nearly related to *D. pentagyna* are *D. grandifolia* in Penang and Malacca, *D. floribunda* in Martaban, *D. reticulata* in Perak, and *D. Hookeri*, *D. elata*, and *D. Blanchardii* in Cochin-China. There remains only *D. elongata* in Sumatra, of whose relationships I am quite uncertain.

The Dilleniaceæ are very marked in Northern Australia, but it will be at once noticed that the genera which occur there, mainly Pachynema and Hibbertia, can be easily derived from Tetracera, which runs down to New Caledonia, where Hibbertia occurs also.

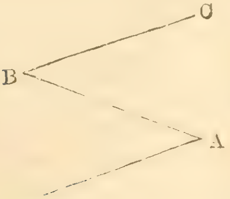
Having now tracked the Dilleniaceæ through the Indo-Malayan region, we may apply the same theory of mutation to the whole order, and we arrive at a surprisingly simple and straightforward result. Hitherto we have tended to look upon the geographical distribution of an order as a fact to be accepted as a fact, but as little else, and not a fact that can be further explained. So long as we accept the theory of infinitesimal variations, this must necessarily be so to a large extent, for if we suppose the origin of any three species, say, A, B, C, to be represented by such a diagram as—



Or



we are necessarily in the dark as to what x and y were like, and can for a long time have no special hope of finding out. But if we assume that the origin was—



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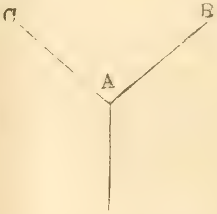

we simplify the problem enormously, and this simplification alone makes a very great claim for the new theory, if it cannot be shown to break down in any way in explaining geographical distribution.

The figures which we have just given explain the essential difference between the two theories. On the theory of infinitesimal variations it is necessary to assume a vast amount of destruction, while on that of mutation there is no need to assume this, unless the mutations are actually harmful in the struggle for existence. There is consequently no reason, so far as we can tell, why *the whole tree of a natural order should not actually exist on the earth at this present moment.* If we apply this to the Dilleniaceæ, we get a tree somewhat like the following (of course these are my own views as to the relationships, and other people will have different views) :—

The order of the names in the top row does not, of course, indicate nearness of relationship. The diagram is an imaginary history of the mutations, and Delima, *e.g.*, is often united to Tetracera.

If now, on this basis, we draw a map of the evolution of this order and its distribution, and assume the former existence of the continent, Brazilia-ethiopica, with land connections to Ceylon and Malaya, we get a surprisingly simple picture, showing that the order probably originated with Tetracera and Saurauia, and of these the former, being the simpler, was probably the older. It would appear to have started in Brazilia-ethiopica, and spread thence to South America, Africa, Ceylon, and Malaya, and from the last to Australia. We are no longer to be led astray by the great numbers of species in Malaya-Australia, for example, for we have learnt that, as a rule, local species do not count. Evidently when it reached Australia the order proved very suitable to that country, for there are now great numbers of Hibbertias, &c., there.

What I claim, then, for the acceptance of the theory of mutation, is that it greatly simplifies the problems of geographical distribution. On the old theory we had to assume a vast amount of destruction, and it was a matter of extraordinary difficulty to trace relationships, and to decide the origin and past history of any plant.

In studying the distribution of any plant about the globe, it is evident that we shall have to take many factors into consideration. For instance, plants of open country will spread more readily than plants of forests; endemics of very restricted range abound in the Ceylon forests, for instance. Frequent crossing with new arrivals will perhaps tend to prevent a newly formed mutation from establishing itself, so that we shall have to take into account the fertilization mechanisms. Connected with this is the fact that I have pointed out, in a paper on the flora of Ritigala,* that the endemics are mainly among the plants that can only rarely arrive there, *i.e.*, among those with very poor distribution mechanisms; whereas, as I have elsewhere shown, in outlying oceanic islands they are more often among the plants with good mechanisms, which will enable them occasionally to arrive.

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* Willis, The Flora of Ritigala, an isolated mountain in the North-Central Province of Ceylon. Ann. Perad., III., 1906, p. 271.

Probable distribution of land at the end of the Jurassic Period.

Probable distribution of land at the end of the Eocene Period.

By kind permission of J. S. Gardiner, Esq., and the Royal Geographical Society, from the Journal Royal Geographical Society.

The Effect of the Moon's Phases on the Period of Felling Bamboos.

BY

A. M. SMITH.

IN the "Indian Forester" for November, 1906, Mr. E. P. Stebbing, in a paper on "The Effect of the Moon's Phases on the Period of Felling Bamboos," calls attention to a belief apparently very widespread in India that the time of full moon is to be avoided in felling bamboos. This belief extends also to the felling of timber of other sorts, but is apparently not so strongly held in the other cases. The idea is also held in Ceylon, and appears to be a commonplace in forest practice in Columbia, South America (see paper by E. R. Woakes before American Institute of Mining Engineers), being there applied to all timber. It is necessary before dismissing such a widespread belief as a superstition to attempt to find some scientific explanation for it, and work which the writer has recently done on the Growth of Giant Bamboos may perhaps afford a clue to whatever basis of truth lies below the idea.

The native foresters themselves attribute the supposed effect to the greater or smaller quantity of sap present in the stems at the time of felling. It is, they say, more abundant at full moon, and therefore this time should be avoided. The evil effects of felling when full of sap have reference to the attacks of boring beetles (*Dinoderus pilifrons* and *D. minutus*), which are supposed to live largely on the sap, and therefore the attacks of the beetle are more extensive if the bamboos are felled when full of sap.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part II, October, 1907.]

Experiments have been carried out in South India to test the theory of the effect of the moon's phases. These have been complicated by the fact that certain remedial measures have been undertaken at the same time, viz., prolonged soaking in water immediately after felling and also covering the felled bamboos from the light. There has not been therefore any decisive test of the effect of the moon's phases, but, as far as it can be ascertained, they lend no support to the native supposition. We have therefore no well-attested facts in support of the idea, and there is really therefore nothing to be explained by any facts known to science respecting the bamboo. It may, however, be worth while for me to indicate along what lines a connection between known facts and the native supposition may be expected if on any, and also to provide a tentative explanation of certain facts which seem to be the outcome of the experiments in South India. The amount of water present in the culms, whether mature or growing, of the giant bamboo depends largely on the humidity of the atmosphere, and to some extent on the intensity of light also. Thus, at night at Peradeniya, when the light is very feeble and the humidity of the atmosphere very high, the adult culms are full of water which rapidly oozes out in drops when any injury is made, such as knocking a nail into the culm. At this time also the young growing culms are so saturated with water that this oozes out spontaneously from the tips and axils of the bracts of the sheathing leaves. The supply of water is no doubt due to the activity of the root system which forces by root pressure a copious supply into the culms above, whether adult or immature. Now, in the daytime this supply is required to replace the rapid loss from the extensive leaf system of the adult culms. It happens therefore that there is a rapid transpiration current along the adult culms and the water is removed as fast as it is supplied from the roots. To be strictly accurate in fact the upward suction of the leaf system combines with the root pressure to produce a current of water more rapid than would be the result of root pressure alone. Not only does the loss of water from the leaves produce a rapid transpiration current in the adult culms, but it also appropriates the supply for the growing culms which are on the same rhizome system.

The bamboo culms, whether mature or growing, all rise from a complicated network of underground rhizomes, in which the food for the young bamboo is stored. Since a young culm is on the same rhizome as several mature ones, they all have a common source of water supply in the roots below, and the water obtained by the young bamboo, which has no leaf system of its own to suck up the water, depends largely on the amount left over when the adult culms have been satisfied.

The growing culms in fact are left with so small a supply of water in the daytime that not only is there no oozing out of water from them, but the supply necessary for their growth is removed, and their growth is slower or altogether stopped.

Should rain occur during the day, with its accompanying high humidity, the loss from the leaves is checked, a supply of water is available for the young culms, and their growth immediately increases in rapidity. It is not as a rule until darkness sets in that the loss of water from the leaf system is completely checked, and on dark nights of high humidity we get conditions in which the supply from the roots, not being required by the leaves, oozes out from the young culms, and so fills the mature ones that if injured in any spot water flows fairly copiously from them.

It seems to follow, therefore, that if any difference in beetle-resisting qualities occurs in the bamboos at different times of the day or month, it must be due to the greater or smaller quantity of water in the culms when cut down, and this, as we have shown, is a direct consequence of the atmospheric conditions, whether of light or humidity.

If therefore there is really any foundation of fact in the belief of the effect of the moon's phases it will be probably found to lie in the different weather conditions prevailing at one period of the moon from those prevailing at another. If it could be shown that at full moon in India the atmosphere was either uniformly drier or moister than at new moon, then we should have some clue to a scientific explanation of the native belief. This point of view brings the native belief into line with the very widespread idea that the moon has an influence on the weather, an idea until recently very prevalent among country people in England. It is quite likely that the Indian belief may turn out as baseless as the English one.

Leaving the region of conjecture in which there are no certain facts to guide us, we may turn to certain results which have been obtained whilst conducting experiments to test the native belief. These experiments were conducted in such a manner as to leave their interpretation somewhat doubtful. For instance, the following result was obtained on the Nilgiris: "Bamboos cut on dark nights and immediately soaked were not attacked." Here we cannot tell whether the fact of cutting them on dark nights had any part in producing the immunity from attack, or whether the whole effect was due to the subsequent soaking in water. Supposing that the fact of cutting on a dark night had something to do with the effect, some such explanation as the following may perhaps hold good. A dark night is usually one of high humidity, and a moonlight night is probably of lower humidity. This may especially be the case in India, where humidity is often much lower at night than in Ceylon. This being the case, the bamboos cut on dark nights would probably be full of water when cut; whereas those cut on a bright night may have contained less. Hence the mere fact of cutting on a dark night may be partially equivalent to the soaking in water, which has been found a fairly good remedy against attacks. Mr. Stebbing states further on that those felled on moonlight nights were more severely attacked than those felled on dark ones. No statement is made as to whether these bamboos were soaked or not, but if not the result shows that some difference does occur between those felled on moonlight nights and those felled on dark ones. The explanation I would apply to this case is the same as that for the previous one.

It is much easier to apply some rational explanation to cases such as the above in which a difference is observed between culms felled in the day and those during the night, or between culms felled on dark and those on moonlight nights, than it is to suggest a reason for the supposition that any difference occurs between those cut in the ordinary way, which is, I presume, in the daytime, at different times of the month.

Turning to another point in Mr. Stebbing's paper there seems to be considerable doubt as to which explanation of the relation between the sap and the beetles is correct. Two are given :—

(1) That an abundance of sap hinders the beetles in their boring and tends to drown them out.

(2) That the beetles feed on the sap and therefore attack more readily when abundance of sap provides a good supply of food.

It will be seen that the two explanations are contradictory and cannot both be true. The former falls into line with the efficacy of soaking the bamboos in water. There seems to be good evidence that this precaution is of considerable value. If my explanation of the effect of cutting on dark as contrasted with moonlight nights be true, then they also would fall into line with this idea. For when the bamboos are felled on dark nights they are full of what is largely pure water containing certain salts, and the sap present is much more watery than when the bamboo culm is drier during the day. Thus any effect of this sort would be explained on the drowning out theory. When we distinguished between an abundance of sap and an abundance of food material in the sap, we may get the above effect also explained on the second theory, for though sap is more abundant on dark nights and it might seem that food for the attacking beetles would be more abundant, yet it must be remembered that the sap is more dilute on dark nights, and though more abundant may possibly contain less organic food for the insects. Thus the comparative immunity may be due to the fact that not only does the large amount of sap tend to hinder the beetles in burrowing, but also the food supply in the sap may be smaller as it is more dilute.

I cannot give any reconciliation between this view and that which supposes that when the moon is full the bamboos contain more sap and therefore that time should be avoided for felling, since the fermenting sap forms an attractive food supply for the beetles. In the few cases in which we have definite facts to go upon the bamboos seem more immune from attack when felled full of sap, and for this fact certain explanations can be put forward, as indicated above. It is quite likely therefore that the supposition that the time when they are full of sap is unfavourable for felling may turn out to be quite groundless, and as yet there are certainly no facts brought forward to support it.

To settle the whole question, felling should be done at different times of the day and night, notes being taken of the humidity of the atmosphere and the state of the light. A series of observations might be made to show whether any particular sort of weather, whether dry or moist, is associated at all constantly with full moon in India. Above all, the experiments should be arranged so that they are not complicated by other factors, *e.g.*, soaking, for then we cannot tell to which cause to ascribe a particular effect.

Note on Apluda varia, Hack.

BY

J. F. JOWITT.

IN a footnote to his description of this grass in Trimen's Flora of Ceylon, Sir J. D. Hooker says : " Hackel regards the swollen base of the spike as the callus* of the lower spikelet, in which view I, supported by Dr. Stapf, do not concur."

Sir J. D. Hooker does not state what he and Dr. Stapf consider this thin-walled utricle or hollow base to be.

The result of examination made by me of a great number of spikes in the fresh state leads me to the following conclusions. The swollen hollow base appears to be common to the whole spike, containing in the substance of its wall vascular bundles running both to the sessile and upper spikelet and likewise three bundles with free ends which unite at the base of the sessile spikelet *within* the hollow of this utricle. On examination it will be found that the bundles of the rachilla divide at the base of the utricle, sending six branches upwards :—

3 branches situated below glume 1 of the sessile spikelet ;
2 branches situated below the arm of the pedicelled spikelet ;
1 branch situated below the arm of the solitary glume.

The central of the three branches below glume 1 of the sessile spikelet has a free end, that is, its end is free from the wall of the utricle and coalesces with the two other branches, hereafter mentioned, at the base of the sessile spikelet. The side bundles run in the thickness of the wall.

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* " Callus " is a special term in agrostology used to denote an extension of the flowering glume below its point of insertion and grown to the axis or rachilla of the spikelet.

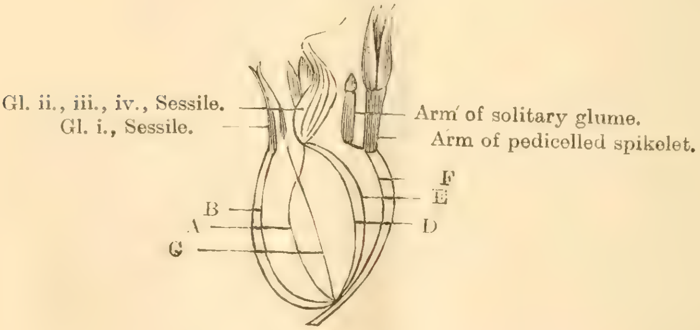
Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part II., October, 1907.]

Of the bundles below the arm of the pedicelled spikelet the one nearest the sessile spikelet sends a free bundle to join the one from the central of the sessile group of three.

The other bundle below the arm of the pedicelled spikelet runs in the substance of the wall of the utricle, and at its apex, at the junction of the arms of the pedicelled spikelet and solitary glume, is forked, sending branches into both arms.

The bundle below the solitary glume runs for about half its course in the substance of the utricle, then becomes free, and joins the free bundles from below glume 1 of the sessile and pedicelled spikelets.

Diagrammatic.



Explanation of Diagram.

A. Central bundle.
B. and C. Side bundles, below glume 1 of sessile spikelet.
D. Free bundle from below arm of solitary glume.
E. Free bundle below pedicelled spikelet.
F. Bundle in substance of wall below pedicelled spikelet, forked at its apex.

This arrangement of the bundles seems to explain the full development of the sessile spikelet which receives five bundles, two in the substance of the wall of the utricle and three free ones ; the comparatively less development of the upper spikelet which receives one bundle ; and the stunted growth of the solitary glume which is dependent on a branch from the bundle running to the pedicelled spikelet for its nourishment.

I am indebted to Mrs. J. B. Carruthers for the drawings of dissection.—

Fig. I.

Fig. II.

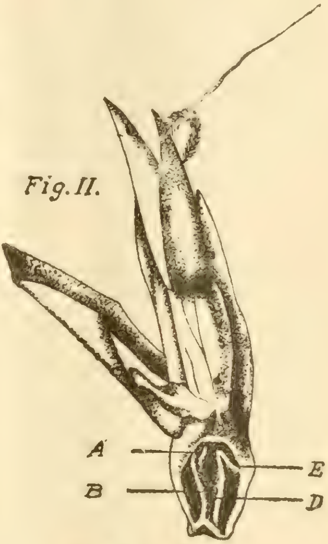


Fig. III.

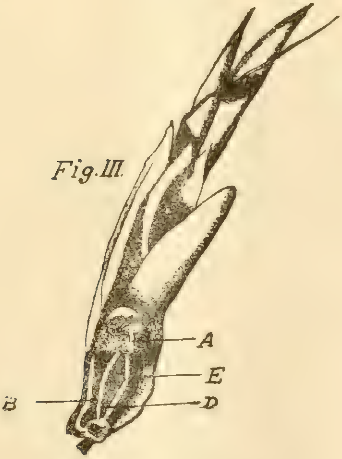


Fig. I. represents utricle opened below arm of the solitary glume, arm and glume removed.

Fig. II. The wall of the utricle below the junction of glume 1 of the sessile spikelet and arm of the pedicelled spikelet, has been removed.

Fig. III. The wall immediately below and at right angles to glume 1 of sessile spikelet removed.

In all three figures.—

A. Central bundle below glume 1 of sessile spikelet.
B. and C. Side bundles.
D. Free bundle below arm of solitary glume.
E. Free bundle below arm of pedicelled spikelet.
F. Bundle in substance of wall below the arm of the pedicelled spikelet, forked at its apex.

REVIEWS.

The Genus Ravenelia.

[P. Dietel. Monographie der Gattung *Ravenelia*, Berk. Beihefte zum Botanischen Centralblatt. Bd. *XX.*, Heft 3, pp. 343-413.]

The genus *Ravenelia* was founded by Berkeley in 1853, the first species being *R. indica*, Berk. When Cooke monographed the genus in 1880, eight species had been described, six of which were from Asia. Since then only one more species has been recorded from Asia, though the total number in the genus has been increased to eighty-one, chiefly from America. (Butler has added two new species from India, since the publication of Prof. Dietel's monograph.) The genus belongs to the *Uredineæ*, and is characterized by the growth of the teleutospores in stalked or sessile heads furnished with peculiar basal "cysts." It is confined to tropical or subtropical regions, and, except three, all members of the genus are parasitic on species of *Leguminosæ*, the exceptions occurring on *Phyllanthus*.

The Ceylon species are six in number. *R. sessilis*, Berk., is parasitic on the leaves of *Albizzia Lebbek ; R. aculeifera*, Berk., on *Mezoneuron enneaphyllum ; R. indica* on *Cassia absus ; R. macrocystis*, Berk. & Br., on *Cassia Tora ; R. Hobsoni*, Cke., on *Pongamia glabra ;* and *R. munduleæ*, Henn., on *Mundulea suberosa*. The two last were included by Berkeley under *R. stictica*, Berk. & Br. With regard to *R. macrocystis*, Dietel states that there is no fungus on the specimen at Kew, and that the species was not seen by Cooke : there is no specimen in the Peradeniya herbarium. *Cassia Tora* is a very common weed in Ceylon, and I have examined all the plants I have seen during the last two years in various parts of the Island. The fungus which always occurs on it—the only one collected from this plant—is an *Erysiphe* which causes black patches on the leaves. As Berkeley and Broome do not record this, though it could scarcely have been overlooked by Thwaites, it seems a fair suggestion (in view of the many errors in the list) that *R. macrocystis* was a misdetermination, more especially as Berkeley and Broome state that it is "Pseudosporis e cellulis paucis magnis compactis e *mycelio radiante oriundis*."

Berkeley's *R. sessilis* was said to be on *Albizzia Lebbek* (Thwaites 1,105) and *Gleditschia*, sp. (Thwaites 1,135). Dietel observed that the latter host plant was wrongly determined, and instituted a new species, *R. zeylanica*, for the fungus on it, but this has since been withdrawn (Bot. Centralb. Bd. 104, p. 209). Thwaites' specimen No. 1,135 labelled "*Gleditschia*, sp." is undoubtedly on

Albizzia Lebbek, and Berkeley's determination of the fungus was correct, though the host plant was wrongly identified. Finally, *R. stictica*, Berk. & Br., has been the source of some confusion, and Dietel takes the shortest way out of the difficulty by substituting the names *R. Hobsoni*, Cooke, and *R. Munduleæ*, Henn., for the two species which Berkeley included under that name.

In his "Fungi of Ceylon," Berkeley cited *R. indica* on *Bauhinia tomentosa* and *Cassia absus* (Thwaites 517). Dietel queries the first host plant, and states that he has not seen a specimen. In the Peradeniya herbarium, *R. indica* on *Cassia absus* is Thwaites 517 ; and Thwaites 519 which was collected at the same time and place is *Uromyces verruculosa*, B. & Br., on *Bauhinia tomentosa.* Probably the original record is due merely to a confusion of the numbers.

Berkeley's original specimens of *R. stictica*, B. & Br., included two host plants, *Pongamia glabra*, Vent., and *Mundulea suberosa* (DC.), Benth. The former is Thwaites 493, and the latter Thwaites 501. Parts of both these type specimens of *R. stictica* are in the Peradeniya herbarium. Cooke made a distinction, describing *R. Hobsoni*, Cooke, on some undetermined leaf, and *R. stictica*, B. & Br., on *Pongamia.* But an examination of Cooke's type specimen of *R. Hobsoni* has convinced Dietel that it is on *Pongamia*, and is identical with the fungus Cooke separated as *R. stictica*, B. & Br., on *Pongamia.* The leaves of the original two host plants cannot be confused. It appears from this that Cooke's separation concerned the fungus on one host only and was incorrect. Unfortunately, however, Cooke's figure 7 which he calls *stictica* is, according to Dietel, the species on *Mundulea suberosa.* Since then Hennings has described the latter as *R. Munduleæ.* Cooke's determination thus rests upon neither his figure, nor his type specimens, and it may be questioned whether the facts warrant the suppression of Berkeley's name *R. stictica* in favour of *R. Hobsoni* for the species on *Pongamia glabra.*

T. P.

Course of Laticiferous Tubes in Leaves.

[Beitrage über den Verlauf der Milchröhren in den Blattern. Oscar Mayus. Beihefte zum Botanischen Centralblatt. Bd. *XVIII.*, Abt. I., Heft 2, pp. 273-286.]

The author has investigated the course of the laticiferous tubes in the leaves of fourteen species. These are chiefly European, but they include the members of the families to which our rubber-producing plants belong. He states that the laticiferous tubes accompany the sieve tubes into the side nerves of the second order, but that in the majority of cases they then replace the sieve tubes and pass through the spongy tissue of the leaf coming in direct contact with the assimilating cells. In *Ficus elastica* and *Euphorbia peplus* they pass between the cells of the palisade parenchyma and also between this and the epidermis. The cells surrounding those portions of the laticiferous tubes which are not in contact with the sieve tubes always contain starch. He further states that there is no system of laticiferous tubes confined to the leaf as was formerly supposed, but that those in the leaf form a self-contained system with those in the other parts of the plant. He concludes that those plants which possess laticiferous tubes gain an advantage over others, in that they are able to remove assimilated material from the leaf in mass, while those without laticiferous tubes must remove it by osmosis, an admittedly more difficult operation.

Castilloa belongs to the same family as *Ficus elastica*, while *Hevea* and *Ceara* are members of the *Euphorbiaceæ*. The points brought out are of interest, since the establishment of a connected system of laticiferous tubes from the leaves to the stem makes it possible that the rubber—or its immediate forerunner—may after all be formed in the leaves.

T. P.

The Germination of the Palms.

[Recherches anatomiques et chimiques sur la germination der Palmiers. Gatin. Ann. Sci. Nat. Bot. J. III., 191. 1906.]

A detailed anatomical and morphological and chemical study of the germination of the palms (including several sent from Peradeniya). It brings out nothing strikingly new, but is a thoroughly worked out paper.

J. C. W.

The Anatomy of Palm Leaves.

[Bobisut, O., Zur Anatomie einiger Palmenblätter. Sitzb. d. k., Akad. d. Wiss. in Wien CXIII., 1904.]

The author has examined a number of palm leaves with reference to the climates they inhabit, and finds adaptation to the climate in all.

J. C. W.

Flora of the Ceylon Coast.

[Tansley and Fritsch. The Flora of the Ceylon Littoral. New Phytologist IV., 1905, p. 1.]

A very clear and readable account of the coast flora by two former visitors here, but containing nothing scientifically new.

J. C. W.

NOTICE.

Volumes I., II., and III. are now complete, and are published at Rs. 15 or £1 each unbound. A few copies of Parts I. (Ceylon Botanic Gardens, &c.), III., and IV. (Podostemaceæ, &c.) of Vol. I. can still be had. The following reprints are also for sale at the prices marked :—

Willis : a Revision of the Podostemaceæ of India and Ceylon, 70 pages	Re. 1·50 or 2*s*.
Willis : Studies in the Morphology and Ecology of the Podostemaceæ of Ceylon and India, 200 pages with 33 plates	Rs. 7·50 or 10*s*.
Wright : The Genus Diospyros in Ceylon : its Morphology, Anatomy, and Taxonomy, 185 pages with 20 plates	Rs. 6 or 8*s*.
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EDITED BY
J. C. WILLIS, Sc.D., F.L.S.
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The Present State of Knowledge of Heredity in Pisum.

BY

R. H. LOCK,

Fellow of Gonville and Caius College, Cambridge.

INTRODUCTION.

IN two papers published in earlier numbers of these Annals (13, 14), and in one which appeared in the Proceedings of the Royal Society (15), some account has been given of experiments carried out at Peradeniya and at Cambridge in confirmation and extension of Mendel's classical work upon peas. Many experiments remain undescribed. The majority of these have led to results which, though new of the genus Pisum, are yet closely paralleled by the published observations of other workers upon other plants. It appears doubtful, therefore, whether the time which would be required for describing them in detail will not be employed better upon other experimerts which seem likely to lead to results of greater novelty. It is proposed in the present paper to summarize briefly those new results which have not been hitherto published, and to indicate very briefly their connection with the work of others. At the same time it appears possible that a concise summary of all the most important facts so far recorded with regard to heredity in Pisum may be of use to others, especially when added to a statement of the gaps which still remain in our knowledge of the subject.

The present paper constitutes such a summary, in which it is hoped that the new records are adequately represented, whilst facts previously known are noted with all possible brevity.

Many of the original crosses upon which the most recent of these results are based were made by Mr. Bateson. I desire to record here my indebtedness to him for handing over to me, in 1905, the greater part of his material relating to Pisum.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part III., June, 1908.]

The characters of which the heredity has been studied are dealt with here in the following order :—

1. The shape of the cotyledons.
2. The colour of the cotyledons.
3. The colour of the testa, corolla, and leaf axils.
4. Characters of the pod.
5. The presence or absence of fasciation.
6. Habit of growth.
7. Duration.

In conclusion, some miscellaneous points will be touched upon, which have less direct bearing upon problems of heredity.

1.—SHAPE OF THE COTYLEDONS.

A.—*External Characters.*

(i.) *Round and wrinkled.*—This is the simplest of the pairs of external shape characters. On crossing, round is fully dominant over wrinkled. To this rule there does not seem to have been recorded any well-authenticated exception in which healthy plants were concerned. In F 2 upon 153 plants Mendel found 7,324 seeds, of which 5,474 were round and 1,850 wrinkled. This result and the results of other observers are tabulated below in order to facilitate reference :—

Shape of Seeds.

	Observer.	Round.	Wrinkled.	Wr. Per Cent.
F 2	Mendel (16)	5,474	1,850	25·2
	Tschermak (17)	884	288	24·6
	Bateson (2)	10,793	3,542	24·8
	Hurst (11)	1,335	420	23·9
	Lock (14)	620	197	24·1
		19,106	6,297	24·8
F 3	Tschermak (17)	2,087	661	24·0
	Lock (14)	769	259	25·2
F 4	Lock (14)	2,328	812	25·8

There is no sensible difference between the ratios found in F 2, F 3, and F 4. In the experiments at Peradeniya the distinction between round and wrinkled was, if anything, sharper in F 4 than in F 2. The offspring of the heterozygotes still exhibit the Mendelian ratio, although three generations of ancestors have shown exclusively the dominant character.

The conclusion drawn by Mendel (16) from this experimental result is well known.* A practical demonstration of the correctness of the theory was obtained by crossing the heterozygote with the dominant and recessive parents respectively. From such crosses the following numerical results have been obtained :—

Heterozygote crossed with the Dominant.

Observer.	Round.	Wrinkled.
Mendel (16)	192	—
Tschermak (17)	38	—

Heterozygote crossed with the Recessive.

Mendel (16)	106	102
Tschermak (17)	26	18

A further visible difference between a round and a wrinkled pea, in addition to the shape, lies in the colour of the cotyledons. This difference was first noticed by Hurst (11), and is only visible after removal of the testa. When this has been done, the colour of the wrinkled pea is seen to be some shades paler than that of the round. This distinction in colour is possibly to be associated with the internal difference described below.

(ii.) *Indent and Smooth.*—The inheritance of these characters was not observed by Mendel, but was first described by Tschermak (19). The indentation, which at first sight appears to be only a mild form of wrinkling, is a totally distinct character. It is, furthermore, a maternal or plant character, being present or absent in all the seeds of the same individual.

The presence of the indented character is dominant to its absence.

The effect of the combination of the two pairs of characters, round–wrinkled and indent–non–indent, is as follows. The two pairs segregate independently. The round character is

---

* In 1900 Correns (4) applied the term Mendel's Law to this conclusion. The rule is to this effect : Hybrid peas produce gametes, which represent in equal numbers all possible combinations of paired characters, no two members of the same pair appearing in the same gamete.

completely masked* or hidden when the indent is present, but the wrinkled character is not. Thus, an indent plant which is a heterozygote in respect of the pair round-wrinkled will bear a mixture of indent and wrinkled seeds in the proportion of three to one.

It seems that the indented character only makes its appearance in association with a pigmented testa.† So that when a pigmented indent plant is crossed with a non-pigmented plant having round seeds, all the non-pigmented plants in F 2 have again round seeds. The indent character is thus itself masked in the absence of pigment, and may make its appearance as a reversion when a round-seeded pigmented plant is crossed with a round-seeded unpigmented, as was observed both by Tschermak and the present writer. In this case the non-pigmented parent must have borne the indent allelomorph in the masked condition.

We have seen that the indent character—a character which affects the cotyledons of the embryo—segregates by plants. It is therefore a maternal character, which becomes impressed upon the offspring in some way unconnected with heredity. This result may be contrasted with the effect of the phenomenon known as xenia—also described in peas—in which the character of a hybrid embryo directly affects the maternal tissues. Phenomena not unlike that shown by the dimpled pea character have been described in wheat and in maize (25, 27).

(iii.) Besides roundness and wrinkledness and the presence and absence of the indent character, other slight nuances of shape are to be observed in different varieties of peas. These are often quite characteristic, though almost impossible to

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* A masked character is a dominant allelomorph which remains invisible (formerly described as latent or, incorrectly, as recessive). This invisibility depends upon the presence (or absence) of an allelomorph belonging to a totally distinct pair.

Thus, in the case of many colour characters, the appearance of the colour depends upon the simultaneous presence of two dominant allelomorphs A and B. ABAB is coloured and so is any other zygote containing both A and B, such as ABab; but AbAb, aBaB, abab, &c., are all colourless. In this case both A and B are masked respectively—each in the absence of the other.

† There is evidence that it may sometimes be coupled with a particular type of testa colour. (Tschermak, 19.)

describe in words. The same shapes may sometimes be recognized again in the later generations from a cross, and are generally uniform upon the same plant, thus showing some analogy with the indent character. It is thus probable that other pairs of allelomorphs concerned with the shape of seeds show segregation in addition to the two pairs referred to above. But it is not easy to obtain proof of this in the case of characters so difficult of definition.

Some of these characters may depend upon pressure in the pod and upon other similar factors.

(iv.) *Characters not inherited.*—Endless differences in the shape of individual seeds are associated with such accidental circumstances as position in the pod, fullness of the pod, the position of the pod on the plant, and many others.

All the seeds of the same pod sometimes show an unusual character, for instance, pitting in the case of a round pea. Or a pod may contain a row of seeds much smaller than the normal. The offspring of such seeds are not to be distinguished from those arising from normal seeds of the same plant.

B.—*Internal Characters.*

Gregory (10) showed that peas belonging to the round and indent classes have similar starch grains which are large and single, whilst the starch grains of wrinkled peas are small and compound.

Darbishire (6) has recently observed that the seeds of heterozygotes from the cross round × wrinkled, though showing the dominant character externally, are intermediate as regards the character of their starch grains.

2.—Colour of the Cotyledons.

In the majority of cases yellow and green are sharply discontinuous. There is, however, a tendency for normally green seeds to turn gradually yellow, especially if kept in the light, and this tendency is much more marked in some strains of peas than in others. In some cases, and especially in bad weather, this tinging may be carried so far that many seeds in the earliest ripening pods of a green-seeded plant may have become more or less distinctly yellow before the upper pods are ripe.

A less common cause of confusion is the tendency for normally yellow seeds to retain some traces of the green colour characteristic of the unripe condition, especially if they are dried off very rapidly by artificial means. It is doubtful whether there is any exception to the rule that yellow and green seeds are readily distinguishable on a heterozygote plant, if the contents of each pod are examined as soon as thoroughly ripe in reasonably good weather.

The result of numerous subsequent observations, therefore, is simply to confirm Mendel's original statement. The numbers dealt with by different observers are given in the following table :—

Colour of Seeds.

	Observer.	Yellow.	Green.	Gr. Per Cent.
F 2	Mendel (16)	6,022	2,001	24·9
	Correns (4)	1,394	453	24·5
	Tschermak (17)	3,580	1,190	24·9
	Bateson (2)	11,903	3,903	24·7
	Hurst (11)	1,310	445	25·4
	Lock (14)	1,438	514	26·2
		25,647	8,506	24·9
F 3	Correns (4)	1,012	344	25·5
	Tschermak (17)	3,000	959	24·2
	Lock (14)	3,082	1,008	24·6
		7,094	2,311	24·5
F 4	Correns (4)	225	70	23·7
	Lock (14)	2,400	850	26·1

In this case also a sufficient number of crosses have been carried out between the heterozygote and the parental types to demonstrate Mendel's deduction from the facts of segregation.

Heterozygote crossed with Dominant.

Observer.	Yellow.	Green.
Mendel (16)	192	—
Tschermak (17)	126	—

Heterozygote crossed with Recessive.

Observer.	Yellow.	Green.
Mendel (16)	104	104
Tschermak (17)	101	100

3.—Colour of the Testa, Corolla, and Leaf Axils.

Mendel's observations upon these characters extended only to the simplest possible case. Stated in general terms, his result is perfectly correct. When a plant with purple flowers and pigmented axils and testas is crossed with an unpigmented plant, the characters of the coloured plant are dominant and Mendelian segregation occurs. If the colour characters are studied more minutely, however, the case is found to be somewhat complicated, and it will be convenient to classify the main colour characters examined by the present writer in the following manner.

A. *Testa.*—(i.) A grayish or brownish pigmentation (gray), as opposed to the absence of this pigmentation (white)—in the latter case the testa is faintly greenish or yellowish or nearly colourless. There are probably several subdivisions of each of these two classes which could be distinguished by a sufficiently skilful observer, but the writer finds it necessary to be content with the statement that the two classes are allelomorphic to one another.

(ii.) The presence (purple spotted) of bright purple spots or dots, very variable in extent, as opposed to the presence of a few very faint bluish or reddish dots only. The two classes are readily distinguishable if the seeds have ripened in dry weather. But in wet weather difficulties may arise, since the purple pigment is soluble in fresh water—a fact which may possibly account for some of the supposed irregularities in the behaviour of this character.

(iii.) The presence of the maple character (maple)—a marbling or mottling of a rich brown colour, as opposed to the absence of this pigmentation.

Purple spotted and maple are only clearly visible when gray is also present; but maple may be faintly recognizable on white plants, constituting what I have elsewhere (15) described as "ghost maple." Purple is completely masked, and maple partly masked, in the absence of gray.

The purple spotting is produced by a pigment dissolved in the sap of certain cells immediately underlying the outermost cell layer of the testa. The brown colour of the maples is almost or quite confined to the walls of the I-shaped cells of the outermost layer itself, and is insoluble in boiling water. The gray colour seems to be due to a greenish solid pigment deposited in the cavities of all or nearly all the cells of the testa.

(iv.) Certain seeds on plants having the gray character, and more especially when the maple character is also present, exhibit a uniform purple pigmentation, effectively obscuring all other colour characters. The latter, however, become visible when the purple pigment is dissolved out with boiling water. Only a few seeds on a plant are usually affected in this way, and, although all the seeds of a pod may be alike in this respect, this is not always the case. Sometimes only half the surface of a seed shows this pigmentation.

Seeds showing this character, and other seeds from the plants which bore them, were not observed to produce a larger proportion of affected plants than seeds from plants not affected. The phenomenon can only be attributed at present to unknown conditions of development.

Seeds of this kind were observed both upon pure strains and upon cross-bred plants.

B.—The *hylum* may be very dark brown or black (dark hylum) as opposed to a very pale brown (pale hylum).

C.—The *leaf axils* may be either green and unpigmented (green axil), or they may show one of two readily distinguishable shades of purple, a dark brownish purple (purple axil), or a pale pinkish purple (red axil).

D.—The *flowers* may have deep blue-purple wings and standard of a pale purplish blue colour (purple), or the wings may be from pink to deep crimson-red with pale pink to nearly white standard (red) ; or as a third alternative the flowers may be entirely unpigmented (white). Red flowers are constantly associated with red, as opposed to purple, axils and with a recognizable tinge of testa colour—the spots on the testa, whether deep or faint, being reddish with scarcely a trace of blue. Plants with white flowers have always unpigmented axils and testas.

The inheritance of all these characters, with the single exception of that referred to under A (iv.) above, can be described in terms of the following five pairs of allelomorphs :—

Dominant Allelomorph.		Recessive Allelomorph.	
Gray testa ; coloured leaf-axils (red in the absence of P) ; and coloured flowers (red in absence of P) ..	C	Absence of pigment, except chlorophyll and allied substances, in petals, axils, and testas ..	c
Marked spotting of some shade of purple on the testa ..	S	Spotting very faint or absent ..	s
Maple marking present ..	M	Maple marking absent ..	m
Presence of factor modifying red pigment to purple ..	P	Purple factor absent ..	p
Dark hylum ..	D	Pale hylum ..	d

In the case of the appearance of plants having coloured flowers but green axils, as described by Tschermak (19), a sixth factor must be introduced, but no such plants appeared among the writer's experiments.

S and P are always quite invisible (masked) in the absence of C ; and M, as before stated, is very nearly invisible when C is absent.

The observed phenomena are readily understood by supposing each of the above five pairs of allelomorphs to segregate according to the ordinary Mendelian rule. So far as is known, the segregation of each pair is quite independent of that of all the others, but the figures available are not sufficient to exclude absolutely the possibility of some partial coupling. There is no definite indication, however, that anything of the kind takes place.

The phenomena thus interpreted are briefly as follows :—

(i.) All combinations of characters possible on the above hypotheses, and no others, have been observed.

(ii.) Mendel's simple case is represented by the segregation of the pair of allelomorphs C–c, P being also present in both parents.

(iii.) Data have already been published with regard to the characters S and M (13, 14, 15). The results of crossing heterozygote plants with recessives were as follows :—

	S.	s.	M.	m.
Number of offspring ..	21	23	25	29

A sufficiently near approach to equality in each case. In addition to this, it was found that—

The Cross			Gives in F 2 approximately
ssmmCC	×	ssmmcc	3 gray : 1 white
SSmmCC	×	ssmmcc	9 purple spotted : 3 gray : 4 white
SSmmcc	×	ssmmCC	9 purple spotted : 3 gray : 4 white
ssMMCC	×	ssmmcc	9 maple : 3 gray : 4 white
ssmmCC	×	ssMMcc	9 maple : 3 gray : 4 white
SSMMCC	×	ssmmcc, &c.	27 maple purple spotted : 9 maple : 9 purple spotted : 3 gray : 16 white*

* These figures may be readily understood on studying the accompanying diagram, in which all the possible combinations of the three pairs of allelomorphs S–s, M–m, and C–c are set down at length. It will be seen that C is wanting from 16 of these combinations; these are therefore white, and though S or M or both may be present in these zygotes, they are masked and unable to make their appearance. S is always completely masked under these circumstances, but M may be only partially masked, and we can then distinguish 12 ghost maples from 4 pure whites.

Among the combinations which contain C, 3 contain neither S nor M: they are therefore gray. Of the remainder, 9 contain S but not M, and 9 contain M but not S, whilst 27 contain both. All these zygotes exhibit their appropriate characters.

	SMC	SmC	sMC	smC	SMc	Smc	sMc	smc
SMC	SMC SMC	SMC SmC	SMC sMC	SMC smC	SMC SMc	SMC Smc	SMC sMc	SMC smc
SmC	SmC SMC	SmC SmC	SmC sMC	SmC smC	SmC SMc	SmC Smc	SmC sMc	SmC smc
sMC	sMC SMC	sMC SmC	sMC sMC	sMC smC	sMC SMc	sMC Smc	sMC sMc	sMC smc
smC	smC SMC	smC SmC	smC sMC	smC smC	smC SMc	smC Smc	smC sMc	smC smc
SMc	SMc SMC	SMc SmC	SMc sMC	SMc smC	SMc SMc	SMc Smc	SMc sMc	SMc smc
Smc	Smc SMC	Smc SmC	Smc sMC	Smc smC	Smc SMc	Smc Smc	Smc sMc	Smc smc
sMc	sMc SMC	sMc SmC	sMc sMC	sMc smC	sMc SMc	sMc Smc	sMc sMc	sMc smc
smc	smc SMC	smc SmC	smc sMC	smc smC	smc SMc	smc Smc	smc sMc	smc smc

Certain irregularities in the inheritance of the purple-spotted character are not yet completely cleared up.

(iv.) The behaviour of the two pairs of allelomorphs C–c and P–p in combination is most readily observed by noting the colour of the flowers of the different plants, though it was also possible in every case to recognize the class to which a plant belonged on examining either the axils or the testas. The two pairs segregate quite independently, P being totally invisible in the absence of C, as the following evidence shows.

The varieties used were :—

(1) *Purple*—Purple Sugar Pea ; Purple Podded Pea ; Maple ; and a Purple Field Pea.
(2) *Red*—Irish Mummy Pea.
(3) *White*—Laxton's Alpha ; Veitch's Perfection ; Sunrise ; British Queen ; Victoria Marrow ; Trés nain de Bretagne ; and various extracted whites.

In the case of crosses between these original strains, purple crossed with white always gave all purple in F 1, and in F 2 yielded a proportion of 3 purple plants to 1 white.

Purple crossed with red gave all purple in F 1, and in F 2 3 purple to 1 red.

Red crossed with white invariably gave all purple in F 1, and in F 2 gave 9 purple : 3 red : 4 white—in a particular case 141 purple : 43 red : 65 white.*

Thus, among extracted whites derived from the cross between the purple sugar pea and different white strains I found no example which did not yield exclusively purple spotted offspring when crossed with gray. The experiment, however, should be repeated, since the whites used were F 3 and F 4 and not F 2 ; also the development of the purple-spotted character varied considerably in coloured F 2 plants.

Bateson found differences between the product of reciprocal crosses in which this character was concerned. Such differences can be accounted for on the supposition of segregation of the S–s pair in the white strain used.

The account given in the text undoubtedly holds good in certain cases, and the possible exceptions are not yet fully established as such.

* That is to say, all the white strains examined contained homozygous P in the masked condition. The absence of white varieties which do not contain the factor for purple may be to some extent understood when we remember the necessary invisibility of this factor in white plants.

In the course of the history of modern cultivated peas, white-flowered plants, which must have arisen in the first instance from purple-flowered parents by the loss of the factor C, could be, and doubtless were, selected.

Further cross-breeding among the offspring of these crosses has given rise to the following results :—

Purple F 1 plants from the cross red × white when crossed again with a pure purple strain yielded 34 plants all purple (6 crosses).

Crossed with different pure white strains they gave 44 purple plants and 26 white (15 crosses. *Expectation equality*—not a very good approximation to the expected result).

Crossed with the pure red strain they gave 21 purple and 17 red (7 crosses. *Expectation equality*).

Among 16 red F 2 plants examined (by self-fertilization) 10 yielded a mixed progeny of reds and white—113 : 50 (*Expectation 3 ; 1*), and 6 yielded red offspring only—83 in number.

White plants of the same generation (F 2 from self-fertilized F 1) were also examined by crossing with the pure red strain. Some of these crosses yielded purple plants only, others purples and reds, and others again reds only.*

Purple plants of the same generation when crossed with pure (*i.e.*, parental) whites yielded in some cases purple plants only. In 5 cases they yielded a mixture of purples and whites 13† purple : 19 white.

(v.) The dark hylum was only observed in plants one of whose parents at least showed the same character. Dark

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Red-flowered plants arising in a similar manner by the loss of the factor P could also be preserved by selection, but they are comparatively uncommon, and have not apparently been observed to give rise to white as a further mutation.

There is no reason for supposing that the loss of both factors is likely to take place simultaneously—rather the reverse.

But innumerable white varieties exist, and it might be supposed that the loss of the factor P would have taken place in some of them. Such a plant, however, could not be recognized, except by the test of crossing. It would therefore not be selected, and its chance of survival would be small. Therefore, although many varieties still remain to be examined from this point of view, it is quite possible that the pure recessive white will not be discovered among naturally existing varieties. It can, however, readily be obtained by crossing.

* So that white plants can be extracted which do not contain the P factor : *cf.* previous note.

† *Cf.* the somewhat wide deviation from equality shown by the corresponding cross in the previous generation.

hylum crossed with pale gave all dark in F 1, and in F 2 approximately 3 dark to 1 pale.

4.—Characters of the Pod.

Mendel described the inheritance of two such pairs of characters.

(i.) The difference in the colour of the unripe pods, whether green or bright yellow. The former character was dominant, and F 2 showed the usual proportion of 3 : 1. I am not aware that any one has repeated this experiment in the case of peas. But several observers have described exactly the same phenomenon in Phaseolus.

(ii.) The presence of the hard parchment layer in the pod was described by Mendel as dominant to its absence—characteristic of the sugar pea. Other observers, including the present writer, have found the heterozygote to be more or less intermediate in this respect. Segregation appears to take place always in the normal way.

Other pod characters also show segregation. Bateson described the stumpy form of pod apex as being dominant over the pointed, and I have observed the same thing.

As regards breadth of the pod, the F 1 plant bears pods which are distinctly intermediate, but there are indications of segregation in F 2.

In a note to his paper of 1865 Mendel stated that he was starting experiments with the purple-podded pea, the pods of which are of a deep purple colour when ripe. But no account of these experiments was ever published. The offspring of a considerable number of crosses between this variety and various green-podded types have been examined by the present writer, but the complexity of the results has so far precluded a simple description. The chief difficulty lies in the existence of a high degree of fluctuating variability in the degree of pigmentation among different pods borne by the same plant. Apart from this, at least five different types of plants appear in F 2. There are plants with fully pigmented pods, and others with wholly unpigmented pods like the parents. Then there are pods with the valves fully pigmented at the margins and the central parts green, and others (on other plants) with this distribution of the pigments reversed. Other plants again bear pods which are only very faintly pigmented. In addition to these types, the pigmented areas may be uniform or more or less broken up into patches.

The great amount of individual fluctuation renders it often impossible to place a particular plant in one or other of the ten presumptive classes thus indicated, and the complete elucidation of the phenomena is thus rendered very difficult, if not impossible. On the whole, the evidence must be taken to indicate that segregation is going on between several pairs of independent factors.

5.—The Presence or Absence of Fasciation.

Mendel quite properly described the non-fasciated character as dominant. He also described normal segregation, and this description is also probably correct.

In my own experiments, when every plant of F 2 which showed any sign of fasciation was counted as recessive, segregation was found to take place in the proportion of 3 : 1 approximately. But very many of the fasciated plants in F 2 showed this modification to a very much slighter extent than their fasciated grandparent, the Irish Mummy pea. Some of this difference is undoubtedly to be ascribed to the effect of crowding and bad conditions of growth, since the fasciated plants of F 2 had to compete with thrice their number of normal sister plants, but it did not seem likely that this would account for the whole difference.

Seeds of very slightly fasciated plants of F 2 were therefore sown to produce a third generation, F 3. The seeds were sown at wide intervals, and the summer (1907) was very wet. All the plants produced in every case were fully fasciated—almost, if not quite, as much so as the plants of the original parental stock. It would seem as if the fasciated character is one which is especially susceptible to the influence of the environment. Other evidence exists which goes to show that fasciation is a character of which the development depends to a very large extent upon the influence of external conditions.

6.—Habit of Growth.

The characters included under this heading require further study. Mendel showed conclusively that the very tall habit is dominant to the very dwarf. But dwarf plants vary very much among themselves in habit and tall ones probably not much less, whilst other plants exist which cannot be placed in either category. The study of these characters is rendered difficult by the great individual fluctuation which plants of the same strain exhibit, and (what is perhaps to a large extent the same thing) its great susceptibility to the influence of external conditions.

The difference between ordinary tall and dwarf depends much more upon the length of the separate internodes than upon the number of these, and the distinction is readily recognizable in quite young seedlings. Considerable differences in the number of internodes also exist however, but the inheritance of these differences has never been adequately studied. In the case of some crosses indications have been observed of phenomena which appear complex, but which might doubtless be elucidated by adequate numerical treatment.

7.—Duration.

This is another feature in which so many fluctuations occur that it is doubtful whether a complete study can profitably be made of it. It is only mentioned here for the purpose of recalling the circumstance that a marked correlation or coupling has been observed between the time of flowering and the colour of the flowers, &c., in F 2 from a cross between a white and a coloured strain (13). This is the only case known in the pea of coupling between characters having no obvious relation to one another.

General Remarks.

Mendel's seven pairs of allelomorphs have now been multiplied with certainty to 13, whilst indications are to be observed of others, which are less definite in their manifestations, but will probably be found to amount to a still greater number.

The behaviour of the colour characters of the testa and corolla have now been worked out completely, and described in terms of Mendelian segregation with the help of the idea of the masking of certain characters when certain other characters are absent.

The principal gaps now remaining in our knowledge relate to the heredity of the purple pod and of the allelomorphs concerned in determining the number and length of internodes.

From De Candolle's remarks in his Origin of Cultivated Plants he does not seem to be aware of the maple type of pea with smooth seeds, and he follows the long established error of distinguishing Pisum arvense and P. sativum as separate species. Darwin states that an extinct variety of pea with very small round seeds allied to the field pea is recorded from the lake dwellings of Switzerland.

After examining the wild pea, seeds of which were brought from Palestine by a member of the firm of Sutton & Sons, and comparing it with a closely similar plant growing in India and Ceylon, the behaviour of which on crossing has been studied in some detail, a near idea of the appearance of the original wild type of the cultivated species of Pisum has, it is thought, been obtained. It is of interest that the dominant member of the pair represents the primitive character in at least 12 out of the 13 cases of allelomorphic pairs which can confidently be claimed as such. The doubtful case is that of the dimpled character, as there is some uncertainty as to whether the primitive type was dimpled or smooth. All the most primitive types of peas known have smooth seeds, and the uncertainty chiefly arises from the fact that all the other primitive characters are dominant.

Xenia.—Bateson records good instances of this phenomenon when green peas with greenish skins are crossed with yellows —yellow cotyledons and yellowish skins. The testas of the resulting seeds turn yellow like the cotyledons. The white peas which I have examined have mostly had nearly colourless testas, and the phenomenon of xenia was not observed.

In this connection reference may be made to a phenomenon which it seems fair to describe as practically the reverse of xenia. That is to say, the direct effect of the maternal character upon an embryo which is incapable of transmitting any trace of the character in question. Some of the dimpled seeds upon a heterozygote plant derived from the cross between dimpled and round give rise to plants in which no trace of the dimpled character is to be observed.

These phenomena lead to a remark upon the one possible source of confusion for inexperienced experimenters with seed characters, which lies in the fact that the testa of a seed on the one hand and on the other the embryo, including the cotyledons, belong to distinct generations. As compared with the cotyledons, the testa is a maternal tissue. When segregation is going on, therefore, it is the rule for all the testas upon the same plant to be alike, but the cotyledons of the different seeds of one plant may be different. To this rule the above cases constitute notable exceptions.

POSTSCRIPT.

In " Nature " for August 22, 1907, there appears an anonymous statement to the effect that no one has repeated Mendel's experiments with the deliberate intention of testing the Mendelian interpretation of the results. The curiosity naturally excited by this statement as to what other object—in the opinion of the writer of the review—could have been in the minds of all those who have laboriously continued Mendel's inquiries, is only partly allayed by the explanation of the same writer in " Nature " of September 12. Here we find that what was meant was that crucial experiments had not been carried out by *sceptical** observers on certain lines which are indicated.

In addition to numerous crosses between heterozygote and recessive carried out with sufficiently conclusive results in the case of peas, the present writer has actually carried out on a considerable scale an experiment with Zea Mays on lines closely similar to those indicated in "Nature " of September 12, 1907. An account of these experiments appeared in " Nature " of October 20, 1904, and a full description of them has since been published (27).

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* My italics.—R. H. L.

I feel bound to admit that since the successful issue of these experiments I am no longer sceptical as to the accuracy of Mendel's experiments or of his deductions from them. And if, as it would appear, "Nature's" reviewer demands confirmation by an observer who shall remain sceptical after the event, I am afraid his doubts are unlikely to be done away with. For I know of no sane person who has carried out a reasonable number of experiments on Mendelian lines and still retains the required mental attitude.

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The Genus Chitoniella.

Chitoniella poderes (*Berk. & Br.*), P. Henn.

BY

T. PETCH.

THE genus *Chitoniella** was founded by P. Hennings (Engler-Prantl, Pflanzenfamilien, 174, p. 240) for the reception of the species named by Berkeley *Psalliota poderes* from specimens forwarded from Ceylon by Thwaites in 1869. There is apparently no other species known of this genus, and as it would certainly not be recognized from the descriptions in "Saccardo," the following details may serve to prevent further synonymy ; errors in the descriptions are italicized.

Hennings (*loc. cit.*) writes :—

"*Chitoniella* P. Henn. Hut und stiel in der jugend von einer häutigen Hülle umschlossen, die bei Streckung des Stieles zerreisst und am Grunde desselben als häutige scheide, *sowie auf der Hutoberfläche in faserigen Schuppen* zurückbleibt. Hut vom Stiele getrennt. Stiel oberhalb der mitte von einem häutigen Ringe umgeben. Lamellen frei. *Sporen purpurbraun.*

"1 Art. *Ch. poderes* (B. & Br.) P. Henn. Hut halbkugelig, *5 cm, breit*, faserig-schuppig, seidig gestreift, *am scheitel von zurückgebleibenen Resten der Volva* rauh ; Stiel 1½ *cm. long*, 1½ *mm. dick*, in der Mitte mit einem, weiten, häutigen, weissen Ringe, am Grunde mit einer bräunlichen, *am Rande gezähnten* Scheide ; auf Ceylon."

Berkeley's specimens are the only ones which have been sent to Europe, and apparently two of them were not returned. But the original drawings are still at Peradeniya, and it is quite evident from these, and the third specimen, that Berkeley gave the species three names, *Psalliota trachodes*, Berk., on specimens sent by Gardner in 1846, and *Psalliota trachodes*, *Psalliota pedilia*, and *Psalliota poderes* on specimens sent by Thwaites twenty years later.

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* The name was first suggested by Massee (Brit. Fungus Flora, Vol I., p. 418).

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part IV., Dec., 1908.]

On the strength of Berkeley's descriptions the species now stands in three distinct genera, viz., *Psalliota trachodes*, Berk., *Chitonia pedilia*, Sacc., and *Chitoniella poderes*, Henn. Needless to say, only Berkeley saw the fungus.

Berkeley's descriptions are as follows :—

" *Psalliota trachodes*, Berk., Lond. Jour. Bot., VI., p. 487. Pileo carnoso, convexo, expanso, demum depresso verrucoso, interstitiis sericeis ; stipite sursum attenuato, farcto, albo ; annulo amplissimo deflexo ; lamellis angustis, *subliberis*, pallidis, demum *fuscis*.

" On the ground in shady places, Peradeniya, Ceylon. Pileus 11 cm. wide, pale reddish brown ; stalk 10 cm. long, almost 2 cm. thick, stuffed with loose fibrils and frequently rooting ; ring 2½ cm. wide. Gardner, No. 64, cum icone. Thwaites, No. 911, cum icone.

" 344. *A.* (*Psalliota*) *pedilius*, B. & Br. Pileo ovato compacto e volva stellata ejusque *apicem obtegente* oriundo, furfuraceo ; stipite cavo farcto sursum attenuato ; lamellis angustis albis (No. 1,221, cum icone).

" Pileus ovate, capped *with the dark remains of the volva*, beneath which it is furfuraceous, fleshy, slightly appendiculate, 1¼ inch high, 1½ wide at the base ; stem 2¼ inches high, 1 inch thick in the middle, obtuse below, attenuated above, with a broad *stellate* volva at the base, and with a narrow cavity in the centre which is stuffed with white flocci ; flesh, like that of the pileus, turning red ; gills, narrow, free, white.

" 345. *A.* (*Psalliota*) *poderes*, B. & Br. Pileo hemisphærico fibrilloso squamoso sericeo-striato, *apice volvæ fragmentis aspero* ; stipite sursum attenuato ; annulo supero amplissimo ; volvæ brunneæ margine dentato (No. 1,220, cum icone).

" Pileus 2 inches wide, stem 1¾ high, ¾ thick. Undoubtedly closely allied to the last, but differs in the hemispherical, squamulose, striate pileus, less ample volva, and above all *in the presence of a large white ring*."

The last two descriptions are from the Journal of the Linnean Society, XIV., 1875, p. 32 ; the measurements are incorrectly stated in Saccardo, Sylloge Fungorum, millimètres being there written instead of centimètres in some cases.

It will be seen that Hennings's description follows Berkeley's closely, but was evidently taken from Saccardo, Sylloge Fungorum, where the same mistakes are made in the conversion of the stem measurements. These mistakes, which occur also in the transcription of *Psalliota pedilia*, give a totally erroneous idea of the stature of the fungus. It is a broad-capped stout-stemmed agaric, and has not the resemblance to such species as *Chitonia rubiceps*, Cooke and Mass., which the substitution of millimetres for centimetres would give it. Hennings was also misled by the fact that Berkeley assigned it to *Psalliota*, and that Saccardo included it in *Chitonia;* from this he concludes that the spores are purple-brown, and makes that a generic character. But Berkeley's specimens were all immature, and, though their general aspect justified their conclusion under *Psalliota*, he was not able to give the colour of the spores. In one of the figures the gills are white, but in the other two they are greenish. This is the normal colour change, and the spores shed by fresh specimens are invariably olive-green. Fortunately, there is only one species of *Chitoniella*, and there is therefore no reason for burdening the species with another name.

The figures which accompanied Thwaites' specimens of agarics were executed by Wm. de Alwis. They are extremely accurate; though as they were drawn from whatever specimens came to hand, they are not in some cases typical examples of the species they represent. Berkeley's descriptions of Ceylon agarics are based almost entirely on these paintings. That labelled *Psalliota trachodes*, B. (Thwaites, No. 911), is a half-expanded specimen. The pileus is hemispherical, 7½ cms. in diameter at the base, and 5½ cms. high; its colour is purple-brown, corresponding with specimens recently collected in fine weather, and it is rough, with darker warts and scales. A dark brown cap remains on the top of the pileus, but it is broken up, and therefore not typical. The base of the stem is covered with soil and the remains of the volva to a height of one centimètre, but no volva is depicted on the longitudinal section. The gills are free, and the flesh of the stem and pileus is reddish. Berkeley was evidently in doubt whether this represented his *trachodes* of 1847, for the drawing is marked in pencil with the alternative name *A.* (*Psalliota*) *hypocarphus*, B. & Br.

The figure of *Psalliota poderes* (No. 1,220) is marked by Berkeley, "vel potius *A. pedilius*, var." It represents a small half-expanded specimen, total height 5½ cms. and diameter of pileus 5 cms. The pileus is slightly paler than that of *Ps. trachodes*, but has the same brown cap at the apex. The base of the stem is enclosed in a brownish sheathing volva with a toothed margin, and as in *Ps. trachodes* there is an ample partial veil. It only differs from the figure of *trachodes* in the presence of the volva at the base of the stem, and as the volva is floccose and frequently remains attached to the soil, this difference is undoubtedly due to carelessness in collecting. The brownish colour of the volva is probably an attempt to represent the red earth stain.

Psalliota pedilia, B. & Br., is Thwaites, No. 1,221. The figure is marked by him "? same as 1,220," and to this has been added later a protest against their separation, "I took them for the same species when they were collected." The specimen had just begun to expand. It is 7 cms. high; pileus 3 cms. high and 3·8 cms. in diameter; stalk 1·9 cms. thick. Two-thirds of the pileus is covered by a smooth brown hemispherical cap, and the base of the stem is enclosed in a large whitish spreading volva with the edge divided into triangular lobes. The flesh of the stem and pileus is reddish in section. Berkeley says that *poderes* differs in the hemispherical squamulose, striate pileus, but this is only a matter of age, *pedilia* being scarcely escaped from the volva, and considering the loose structure of the volva it is not surprising that the younger specimen possesses it to the greater extent. But the great difference, "the presence of a large white ring," is an oversight, for the figure of the section of *pedilia* shows the partial veil between the gills and pileus quite distinctly. There is no room for doubt that Thwaites' view was correct, and that *Psalliota poderes* and *Ps. pedilia* are the same species.

It is not uncommon at Peradeniya, where it usually grows among grass in the open. The pileus is hemispherical at first, and afterwards almost plane ; it varies from seven to fifteen centimètres in diameter ; the flesh is about 1 cm. thick in the centre, and thins rapidly in the outer half. In the centre of the pileus is a *smooth* brown or reddish-brown cartilaginous patch, attached to the pileus in the middle but separated from it elsewhere by a loose brown layer. This patch is 2–4 cms. in diameter, generally split at the edges, but seldom entirely broken up into separate scales. Elsewhere the cuticle of the pileus is split into ashy-brown or purple-brown, narrow, revolute scales, and mingled with these scales are, as a rule, radially arranged brown warts of varying size. These warts are not always present ; they are formed from the loose tissue which lies between the cartilaginous cap and the pileus, and this tissue either remains in fragments on the pileus as it expands or is retained beneath the unexpanding cap. The greatest development of these warts appears to take place when the agaric emerges during constant rain, and under these circumstances the purple-brown colouration of the scales is often wanting, so that the pileus is cream coloured or yellowish, studded with brown warts. The margin of the pileus is appendiculate.

The volva at the base of the stem is 1·5–3 cms. high. In young specimens it is slightly spreading, but in older examples it is usually pressed close to the stem. The upper edge is entire or irregularly lobed. In colour it is gray or purple-gray, and generally it is quite loose and floccose. It differs altogether in colour and texture from the cap which adheres to the pileus. Very young specimens show that the volva is entirely loose and floccose, and that the young pileus within it is entirely covered by a brown cartilaginous layer. Dehiscence of the volva takes place very early, when the agaric is less than a centimètre high. The brown layer increases in diameter with the pileus until it attains a diameter of 2–3 centimètres, but it then separates from the latter, except in the centre, and the pileus extends to a diameter of about 10 centimètres, sometimes carrying with it in the form of warts part of the looser tissue which separated it from the cap. The latter is really the outer layer of the young pileus.

There are thus three layers to be taken into consideration in estimating the former relative position of the tissues on the pileus :—

(1) The loose grayish universal veil, *all* of which remains at the base of the stalk.

(2) The brown outer layer of the pileus which never extends beyond the margin of the young pileus, and later fails to grow equally with the underlying tissues ; it remains as a brown, almost cartilaginous, patch attached to the pileus only in the centre. Berkeley supposed that this patch was a part of the volva.

(3) A brown floccose layer between (2) and the expanding part of the pileus ; this may remain beneath the brown patch, or, especially in very rainy weather, is carried along by the expanding pileus in the form of coarse warts.

A non-expanding outer layer of the pileus, exactly similar to that of *Chitoniella poderes*, occurs also in *Lepiota alphitochroa*, B. & Br. ; this species, by the way, is a *Psalliota*, and is the same as *Psilocybe cano-rubra*, B. & Br.

The stalk is 9–12 cms. long, 1½–2 cm. thick at the base, narrowing to two-thirds this diameter at the apex. It is fawn coloured or ashy-brown, becoming red-brown or purple-brown when handled, and is clothed with minute upwardly-directed squamules. Above the veil it is white, smooth, and shining. The base is somewhat bulbous, and the attachment of the volva is marked by a distinct ridge. When cut longitudinally the flesh of the stalk and pileus turns red, but a cross section of the stalk turns first orange, and then changes rapidly to red. The cavity of the stalk is partly stuffed with shining white, silky, longitudinal fibres.

The partial veil forms an ample curtain about 3 cms. deep. It is thick, but fragile. The upper (inner) surface is white and shining, and is continuous with the surface of the stalk above ; the lower layers are usually split into thick brown-topped or white warts.

Most of the larger Ceylon *Psalliotas* have a veil of this type, though in each species the variation is enormous. The partial veil represents the tissue which lies between the gill chamber and the developing stalk, and this appears to be accentuated in tropical forms. This intermediate tissue is so well developed that the veil may be 5 millimètres thick, and with variations in weather there result variations in dehiscence which convert one species into half a dozen. For example, *Psalliota bolorhiza*, B. & Br., has a thin fragile veil and a stem clothed with large floccose warts, or a thick warted fragile veil and a smooth stem, or in cases where the veil tissue is not so strongly developed, the stem may be smooth and the veil firm and rigid.

The gills of *Chitoniella poderes* are widely free from the stem, rather narrow (about 7 mm. broad in large specimens), equal, at first white, then greenish. The spores are olive-green in mass, and pale green when magnified, elliptic, with a large sublateral apiculus ("pip-shaped"), 6–8 × 3·5–4 μ.

The under surface of the pileus is produced beyond the inner ends of the gills, and forms a translucent ring occupying half the space between the gills and the stalk. This ring is frequently, but not always, crenate.

The synonymy runs as follows :—

Chitoniella poderes (B. & Br.), P. Henn. (1898)
= *Psalliota poderes*, B. & Br. (1875)
= *Psalliota pedilia*, B. & Br. (1875)
= *Psalliota trachodes*, Berk. (1847)
= *Chitonia poderes* (B. & Br.), Sacc. (1887)
= *Chitonia pedilia* (B. & Br.), Sacc. (1887)

There is at present no recognized position for green-spored agarics in the classification of the group according to the mass-colour of their spores. Black, purple, ochraceous, pink, and white are supposed to be able to cover all shades of colour which can occur. The attempt to force all spore colours under these five heads does not give very satisfactory results in the case of tropical species, and it seems probable that as our knowledge of tropical agarics is extended by observations on living specimens, and the colour of the spores is observed free from any discolouration by contact with the dying pileus, it will be necessary to institute other groups, or to classify by means of other characters. In this connection, it may be stated that the colour of the spores shed by an agaric which is suspended over a sheet of paper often differs from the colour of those shed by the same agaric in contact with the paper.

Volvaria terastia, B. & Br., appears a typical *Volvaria*, but its spores are deep Indian red, or chocolate where they have been moistened by contact with the pileus; and they retain this chocolate colour when re-dried. "*Lepiota flavidorufa*, B. & Br.," when laid on paper deposits either yellow or dark slate-coloured spores. "*Lepiota lignyodes*, B. & Br.," deposits spores which are brown with a tinge of olive, and pale brown when viewed by transmitted light, while at the margin of the print there is a reddish tinge which one at first attributes to a stain caused by the pileus; but a few hours later the print is brownish red, the red distinctly predominating, and on covering it with shellac in alcohol for preservation it changes to purple.

Massee (Kew Bulletin, 1898, p. 135) says, "the discovery of fungi having green spores necessitates the formation of an additional section, which will naturally stand as *Chlorosporæ*. This section occupies an intermediate position between the *Leucosporæ* and the *Rhodosporæ*." He divides the green-spored species into two genera, *Chlorophyllum* and *Chlorospora*, the first being characterized by the possession of a ring, but without a volva, and the second by the absence of both ring and volva.

The genus *Chlorophyllum* includes *C. esculentum*, Mass., from British Guiana, *C. morgani* (Peck), Mass., from North America, and *C. molybdites* (Meyer), Mass., from Brazil. There is, however, apparently a difference in the colour of the spores; those of *C. morgani* are described as "*Chlorinæ*," and those of *C. esculentum* as "*olivaceo-virentes*." Copeland (Edible Philippine Fungi, Manila, 1905) has recently described a green-spored species as *Lepiota chlorospora*. He says: "Massee established the genus *Chlorophyllum* for these green-spored species, but it seems to me better to keep them in *Lepiota* and extend its characterization sufficiently to cover them. The spores are of the same colour as those of *Aspergillus glaucus*." If all green spores were of this colour, such a course would be advisable, but *Chitoniella poderes* and *Chlorophyllum esculentum* have olive-green spores (in mass), and would stand better between the *Ochrosporæ* and the *Porphyrosporæ* than next to the *Leucosporæ.* It may be noted that the description of *Lepiota chlorospora*, Copeland, exactly fits *Chitoniella poderes*, except that no mention is made of a volva. Its pileus has a central brown, entire or fissured cap, and is elsewhere covered with pale brown scales and fibres; the gills exhibit the same colour change, and have the same large hyaline vesicles (25–35 × 20μ) forming the edge; the stalk is brown inside and outside, with white pith. The only points which make the identity doubtful are the lack of reference to any colour change in the flesh of the pileus and stalk, and the colour of the spores. Copeland says that the spores are hyaline green, each with a single large globule containing the green pigment; the colour would fit the spores of *Chitoniella poderes* under a high magnification, but not in mass; and though the spores of the latter have a single large globule, the green colouring matter is not confined to it. On the whole, it seems questionable whether *Lepiota chlorospora* is not *Chitoniella poderes* carelessly collected, and thus corresponding with *Psalliota trachodes.*

Chlorophyllum esculentum has the cuticle broken into large scales in the centre, and smaller ones near the margin; its spores are 7–8 × 5. *C. molybdites* has the cuticle "ad medium in squamas crustaceas secedente." *C. morgani* has "cuticula brunneo-alutacea in squamas, excepto disco, fissa," but its spores are 10–12 × 7–7·5. It appears therefore that the peculiar cap in the centre of the pileus is common to all these forms; and to one who is aware of the errors which abound in most descriptions of tropical fungi it seems probable that we are dealing throughout with only one species. *C. morgani* is possibly distinct. That an agaric which has a volva should be gathered in such a condition that the volva is not evident is not an unparalleled occurrence; in Ceylon *Chitoniella* has been misdescribed through this mishap, and an *Amanita* has been assigned to *Collybia.*

Massee's genus *Chlorospora* includes one species only, viz., *Chlorospora Eyrei*, Mass., from the New Forest. The spores are described as "*Cyaneo-viridibus.*" As Saccardo (Vol. XVI.) points out, the name *Chlorospora* is preoccupied by *Chlorospora*, Speg.

Assuming that a separate division is required for the classification of green-spored agarics, the name *Chitoniella* must be used to denote those which possess both a ring and a volva; the genus thus corresponds to *Amanita* in the *Leucosporœ*. The question whether any of the species of *Chlorophyllum* are identical with *Chitoniella poderes* can only be decided on the spot. That the dried specimens have no volva proves nothing.

Pl. 1 A. *Chitoniella poderes.*—Pileus seen from above. Small specimen. One-half natural size.

Pl. 1 B. *Chitoniella poderes.*—One-half natural size. The black spots on the volva are particles of earth; those on the partial veil are brown warts.

Pl. 2, fig. 1, "*Psalliota trachodes*," Berk.—Natural size.

Fig. 2, "*Psalliota trachodes*," Berk.—Longitudinal section of the specimen of fig. 1.

Fig. 3, "*Psalliota poderes*," B. & Br.—Natural size.

Fig. 4, "*Psalliota pedilia*," B. & Br.—Natural size.

Fig. 5, "*Psalliota pedilia*," B. & Br.—Longitudinal section of the specimen of fig. 4.

Fig. 6, *Chitoniella poderes.*—Unexpanded specimen, partly diagrammatic. (*a*) volva; (*b*) upper layer of pileus.

Figs. 3–5 are faithful drawings of the paintings from which Berkeley and Broome described their species. Figs. 1 and 2 are copied from one of Thwaites' paintings which Berkeley named.

CHITONIELLA PODERES

A. De Alwis del. Lith.Anst.v.E.A.Funke, Leipzig.

CHITONIELLA PODERES

Flowering of Dendrocalamus giganteus, the "Giant Bamboo."

BY

H. F. MACMILLAN.

THE phenomenon of the simultaneous flowering of bamboos has been often recorded and confirmed. Whilst no one seems to have explained the cause, a great many at the present day believe in the existence of a certain infectious condition which at once influences the flowering of all specimens of the bamboo tribe, whether it be annually or once in a number of years. In the case of species of Dendrocalamus it is considered by expert Indian foresters that the occurrence takes place once in thirty years, and it is a common belief that when the given moment has arrived, every plant of the same species, whether old or young, over a vast region, will put forth its flowers simultaneously, and that having seeded for a time the plant dies. August St. Hilaire, a botanist who explored Brazil, mentions a whole forest of a certain bamboo disappearing in a few months after flowering. So recently as during the hot season of 1901 the " Indian Forester " records " the flowering of the ordinary bamboo (*Dendrocalamus strictus*) extending over an estimated area of 1,200 square miles in the Central Provinces." Though a few clumps here and there have escaped, the phenomenon is described as universal, affecting not only mature clumps, but quite slender seedlings of a few years' growth. But against this report there is the statement by Lord Redesdale in his book on Bamboos, that this same species (*Dendrocalamus strictus*), also known as the " Solid " or " Male bamboo," flowers every year. At Peradeniya, where this has flourished for the last thirty-nine years, an occasional stem has been seen to blossom, but neither annual nor periodical wholesale flowering has as yet been observed. We can therefore at least contradict the statement that it blossoms annually so far as Peradeniya is concerned.

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In regard to the Giant bamboo (*Dendrocalamus giganteus*), this species has now been in a condition of flowering here for the last eight years, and elsewhere in Ceylon at different elevations for a longer period. The first case of flowering in Ceylon was not at Peradeniya (elevation 1,500 feet), but on Abbotsford estate at about 5,000 feet elevation. That occurred about 1886 (approximately thirty years after the introduction of the plant at Peradeniya), when Mr. A. M. Ferguson, the proprietor, sent specimens to Dr. Trimen, then Director at Peradeniya. This coincides very closely with the period taken by the Giant bamboo to flower at the Royal Botanic Gardens, Calcutta, after its first introduction.

It may be interesting here to note the history of the introduction of this noble bamboo into Ceylon. The plant is a native of moist forests of Lower Burma, and was introduced from Penang to the Royal Botanic Gardens at Calcutta in 1831. From there Peradeniya obtained it in 1856, and all the clumps now in Peradeniya Gardens, if not in Ceylon, have been derived by division from this source. The clumps at Peradeniya, especially those near the river or in moist situations, have grown to enormous sizes, much exceeding, it is said, the dimensions normally attained by them in their native habitat, and these majestic growths have formed a feature of Peradeniya Gardens for many years past. Some of the clumps are 150 feet or more in circumference, the stems reaching a height of 120 feet each, being about 10 inches in diameter at the base. At Calcutta it flowered for the first time in 1861, exactly thirty years after its introduction; at Abbotsford the recorded flowering was, as stated, about 1886, twenty-nine years after the introduction of the plant at Peradeniya. It is interesting to note here that on the authority of Mr. John Fraser, the present manager of Abbotsford estate, the same bamboo which flowered about twenty years ago is still alive and in a condition of mixed flowering.

The first signs of flowering in Peradeniya Gardens were noticed in January, 1903, when three or four stems in each of three clumps were in blossom. Each year since has in most cases produced a greater number of flowering stems, the increase being noticeable in the dry hot season, February to May. In the course of three or four years the flowering condition extended to other clumps some distance away, whilst yet other clumps within a distance of 200 yards or so, being young and vigorous, have so far shown no signs of flowering. Up to the present, out of a total number of twenty-one clumps in these Gardens, eleven have partly flowered or are at present in a state of flowering, thus leaving ten clumps which have not as yet blossomed. The first clump of all which flowered does not at the time of writing contain any flowering stems; on the other hand, a number of young leafy stems have sprung up on its circumference. Other cases of flowering of the Giant bamboo have been observed in different parts of the Island during the last several years at elevations varying from 1,000 to 5,000 feet, but no death of clumps has as yet been reported. Most probably all such clumps have originated from Peradeniya, and are therefore off-sets of the original plants imported, so that, strictly speaking, all the clumps so derived are of the same age.

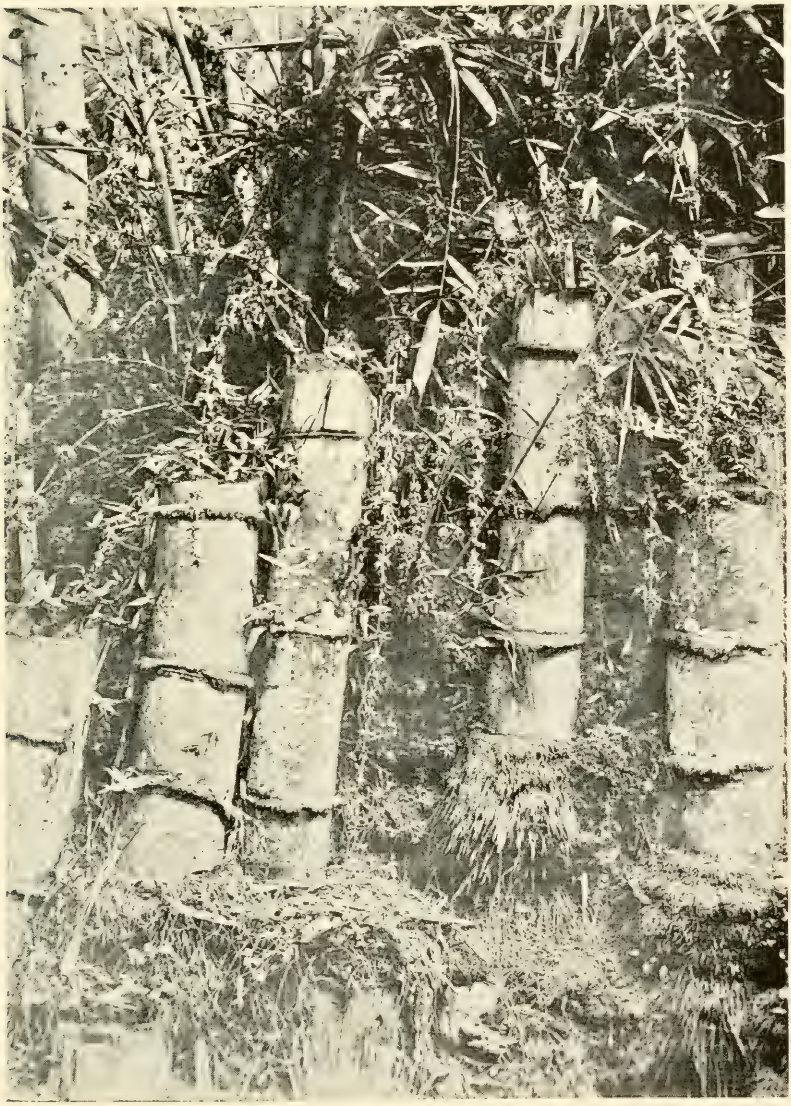
It would thus seem as if the exhaustion of nutriment rather than an infectious influence were responsible for the more or less simultaneous flowering of the Giant bamboo. The vigorous growth of the plant is such that it cannot go on growing and extending indefinitely. The enormous demands it makes on the soil can be realized by any one who has seen the "ruins" of an old clump, the huge crevices and upheavals formed by the elevated stumps as if the result of an earthquake. The gregarious habit of the plant also prevents its spreading indefinitely over fresh areas for fresh nutriment. Two of the flowering clumps at Peradeniya having regained a more vigorous condition have now given up blossoming entirely, presumably because their circumference has struck richer soil. Although none of the flowering clumps have as yet actually died, one or two are so nearly exhausted, evidently as a result of flowering and starvation combined, that another year will probably see an end to their existence. All the flowering clumps regain energy to some extent in the wet weather; the stems produce young leaves, and new culms are put forth from the base.

The inflorescence consists of long drooping panicles (the branchlets varying from 1 to 6 feet in length) produced normally at the nodes all along the leafy portion of the stem. At first green, it gradually changes to dingy yellow, and then light brown. Although it ordinarily occurs only on the leafy top portion of the stem, the inflorescence also arises occasionally at the base of the stems. Plate IV. shows the ruins of an old clump which had been devastated by the wind and axe. The whole mass of stumps is literally smothered with the inflorescence issuing in masses from almost under the ground surface. Mixed with the surface dead roots of the stumps are masses of sessile spikelets forming a cushion around the node. Plate V. shows these as if being vomited forth from the earth.

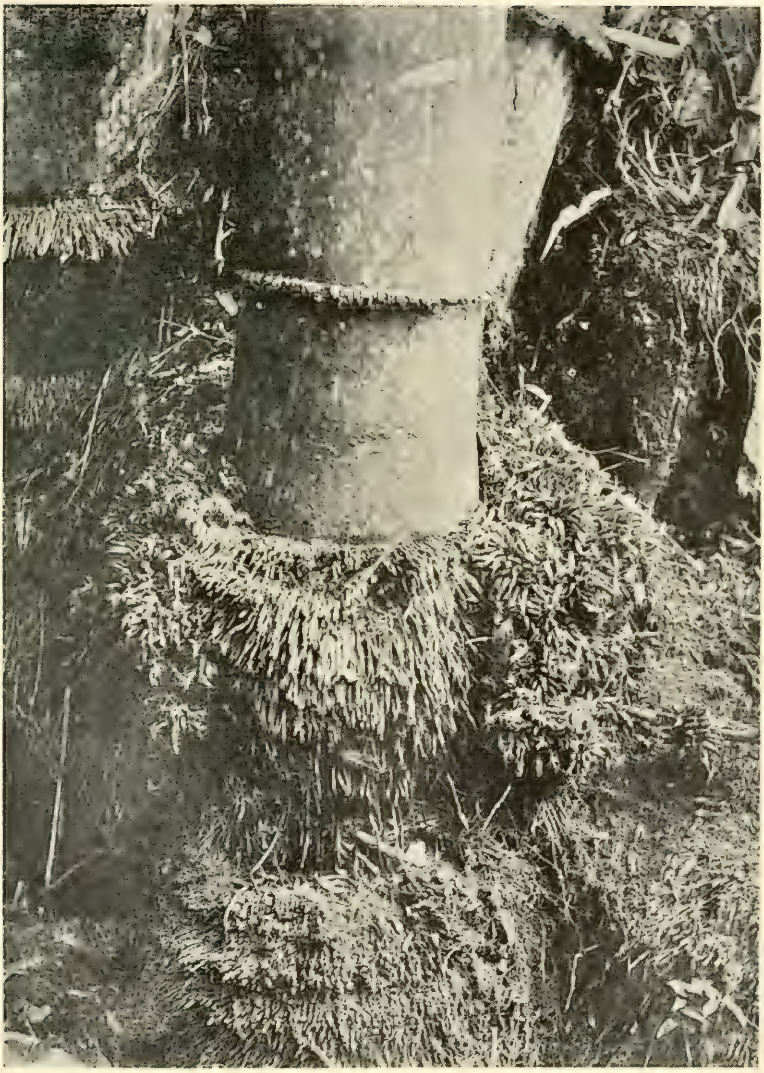
Up to 1907 fertile seed had not been produced at Peradeniya, and even now only very scantily. Its presence was only discovered by chance, a few seedlings appearing from large quantities of the chaff-like empty glumes which were sown. The first seed actually handled and sown here was found by Mr. Petch, Government Mycologist, amongst a mass of basal flowers. It was duly sown and germinated in seven days, and the seedling is now growing rapidly. This suggested that the basal flowers might be more productive than the usual stem flowers. Accordingly a bushel each of both basal and stem mature " flowers " was carefully gone over one by one, but the number of seeds obtained was practically the same in both cases, viz., 44 and 47 respectively. Therefore, a very large quantity of the chaff-like glumes must be sown in order to obtain any seedlings.

The following description is from Hooker's " Flora of British India" :—*Stems* 80–100 ft. by 8–10 in. diam. branched above, nodes hairy, internodes rather short, gray-green, young with waxy scurf, walls thin. *Stem-sheaths* 20 in., as broad at the base, deciduous, thinly stringose, with golden hairs, top depressed ; 5–15 by 3½ in., decurrent into glabrous stiff brown wavy auricles, narrowed above into a short point ; ligule 2–5 in., stiff, black, margin serrate. *Leaves* cuspidately acuminate, tips twisted, young hairy beneath, mid-rib strong, nerves

A CLUMP OF GIANT BAMBOO IN FLOWER.



BASES OF SHOOTS.



BASE OF A SHOOT.

INFLORESCENCE.

12–16 pairs, with pellucid cross bars. *Panicle* very large, branchlets slender curved ; heads up to 1 in. diam. ½–1 in. apart. *Spikelets* sometimes all flowering, rachilla produced with an imperfect gl. (Munro :—Spikelets ½ in., ovoid acute spinescent puberulous, empty gls. ovate mucronate striate, fl. gls. 3–6 thin puberulous, empty gls. ovate mucronate striate, fl. gls. 3–6 thin mucronate many-nerved, anthers acuminate.) *Ovary* ovoid and long style hairy, stigma simple. Grain oblong, obtuse, hairy above.

Extract from the "Ceylon Observer" of 1886.

The Giant Bamboo in Flower.—Dr. Trimen, Director of the Royal Botanic Gardens of Ceylon, having seen our notice of some stalks of the "Giant bamboo" having flowered at Abbotsford, asked for specimens, as he had never seen the inflorescence in its fresh state. We accordingly, before returning from a recent visit to the estate, had specimens despatched. We expressed some doubt as to the flowering being quite normal, because only a few stems out of probably one hundred in a dense clump had blossomed. But from Dr. Trimen's report, which we append, it will be seen that the flowers are quite natural :—

"Peradeniya, February 26, 1886.

"The specimens of Giant bamboo reached me yesterday afternoon. There is nothing abnormal about them ; they are the natural flowers, and I have examined them with much interest, as I have never before seen them in a fresh state. Our numerous plants at Peradeniya were all derived by division of one received from the Calcutta Gardens in 1856 and still growing there ; but none have ever shown any disposition to flower. I am told, however, that about five years back a clump at Nawalapitiya produced flowers, but I did not get an opportunity of seeing it.

"There is some difficulty in ascertaining the native country of this fine bamboo, *Dendrocalamus giganteus*. Wallich obtained the original plant in the Calcutta Gardens from Penang, and Kurz states that it grows only at 'Malacca and adjacent islands.' Munro, the monographer of the bamboos, gives also Tennasserim, on the authority of Dr. Brandis, but Kurz says this is incorrect. This latter botanist has, however, a Burmese species, which he calls *Dendrocalamus brandisii*, ' common in tropical forests of Pegu and Mataban up to 3,500 feet,' which is probably the same as our plant.

" In the Calcutta Garden, where it was introduced in 1831, it did not flower till 1861, and the plant though weakened did not die ; we may hope therefore that this is not one of those kinds which succumb to the effort of flowering. It will be most interesting to see if the Abbotsford plant ripens seed, and I hope it will be carefully watched and all the seed secured."

We are very glad, indeed, to be the means of enabling Dr. Trimen to see and examine fresh blossoms of a very interesting plant. We have always regarded Burma as the habitat of this grandest of the bamboos, the late Mr. John Armitage having reported after a visit to the rice region of Pegu that there sections of the stems were used as grain measures and vessels for carrying water. In Darjeeling we saw sections of a closely allied species, *Dendrocalamus hamiltoni* (which is also grown on Abbotsford from *seed* sent by Mr. Gammie), employed by the Bhooteas to carry milk and butter to market, and also for holding supplies of the mild beer, which many of them imbibe, made from crushed grains of kurakkan with water poured on it and allowed to ferment in the bamboo sections, which the beer drinkers carry slung over their necks. We got plants of the Giant bamboo from Peradeniya about the middle of 1874 ; so that the stems which have flowered on the banks of the Dimbuldanda-oya at an elevation of 4,460 feet above sea level were between 17 and 18 years of age. At the elevation mentioned the growth and size of stem are quite equal to what can be seen at Peradeniya or in the Pavilion grounds at Kandy ; while at an altitude of 5,200 feet, on the summit of " Knock Ferrol," the height and circumference of the stems are not very greatly diminished. Split, seasoned, and properly prepared stems of the Giant bamboo have proved useful as water spouts and as substitutes for tiles, tarred in this latter case. Of course, they could be employed for a variety of structural purposes, and at Peradeniya they are largely used as flower pots. It may be interesting to state that sections of the stems, well seasoned, and the outside siliceous covering well cleaned and polished, are favourite substitutes for canvas with lady artists. We prize very much a section on which a lady visitor to Abbotsford painted two of the most prominent of our flowers —strong contrasts in form and colour—the snow-white "lily of the Nile" arum and the orange and scarlet "hot poker." A large stem was cut down during our recent visit to meet requisitions from lady amateurs. The clump which has blossomed is one of two which flank a pretty bridge, and up through the centre of one a blue gum tree grows and flourishes. Specimens growing in a ravine and around a lakelet are magnificent in growth and size of stems, while the curving downwards of the feathery foliage at the tall summit branches of the groups has an exquisitely beautiful effect. In Java, where the prevalence of earthquakes renders bamboo houses a necessity, the life of such a building is calculated at twelve years. This is surely an encouragement to use Giant or other bamboos for estate lines, cattle sheds, and outhouses. Indeed, we see nothing impossible in a factory and drying house of Giant bamboo.

The Floras of Hill Tops in Ceylon.

BY

J. C. WILLIS.

(With a Map.)

THE case of the flora of Ritigala, described in two previous

Put in at first

Owing to certain difficulties as to contours, this map is not yet ready, but will appear later.

the three highest mountains in Ceylon, Pedurutalagala (which has itself one or two species confined to it), Kirigalpota, and Totapella. The latter lies north-east of Kandy, and though an important planting district, does not include any towns or well-known resorts. The other isolated districts are mostly very small, such as Adam's Peak, Hunasgiriya, Hinidunkanda, Ritigala, and so on.

In considering the number of forms to be found upon these mountains, the course of the monsoons must be remembered. These blow (and must have blown for countless years) regularly from north-east and south-west alternately in each

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The Floras of Hill Tops in Ceylon.

BY

J. C. WILLIS.

(With a Map.)

THE case of the flora of Ritigala, described in two previous papers, is by no means isolated, though one cannot often be so fortunate as to find two species side by side, the one evidently most nearly related to the other, and yet impossible of derivation from a common ancestor by infinitesimal variation. I hope shortly to have completed the floras of at least two other hill tops in the Island, which have not yet been botanically worked out, and which both appear to contain endemic species confined to the one spot; but in the meantime it may be of interest to record from the known flora of the Island, which has been very thoroughly worked by botanists, the plants found only on isolated hill tops, including in that term groups of hills which form a somewhat more extended "top" than that of Ritigala, for instance.

We give a rough contour map, which shows these isolated hill-top areas. It will be noticed that there are two of somewhat large size, which we may call the central area and the north-east area. The former includes the country from the upper end of Maturata, through the mountain capital of Nuwara Eliya, by Elk Plains to Horton Plains, and includes the three highest mountains in Ceylon, Pedurutalagala (which has itself one or two species confined to it), Kirigalpota, and Totapella. The latter lies north-east of Kandy, and though an important planting district, does not include any towns or well-known resorts. The other isolated districts are mostly very small, such as Adam's Peak, Hunasgiriya, Hinidunkanda, Ritigala, and so on.

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direction for about half the year. At the changes of the monsoon, in April and October, there is a period of variable winds, but these are usually extremely light. The general result then, so far as carriage of seeds and plants is concerned, will be that these will tend to travel mainly in the north-east–south-west direction, whether carried by wind or by birds. Peaks which lie to the south-east or north-west of the main line will also be in actual fact more isolated than if they lay a similar distance to the north-east or south-west.

Now, the climatic conditions on most of these hill tops are to all intents and purposes exactly similar, and why, if natural selection is the rule, should we, in *Eugenia*, for instance, get *E. Fergusonii* in the north-east mountains, a variety of it upon Adam's Peak, *E. cyclophylla* on Adam's Peak, *E. rotundifolia* and *E. sclerophylla* above 6,000 feet, *E. phillyrœoides* on Kalupahanakanda, *E. aprica* in the north-east mountains, and *E. pedunculata* on Rangala ? Or again, the genera Hedyotis, Anaphalis, Strobilanthes, Phyllanthus, &c., may be similarly considered.

With this introduction, we may proceed to give the actual list of endemic species in Ceylon confined to one hill top or small group of mountains :—

		Dispersal Method.
Ranunculus sagittifolius ..	Central mass ..	D.
Acrotrema lyratum ..	Nillowekanda ..	A.
Goniothalamus Thomsoni ..	Hinidunkanda* ..	D.
Calophyllum cordato-oblongum	do. ..	D.
Balanocarpus zeylanicus ..	Doluwakanda ..	D.
Stemonoporus affinis ..	North-east mass ..	D.
S. reticulatus ..	Nillowekanda ..	D.
S. Lewisianus ..	Hunawalkanda ..	D.
Elæocarpus obovatus ..	Central mass ..	A.
E. montanus ..	do. ..	A.
E. zeylanicus ..	Adam's Peak ..	A.
Impatiens elongatus ..	do. ..	D.
Ochna rufescens ..	Nillowekanda ..	A.
Rhamnus Arnottianus ..	Central mass ..	A.
Semecarpus parvifolia ..	Hinidunkanda† ..	A.
Desmodium jucundum ..	Half way up Lakkaigalla (north-east mass) ..	D.
Poterium indicum ..	Adam's Peak ..	D.

* Possibly elsewhere.

† Possibly Hinidum korale, but in any case strictly localized.

		Dispersal Method.
Eugenia Fergusonii	North-east mass	A.
Var.	Adam's Peak	A.
E. cyclophylla	do.	A.
E. rotundifolia	Central mass	A.
E. sclerophylla	do.	A.
E. lucida	North-east mass	A.
E. phillyræoides	Kalupahanakanda	A.
E. aprica	North-east mass	A.
E. pedunculata	Rangala	A.
Osbeckia Walkeri	Central mass	A.
Var.	North-east mass	D.
Sonerila hirsutula	Central mass	D.
S. robusta (type)	Adam's Peak	D.
Medinilla fuchsioides	Central mass	A.
Memecylon orbiculare	Kalabowitiyakanda	D.
M. phyllanthifolium	Bogawantalawa (? on hill)	D.
Peucedanum zeylanicum	Central mass	D.
Hedyotis evenia	Adam's Peak*	D.
H. cinereo-viridis, var.	do.	D.
H. rhinophylla	North-east mass	D.
H. quinquenervia	Pedurutalagala	D.
H. Gardneri	Adam's Peak	D.
H. inamœna	Pitigalakanda	D.
Anotis nummularia	Central mass	D.
Canthium macrocarpum	Hantane	A.
Psychotria plurivenia	Hewaheta	A.
Lasianthus Thwaitesii (type)	Laxapanagala	D.
Dipsacus Walkeri	Central mass	D.
Anaphalis pelliculata	Totapella	D.
A. fruticosa	Adam's Peak	D.
A. Thwaitesii	Central mass	D.
A. zeylanica	do.	D.
Gynura hispida	do.	W.
Diospyros oppositifolia	Hiniduma	D.
Symplocos minor	Central mass†	A.
Gærtnera Walkeri, var.	Adam's Peak	A.
G. ternifolia	Adam's Peak and Maskeliya	A.
Exacum zeylanicum, var.	Ritigala	D.
E. macranthum	Central mass	D.
Crawfurdia japonica, var.	Totapella (Central mass)	A.
Swertia zeylanica	Central mass	D.
Christisonia Thwaitesii	Palagala	D.
C. albida	Hakgala	D.
Didymocarpus floccosus	Raxawa	D.

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* And on rocks in Maskeliya river, below.

† A little doubtful whether not more widely spread.

		Dispersal Method.
Thunbergia fragrans, var.	Ritigala	D.
Strobilanthes* Nockii	Central mass	D.
S. stenodon	North-east mass	D.
Var.	Ritigala	D.
S. exareolatus	Maturata at 3,000 ft.	D.
S. nigrescens	Ambagamuwa above 3,000 ft.	D.
S. rhamnifolius	Hantane	D.
S. punctatus	Adam's Peak	D.
S. Arnottianus	Central mass	D.
S. Gardnerianus	Hantane	D.
S. Hookeri	Central mass	D.
S. calycinus	do.	D.
Gymnostachyum Thwaitesii	Ambagamuwa	D.
Coleus inflatus	Central mass	D.
C. elongatus	Ritigala	D.
Pogostemon hirsutus	Central mass	D.
Peperomia pseudorhombea, var.	Ritigala	D.
P. Wightiana, var.	do.	D.
Hortonia floribunda, var	Adam's Peak	A.
Cinnamomum litseæfolium	Haputale	D.
Actinodaphne molochina (type)	Central mass	D.
A. glauca	Pedurutalagala	D.
Litsea Gardneri	Central mass	A.
L. fuscata	do.	A.
Loranthus ensifolius	Karawitakanda	A.
Phyllanthus anabaptizatus	Adam's Peak	D.
P. hakgalensis	Hakgala	D.
P. cinereus, var.	Ritigala	D.
Liparis brachyglottis	North-east mass	W.
Bulbophyllum, sp.	Ritigala	W.
Cirrhopetalum Trimeni	Hakgala	W.
C. Macræi, var.	Ritigala	W.
Cœlogyne breviscapa	Nuwara Eliya	W.
Vanda Thwaitesii	Hunasgiriya	W.
Commelina Thwaitesii	Maturata	D.
Cyanotis obtusa	Doluwakanda	D.
Eriocaulon zeylanicum	Central mass	D.
E. Trimeni	Dambulla rock	D.
Cyperus, sp.	Ritigala	D.
Hypolytrum longirostre	Hiniduma	D.
Carex Arnottiana	Central mass	D.
C. zeylanica	Maturata	D.
C. lobulirostris	Central mass	D.
Isachne elatior	Nuwara Eliya	D.
Pollinia Thwaitesii	Central mass	D.
Andropogon Thwaitesii	do.	D.
Garnotia Fergusonii, var.	Knuckles Mountain (north-east)	D.

* Possibly carried by the jungle-fowl that eat the seeds.

This list is not to be regarded as absolutely accurate, for so much forest clearance has gone on that it is possible that some of the species once had a wider range. Thwaites's work, upon which most of our knowledge of the Ceylon flora rests, was, however, mostly done before there was much clearance, and most of the isolated hill tops are to this day covered with forest. One can never, of course, except in rare instances, be absolutely certain that a given plant does not occur in a given place, especially in the mixed vegetation of the tropics. The fact, however, stands clearly out that, although so near together, the mountains of Ceylon are like so many oceanic islands, being almost as marked in the possession of local species as if they were fairly far apart in mid-ocean.

From this we may conclude that there is nothing peculiar in the existence of an oceanic island that should give rise to new species other than the qualities that it shares with mountain tops. Of these, the most obvious is *isolation*; and we may, I think, justly draw the conclusion that has often been put forward, and say that isolation, *as isolation*, favours the production of new forms.

This may be confirmed, as was done in the case of the single mountain Ritigala, by an examination of the methods of distribution of the plants. Opposite to each in the table is given the mode in which it is distributed from place to place, whether by wind (W), birds or animals (A), or by some accidental method (D). It will be seen that there are Wind 7, Animals 27, Doubtful 74.

An approximate comparison with the entire flora of Ceylon gives—

	Hill Top Species.		Total Flora.	
	No.	Per Cent.	No.	Per Cent.
Wind	7	6·5	234	8·6
Animals	27	25·0	689	25·2
Doubtful	74	68·5	1,803	66·0

too small differences to base any conclusions upon, except that possibly the wind-carried plants arrive more often, and so are in a sense less "isolated."

The same phenomenon as is shown in Ceylon occurs also, so far as a cursory examination shows, in South India and in the

Malay Peninsula, but until their floras have been more completely worked out it is hardly possible to give details.

The first question that will occur to every one is, Why do not the hills of, say, Great Britain, show similar phenomena ? Is it that evolution goes on more easily or rapidly in the tropics, or is it that the hills in Ceylon, &c., are older, or that distribution is less easy in a forest-covered country ? In the great ranges of the Alps, Pyrenees, &c., there are a good many local endemic forms, but probably the two latter, at any rate, of the causes mentioned, have prevented their occurrence in Britain.

The next question will be, are not these isolated species to be regarded as survivals upon the hill tops of species that may at some former period have lived lower down ? We have no evidence, so far as I am aware, that the glacial period produced much effect so near to the equator ; but apart from that, why should there be different survivals upon nearly every hill, while the bulk of the flora is the same, showing that the composition of the flora of the plains—assuming that the hill flora did ascend from below—was much alike, all over the wet country at any rate ? If the hills were far apart, and if there were any evidence to show that the different parts of the plains—other than the wet and the dry—ever differed in climate, we might consider this objection as sound, but it is impossible to so regard it in the actual state of affairs.

Now, if isolation alone is to effect specific difference, the general evidence is necessarily against selection of infinitesimal differences from the adaptation point of view. Why should some species range over the whole of the mountain tops, while others are confined to one ? Why should there be a great many Eugenias each confined to one hill top, while *E. subavenis*, *E. assimilis*, *E. mabœoides*, &c., though endemic to Ceylon, range over the bulk of the higher mountains ? The common-sense view is that these plants are not specially adapted for their situations, but that the commoner or more widely spread species are better suited to mountain tops generally, or were evolved sooner and have had time to spread more widely.

Or, again, look at the climatic range in which the bulk of the species found in Ceylon can survive and prosper, and it will be seen at once that these are far greater than any climatic differences between the mountain tops, while the soil differences are almost nil, the geological formation of Ceylon being very uniform. The chief climatic differences between mountains of similar heights are in the amount and distribution of the rainfall, and yet far greater differences are to be found between the many places in the plains, or in the mountain zone, in which very many species of Ceylon live, and this whether these species be endemic to the Island or not. To take the first that comes to hand in Trimen's Flora, *Naravelia zeylanica* lives in Galle, Colombo, Kalutara, Kandy, Lunugala, whose rainfalls are as follows :—

	Galle.	Colombo.	Kalutara.	Kandy.	Lunugala.*
January	4·55	3·54	4·25	4·95	8·90
February	3·02	2·08	2·41	2·33	5·35
March	4·23	4·80	4·13	3·41	2·68
April	10·24	11·03	10·73	7·32	9·04
May	11·47	12·04	15·13	6·10	7·08
June	8·35	8·27	10·21	9·24	2·91
July	5·77	4·61	5·20	6·96	2·20
August	5·45	3·67	4·94	5·55	4·77
September	7·51	5·03	7·77	5·81	7·79
October	13·22	14·67	8·36	11·09	13·43
November	11·48	12·38	12·25	11·38	13·03
December	6·18	6·03	5·92	8·87	11·63
Year	91·47	88·15	91·30	82·01	88·81

It also lives in tropical India, the Himalaya, Assam, Malaya, Java, &c., places in which the climatic range is very varied.

Or take *Bocagea Thwaitesii*, a Ceylon endemic. This lives in Ratnapura, Maturata, Maskeliya, Ambagamuwa, and on Doluwakanda, places which show an enormous range of climates.

Or, again, it may be objected that why should a species stay confined to a mountain top, when others with similar mechanisms are found all over the country, and in India, &c.? As every stage may be found from species with very limited distribution to species on two or three mountains, species occurring over larger ranges, and species all but universally distributed, we may probably conclude that they were evolved

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* No rainfall record, but Passara, close by, has.

at different times, and that the older, and those with the better mechanisms, have spread the most. Those most early evolved would also perhaps find the forest less dense, and be more easily able to get about.

Most mountain countries show a fair number of endemic forms, even if they be not confined to one mountain top, and Ceylon has numerous endemic forms ranging over a greater area in the mountains than those dealt with in this paper.

The general conclusion, then, must be that isolation, as isolation, favours the development of new forms, and that local conditions have but little effect in developing, though they may have much in determining the survival of these new forms, and that consequently natural selection of infinitesimal variations, on ecological grounds, is unlikely. It is more than doubtful if any given species is specially adapted to the exact local conditions in which it is found.

The Phalloideæ of Ceylon.

BY

T. PETCH.

THE earliest records of the fungi of any country usually include some mention of its phalloids, since the bizarre forms of this group cannot fail to attract the attention of the most casual observer. Hence it happens that, considering the relatively small number of species, we probably know more about the occurrence of this family than of any other. At the same time it may be said that we know very little about the species recorded: they do not lend themselves to easy preservation, either dry or in liquid preservatives, and therefore the descriptions and figures of many species illustrate chiefly the imaginative power of the describer. There is no doubt that far more names than species of phalloids are in existence. In many cases species have been founded on only a single specimen, without any idea of the variations which occur within the species.

Five Ceylon species were collected by Gardner in 1844, and were described by Berkeley (Hooker's London Journal, 1847). Three of them were considered new species, viz., *Aseroë zeylanica*, Berk., *Simblum gracile*, Berk., and *Lysurus Gardneri*, Berk.: the remaining two were attributed to *Dictyophora dæmonum*, Rumph., and *Clathrus cancellatus*, L. The *Aseroë* and the *Simblum*, however, are only forms of previously known species, while, on the other hand, the *Clathrus* has been considered to differ from *C. cancellatus*.

From Thwaites's collections, made between 1863 and 1868, Berkeley identified all the five species previously collected by Gardner, in addition to a new species, *Clathrus delicatus*, which has not been recorded from any other country. The five were listed under the same names as before, though Thwaites had considered that his large *Clathrus* was not *C. cancellatus*, and

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had marked the drawing "*Clathrus crispatus.*" Thwaites also forwarded another species, which Berkeley and Broome named *Phallus proximus*, but the name was not published in the "Fungi of Ceylon": Massee discovered the figure and specimen in Berkeley's herbarium and published a description in Grevillea, XIX., p. 94. Fischer states that Berkeley's herbarium also contains specimens from Ceylon marked *Phallus pallidus*, which are really *Ithyphallus tenuis*, Ed. Fischer: Berkeley's name was never published, and we have no record, either name, figure, or specimen in the Peradeniya herbarium.

In the Introduction which Thwaites wrote for Berkeley and Broome's Fungi of Ceylon, he states, "At an elevation of more than 7,000 feet, I found a single specimen of a new species of *Phallus* of a deep red colour, which has not occurred to me elsewhere." There is nowhere any indication of what this species was: all Thwaites's recorded specimens are from much lower elevations, and the description does not agree with any species of *Phallus* known to exist in the Island.

During the last three years all the recorded species (except *Ithyphallus tenuis*) have been collected, with the addition of *Dictyophora irpicina*, Pat., and *Aseroë arachnoidea*, Ed. Fischer. Ten species have now been found, viz.:—

Mutinus proximus (B. & Br.).
Ithyphallus tenuis, Ed. Fischer.
Dictyophora phalloidea, Desv.
Dictyophora irpicina, Pat.
Clathrus crispatus, Thw.
Clathrella delicata (B. & Br.).
Simblum periphragmoides, Klotzsch.
Colus Gardneri (Berk.), Ed. Fischer.
Aseroë rubra, La Bill.
Aseroë arachnoidea, Ed. Fischer.

The number of species compares very unfavourably with that recorded from Java, viz., seventeen. Most of the Ceylon fungi hitherto recorded have been collected at Peradeniya (1,600 feet), and it may be that many other species are to be found in the low-country or on the hills. The species already known exhibit a marked distribution according to altitude:

Dictyophora is essentially a low-country species, extending up to about 2,000 feet, while *Aseroë rubra* and *Clathrus crispatus* have not been found below 4,000 feet. The last fact explains why it has not been possible to provide photographs of these species: they have been found only when visiting up-country estates in the course of disease investigations when a camera was not available. The omission will be remedied as soon as possible.

PHALLACEÆ.

Genus 1. *Mutinus* Fries.

Receptaculum tubular, cylindric, wall chambered or simple, without a cap or net. Gleba covering the upper part of the receptaculum when ripe.

1.—*Mutinus* (*Jansia*) *proximus* (B. & Br.).

Among the paintings of phalloids in the Peradeniya herbarium is one marked "*Phallus proximus*, B. & Br. (Thwaites, 1,058.) January 9, 1869." There is no reference to this number or species in Berkeley and Broome's Fungi of Ceylon. Massee (Grevillea, XIX., p. 94) has published a description, based on the specimens in Berkeley's herbarium, under the name *Mutinus proximus*. I have not seen this description, and therefore cannot say how the discrepancies in the reputed transcriptions have originated. Fischer, quoting Massee, says, "Entire fungus 3–5 mm. high: stem white (auf einer Skizze im londoner Museum of nat. history ist aber der Stiel gelb), slender, wall with a single layer of cavities, externally alveolate: sporiferous portion about 4 mm. long, subglobose, apex obtuse, imperforate, orange-red, and covered with olive mucus: spores colourless, elliptic-oblong $3 \times 1\mu$: volva ample, springing from cord-like white strands of mycelium:—on the ground, Peradeniya, Ceylon." Saccardo says, "parte sporifera 4 cm. long.," "Totus fungus 7–12 cm. alt." Saccardo's measurements are nearer the truth, though they are too great in each case. As far as the general description is concerned, it is wrong in stating that the stalk is white, the head subglobose, imperforate, and orange-red, and that the fungus grows on the ground.

The figure in the Peradeniya herbarium shows a specimen 7 cms. high: the volva is white and narrow oval, 2 cm. high and 8 mm. broad, and the stalk is of uniform diameter, 5 mm., throughout: it terminates in a short, conical head, 8 mm. high, covered with the olive gleba: the apex is perforated. The stalk is white at the base, and gradually becomes dirty yellow upwards: it is externally alveolate, and is not perforated laterally. The appearance of the volva and stalk exactly agrees with the *Jansia* described below, but the head is shorter. The figure of course gives no clue to the colour of the head after the gleba has been removed.

Specimens of a *Jansia* have been gathered recently at Peradeniya on two occasions, among decaying leaves and on fragments of bamboo. The mycelium consists of the usual white strands, but before it produces the volvæ it forms a continuous white sheet over the substratum, and on this the "eggs" are produced in crowded groups. After one group had been developed and removed from a mass of decaying leaves brought into the laboratory, a second lot of over a dozen began to develop a fortnight later: they were at first exactly spherical, and remained so until they attained a diameter of about 2 mm.; then they lengthened vertically and became brownish on the top. Unfortunately all these were attacked by moulds and did not expand.

The volva is narrow oval, somewhat swollen upwards, white, 1·5 cm. high and 6 mm. in diameter, white or brownish on the top.

The fungus usually grows in clusters of three or four. The unexpanded volva is semitransparent, and the gleba can be seen through it. The total height of the fungus is 6–8 cm. The stalk is dirty yellow, reddish towards the top, smooth, without perforations, semitranslucent, slightly narrowed upwards, 4 mm. in diameter: its wall is composed of one layer of chambers. The upper part for a length of about 1·5 cm. (roughly a quarter the total height) bears the gleba, and has a different structure and colour from the rest of the stalk: the diameter increases slightly, though usually without the evident constriction of the one photographed, and then tapers gradually to the apex. The colour becomes dark red or crimson. This head is covered with irregular projections, which are either short, blunt, curved ridges, sometimes arranged in a network, or separate, blunt, cylindrical appendages. In the sculpture of the head, this species is intermediate between *Jansia rugosa* and *Jansia elegans*; in fact, it combines the structure of these two species. It has the blunt anastomosing ridges of *J. rugosa* mingled with the appendages of *J. elegans*.

The head is usually curved, and the truncate apex is perforated by a circular opening. The gleba is dark olive, and the spores are hyaline, oval, $3 \times 1 \mu$. In the head the inner walls of the chambers are perforated or absent, except at the septa, and the septa diminish until, near the apex, there is only a membrane bearing the red appendages. This agrees with Penzig's figure of the inside of the head of *Jansia elegans*.

Penzig states that the head of *Jansia elegans* is light brown, but he does not give the colour of the head of *Jansia rugosa*. Fischer (Untersuch. Phall., 1900) says that the processes of the head of *J. rugosa* are red-brown, and does not give the colour of *J. elegans*. Both these authors state that the stalks of both species are white. *Mutinus proximus* apparently differs in having the stalk yellow, and in some cases reddish towards the head, and in having the head deep red or crimson: but this is not a great difference, and a comparison of a series of specimens of the three species would probably show that no distinction could be made on this point. As in *Aseroë*, the colour persists for a long time when the fungus is placed in alcohol, so the comparison should be possible. As stated above, *Mutinus proximus* is intermediate, in the sculpture of the head, between *Jansia rugosa* and *J. elegans*, a fact which suggests that the three species might be thrown into one, but the latter two are quite different in having the apex imperforate. As I have pointed out under *Dictyophora*, the description of a head as imperforate is often based on an incompletely developed specimen, but in this case Penzig's figures leave no room for the supposition that an apical opening was closed by an evanescent membrane or by the jelly of the volva. Apparently, then, *Mutinus proximus* is a distinct species.

But Penzig mentions under *Jansia elegans* two examples which differed from his type specimens in their greater size, in their perforated apex, and in the arrangement of the processes, especially at the base of the head, in a net work. These are just the points in which *Mutinus proximus* differs from *Jansia elegans.* If Penzig's view is correct, then our Ceylon species is *Jansia elegans*, with which it agrees in general appearance and habitat. But if there has been no mistake in the description of the head of *Jansia elegans* as " imperforate," it would seem preferable to conclude that *Mutinus proximus* is found in Java, as well as in Ceylon, and that Penzig's aberrant specimens belong to this species. Fischer (Untersuch. Phalloid., 1900, pl. 5, fig. 31) gives a figure of a median section of an unexpanded head of *Jansia Nymaniana* (= *rugosa*) : it certainly appears from this figure that the apex is perforated, and in his description Fischer says, " am Scheitel abgestutzt, mit einer Mündung " : but Penzig states that the upper ends of his specimens were always closed, and his figures show the netted bands of the head continuous over the apex. The difference of opinion would be comprehensible if both describers had examined dried specimens only, but in this case Penzig's descriptions were presumably drawn up from fresh examples. Lloyd (Myc. notes No. 30) gives a *photograph* of the head of *Jansia rugosa* enlarged six times : the apex is truncate, and in this respect differs completely from Penzig's figures. It seems most probable that Penzig's figures are incorrect : the structure which they show is an impossible variation from a perforate apex.

At present it seems advisable to leave the Ceylon species as *Mutinus* (*Jansia*) *proximus*, with the probability that the head of *Jansia rugosa* and *J. elegans* will be found to be perforated, and that one name will suffice for all three.

Genus 2. *Ithyphallus* Fries.

Receptaculum consisting of a hollow stalk with a chambered wall, with a bell-shaped cap attached to the upper end : outer surface of the cap smooth or ornamented with netted bands or minute folds : gleba adhering to the cap when ripe. Apex of the receptaculum perforated (exceptionally closed).

Ithyphallus tenuis, Fischer.

In "Neue Untersuchungen Phalloideen," 1893, Fischer states that in Berkeley's herbarium and in the British Museum there are specimens from Ceylon which undoubtedly belong to this species. Those in Berkeley's herbarium are labelled *Phallus pallidus*, Berk., a name which was never published. There is no record of this species in the Ceylon lists, and no specimens in the Peradeniya herbarium. Since it was named by Berkeley, not Berkeley and Broome, the specimens were probably collected by Gardner.

Genus 3. *Dictyophora*, Desv.

Receptaculum as in *Ithyphallus.* Cap reticulated with raised bands, or covered with closely packed processes. From the upper part of the stalk, beneath the cap, hangs a bell-shaped, netted structure, the indusium.

1.—*Dictyophora phalloidea*, Desv.

This elegant species is probably the most widespread of tropical phalloids, and has been described from many countries under as many different names. It is the commonest species in Ceylon, at least in the low-country and at medium elevations. The Sinhalese know it as the "cobra fungus," and say that it is poisonous. Gardner collected it in 1844, Harvey in 1853, and Thwaites in 1868. All these specimens were named by Berkeley *Dictyophora dæmonum*, Lév. Beccari also collected it in Ceylon in 1865. Two specimens and drawings are in the herbarium, but one of the specimens is a later addition by Trimen in 1881. Fischer includes *dæmonum* under *phalloidea:* and as all Ceylon forms (except Beccari's specimens) have been given the former name, it is apparent that this view is correct. *Dæmonum* is supposed to be characterized by the possession of a narrow ring at the apex, a feature which the Ceylon figures show well developed, but, as will be explained later, this is quite a common and easily understood variation in *phalloidea.* Cesati named Beccari's specimens *Hymenophallus indusiatus*, and added the note "Certe iconi *Phalli Dæmoni*, Rumph, non respondet."

The volva is about 3·5–4 cm. in diameter, and is white or grayish, sometimes brown or purple in the upper half : it is either smooth, or clothed with small white fibrils and scales, which give it the appearance of *Echinophallus* (the latter is only known from unexpanded examples, and is evidently closely allied to *Dictyophora*). The mycelium is white or violet.

The total height of the fungus is very variable. My specimens range from 10·5 to 20 cms., while one of the herbarium paintings (which are all "life-size") shows a specimen 31·5 cms. high. The stalk above the volva is attenuated upwards, the diameter diminishing from 2·8–2·2 cms. to 2–1 cms. : there is a more rapid diminution of the part of the stalk within the volva down to the base. The stalk is hollow ; its wall consists of polygonal, isodiametric chambers, usually in three layers at the base, two in the middle of the stalk, and only one towards the apex. The outer walls of these chambers are perforated here and there in most cases. In one abnormal specimen the stalk is conical, 16 cms. high, 2·8 cms. diameter at the base, 8 mm. diameter at the apex.

The top of the stalk is surmounted by a truncated conical or conico-campanulate cap, 2·5–4 cms. high and 2·5–4 cms. in diameter at the lower edge. This cap is only united to the stalk at the upper edge. Underneath the cap the wall of the stalk is thin and solid (*i.e.*, without large cavities), and this structure continues with a slight increase in thickness into the cap : the arrangement is exactly that of the turned-down top of a golf stocking. The presence or absence of a ring at the top of the cap, which has been considered a specific difference, depends merely on slight variations in the manner in which the stalk wall turns over into the cap : these variations will be understood from the diagrams : in the most general case there is no "ring," and in no case is there a *solid*, swollen ring. The outer surface of the cap is covered with a network of raised bands, which are more or less parallel near its upper and lower edges. In general the bands are narrow and deep, and project almost perpendicularly from the surface : but in many cases they are rounded off on either side. In the first they have the appearance of thin bars applied edgewise to the cap ; in the second case the cap appears to have a series of close-set depressions. The gleba is olive, and the spores are $3 \cdot 5 – 4 \times 1 \cdot 5 \mu$.

Much confusion has arisen in the descriptions of the various "species" of *Dictyophora* by the varying accounts of the top of the stalk, whether the apex is open or closed. When the receptaculum first expands the cap is covered wholly or in part by a fine white membrane which vanishes as the fungus matures: in general, it persists for some time over the opening of the stalk and thus makes it appear to be closed, and if specimens in this state are dried or placed in alcohol this membrane is preserved. It is merely a free superficial film, which is not present when the fungus has ripened completely. The apex of the stalk is open in all Ceylon examples of *Dictyophora*, and from their structure it may be fairly assumed that it is the presence of this membrane which has misled describers. The opening varies from 5 mm. to 1 cm. in diameter.

The netted indusium, which is the characteristic feature of *Dictyophora*, is united to the stalk, the junction being usually hidden by the cap. In this, the general case, the free edge of the cap rests on the net, but specimens are common in which the two are not in contact, owing either to an upward curl of the lower edge of the cap through age, or to a greater extension than usual of the thin upper portion of the stalk. The outer chambers of the wall of the stalk break up into a series of more or less longitudinal ridges, and to these the net is attached. There is a considerable amount of variation in the thickness of the bars of the net at the top; sometimes they are immensely thickened and form plates which coalesce with the stalk, producing a honeycomb of large chambers. In outline the net is broadly campanulate: it collapses into folds when old, and is then conical, the outline then depending on the thickness and rigidity of the upper bars. If the net before collapsing is resting on the ground, we get the appearance of Möller's fig. 4, pl. 4. The meshes of the net are rounded or polygonal: the bars are flattened or somewhat rounded, hollow, and often perforated. The lower edge of the net is entire or broken.

In general the fungus expands in the early morning, but apparently not so early in Ceylon as noted by Möller in Brazil. I have gathered specimens at 9 A.M. in which the net was not yet expanded, but was folded up just below the cap, and have seen them expand during the next half hour when lying on the table in the laboratory. Perfect specimens with the net still rigid can be gathered between 8 and 9 A.M. Möller observed the time of opening of ten specimens, most of which expanded between 2 and 7 A.M. : and he remarks that since they expand during the night it is difficult to obtain a photograph, for as soon as the sun strikes them the net collapses. In Ceylon, though the exact time of expansion has not been observed, it is evidently later than in Brazil, and I have no difficulty in obtaining perfect specimens with the veil still rigid between 8 and 9 A.M. It seems reasonable to suggest that the precise time of opening is controlled by the supply of water, and therefore by the time of maximum humidity, which occurs in Ceylon about 6 A.M. Since the net is fully expanded for at least two hours of daylight, or longer on wet days, Möller's objection to the net being considered attractive to insects because it is only fully spread during the night, has no weight in Ceylon. However, it may be granted that the insects which visit our Ceylon phalloids are attracted by the smell, not by the colour.

The net extends, in general, about two-thirds of the length of the stalk : in some cases it reaches down to the ground, and cases of imperfect development in which the net remains partly expanded at the top of the stalk are not uncommon.

Nothing has yet been said as to the colour. Fischer says that *D. phalloidea* is snow white, or, less frequently, rosy. The commonest Ceylon form has a white stalk, a white cap, and a salmon pink net. A pure white specimen is rare, though curiously the specimens I have developed from " eggs " have been white. This, together with Möller's results, suggests that the separation of the egg from the mycelium may in some way influence the colour. Frequently the cap is pale yellow. Two specimens from the low-country had a bright orange stalk, cap, and net, but they did not differ in structure from the common form. A large white specimen gathered at Peradeniya had one part of the net undeveloped, *i.e.*, forming a solid plate which threw the remainder of the net into folds : this plate was pinkish. One specimen with a very pale pink net was reddish purple at the base of the volva. Altogether it may be said that the cap may be white, pale yellow, or orange ; the stalk may be white, yellow, orange, or pink ; and the net may be white, yellow, orange, orange-red, pink, or salmon. Examples occur with all possible combinations of these colours, without any structural differences which would warrant their separation as species.

The Ceylon specimens named by Berkeley and Broome were called *D. dæmonum* : one drawing shows a white stalk, a yellow cap, and a reddish pink net : another is labelled "veil bright orange." In structure they are typical *phalloidea*. Möller's specimens of *D. phalloidea* were pure white, and he called his solitary coloured specimen *callichroa*. Berkeley founded *D. multicolor* on a specimen from Australia, which had a bright yellow stalk, a lemon-yellow veil, and an orange-red pileus : the net was poorly developed, but except for this it does not differ from *phalloidea*. Penzig records the same species from Java, and says it can be at once distinguished by the orange net : the only structural difference mentioned is the occurence of small branches running from the bands into the meshes of the reticulations on the cap, but this occurs also in some Ceylon specimens of *phalloidea*. Penzig's figures would pass for small specimens of *phalloidea* with a poorly developed net. Lloyd states that Penzig found it abundant : Penzig says not very common. In some of the Ceylon specimens the mycelium and volva are white, in others they are violet, or the top of the unopened egg is purple : and there seems to be some correlation between the presence of colour in the volva and mycelium, and its absence from the mature fructification. Möller found coloured mycelium but white mature forms : in Ceylon we usually find white mycelium and highly coloured fructifications. Similarly, *Dictyophora irpicina*, which is always white, has the top of the egg purple, or sometimes almost black.

It seems impossible to maintain species on colour. In Ceylon, one is certain after gathering fifty specimens that he has *phalloidea*, *multicolor*, and *callichroa* : by the time he has seen one hundred this belief is considerably shaken : and further experience forces him to the conclusion that there is only one species. Nor is it possible to separate forms on such characters as the relative position of the cap and net, the rounded or flattened bands of the net, the size of the meshes, the depth of the net, and the extent of its spread. Where can there be individual variation except in these points? The comparatively complicated structure of *Dictyophora* seems to have given rise to the idea that every specimen should be cast in the same mould. As a matter of fact, only the general outline is constant.

It is possible to separate one, rather rare, Ceylon form, though it is doubtful whether it deserves to be called a distinct species. I have found it on two occasions at Peradeniya, and once in the low-country. The egg is small, about 1·5–2·5 cms. in diameter, and owing to the thin outer wall is somewhat translucent. The total height is 7–8 centimètres. The stalk tapers slightly upwards, and is 9–11 mm. in diameter: in structure it agrees with *D. phalloidea.* The net is conical, descending about one-half or two-thirds the length of the stalk: in some cases the upper bars are so broad that they appear as holes in a continuous plate, but generally the net resembles fairly closely that of *D. phalloidea.* The cap is conical, about 1·5 cm. high and 1·3 cm. diameter at the lower margin. When growing the net and stalk are somewhat translucent: they may be white, pale salmon, or pink. The cap is always bright orange-yellow. It is readily picked out in the field by its smaller size, peculiar translucent appearance, and the orange cap: but the only difference which would warrant its separation as a species lies in the arrangement of the bars of the cap. These are thin, deep, and slightly wavy, and are arranged in two series of different height. The deeper bars form a network of large meshes, each of which is subdivided into smaller meshes by lower bars. This arrangement gives the cap a characteristic and easily distinguished appearance. When the gleba begins to disappear, only the deeper bars are visible at first, and the cap appears to be covered with large meshes. The intermediate meshes, being so much lower, are not seen until the gleba has almost entirely disappeared. The photograph illustrates both stages, but the lower bars do not come out clearly. On one occasion, eight examples were found arranged in a ring about four feet in diameter.

I have followed Fischer in retaining the name *Dictyophora.* Lloyd ("Concerning the Phalloids," May, 1907) unites *Dictyophora* with *Phallus*, on the ground that all have a net, though it is rudimentary in the accepted species of *Phallus.* It is true that *Phallus impudicus* sometimes has a thin white sheet of tissue underneath the cap or adhering in patches to the stalk, but this is not homologous with the net of *Dictyophora. Dictyophora phalloidea* frequently has exactly the same patches on the stalk, but this is in addition to, not instead of, the net. In both cases this represents a part of the "ground tissue" between the cap and the stalk, which, like the white film on the cap, should have disappeared as the fructification matured. Penzig's photograph of *D. multicolor* shows the same patches.

Lloyd (Myco. notes, May, 1907) says, "Alfred Möller figures a form which seems to us quite distinct in its *rigid* veil." This specimen had been developed under a bell glass, and therefore had not collapsed. All our specimens of *Dictyophora* have rigid veils when first expanded.

Möller says that *D. phalloidea* has a most offensive, intolerable smell, and that it compelled him to leave the room in which he was examining his specimens. On the other hand, most people whom I have tested with the Ceylon form agree that from this point of view it is a failure. It is not by any means so offensive as *Phallus impudicus.* The smell is rather sweet, slightly offensive indoors, but is scarcely perceptible at a short distance from the fungus in the open. I have never been able to detect *D. phalloidea* by the smell as I have *Phallus impudicus.*

2.—*Dictyophora irpicina*, Pat.

This species was described by Patouillard from specimens collected in Java, and further details have been added by Penzig. The latter states that it is rarer than *D. phalloidea*, he having found only nine specimens. Apparently it was not seen by Thwaites or Gardner in Ceylon, or, if seen, was not distinguished from the common species. It is now fairly common in the Royal Botanic Gardens, Peradeniya, though it is peculiarly confined to that part of the flower garden where the grass is cut every few days. Over this area *D. irpicina* grows in some abundance among the closely cut grass and at the edges of the flower beds : elsewhere in the Gardens one finds only *D. phalloidea.*

This species is always pure white, and is smaller than *D. phalloidea;* the total height varies from 8 to 16 centimètres, most of the specimens being about 10 cms. In large specimens the stalk is attenuated upwards, while in the average specimen it is almost of uniform diameter throughout. The structure of the lower part of the stalk is the same as that of *D. phalloidea.* The cap is of the same shape as in *phalloidea*, or often rather wider in proportion to its height than in that species.

The difference between the two species lies in the structure of the cap. The outer surface of this in *D. irpicina* appears granular, with a few obscure, irregularly curved or longitudinal elevations. Patouillard says, "des cretes minces, peu élevées, rectilignes ou diversement contournées, tres rapprochées les unes les autres, parfois incisées ou interrompues, simple ou rameuses, à arete obtuse, qui couvrent toute la face externe."

The cap has the appearance of the arm of *Colus Gardneri*, and, as in that species, the sporiferous part consists of closely packed, contorted, or flat, anastomosing membranous processes at right angles to the basal layer of tissue. The thickness of the cap varies from ·75 to 3 mm. in the middle, diminishing towards the upper and lower edges. The basal layer is about ·2 mm. thick : when viewed from the under surface it appears irregularly reticulated with fairly close-set, straight, or curved thickenings, between which it is often perforated. These thickenings mark the lines of origin of the side walls of a single layer of closed chambers which underlies the membranous gleba-bearing processes. These chambers are ·75–1 mm. broad, and ·25–·5 mm. high, in cross section. From the upper surface of these arise the branching, close-packed processes which form the remainder of the thickness of the head. Towards the edge of the cap the basal layer of chambers may be wanting. As a rule, the surface of the cap, though appearing granular, is even : in exceptional cases it is thrown into irregular longitudinal ridges which are produced by the different lengths of the processes in different parts of the cap.

The rather pale olive spore mass penetrates between the processes. The smell is rather like that of sour paste, not at all offensive.

The mycelium is white, or slightly violet, or pinkish : the "egg" is brownish or purple, sometimes almost black in the upper half. All the colouring matter of the fungus seems to have accumulated in the wall of the egg.

But the most striking feature of *D. irpicina* is its damaged unfinished appearance. Compared with the regularly symmetrical *D. phalloidea*, it is a thing of shreds and patches. The cap is frequently interrupted on one side by a broad vertical fissure (sometimes 1 cm. wide) which extends to the apex ; sometimes it is not united to the stalk at the apex, but remains behind in the volva as the stalk expands, or adheres to the expanded net. In such cases the free edges of the cap show that it has not been broken : they thin away gradually, and the apparently broken edges are bordered by a narrow band of white tissue without any gleba or lamellæ. In the case of the vertical fissure, part of the cap has failed to develop : and when the cap remains in the volva, the stalk and cap have developed separately, as Fischer states, but the apical connecting tissue is wanting. The cap may be broadly campanulate, and placed obliquely across the apex of the stem : when it is fully formed and in its proper position it is often laterally compressed : the opening which should be apical is frequently on one side at some distance from the apex : the white membrane which covers the deliquescent gleba and ought to disappear at maturity persists for a long time over the head, and in many cases there is no spore mass beneath it. The pale olive colour of the head is due to the almost total absence of the deliquesced gleba, and in some instances the head is white. When proper deliquescence does occur it is often confined to one side : but in the more usual case there is only a thin olive covering over and between the membraneous processes. Sometimes part of the jelly which should remain in the volva adheres in a large mass to one side of the cap and is carried up with it.

The stalk is often laterally compressed, and it usually retains its chambered structure up to the apex, instead of becoming membraneous there as in *D. phalloidea*. The net is always short and extremely irregular, and often almost absent. Where it joins on to the stem there is a mass of large chambers forming a honeycomb structure which unites the upper part of the net to the stem, instead of the thin ridges of *D. phalloidea.* The upper meshes of the net are large and irregular and the bars are sometimes 5 mm. broad. The remainder of the net may be rigid, but is usually weak and ragged. The extremes of net development are shown on plate 10. The two specimens in the centre have a coarse system of rigid bars at the top which keeps this part of the net horizontal : the remainder is fairly completely formed, but is weak and hangs vertically. The two outer specimens have scarcely any net at all, and in the one on the right it joins on to one side of the stalk which here presents a coarse network of open cavities. In some cases the meshes of the net are filled here and there by a continuous plate, and the bars instead of being tubular are open on the outer side.

Penzig's photographs show the same irregular ragged net, with coarse rigid bars at the top. The cap of one shows at the apex an approach to the reticulation of *D. phalloidea*, but, to judge from fresh specimens which present a similar appearance, these markings are merely lines in the persistent white covering membrane. Lloyd reproduces an interesting photograph of Patouillard's type specimen, showing that the cap was bent over to one side.

As previously stated, this species is confined at Peradeniya to the part of the Botanic Gardens which is laid out as an ornamental garden. From this area I have seen more than 150 specimens in eighteen months. The grass over this area is cut every few days with small garden mowing machines, and the edges of the beds are trimmed by cutting them vertically. It will be understood, therefore, that the greater part of the abnormalities referred to above are caused by injuries to the " egg," though the wall of the latter remains unbroken. But in view of the fact that *D. irpicina* is confined to this area, it seemed worth while to try to discover whether *D. irpicina* is not really an undeveloped state of some other species, *i.e.*, whether some accident to the egg prevented the full development of the cap. Such accidents certainly do prevent altogether the formation of parts of the cap.

There are two senses in which the term "immature" may be applied to expanded phalloids. We may speak of "immaturity" in the sense that an expanded phalloid is not mature until its spores have been dispersed and it is about to collapse, or, in the case of *Dictyophora*, it may be styled immature during the short period when the stalk is fully expanded, but the net still contracted just below the cap. But there can be no immaturity in the sense that a *change of structure* might occur after expansion. As far as its structure is concerned a phalloid is mature as soon as it is fully expanded. There is, however, another possible application of the term. May not a phalloid burst from the volva before the receptaculum has been fully formed? We know from Fischer's researches that in *Dictyophora*, for example, the cap and stalk originate as independent structures. If the formation of the cap is delayed from any cause, while that of the stalk proceeds as usual, we might expect that dehiscence (which probably depends to a great extent on external factors) would occur when the stalk was fully formed, but the cap was still immature, *i.e.*, incomplete. In that case the cap would remain permanently immature. This leads at once to the tempting theory that all "rugulosi" phalloids are immature examples. The theory appears to gain probability from the fact that the gleba is always scanty in such species; that the processes of the cap bear at least a superficial resemblance to the trama plates of the gleba; and that, in general, for each member of the "rugulosi" there is a parallel, but more regularly developed non-rugulose species. Penzig assumed that the processes of the cap were indeed the non-deliquesced trama plates, but Fischer, after an examination of the egg of *D. irpicina*, asserts the contrary. Needless to say, such a theory would have to apply to all the "rugulosi," and we should be faced with the fact that all our specimens of *Colus Gardneri*, those gathered forty years ago and those of the present day, are "rugulosi." The experiment recorded below afforded no support to this theory: still the possibility that some of the recorded phalloids may be "immature" in the sense indicated is worthy of note.

A small bed, about ten square yards, was fenced round on April 11; the bed was not weeded nor the margin trimmed until July 4, by which time it had become so overgrown that it could be left no longer ; after weeding it on this date it was again left untouched until October 26. During this time I obtained 119 specimens from the bed and the surrounding unfenced lawn, that is, from a circle of about 10 yards radius. Some of the specimens from the protected bed showed a diminution in the honeycomb attachment of the net to the stalk, and thereby came nearer *D. phalloidea*, but they were all undoubted *D. irpicina*. It is unfortunate that all our specimens appear in a locality which cannot be left untouched. The interruption in the middle of the experiment was unavoidable in a " show " garden, but apparently it did not affect the result, which furnishes no support to the idea that *D. irpicina* is an " immature " form.

It is evident from the times of appearance of the specimens seen during these six months that they do not appear during the heavy rains, but during the periods of light showers, or even dry weather, which succeed them. Roughly, the crop of *Dictyophora* follows about three weeks after the heavy rains. It seems probable that the explanation is that the " egg " can only develop during the very wet weather. If this is so, then the time of formation of the " egg " is about three weeks. Cobb (Diseases of Sugar Cane) estimates the period of formation of the " egg " of *Ithyphallus coralloides* at about twelve months. It is quite impossible that the " egg " should survive the baking which the lawns undergo in the dry months of January and February. The rainfall at Peradeniya during January and February, 1907, was ·99 and 1·69 inches respectively ; it is unlikely that the *Dictyophora* egg would survive this drought, as it must be within an inch of the surface, and the places where it grows are, as a rule, absolutely without any shade whatever. Consequently it may be assumed that we begin with a clear field in March.

The following summarizes the records of rainfall and the appearance of *Dictyophora irpicina*. The rainfall of March, 6·01 inches on 19 days, produces the crop of the beginning of April, and the April rainfall continues it into May. Specimens still appear in May after fourteen days without rain, the result of the rainfall at the end of April and the beginning of May.

June has a heavy rainfall, 12·36 inches on 13 days, and consequently specimens appear later in the dry weather towards the end of the month, and some belated ones at the beginning of July. July has 9·20 inches of rain on 24 days, but no specimens appear until the end of the month, when they occur in abundance. This shows that those which began to develop in the early part of June had all ripened by the beginning of July. The distributed rainfall of July produces more specimens (in July and August) than the heavier, but more restricted, rainfall of June. The rainfall at the beginning of August carries on the production of *Dictyophora* into the dry weather of September, when they again cease: there is a solitary specimen on September 29, but this was protected by a rose bush. Though the end of September and the beginning of October were wet, there was no appearance of *Dictyophora* until the middle of October. Full details are given in the accompanying table. The specimens were collected between 8 and 9 A.M., and the rainfall was measured at 9.30 A.M. The figures for the latter, therefore, give the rainfall for the previous twenty-four hours.

A group consisting of an expanded specimen and three eggs, attached to the same mycelium, was gathered at 9 A.M. The wall of each egg was already split, in two cases by single fissures extending over the apex and half way down to the base, and in the third by two similar fissures at right angles to each other. The jelly was only slightly cracked. They were planted at once in damp sand and covered with a bell glass, but no further expansion occurred during the time they were under observation, viz., until 11 P.M. All three expanded during the night before 5.30 A.M. The case is interesting in showing the length of time which may elapse between the rupture of the volva and the beginning of expansion.

When the fungus first expands it is visited by myriads of the common wine fly (*Agromyza*, sp.), which is always found on decaying fruits. An ant, *Cremogaster biroi*, Mayr., has also been found on this fungus in numbers, probably attracted by other insects, and on one occasion a butterfly, *Mycalesis mandata,* was observed on the cap.

Date.	March.		April.		May.		June.	
	Rain-fall.	Speci-mens.	Rain-fall.	Speci-mens.	Rain-fall.	Speci-mens.	Rain-fall.	Speci-mens.
1	—	—	—	—	—	—	—	—
2	—	—	·21	—	—	—	·80	—
3	—	—	·18	—	·44	1	·06	—
4	·30	—	·17	—	—	1	—	—
5	—	—	1·45	5	—	1	·10	—
6	—	—	·41	—	·08	1	·46	—
7	·04	—	·04	—	·63	—	—	—
8	—	—	·03	—	—	—	4·40	—
9	—	—	·02	—	—	—	—	—
10	·85	—	·16	6	·29	—	·29	—
11	·35	—	—	1	·16	—	2·36	—
12	·06	—	·04	1	·02	—	·68	—
13	—	—	·15	2	—	—	·18	—
14	·06	—	·35	—	·18	—	1·29	—
15	·03	—	·10	—	—	—	·83	—
16	—	—	—	2	—	—	·84	—
17	·46	—	·11	—	—	—	—	—
18	1·30	—	—	—	—	—	—	—
19	·24	—	—	—	—	1	·07	—
20	·21	—	—	1	—	—	—	—
21	·17	—	—	—	—	—	—	—
22	·30	—	—	—	—	—	—	1
23	·18	—	·17	1	—	2	—	2
24	·10	—	·56	—	—	2	—	3
25	—	—	·03	—	—	—	—	3
26	—	—	—	—	—	—	—	4
27	·91	—	·72	1	—	2	—	—
28	·15	—	·20	1	—	2	—	—
29	—	—	2·70	—	—	—	—	—
30	—	—	·11	1	·31	—	—	—
31	·30	—	—	—	—	—	—	—

Date.	July.		August.		September.		October.	
	Rainfall.	Specimens.	Rainfall.	Specimens.	Rainfall.	Specimens.	Rainfall.	Specimens.
1	·22	—	—	8	—	—	—	—
2	·37	—	—	8	—	—	4·18	—
3	1·18	6	—	8	—	4	2·16	—
4	·16	1	·48	8	—	—	·64	—
5	—	—	·14	7	—	3	·24	—
6	—	—	·99	5	—	—	·20	—
7	·35	—	·16	5	—	—	—	—
8	—	—	·18	3	—	—	·06	—
9	·03	—	·33	6	·18	2	·01	—
10	·06	—	·11	4	—	—	·23	—
11	·39	—	·08	3	·03	—	·02	—
12	—	—	·23	—	—	—	1·17	—
13	·88	—	·84	3	—	—	·55	—
14	1·40	—	·04	2	—	1	·47	—
15	·07	—	—	—	—	—	·01	—
16	·49	—	·02	—	—	—	·41	—
17	·10	—	—	—	—	—	·01	—
18	·07	—	—	—	—	—	—	4
19	·09	—	—	—	—	—	·12	—
20	·66	—	·23	—	—	—	—	—
21	·40	—	1·28	—	—	—	·02	—
22	·61	—	—	1	—	—	·83	2
23	·68	—	·01	2	·10	—	·05	1
24	·03	—	—	—	·61	—	1·39	1
25	·64	—	·87	—	·07	—	·18	4
26	·30	—	·46	1	·04	—	·08	1
27	·14	—	·04	—	1·98	—	·06	1
28	·10	—	·06	1	·20	—		
29	—	16	1·23	1	·41	1		
30	—	—	·36	2	·45	—		
31	—	3	·05	—	—	—		

CLATHRACEÆ.

Genus 4. *Clathrus*, Micheli.

Receptaculum netted, without a stalk : branches of the net many-chambered : gleba covering the inner surface of the net when ripe.

1.—*Clathrus crispatus*, Thwaites.

A *Clathrus* attributed by Berkeley to *C. cancellatus* was collected by Gardner in 1844. Others were collected by Thwaites in 1859, and, of these, figures and one specimen remain in the herbarium at Peradeniya. One drawing, labelled July 29,, 1859, shows two unexpanded specimens: they are spherical, brownish or yellowish gray, seven centimètres in diameter, marked above with roughly hexagonal areas about 1–5 cms. across, and below with elongated polygonal areas which meet at the base : the mycelium is composed of numerous, thick, white strands. Another drawing, labelled "*Clathrus crispatus ;* Hantane, elev. 4,000 feet, August, 1859," represents the same two specimens, one of them now expanded ; the net is broken into four parts, one of which is half the whole receptaculum, while each of the other three consists of a basal arm and a small part of the net : the broken outspread receptaculum is 24 cms. in diameter. The basal arms are six in number ; they vary in length from three to six centimètres and in breadth from 1½ to 2 cms. The arms of the net are of the same breadth, and the oval meshes are only about 2 by 1¼ cms. The inner surfaces of the arms are perforated ; the sections of the broken arms show two or three layers of cavities : the external surface is figured quite smooth. The colour of the exterior is pinkish with a red margin to the meshes ; the interior varies from pinkish at the base, through rose, to deep red in the middle of the arms. The gleba is indicated by black patches on the inner surface. The herbarium specimen consists of two pieces, one of four meshes and the other of nine, apparently from the upper part. Another herbarium specimen is labelled "Hakgala, 1881" ; it shows the same structure of the volva, an apparently smooth external surface of the net, and a continuous coat of the gleba on the inner surface of the arms ; it is nearly the whole fungus, but is split and pressed out.

Fischer (Neue Unters. Phalloideen, 1893) adopts Thwaites's unpublished name for this species. He examined fragments of the Ceylon specimens gathered by Thwaites on Hantane in 1859, which were in the Kew herbarium, together with pieces from Myrong, Khasia, and Merida, Yucatan, doubtfully referred to *crispatus*. He says, "Alle vorliegenden Exemplare befinden sich in mehr oder weniger fragmentarem Zustande. Soweit man es aber kann, handelt es sich hier um eine besondere Art, die zwischen *Clathrus cancellatus* und *Cl. crispus* die mitte hält : in Uebereinstimmung mit *Cl. crispus* sind die Receptaculummaschen gerundet und nehmen nach oben an Grösse ab, auch durften die aeste eher flach und dünn und nicht so massiv ausgebildet sein als wie bei *Cl. cancellatus*. Dagegen konnte ich an den Receptaculummaschen den querrunzligen Rand, der für *Cl. crispus* so charakteristisch ist, nicht finden. es dürfte somit die Sporenmasse mehr auf die Innenseite des Receptaculums beschränkt gewesen sein. Eines der Examplare in Herb. Kew ist von Thwaites Hand als *Cl. crispatus* bezeichnet, und ich behalte diesen Namen hier bei. Freilich sind Untersuchungen an besseren Materiale nötig, um testzustellen, ob wirklich eine gute Art vorliegt." In Untersuch. Phalloideen, 1900, Fischer lists *Cl. crispatus* among the " ungenugend bekannte Arten."

Unfortunately I have not been able to obtain expanded examples of this species. In April, 1907, I found the mycelium with several small " eggs " and one large one at Hakgala (5,500 feet). These were brought down to Peradeniya, but though the large egg was kept for twelve days it did not develop further. The outer surface of the egg is elevated in close-set polygonal tubercles, somewhat flattened on the top. In this respect it appears to differ from the egg of *Clathrus cancellatus*, as represented in all the available drawings and photographs. This specimen is 5 cm. long, 5 cm. broad, and 4 cm. high. It has eighty-two meshes to the net. These meshes correspond in number and position with the outer tubercles, and a series of cross walls extends from the furrows of the volva to the bars of the net, thus dividing the jelly of the volva into separate compartments. In the unexpanded state the bars are thin, and the meshes polygonal : but in the painting of Thwaites's specimen the bars are very broad and the meshes are rounded.

Genus 5. *Clathrella*, Ed. Fischer.

Receptaculum netted, with or without a short stalk ; branches of the net consisting of a single chamber : gleba when ripe adhering in separate masses to the junctions of the branches only.

Clathrella delicata (B. & Br.).

This species was described by Berkeley and Broome under the name *Clathrus delicatus* from specimens sent from Ceylon by Thwaites (Journ. Linn. Soc., XIV. (1875), p. 77). Their description runs, " *Clathrus delicatus*, B. & Br. Minuta : reticulo parco delicato : sporis in glomerulos hic illic sitis (No. 784 cum icone). On rotten coconut trunks, &c. Peradeniya, November, 1868. Whole plant scarcely ½ inch high ; volva brown : network pale : hymenium confined to certain points, so that the spores appear to be collected into little scattered heaps." The figure is not in the collection now, and the single specimen is in very bad condition. Fischer (Engler-Prantl, die naturlichen Pflanzenfamilien, pt. 181, p. 248) suggests that the species probably belongs to the genus *Ileodictyon*, Tulasne, but in Untersuch. Phall., 1900, he says that in the arrangement of the gleba and the short stalk it is nearer *Clathrella*. He examined the specimens at Kew and the British Museum. Saccardo says of it, " non satis nota species : minuta, vix. 1½ cm. alta : receptaculo parce et delicate cancellato, pallido."

I have recently found it on five occasions at Peradeniya, growing under dense shade on sticks, rotten palm fronds, and fragments of bamboo culms, and though the number of occurrences is not large, it usually occurs in such abundance that more material is available than in the case of any other Ceylon phalloid except *Dictyophora*. More than fifty have been found in course of development on a piece of bamboo culm, 25 × 10 cms. In the open it is generally damaged by insects, &c.,

soon after expansion, but perfect examples are easily obtained by allowing it to develop under a bell glass in the laboratory. Under such conditions, though in a constantly saturated atmosphere, all expand during the night, and this rule was not altered by keeping them in a dark room subject only to a faint red light.

Unexpanded specimens are white or brownish, up to 8 mm. in diameter, smooth, arising singly or in clusters from a network of white strands, up to 5 mm. diameter, which adheres to the substratum. These strands contain the well-known sphæro-crystals of calcium oxalate which in this case are about 20 μ in diameter. The volva splits irregularly at the apex and remains as a cup with the edges closely applied to the lower portion of the net.

Expanded specimens are up to 2·5 cm. high and 1·5 cm. broad. The basal portion of the receptaculum shows considerable variation: sometimes it consists of a uniformly conical tube which divides above into the primary arms of the net, while in other cases it forms a uniformly narrow tube, 5 mm. long and 2 mm. in diameter, which expands abruptly into a shallow saucer-shaped structure from which the arms arise. In the latter case the receptaculum is distinctly stalked. The primary arms of the net are from four to six in number, and after a short distance divide into a wide meshed network with from ten to eighteen roughly pentagonal meshes. The branches of the net are hollow and have a single continuous chamber: the surface towards the interior of the net is rounded, the outer surface is flat, but with a solid projecting flange extending from either side almost to the centre and making the branches appear grooved externally. A cross section of a branch is semicircular with converging projections at either end of the flat side. Perforations are more common on the inner side than on the outer. The arms of the net are about 1 mm. broad.

The spore masses are collected at the nodes of the net. Each node bears on its inner surface a raised area, which is more or less triangular in a plane parallel to that through the three branches which meet at the node, the sides of the triangle being at right angles to the branches. This raised area forms a shallow cup supported on three short legs, one continuous with each arm. This is the general case, but in some instances the "legs" are more numerous, and it is evident from these exceptions that there is an additional chamber superposed on the arms at the node, and that its lateral wall is perforated to such a degree that only three narrow strips remain in most cases. The sporiferous mass is confined to the concave upper surface of the cup. The spores are narrow-oval, 4 × 1·8 μ.

In unopened specimens, 5 mm. diameter, the receptaculum is closely applied to the volva, and the nodes are already covered with the separate spore masses. Specimens 3 mm. in diameter have the olive, convoluted gleba intact, surrounded by the crumpled receptaculum, and it can be determined by a series of sections that only the nodes of the net come in contact with the gleba. When the gleba deliquesces the spores therefore adhere only to the nodes. In *Clathrus crispatus* the whole of the net is in contact with the undeliquesced mass of trama plates and spores.

The expanded receptaculum is pure white. The jelly remains within the volva, and as in all phalloids, the receptaculum after maturity is free from the volva, and is only held in position by the jelly. It has no appreciable smell.

This species appears to agree with *Ileodictyon* in the folding of the young unexpanded receptaculum, and the general absence of folds on the individual branches when expanded. But in the collection of the spore masses at the nodes of the net, the distinct tube at the base of the receptaculum, and the furrowed outer surface of the branches it is undoubtedly nearer to *Clathrella*. The differences between the two genera, however, hardly seem to warrant any distinction. *Clathrella delicata* appears to resemble *Clathrella chrysomycelina* (Möller), from which it differs in the colour of the mycelium, smaller size, and the structure of the arm which produces the external furrow. The Rev. A. Schupp, however, states that the mycelium of *C. chrysomycelinus* is not always yellow.

A rectangular piece of bamboo about 14 cm. × 12 cm., on which were several developing specimens was placed in a glass dish in the laboratory. On July 7 all the developing specimens, which grew chiefly along one edge, were removed, and the bamboo was placed with the mycelium-covered side downwards. The mycelium had grown round to the upper surface on July 8, and fresh developing specimens of *Clathrella* were observed on this new mycelium on July 10. One was about a millimètre in diameter, and there was another group of three about the same size. The first specimen was 2·5 mm. diam. on July 13, 4 mm. on July 18, and expanded on July 24. Of the group of three, only one grew: this expanded on July 26. The period of formation of the egg is therefore 15–17 days.

Genus 6. *Simblum*, Klotzsch.

Receptaculum netted, with a long cylindric hollow stalk, whose wall is composed of several layers of chambers : gleba confined to the meshes of the net when ripe : arms of the net one-chambered.

Simblum periphragmoides, Klotzsch.

In 1846 Berkeley described and figured a *Simblum* as *Simblum gracile*, from a specimen and figure sent by Gardner from Ceylon. His description is: "Stipite utrinque attenuato, gracili, circ. 6 cm. alto, 1–1½ cm. crasso, pallide luteo : parte clathrata ovata (in Gardneri icone), infra a stipite discreta : interstitiis parvis, rotundis : ramis luteis, subtenuibus. Ex icone non certe elucet, utrum receptaculi pars superior pileo ovato margine libero instructa sit, an, ut in *Simblo*, efformata sit e stipitis apice dilatato, cancellato, Quamobrem, dubium est an hæc species profecto g. *Simblo* sit inserenda." Fischer includes it under *S. periphragmoides*, which differs only in having the thickness of the stalk one half its length : Penzig (Ann. Buitenzorg, Ser. 2, I., p. 157) prefers to call it *S. periphragmoides* var. *gracile*, on account of the smaller relative diameter of the stalk, but this is a variable feature and is hardly sufficient to mark even a variety. *Simblum sphærocephalum*, Schlect., apparently differs only in being red.

The species was collected again by Thwaites in 1854, and two of his specimens, with paintings of them, are in the Peradeniya herbarium. Several examples have been gathered during the last two years, and in the number of occurrences it ranks next to *Dictyophora* in point of frequency at Peradeniya.

The volva is white or brownish, spherical or vertically elongated, 3–3½ cm. high, 2½–3½ cm. broad : it usually terminates below in a conical extension to which the white mycelium is attached. This projection occurs in most of my specimens, and is shown also in Penzig's figure. The total height of the fungus is 9–12 cms., and the diameter of the stalk varies from 1·2 to 3·4 cms. The stalk may be of uniform diameter throughout, or slightly swollen in the middle. It shows few perforations on the exterior. In some specimens it is longitudinally striate, owing to the radial walls of the chambers showing through the outer layers, as in *Colus Gardneri*. Its colour is pale yellow : when placed in alcohol it turns temporarily pink or reddish.

The structure of the stalk varies. In cross section there is an inner layer of large polygonal chambers up to 3 mm. in diameter : outside this there may be one, two, or three layers of much smaller chambers, which are often tangentially elongated. When there is only one layer of these small outer chambers and they are about 1 mm. broad, the radial walls of the larger chambers make the stalk appear striate. Penzig says that the wall of the stalk consists of two layers of *closed* chambers, of which the inner are larger than the outer. But the number of layers varies ; and in all my specimens the inner chambers are not closed. Two walls, the upper and lower, are wanting in each chamber, so that it might be said that the outer layer of small chambers is supported by radial struts from the membraneous inner wall of the stalk. As in *Colus Gardneri*, there are continuous cavities running the whole length of the stalk, though they do not keep the same straight line as in that species. Thus on looking at the cut end of the stalk one either sees down to the base, or else sees the sharp edge of another radial wall a few millimètres down the cavity : but the horizontal cross walls, if there ever were any, have disappeared in the expansion of the stalk.

The stalk merges into a netted head, 2½–3 cms. high, rounded above. The head may be of the same diameter as the stalk, or it may swell out to almost double the diameter. For example, fresh specimens have a stalk 1·2 cm. diam., head, 2 cm. diam.; stalk, 2·7 cm., head, 3·1 cm.; stalk, 2·2 cm., head, 2·2 cm.; stalk, 2·2 cm., head, 3 cm.; stalk, 1·5 cm., head, 2·5 cm. In probably the most usual case, the head is wider than the stalk, and forms a spherical or ovoid network at the top. The number of meshes varies in my specimens from 60 to 80: according to Penzig, Klotzsch's specimens of *S. periphragmoides* had 98 and 124 meshes, while his own recent examples had 64 and 66. The meshes are pentagonal or hexagonal, and from three to eight millimètres in diameter, measuring from keel to keel of the bars: they are usually very uniform in size, but in a few cases one mesh is double the size of the others, owing to the suppression of a bar. In one specimen photographed the lower meshes are large and the upper ones small, with an almost complete circle of elongated double meshes. This specimen is the most irregular I have met with. Specimens with two distinct stalks, but a single head, have been reported from South America. I have met with this abnormality once in Ceylon. It is scarcely necessary to point out that the fusion of the heads must take place within the volva, and that there can, therefore, be no partition between the eggs which form such twin specimens. I have had an undeveloped "twin" egg, but the two eggs which composed it were separated by a membraneous partition, and they developed two distinct stalks and heads. Lloyd, in recording a double specimen from Brazil, refers to Penzig's photographed specimens of *Dictyophora multicolor* as a similar instance, but these are really only two specimens placed side by side.

The ideal cross section of a bar has the shape of an isosceles triangle with the apex directed outwards: but the actual varies from this, and is more generally irregularly oval or lozenge-shaped. The bar is always sharply keeled on the outer edge, but it may be either flat or keeled on the inner surface. Owing to the persistent folding of the walls of the bars the sides are furrowed and the keel is wavy. The bars are hollow and the cavities are continuous, being in some cases continued also into those of the inner layer of the stalk. The lowest meshes, whose lower edge is part of the stalk, have a keeled edge all round them: so that although the head appears sharply defined, it really merges into the stalk below without a definite limit. The lowest meshes are sometimes destitute of gleba.

The gleba is suspended in the meshes of the head, and sometimes covers the inner surface of the net also. There is no special suspensory apparatus. When the fungus first expands, the head is covered by a fine white membrane, as in *Dictyophora* and *Colus*. The spores are oblong with rounded ends, 4–6 × 2 μ. The smell resembles that of sour paste, and is not offensive.

I have received specimens which came up through the earthen floor of a store-room, and others which grew in a nursery of *Hevea brasiliensis*.

Genus 7. *Colus*, Cav. et Sech.

Receptaculum cylindric, hollow, with a chambered wall, dividing above into a number of simple arms which unite again at the apex.

Colus Gardneri (Berk.), Ed. Fischer.

This species is only known from Ceylon specimens. It was collected at Peradeniya in 1835 by J. G. Watson, who left a coloured drawing of his specimen on record, but it was not described until 1847, when Berkeley named it *Lysurus Gardneri* from specimens forwarded by Gardner. Thwaites sent specimens and drawings (including a copy of Watson's) which were recorded by Berkeley and Broome in Jour. Linn. Soc., vol. 14 (1875), p. 78. Three specimens and three paintings of it are now in the Peradeniya herbarium. Berkeley's figure (Hooker's Lond. Jour., 1846), which is reproduced in Engler-Prantl., is apparently a copy of Gardner's drawing (not in our possession), and is not a good representation of the fungus.

Berkeley described it fairly completely as follows:— "Receptaculo elongato, stipitiformi 17–18 cm. alto: stipite longo (15 cm. alto) superne dilatato in partem clathratam apicem conicum receptaculi efformantem transeunte: partis clathratæ interstitiis 5, verticalibus, linearibus: ramis superne attenuatis, apice junctis, extus medio structura stipiti æqualibus, latere rugosis." Fischer states, "Receptaculum langgestielt, oben mit einer Reihe von 5 verticalem spaltförmigen Öffnungen, die durch eine entsprechende Zahl am Scheitel verbundener Arme getrennt sind. Bildet den Uebergang zu *Anthurus*."

I have found only two specimens of this species. The total height of the first is 12 cms.: the volva is oval, 3·5 cms. high and 2·5 cms. broad, white, somewhat tomentose; the stalk is white and hollow, 1·4 cm. diameter at the base, 1·2 cm. diameter near the top, where it divides into five equal arms which unite again at the apex. The arms are about 4 mm. diameter below and taper slightly up to the gleba-bearing part. The total length from the point of origin of the arms to the apex is 2·8 cm., and the sporiferous mass occupies the upper 2 cms., except at the extreme tip. The diameter of the head is 1·8 cm., the increase over the width of the stalk being due to a slight outward bending of the arms and the thickness of the plates which bear the gleba.

The cross section of the stalk shows that the wall consists of a single layer of large chambers, with occasionally a small chamber wedged in here and there at the periphery. These chambers are continuous throughout the greater part of the stalk, and their radial walls are discernible exteriorly as longitudinal striæ to the number of about sixteen. Practically then the stalk consists of sixteen parallel tubes arranged in a ring. There are no external perforations such as occur in the stalk of *Dictyophora.*

At varying distances within the upper three centimètres the wall between a pair of tubes vanishes, and so diminishes the number seen in cross section, until at the point of origin of the arms there are only ten tubes, two of which are continued into each arm.

The arms retain the structure of the stalk for a length of about a centimètre, and in this part are transversely wrinkled. The cross section of each is roughly oval and is bisected by the joint wall of the tubes which compose it. At the commencement of the sporiferous portion this septum vanishes, and the arm continues to the apex as a single tube. At the same time the cross section increases from three millimètres to six millimètres in diameter. This increase is produced by closely packed lamellæ which project horizontally from the arm over the whole of its surface, except along the median line on the exterior side. The gleba-bearing tissue thus covers the inner surface and side of the arm, but leaves free a narrow median furrow externally : and as the sides of adjacent arms are usually in contact these median furrows are more evident than the divisions between the arms. Watson's figure, and also Berkeley's (copied by Fischer), emphasize these furrows and omit the lines which distinguish the separate arms. The most evident line on the photograph is a median furrow. The furrow widens out above and below, and makes it appear at first sight as though the gleba were an additional thick oblong sheet with the corners rounded off, wrapped round each arm but not quite meeting exteriorly.

The sporiferous portion appears granular, like the head of *Dictyophora irpicina*, and it is somewhat wrinkled transversely. Slight magnification shows that the granular effect is produced by the plicate free ends of innumerable processes. In cross section these are seen to consist of numerous thin lamellæ which project from the thin wall of the central tube, except along the external median line. The wall of the tube is infolded beneath the furrow thus left, and the cavity is slightly reniform in section. These lamellæ arise usually from a narrow base and expand outwards. Most of them are divided or branched in the outer half, and the outer edge is usually plaited. The bases lie somewhat regularly in horizontal rows round the arm, and the lamellæ near the points of origin are entirely in the same horizontal plane, but towards the outer extremity a lamella may be irregularly folded or even bent round upon itself. In dissecting out a ring of lamellæ, these folds are more or less flattened out, and the whole appears as a frill round the central cavity of the arm. The lamellæ are only a few cells thick, except at the outer edge : here they become about twice as thick, and are darkened with the gleba, which penetrates between them. The structure is similar to that of *Dictyophora irpicina*, and as in that species the gleba is scanty. The herbarium specimens collected by Thwaites have the same structure. The gleba is absent from the upper three millimètres of the arms. The latter bear no lamellæ in this region, and diminish therefore to their original thickness. The infolding of the tube is continued along each arm up to the apex, and forms a shallow narrow furrow which joins those on the other arms. The apex may be pointed (Thwaites's figure), or obtuse as in the photograph : in the latter, two pairs of arms unite and the junctions are joined by a cross bar which the fifth arm meets laterally.

The gleba is at first covered by a fine membrane continuous over all the arms. This is homologous with the membrane which covers the head of *Dictyophora* and *Simblum* and underlies the gleba of *Aseroe* ; it vanishes at maturity, but becomes tough or persistent if the specimen is put in alcohol. The smell is rather like that of sour paste, and is not unpleasant. The spores are narrow oval or oblong, 4–5 × 1·5–2 μ. The volva turns bright yellow when placed in alcohol, but this colour soon vanishes.

A second fresh specimen is 9 cm. high and 2·5 cm. in diameter : the sporiferous arms are 1·5 cm. long. Owing to the greater diameter of the stalk the five arms are widely separated for the greater part of their length, and they form a rather abruptly tapering pyramid. Compared with the last specimen this is short and stumpy, and has no outward curve in the head. This variation—a short thick stalk with a head of the same or a smaller diameter, and a long narrow stalk with an enlarged head—is exactly paralleled in Ceylon specimens of *Simblum periphragmoides*.

Berkeley's figure shows a specimen about 18 cms. high. The stalk expands upwards uniformly, and, though the lines on the lower part correspond with the indications of the radial walls of the fresh specimens, the upper part is represented as consisting of polygonal, isodiametric cavities. The head is 2·5 cms. high, about the same diameter as the stalk, and the gaps between the lower (non-sporiferous) portions of the arms are only 7 mm. long. The white stem tissue is represented as continuous from one arm to the next beneath the gleba, and in this the figure gives quite an erroneous idea of the structure of the head. Apparently the specimen had five arms. It differs from my dried and recent specimens in the stalk expanding upwards and in the representation of the upper parts of the stalk in imitation of *Dictyophora.*

Watson's unpublished figure shows a specimen 15 cms. high. The volva is brown, with darker brown patches. The head is 2 cm. high, broader than the stalk, but the openings below it are only about 2 mm. long. The specimen had six arms, and these (in error ?) are represented as free, though in contact, at the rounded apex : at least this deduction appears to be warranted by the fact that six black lines meet at the apex. These black lines represent the spaces between the arms, and it is possible that the artist has carried them too far, or that the junction of the median furrows was obscured.

Another unpublished figure, drawn by W. de Alwis under the direction of Dr. Thwaites, shows a specimen 14 cm. high. The volva is white, with brownish yellow stains. The stalk thickens somewhat abruptly towards the apex, but it was evidently damaged in this part. Numerous perforations are figured all over the stalk. The head, which is 2 cms. high, is at first of the same diameter as the stalk, and tapers gradually to the top, and the gaps below it are about 4 mm. long. The arms unite in a point at the apex, and a separate figure giving an apical view shows that there were only four of them.

All the figures agree in making the gaps between the arms shorter than those of my specimens, and rounded instead of pointed below. The three herbarium specimens collected by Thwaites all show the longitudinal striæ indicative of the tube-structure of the stalk : each has five arms, the stalks are not perforated, and the gaps below the arms are comparatively long and narrow, as in my specimen. In the last respect they do not agree with the figures.

Fischer (Engler-Prantl, Pflanzenfamilien) says that *Colus Gardneri* shows transition to *Anthurus :* in the arrangement of the gleba on the inner face and sides of the arm it resembles *Anthurus* more than *Colus*, but it differs from the former in having the arms united at the apex. But although there may be a superficial resemblance to *Colus* in the dried specimens and figures, great differences are apparent when the head is examined in the fresh specimen. *Colus* has an external median groove on each arm, but this is formed by two thin wings which spring from the edge, and are continuous along the whole length of the arm : and in *Colus javanicus*, Penz., the inner side of the arm bears small groups of processes, which Penzig says are additional chambers with perforated walls : these latter bear the gleba. On the other hand, the median groove of *Colus Gardneri* is a gap in an otherwise continuous series of close-packed lamellæ which cover the arm everywhere else : the species differs in the structure of the arm, the gleba-bearing processes, and the stem, leaving nothing but the general appearance to justify its inclusion in the genus *Colus*. Following Fischer's classification according to the general shape of the receptaculum, the species must remain as *Colus*, but it would seem preferable that the structure of the gleba-bearing portion should be taken into account, and *Colus Gardneri* separated from such a totally different species as *Colus javanicus*. Neither *Colus javanicus* nor (apparently) *Colus Garciæ* belong to the " rugulosi."

When Fischer wrote his " Untersuchungen zur vergleichenden Entwicklungsgeschichte und Systematik der Phalloideen " in 1890 he had examined one of Berkeley's Ceylon specimens in the herbarium of the Paris Museum. He says that this example did not allow the arrangement of the dorsal median line and the apex to be clearly understood. In 1893 he writes : " In Berkeley's and the Kew Herbarium there are numerous examples of this fungus, all from Ceylon. I was able to determine with certainty on some of them that the arms are actually united at the top, though the junction is extraordinarily thin. But the possibility is not excluded that examples may occur in which the arms are free. Further, it is a characteristic of this species that the lowest part of the arm is non-sporiferous, and correspondingly not transversely wrinkled." The last phrase indicates that Fischer did not discover that the species belongs to the " rugulosi " section of Phalloids, for the transverse wrinkles which he refers to are the ends of the gleba-bearing plates : as our photograph shows, the lower parts of the arms are transversely wrinkled, though not in the sense intended by Fischer.

In 1900 Fischer refers to Massee's statement in Grevillea, XIX., p. 94 (which I have not seen), that the arms are free, and refers his readers to his views expressed in 1893.

Recently C. G. Lloyd has published an account of what is known of the Phalloids of Australasia. He gives copies of the figures of *Lysurus australensis* and *Mutinus pentagonus*, which show that in outward appearance these species closely resemble *Colus Gardneri*. This resemblance has been noted by him, and he expresses his views in the following terms:—" The early stages of *Lysurus* with the arms connivent have led to some very misleading pictures. Thus, Berkeley's original picture of *Lysurus Gardneri* so misled Professor Fischer that he transferred it to another genus, but after he visited Kew and saw that it misrepresented the plant he should have transferred it back. Our American species *Lysurus borealis* was named *Anthurus borealis*, but in my opinion is a *Lysurus*, and I think the same as the Ceylon species. It was originally illustrated with a drawing subject to the same criticism as the original drawing of *Lysurus Gardneri*." " *Lysurus Gardneri* of Ceylon, which was so named and described by Berkeley, is a true *Lysurus* with spreading arms, and not a ' *Colus*,' as found in Fischer's latest work. Fischer referred it to the genus *Colus* on the strength of Berkeley's figure, and he was justified, if one is ever justified in changing classification on the evidence of a figure. When Professor Fischer came to Kew, however, and saw the specimens, he should have receded from his position, for it is quite evident the plant is a *Lysurus*, and not a *Colus* in any sense of the word. The arms are entirely separate and spreading when mature. Like all species of *Lysurus*, they are connivent when young, but they are not joined at the apex, however slightly."

It may be pointed out in the first place that this does not represent Fischer's account correctly : the latter did not find the arms free. If the Kew specimens now have spreading arms, how is Fischer's statement to be interpreted ? Again, it seems strange that there should be numerous specimens at Kew, in view of the comparative rarity of the species at the present day. Consignments were sent to Berkeley by both Gardner and Thwaites. Gardner's specimens ought to be in the British Museum with the remainder of his herbarium, unless Berkeley retained all of them : and three of Thwaites's specimens are at Peradeniya.

At present we have at Peradeniya two recently collected specimens, three dried specimens collected by Thwaites and named by Berkeley, two drawings executed under Thwaites's supervision, one drawing by J. G. Watson (1835), and Berkeley's illustration of 1847. In all the specimens the arms are united at the apex, and the only suggestion that the arms are free is in the drawing by Watson, who certainly knew least about fungi of all who have seen *Colus Gardneri*. In the light of this, we must continue to consider the species *Colus*.

Is it certain that the Kew specimens are really the Ceylon fungus? How does it happen that Fischer saw the arms united, whereas they are now spreading? Assuming that these are Ceylon specimens, there are two possible explanations. The first explanation is that the specimens have been examined so often that they are now in damaged condition. The second more improbable is that there are two species in Ceylon, a *Lysurus* and a *Colus*, which resemble one another so closely that Berkeley, Thwaites, and Gardner could not distinguish them, dried or fresh. It cannot be maintained that one is the immature state of the other, for one of my specimens was found when just expanded, and the other when about to collapse, and, moreover, the structure of the apical connection negatives the idea.

Genus 8. *Aseroë*, La Bill.

Receptaculum consisting of a hollow cylindric stalk with a chambered wall, crowned above by a horizontal perforated disc, from the outer edge of which arise simple or longitudinally divided arms (disc absent in *A. arachnoidea*): gleba when ripe surrounding the mouth of the stalk.

1.—*Aseroë rubra*, La Billardière.

This species was described by Berkeley (Hooker's London Jour. Bot., 1847, p. 512) under the name *Aseroë zeylanica*, from specimens and figures sent by Gardner. Thwaites refers to it in his account of the Fungi of Ceylon (Jour. Linn. Soc., XIV.

(1875), p. 31) as *Aseroë actiniformis*, probably a mistake for *A. actinobola*, Corda. *A. zeylanica* is described as "mycelium and volva purple, receptaculum shortly stalked, reddish, with twenty vermilion arms obscurely arranged in pairs, which are separated by a rounded sinus: gleba surrounding the orifice of the stalk, purple-red." Various other "species" have been described, differing in colour and the number of arms, but all are included by Fischer under *A. rubra*.

Specimens were collected in Ceylon by Gardner and Thwaites; the latter states that it is usually met with at an elevation of about 5,000 feet, and it is sometimes rather common upon the ground under coffee trees. There is neither specimen nor figure in the herbarium. It is probably rarer at the present day, now that coffee has been replaced by tea, but it is still common enough to be known by "up-country" planters. Unfortunately it does not grow at Peradeniya, and I have therefore not been able to secure a photograph, or obtain a large series of specimens.

Fischer states (Untersuch. Phalloideen, 1890) that *Aseroë rubra zeylanica* differs from *A. rubra typica* in having the arms not only split to the base, but also separated by a rounded sinus: "die beiden Extreme, *A. rubra typica* and *A. rubra zeylanica* sind zwar ausserordentlich verschieden, allein die zwischen liegenden Formen verbunden sie so gut, das es unmöglich wäre, eine Speciestrennung vorzunehmen." Both forms occur in Ceylon, with all possible intermediate stages.

My finest specimens were gathered in Pundalu-oya, at 4,500 feet, late in the afternoon of a typical monsoon day. They grew among dead Grevillea leaves at the base of tea bush. Of three fully expanded specimens, one had the gleba still covering the opening of the stalk, the second had the gleba and disc partly eaten, while all trace of gleba had disappeared from the third.

These specimens measure 12 cms. from tip to tip of the arms, and are about 5 cms. high. The first point one notices is that the arms are rigid, not curled up at the extremity as in the usual figures of this species. The general outline of the arms and disc is concave or saucer-shaped. The colour, too, is not uniform, as the books would lead us to except: the part of the disc immediately surrounding the opening of the stalk. *i.e.*, the part covered by the gleba, is deep red, and sharply defined from the remainder of the disc, which with the arms is deep pink : the stalk shades off to white at the base. Schlechtendal (De Aseroës) records this difference in the colour of the disc, styling the centre " kermesinus," and the other parts " carneæ." The gleba is purple, and is at first continuous over the opening of the stalk, being supported by a thin membrane, but when this membrane disappears, the gleba retracts and surrounds the opening : it does not cover the arms.

The volva is somewhat pear-shaped, rounded above, about 3 cms. high and 2·5 cms. in diameter at the top : it is white below and blackish above. The wall of the volva is thick, and its inner surface is marked with white, slightly thickened bands, radiating from the base and broadening upwards. When the specimen has seventeen or eighteen arms, there are nine such bands ; if it has sixteen arms, there are only eight bands.

The stalk is about 4 cms. high, hollow, 1·5 cm. diam. at the base, expanding to 2 cms. diam. just below the disc where the wall curves outwards to the arms. The wall is composed of two layers of chambers with their horizontal walls partly absorbed : these chambers are arranged in vertical rows as in *Colus Gardneri*, so that the stalk appears longitudinally striate, at least when old. The outer chambers are much smaller than the inner : in a cross section of the stalk there are about three outer chambers to each inner chamber. The inner surface of the tube is practically vertical : there is a narrow horizontal projecting ledge at the upper edge.

The chambers beneath the central portions of the disc are much larger than elsewhere. There is a single ring of large chambers, which may be regarded as the continuation of the inner layer of the stalk : the inner walls, *i.e.*, towards the central tube, of these chambers are usually perforated. The outer layer of the stalk is continued under the disc for a breadth of about two chambers. Between these and the large chambers there is an extra ring of chambers which is not represented in the stalk. The disc here is three chambers in thickness. Midway to the periphery, the thickness is reduced to two chambers, which are more polyhedral than those of the stalk. This structure is continued into the arms, but between the arms the disc is reduced to one chamber in thickness.

In large specimens the disc is about 5 cms. diam., slightly concave. The mouth of the stalk is 6–8 mm. diam. ; its outline is not exactly circular, but broken by small horizontal projecting teeth, one opposite every alternate division of the arms : there are either eight or nine such teeth in my specimens. Round this opening is a circular patch, about 2·5 cms. diam., deep red, with an irregularly toothed margin. This deeply coloured area is covered with low, thin, wavy ridges, which are arranged more or less in stars in the outer half, and converge towards the projecting teeth of the mouth of the stalk in the inner. The upper wall of the disc is slightly thickened over this area. Elsewhere the disc is deep pink and slightly radially corrugated. The purple gleba is confined to this deep red area ; at first it is continuous over the opening, but afterwards retracts, and forms a ring round it ; it does not extend to the arms. These points were noted in Schlechtendal's original description of *Aseroë Junghuhnii.* He says, "Stipitis orificium latius quam in aliis speciebus esse videtur, margine varie lobato cingitur, et limbi regio contermina, in qua sporarum massa conglobata et quasi coagulata deposita est, rugis bullosis innatas cristulas humiles laxe reticulatas offert, procul dubio membranæ sporophoræ S. hymenii residua."

The arms of these three large specimens are about 4 cms. long. One has seventeen, and the other two have eighteen each. There is no indication of an arrangement in pairs, but Mr. E. E. Green informs me that he has frequently seen this species in the same district with paired arms, and with arms split for half their length. The arms are separated by a rounded sinus : they are about 5 mm. broad at the base and taper gradually to the tip. They are quite smooth, rounded on the upper side and flattened below. The cross section is semi-elliptical with the flat side downwards. A cross section through the middle of an arm shows about eight chambers arranged in a single ring : the number diminishes to the tip, which is one-chambered.

The spores are hyaline, oblong, 6–10 × 1·5–2 μ.

A smaller specimen gathered by Mr. J. F. Jowitt, at Craig, Bandarawela (5,600 feet), agrees with the former in general details, but has only sixteen arms, which are obscurely arranged in pairs, *i.e.*, each second division between the arms is slightly shorter than the intermediate divisions.

The smell is extremely fœtid, but in my specimens, which I have gathered during heavy rains, it was not perceptible at a short distance, not until the specimens were held in the hand. But Mr. Green informs me that when entering a plantation he has detected it by its odour. Junghuhn says (Schlecht., de Aseroës), "Geruch des ganzen Pilzes ist schwach aber eher angenehm als widrig." The current opinion in Ceylon is decidedly to the contrary.

Berkeley's figure of *Aseroë rubra* shows perforations in the disc opposite each pair of arms. No such perforations occur in any of my Ceylon specimens.

The immature fungus removed from the volva consists of a short somewhat conical stalk and a spherical head. The lower third of this head is formed by the disc and the remainder by the closely packed arms. The arms do not meet in a point at the top, but fold over one another in a most complicated fashion, as shown in the drawing. The ends are not visible. A longitudinal section shows that the upper part of the head is hollow, the trama plates of the gleba are confined to the region immediately above the mouth of the stalk, and the arms are continued into the head, twisted together as far as the gleba. In younger specimens, when the egg is solid, the infolded arms fill the upper third and the gleba the lower two thirds of the central space, the interstices between the central mass of arms and the exterior being filled with transparent jelly.

Schlechtendal's figure of the longitudinal section shows the outer circumference formed by the arms, and a central tube extending from the stalk to the apex: the remaining space is completely filled by the gleba (?). It is no doubt intended to show the infolding of the arms, but it is incorrect in representing them as passing through the gleba.

2.—*Aseroë arachnoidea*, Ed. Fischer.

This species is said by Fischer to differ from *A. rubra*, La Bill., in that its arms are one-chambered, and are produced into a long flagellum. The flagellum is certainly not as long as in some examples of *A. rubra*. Penzig, who found it fairly common in Java, says that it differs from the numerous forms of *rubra* in its white colour, and its one-chambered, less numerous arms, which are not arranged in pairs. As *Aseroë rubra forma zeylanica* usually has the arms not arranged in pairs, the last point of distinction is invalid. The chief differences between the two species appear to be (1) the colour, (2) the structure of the arm, and (3) the arrangement of the arms in the egg. The arm of *A. arachnoidea* is one-chambered and has two longitudinal ridges, united by cross ridges, on the ventral surface, and often a longitudinal furrow on the dorsal surface: the arm of *A. rubra* is composed of many chambers and is smooth externally. In the egg the arms of *A. arachnoidea* are closely applied to, but do not hide the gleba, and meet in a point at the upper pole, while the arms of *A. rubra* hide the gleba completely and are prolonged down the middle of the egg, twisted into a column as previously described.

I have only met with this species once. The specimens had been torn up by the reaper when cutting grass at Peradeniya, and they were considered at the time too damaged to photograph. Three eggs were united in a cluster by the fusion of the volvæ. The volva is spherical and white.

The only expanded specimen was 3 cms. high with an almost uniform stalk, 1 cm. diameter. The wall of the stalk consists of two layers of chambers, the inner of which are much larger than the outer, as in *Simblum periphragmoides*, and, as in the latter species, the inner chambers form, in some parts, continuous tubes extending into the arms. The wall of the stalk bends out horizontally at the top for a distance of about 3 mm., and then divides into narrow arms about 1·5 cm. long, tapering to the apex. My three specimens have 11, 12, and 13 arms respectively. Penzig says that the number of arms varies from seven to thirteen, but that the commonest number is nine.

There is practically no disc in fully matured specimens. The upper end of the stalk is at first closed by a thin membrane as in *Dictyophora ;* this membrane becomes tough in alcohol, and then appears to be a permanent covering, but, presumably, it vanishes soon after the receptaculum has expanded, and leaves the black gleba adhering to the bases of the arms. Before this happens the disc viewed from above looks like that of a sea anemone: in the centre is a small clear circular area with a crenate border: from the indentations of this border white lines extend through the black gleba towards the junctions of the arms, while the whole is fringed by the long white arms. The white lines are slight thickenings of the evanescent membrane, one between each pair of arms.

The upper (ventral) surface of an arm bears two thin longitudinal wings, often connected here and there by netted folds between them. A single cavity extends the whole length of an arm, and the cavities of adjacent arms may be continuous or distinct, even on the same specimen: there is a cross wall between each pair of arms, but it is sometimes perforated.

Unexpanded specimens when removed from the volva have a short conical stalk surmounted by a somewhat flattened spherical head. The head consists of the black gleba enclosed in a meridional series of white arms. The arms are closely applied to the gleba throughout their whole length, but they do not hide it completely. They meet in a point at the upper pole, and in the last few millimètres are regularly wavy.

This species has been beautifully illustrated by Penzig, and my specimens match his figures so exactly that drawings of them would be merely duplicates.

ADDENDA.

Whilst the foregoing account was in the Press, the following additions to our knowledge of Ceylon Phalloids have been made :—

A red *Phallus*, most probably Thwaites's "new species of *Phallus* of a deep red colour," has been found at Hakgala (5,800 feet): it is closely allied to, probably identical with, *Mutinus Fleischeri*, Penzig. From the same locality was also obtained *Ithyphallus tenuis*, Ed. Fischer, differing from the original description in having pure white stalks: and a species of *Protubera*, apparently new, has been found at Nuwara Eliya (6,200 feet).

Further collections of *Aseroë* show that the disc of this species is subject to considerable variation in the part which bears the gleba. Fig. 12 was drawn from a specimen of *Aseroë rubra typica*. Recent specimens of *Aseroë rubra zeylanica* have a more elaborate structure ; and the examples of *Aseroë* at present available seem to indicate that the difference in the structure of the disc is correlated with the difference in the arrangement of the arms.

EXPLANATION OF PLATES.

Pl. 7. *Dictyophora phalloidea* × ⅔. A white specimen, developed from the egg under a bell glass. Net still rigid, and gleba intact.

Pl. 8. *Dictyophora phalloidea* × ½. Specimen with a white net, which forms a continuous plate on one side. This plate was pink. Gleba partly disappeared from the cap, which shows the normal arrangement of the bars.

Pl. 9. *Dictyophora irpicina* × ⅔. A well-developed specimen. Cap slightly compressed. Part of the volva jelly adheres to the cap on the left side.

Pl. 10. *Dictyophora irpicina* × ½. On the left a specimen with the cap undeveloped on one side, and a rudimentary net. The two middle specimens have the cap compressed, and the net partly collapsed : the rigid bars at the top of the net prevent the collapse of this part. On the right a specimen with fully developed cap and a fragmentary net, which is united to the stalk on the right.

Pl. 11A. *Dictyophora phalloidea* (?) × ¾. Specimens with the net whitish and somewhat translucent (when fresh), and a bright orange-yellow cap. The outer specimens show the deeper bars of the cap just appearing through the gleba. The gleba has disappeared from the middle specimen, which shows a second set of less elevated bars within the meshes visible on the two outer specimens.

Pl. 11B. *Simblum periphragmoides* × ⅔. Specimen on the right with gleba removed, showing (abnormally) large meshes below and small meshes above, with a ring of double meshes near the apex. The specimen on the left has not developed normally : part of the volva remains on the head, and the stalk is damaged on one side : the bars of the net are covered with fragments of the white evanescent membrane, and therefore appear broad.

Pl. 12A. *Jansia proxima* × ¾. Growing on decaying palm frond. Stalk translucent, yellowish, reddish above. Head deep red.

Pl. 12B. *Simblum periphragmoides* × ⅔. Specimen with gleba intact.

Pl. 13A. *Clathrella delicata.* Nat. size. Expanded specimen, mycelium, and " eggs," on decaying sticks.

Pl. 13B. Egg of *Clathrus crispatus.* Nat. size.

Pl. 14. *Colus Gardneri.* Nat. size. Specimen with five arms, which are united at the apex.

Pl. 15. Section of the "egg" of *Aseroë rubra.* Nat. size. Showing the infolded arms extending to the gleba.

Pl. 16. Fig. 1. Copy of Thwaites's figure which was named *Phallus proximus* by Berkeley and Broome.

Fig. 2. Cross section through the cap of *Dictyophora irpicina* taken about the middle × 20. The parenchymatous tissue is unshaded : the gleba is shown in black.

Fig. 3. Longitudinal sections through the cap of *Dictyophora phalloidea*, showing the variation in the attachment to the stalk. Diagrammatic.

Figs. 4, 5. *Clathrella delicata.* Nat. size. Specimens removed from the volva, showing the variation in the length of the stalk.

Fig. 6. Cross section of an arm of *Clathrella delicata* × 8. Outer surface winged, inner surface rounded.

Fig. 7. Arms of *Clathrella delicata* × 8. Outer surface.

Fig. 8. Arms of *Clathrella delicata* × 8. Inner surface, with triangular masses of spores at the nodes.

Fig. 9. Arms of *Clathrella delicata* × 16. Side view, showing the spore-bearing cup, which results from the perforation of the wall of the superficial chamber at the node.

Fig. 10. *Aseroë rubra.* Nat. size. Unexpanded specimen, removed from the volva. Viewed from above. Showing the infolding of the arms.

Fig. 11. *Aseroë rubra.* Specimen of fig. 10 viewed laterally.

Fig. 12 Part of the disc of *Aseroë rubra*, showing the ridges on the deep red area surrounding the mouth of the stalk, and the projecting teeth. Nat. size.

Fig. 13. Longitudinal section through the disc and stalk of *Aseroë rubra*, between a pair of arms. Nat. size.

Figs. 14, 15. Cross sections through arms of *Aseroë rubra.* × 4.

Pl. 17. Figs. 16, 17. Copies of Thwaites's figures, named *Simblum gracile* by Berkeley and Broome. Nat. size.

Fig. 18. *Colus Gardneri.* Copy of Thwaites's figure named *Lysurus Gardneri* by Berkeley and Broome. It is exceptional in having a pointed apex. The specimen had four arms only. Nat. size.

Fig. 19. An arm of *Colus Gardneri.* Nat. size.

Fig. 20. Cross section of the stalk of *Colus Gardneri.* Nat. size.

Fig. 21. Cross section through the head of *Colus Gardneri.* Nat. size.

Fig. 22. Cross section through the arms of *Colus Gardneri*, below the gleba-bearing part. Nat. size.

Fig. 23. Head of *Colus Gardneri*, viewed from above, showing the junction of the arms. Nat. size.

Fig. 24. Cross section through an arm of *Colus Gardneri*, showing the gleba-bearing processes. × 4.

DICTYOPHORA PHALLOIDEA X 2/3

DICTYOPHORA PHALLOIDEA X 1/2

DICTYOPHORA IRPICINA X 2/3

DICTYOPHORA IRPICINA X 1/2

DICTYOPHORA PHALLOIDEA X 3/4

SIMBLUM PERIPHRAGMOIDES X 2/3

JANSIA PROXIMA X 3/4

SIMBLUM PERIPHRAGMOIDES X 2/3

CLATHRELLA DELICATA Nat. Sire

CLATHRUS CRISPATUS Nat. Sire

COLUS GARDNERI Nat. Sire

ASEROE RUBRA Nat. Sire

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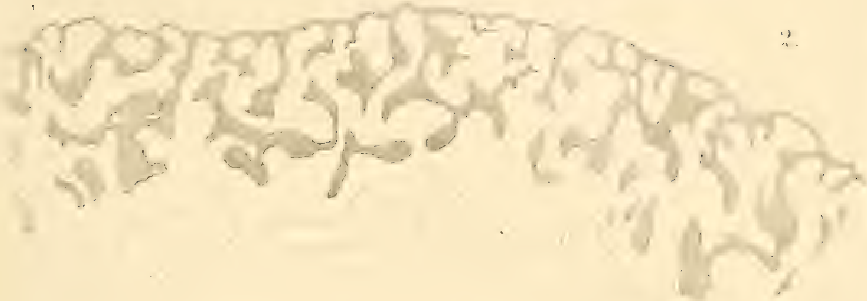

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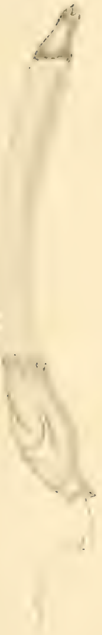

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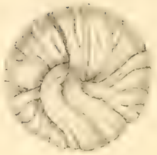

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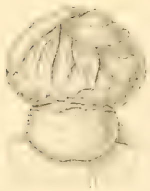

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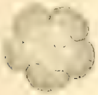

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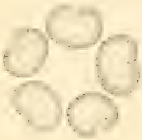

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Lith. Anst v E. A Funke, Leipzig

Note on Dr. Otto Stapf's Nomenclature of Cymbopogon Nardus, Rendle, and C. confertiflorus, Stapf.

BY

J. F. JOWITT, B.A. Oxon.

STUDENTS of oil grasses are, I take it, much indebted to Dr. Otto Stapf for the information afforded in "The Oil Grasses of India and Ceylon," Kew Bulletin, No. 8 of 1906. In the face of the dicta of such an authority as Dr. Otto Stapf, I approach this subject with the greatest diffidence, but venture the following remarks, as I have been studying oil grasses for the last four years, growing them and distilling oil therefrom.

My difficulty is as regards *Cymbopogon nardus*, Rendle, and *C. confertiflorus*, Stapf.

Dr. Stapf under *Cymbopogon nardus*, Rendle, refers the reader for descriptions to Hackel, Androp., pages 601 and 602 (subsp. genuinus), and to Hook. f. in Trimen, Fl. Ceyl., vol. V., p. 242. The former I have not seen, but with the latter I am well acquainted.

Sir J. D. Hooker refers to C. P. 2,733, and states that it is the mana grass of the patanas, and on this specimen presumably his description was mainly based.

Dr. Willis kindly allowed me to examine C. P. 2,733. In a pocket attached to this specimen, also numbered 2,733, is a beautifully dissected spikelet which I should, from the description in Fl. B. Ind., pronounce to be *A. nardus*, var. *nilagiricus*, Hack ; this is an awned spikelet. The spikelet I dissected was awnless, which bears out my contention that in this species the presence or absence of an awn alone is of but little taxonomic value.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part IV., Dec., 1908.]

Sir J. D. Hooker's description of *A. nardus*, L., covers all the varieties of mana grass growing wild on the patanas in this neighbourhood, and the only point I can take exception to is Glume 1 ......" obscurely veined."

In many varieties Glume 1 is often strongly veined, veins in the flexures well defined, and the intermediate veins numbering 3–5; this venation occurs in varieties with light coloured inflorescences.

From the context and the footnote on page 243, this description includes the cultivated form, but in my opinion it does not embrace Maha-pangiri.

Regarding *C. confertiflorus*, Stapf, Dr. Stapf refers one to Steud. Syn. Pl. Glum, vol. I. (1885), page 384, Hook, f., Fl. Br. Ind., vol. VII., p. 206 (under *A. nardus*, var. *nilagiricus*).

I have consulted this latter authority, and the description tallies with many varieties of wild mana. Sir J. D. Hooker states that his description of *A. nardus*, L., is the var. *nilagiricus* of Hackel, the wild mana of the patanas, whereas Dr. Stapf refers one to this description as being one of *C. nardus*, Rendle, and states " only known in cultivation."

Dr. Stapf in his key gives—

All the spikelets awnless ..	*C. nardus.*
Sessile spikelets awned ..	*C. confertiflorus.*

Sir J. D. Hooker says, IV......." awned or not between the acute lobes," and this is the case in varieties of wild mana examined by me, and in the same inflorescence I have found Gl. IV. of sessile spikelet, long-awned, short-awned, and awnless.

Dr. Stapf refers to " a suite of excellent specimens of the cultivated awnless *C. nardus* from Mr. Jowitt's estate at Bandarawela, and sent with them at the same time and from the same locality, and numbered concurrently with the first, is another set which is undoubtedly '*Andropogon nardus*, var. *nilagiricus*,' whether they grew wild on the estate or were cultivated is not stated."

These specimens were originally sent to Mr. C. A. Barber, Madras. In covering letter I wrote, " the specimens were all collected on Craig estate, Bandarawela, elevation 4,800 ft. to 5,000 ft., on November 5, 1904."

I can assure Dr. Stapf that the whole ten specimens were growing wild, and I regret that I did not state on the labels that they were wild, as I did not consider it necessary to do so.

Dr. Stapf includes under *C. nardus*, Rendle, Nos. 2,383 to 2,386, 2,388, 2,389, and under *C. confertiflorus*, Stapf, Nos. 2,384, 2,387, 2,390, 2,391. These numbers I maintain represent varieties of what is known in Ceylon as mana, and come under either *A. nardus*, proper, *A. nardus*, var. *nilagiricus*, Hack., or var. *luridus*, Hook., f., Fl. B. Ind. It may be that it is possible to recognize two species of mana, an awned and an awnless one, but neither of them includes Maha-pangiri.

I did not keep duplicates of these specimens, but before despatching them I examined each one, and drew out a schedule under Nos. 1 to 10, noting down differences in leaves, Haulm, Glumes I. and IV. ; this schedule I append.

If, as is probable, Mr. Barber gave them numbers corresponding in sequence to my numbers, Dr. Stapf has grouped those with sessile spikelets "awned" as *C. confertiflorus*, and those with awnless, Gl. IV., under *C. nardus*.

2,383 and 2,385 should have short awns, and on 2,384 I found long and short awns and none.

I am somewhat sceptical as to whether *Andropogon nardus*, var. *nilagiricus*, Hack., is the mother plant of Maha-pangiri. Seeing that "Hermann's specimen agrees absolutely with the ordinary citronella as it is at present cultivated in the south of Ceylon," I cannot reconcile the fact of Dr. Stapf having included 2,383 to 2,386, 2,388, 2,389 of my suite under *C. nardus*, Rendle, for they are but specimens of the wild mana.

Why should not Maha-pangiri have been a distinct species in Hermann's time, 1672–1677 ?

The Messrs. Winter have cultivated it since 1839, and the specimens that Mr. Winter kindly sent me from the south of the Island entirely agree with those grown at 4,500 ft. Lena-batu-pangiri, I hazard an opinion, may be a hybrid from Maha-pangiri and mana. If Maha-pangiri and Lena-batu-pangiri have descended from *A. nardus*, var. *nilagiricus*, Hack., whence have the two derived the valuable properties of their oils, which do not exist in mana ?

Dr. Stapf for description of *C. nardus*, Rendle, refers one to Hook., f., in Trimen, Fl. Ceyl., vol. V., p. 242. I maintain that any one turning this up for the purpose of identifying Maha-pangiri would find a stumbling block in his way, as I have found to my cost. Hook., f., refers to Herm. Mus. 26. Is this Hermann's specimen that Dr. Stapf refers to as the foundation of *C. nardus*, Rendle, " only known in cultivation," and if so, why does Sir J. D. Hooker refer to it, and then describe wild mana ?

Is it possible that Hermann's specimen does not represent " Old Citronella " or " Winter's Grass," but some variety of mana, cultivated by the Dutch ?

I annex descriptions of wild mana and Maha-pangiri, retaining Dr. Stapf's nomenclature, but can but consider that " Maha-pangiri " is worthy of specific rank as *Cymbopogon Winterianus.*

Cymbopogon Confertiflorus, Stapf, Syn. *Andropogon nardus*, L., var. *nilagiricus* of Hackel.

Mana S., Mana-pillu T., Mana Sanskrit—thatching

This grass is most variable.

Roots, either fibrous from a thickened base or from a strong, thick candex, marked with circular cicatrices.

Stem, this may be either yellow or reddish pink, a single stem or more of the latter being often found on a plant on which the majority of the other stems are yellow.

Leaf sheaths, these may also be green or tinged with red to a greater or less degree—ventral surface reddish pink, except in one variety.

Leaves, these may vary considerably in length, and in width from one inch or more to quarter inch, and be flat or sub-conduplicate. The mid-rib may be broad or conspicuously white, this as a rule when stems and sheaths are yellow, or the colour of the mid-rib may be only slightly or scarcely paler than the blade. The colour varies considerably, some leaves being conspicuously glaucous on both surfaces ; of others the upper surface is a dull green and the lower glaucous, or both surfaces may be dull yellowish-green.

Ligule, this appears to be constant in all varieties.

Panicle, very variable, effuse, correlated with white stems, broad leaves, light coloured strongly veined Glume I. of sessile spikelet; contracted, correlated with red stems, narrower leaves, and obscurely veined reddish brown Glume I.

Spikelets, variation occurs only, according to my observations, in Glumes I. and IV. of sessile spikelet.

In Glume I. variation is noticeable, more especially in venation, wings, colour of the Glume.

In Glume IV. in presence or absence of an awn.

Venation, veins in flexures well defined, with intermediate ones 3 to 5, these in yellow-green glumes.

Wings very broad, moderately so or 0.

Colour varies from yellowish green through varying degrees of reddish brown.

Glume IV., awn long, short, or 0, and I have found all three variations in spikelets of the same panicle.

Cymbopogon Nardus, Rendle, Syn., *Andropogon Nardus*, L., Subsp. *Genuinus*, Hackel. Yielding citronella oil—known in Ceylon as Maha-pangiri, S., " Maha " signifying " large " and " pangiri " the vapour of the essential oil that is forced from orange or lemon peel when squeezed.

The following description of Maha-pangiri is written from specimens grown on Craig, Bandarawela, at 4,500 ft., compared with inflorescences kindly sent me by A. W. Winter, Esq., of Pillagodda Valley, Baddegama; this is the true " Old Citronella Grass " or " Winter's Grass."

A tufted perennial, tufts composed of plants connected by their roots.

Roots fibrous from the thickened bases of the stems. The root system is superficial, and old bushes push themselves out of the ground, so that there are often four or five inches of leafless caudex above the ground surface.

Stems.—Seven feet or more, leafy, stout, erect, smooth, polished, or more or less tinged with red, nodes tumid, glabrous, lower internodes terete, upper grooved for the pedicels of the panicles.

Leaves erect for about a third, then drooping for about two-thirds of their length, linear, very long at low elevations, 30 to 40 in., tapering to a fine membraneous point and from the middle, which is ½ to ⅝ inch wide, to a narrow base, in flowering stems decreasing in length upwards, but generally with broader bases and larger auricles, coriaceous, surfaces smooth, margins softly serrate, yellow-green above, in young plants bright green, glaucous beneath, mid-rib depressed above, well defined, paler than the rest of the blade, but not conspicuously white, except occasionally in floral leaves, prominent beneath—mid-rib dries white.

Sheaths much shorter than the internodes, smooth, shiny, many, and closely veined, light yellowish green or tinged with purplish red, auricle the thickened tinged base of the leaf, ligule short, or somewhat ovate dorsally, ventral margins produced into irregularly obtuse auricles, scarious, often lacerate, ciliate.

Panicle leafy, erect when young, afterwards drooping, zigzag, elongate, interrupted, effuse, very many flowered, villously ciliate.

Spikes on the branches of a slender pedicel or on those of fascicled unequal pedicels, springing from the nodes of the stem, with chaffy bracts at their bases, stem channelled for their reception, protected by the sheath of a leafy bract.

Bracts and chaffy bracteoles at the base of all the pedicels, upper portion of pedicel ciliate, bracts lanceolate, acuminate, glabrous, coriaceous, many veined, margins of sheathing petioles membraneous, of blades serrulate.

Spikes binate, unequal, at first erect, afterwards deflexed, a longer shortly pedicelled arm and a shorter sub-sessile one.

Spikelets in pairs, a sessile bisexual and a pedicelled male, 3 to 4 on each arm, on both, the terminal pedicelled spikelets are binate. The pair of homogamous spikelets at the base of the sub-sessile arm are male.

Internodes and pedicels of upper spikelets villously ciliate.

Sessile Spikelet.—5 to 6 mm. long, ovate oblong, acute, callus bearded. Glume I., flat, softly coriaceous, acuminate, often obliquely so, occasionally bifid, margins inflexed, scaberulous, wings none or obscure, green or slightly coloured, intermediate veins 3 to 5. II. as long as I., translucently coriaceous, 1 veined, vein excurrent, merely a trace of a wing on the keel, the upper portion of which is minutely toothed.

III. as long as I., hyaline, ciliate, mucronate.

IV. shorter than II.—III., hyaline, ciliate, entire, acute or mucronate, occasionally a hardened excurrent vein runs from the base. Palea when present, small oblate with ciliate arms. Lodicules cuneate, toothed.

Pedicelled Spikelet.—I., II., III., as in sessile, though narrower—IV. absent, though often the palea is present, or IV. is present as in sessile, but not mucronate.

Grain not seen.

An attempt to collect seed failed owing to the muslin bags being stolen; the attempt has failed a second time owing to insect pests.

Dr. Stapf and Mr. Wright are of the opinion, I believe, that the pistil does not mature—stigmas and ovary in many young spikelets appear perfect, and anthers that have dehisced are come across in course of dissection.

Distinguishing Characteristics.

	"Maha-pangiri."	"Lena-batu."	"Mana."
Root system	Superficial	Deep-rooted	Deep-rooted
Stems	Tall	Dwarfed	Tall
	Arising from crown at an acute angle	Erect	Erect
Sterile shoot	Cream coloured in section	Red	Red
Leaves	Drooping for $\frac{2}{3}$ length	$\frac{1}{3}$ length	$\frac{1}{3}$ length
	Light green	Darker green	Every shade
	Smooth to touch	Rough	Generally very rough
Panicle	Effuse, spikelets green, many, crowded, villous	Open, very zig-zag, spikelets scattered, villous	Varies
Sessile-pedicelled, spikelets in colour and venation	Usually similar	Usually similar	Dissimilar
Glume I.	Wingless	Wingless or slightly winged	Winged or wingless

	"Maha-pangiri."	"Lena-batu."	"Mana."
Glume II. ..	Mucronate, keel obscure	Mucronate, slight keel	Well developed keel, acuminate but no mucro
Glume III. ..	Hyaline, ciliate, acuminate or with mucro	As in Maha-pangiri	Not mucronate
Glume IV. ..	Entire acute or mucronate	Entire or microscopically bifid	Bifid with well developed acute or linear lobes

Even × 20 I cannot find that Glume IV. in "Maha-pangiri" is ever bifid; the blades of the glume form a margin to the mucro or short awn, which is exerted beyond them.

In "Lena-batu," the rib of the glume stops short with the blades of the glume extended beyond it, or if there is a short awn, the minute lobes are only distinguishable under a lens.

In "Mana" in both awned and awnless varieties Glume IV. is deeply bifid, lobes acute or subulate.

Crushed leaves of all three are distinguishable by their scent.

JOHN F. JOWITT.

October 5, 1908.

A. Nardus, Nilagiricus, Hackel, and Varieties.

No.	Leaves.	Haulm.	Glume I.				Glume IV.		Subsequently added, Dr. Stapf.
			Veins in flexures.	Inter-mediates.	Wings.	Colour.			
1	Glaucous	Slightly red	Strong	Obscure	Hardly	Red	Awn long	Var. nilagiricus	2382, C. C.
2	Very glaucous	White and red in the same plant	Faint	Obscure	Hardly any	Tinged with red	Awn short	do.	2383, C. N.
3	Glaucous	Fairly red	Obscurely	Faint veins when flexure vein is strong	Broad	Red	Awn long, short, or 0	Var. luridus	2384, C. N.
4	Broad, glaucous	Slightly tinged red	Obscurely on red, distinct in yellow green glumes	Faint	Moderate	—	Awn short	Var. nilagiricus	2385, C. N.
5	Glaucous, broad	Red	Strong	Obscure	Strongly	Red	Awnless	Var luridus in Gl. I, single pit	2386, C. N.
6	Do.	Yellow or pale	Strong	Absent or obscure	Hardly	Red	Long awned	Two pits with transverse ridges, var. nilagiricus	2387, C. C.
7	Glaucous, mid-rib white above	Merely tinged with red	Absent or	obscure	Hardly	Red	Awnless	Var. nilagiricus	2388, C. N.
8	Fairly broad, yellow green above with white mid-rib, glaucous beneath	Yellow	Visible	in both	Moderately	Tinged or yellow green	Awnless	Indented with pits, var. nilagiricus	2389, C. N.
9	Narrow	Tinged	Faint with	1 lateral	Hardly	Tinged	Awned	Approaches var. luridus	2390, C. C.
10	Do.	Red	Obscure	Obscure	Hardly	Red	Awned	do.	2391, C. C.

Copied from rough schedule drawn out in November, 1904.

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EDITED BY

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CONTENTS.

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A Preliminary Survey of Species Crosses in the Genus Nicotiana from the Mendelian Standpoint.

BY

R. H. LOCK, M.A.,

Fellow of Gonville and Caius College, Cambridge.

CONTENTS.

1.—*INTRODUCTION.*

THE original crosses from which the plants described in the present paper originated were carried out at Cambridge in the summer of 1906. The first generation of hybrids (F 1 plants) was also grown at Cambridge in 1907. The seeds of such of these plants as produced any accompanied the

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writer to Ceylon at the beginning of 1908; and the F 2 generation was raised at the Peradeniya Botanic Gardens from this seed.

Most of the more important families, which should have formed the third generation of hybrids, have failed to germinate; and, as it is doubtful how soon the experiments can be repeated, it was thought desirable to publish a brief sketch of the results so far obtained. No one is likely to be more conscious than the writer of the incompleteness of these results, but it is hoped that the experience gained so far will be of use to other workers.

The object with which these experiments were begun was in order to throw light, if possible, upon the question whether characters are to be found among plants of such a kind that their inheritance cannot be brought into line with the results of Mendelian investigation. This is a subject which has recently come in for a good deal of discussion. It has been suggested in several quarters that the Mendelian phenomena are confined to cases of crossing between types which owe their origin to the effects of cultivation.* One critic has even gone so far as to describe the Mendelian rules as representing pathological phenomena confined to the unnatural forms produced by man's interference with certain types of life. The behaviour, it is asserted, of true natural species, when crossed together, is entirely different.

Those who claim in this way that a difference in kind exists between variety crosses and species hybrids rely chiefly upon the authority of de Vries; and they frequently forget that the distinction drawn by de Vries was not between individuals as units, but between different kinds of unit characters. De Vries in fact maintains that two types may differ from one another by segregating (Mendelian) characters, or by non-segregating characters, or by both. On the other hand, a considerable number of students of heredity, impressed by the steadily increasing number of cases in which all kinds of characters can be shown to conform to the Mendelian rules, await a more certain proof of the existence of true blended

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* Although it has not been satisfactorily shown that simple cultivation can cause the origin of anything new.

inheritance before they are prepared to accept de Vries' assertion.*

Now the statistical behaviour of the offspring of species crosses is a subject upon which practically nothing is known. Gærtner and others have recorded the observation that in a certain number of instances the hybrid form breeds true in the second and third generations. But this proves nothing, since it is well known that, even in cases where complete segregation takes place, the new combinations which may arise between the different characters concerned breed true in a definite proportion of the plants which exhibit them, so that, in the absence of large numbers of individuals, no definite conclusion could be drawn from such an observation. It is in fact impossible to prove the absence of segregation in cases where the first hybrid generation is markedly sterile, with the result that only a small proportion of the germs give rise to mature offspring, because it is always possible to suppose that the power of development is coupled with the particular combination of characters shown by the original hybrid—a combination which we already know to be capable of development, and, in the conditions supposed, the only one of which so much can be said. On the other hand, in the cases of less sterile species hybrids, where a considerable number of individuals could be raised in F2 and onwards, it has been noticed that whilst the majority of the individuals in the second generation resemble the original hybrids more or less closely, other individuals show considerable deviations in the direction of one or the other parent form. This is precisely what would be expected in the case of a cross between two forms which differ in a considerable number of segregating characters, when only a limited number of individuals is available in the second hybrid generation.

One of the first objects of the present experiments therefore was to discover, if possible, a non-segregating hybrid

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* Since writing the above, I find that Prof. Bateson in his inaugural lecture on Genetics (Cambridge, 1908) accepts as a definite exception Prof. Castle's discovery that the intermediates produced from a cross between the long-eared lop rabbit and a short-eared variety breed approximately true. I have not had access to this work of Prof. Castle's.

between parents of incontestable specific distinctness, or, failing that, to find some blended character, which should remain constant in all the offspring of a hybrid when these amounted to a considerable number. It may be stated at once that the proof of this kind of blended inheritance is not as yet forthcoming. On the other hand, the great majority of the visible characteristics of the hybrids studied were so elusive and difficult of definition that indications of the actual probable method of inheritance have so far been obtained in the case of a very few characters only. That most of the characters which show signs of definite Mendelian behaviour are characters of colour, and that all the colour characters observed seem to show some kind of segregation, I am inclined to attribute, not so much to any peculiarity in the nature of colour characters as such, as to the much greater readiness with which such characters can be recognized and defined than is the case with almost any other features.

For the study of the behaviour of crosses between forms, which must be recognized by every botanist as species in the strictest sense, no better material seems likely to be found than the genus Nicotiana. Few genera, too, have been more completely explored by the older hybridizers from Kölreuter onwards. Since the revival of interest in Mendel's work, however, the subject, so far as I am aware, has not been touched, and the importance of dealing with large numbers of individuals in the second and later generations was not realized by the early workers. The amount of work which is still required is very great—far more than can be adequately dealt with by one person—and one of the chief objects of the writer in publishing these early attempts at a Mendelian analysis was that others might be found to undertake a part of the burden. An excellent account of the crosses carried out prior to 1881 is to be found in W. O. Focke's Pflanzen Mischlinge.

2.—*THE SPECIES EMPLOYED IN CROSSING.*

The classification here adopted is that of Comes in his Monographie du Genre Nicotiana (Naples, 1899). This agrees in the main with that of Dunal in De Candolle's Prodromus, Vol. XIII. (Paris, 1852). It is unfortunate that the publication of Gærtner's work preceded that of the Prodromus, since, owing to Gærtner's omission of references to the authorities for specific names employed in the "Bastarderzeugung," there is a doubt as to the identity of some of the forms which he made use of.

Nicotiana is not an easy genus for the identification of species from published descriptions, and very little help was obtained from the collections at Kew and the British Museum, both of which are far from complete. The terminology employed by many of the chief European Botanic Gardens, from which seed was very kindly obtained for me by Mr. R. I. Lynch, appeared to be largely fortuitous.*

Some of the plants obtained in this way under the names of particular species turned out to be themselves crosses.

The following is a list of the types employed by me as the parents of crosses—so far as they have been identified :—

Section Tabacum.

Nicotiana tabacum, var. fruticosa, Hook. f.
———————— var. macrophylla, Schrank.
———————— var. calycina, Hort.

Section Rustica.

Nicotiana rustica var. humilis, Schrank.
———————— var. scabra, Comes.
———— paniculata, L.
———— glauca, Grah.
———— glutinosa, L.
———— langsdorfii, Weinm.
———————— var. grandiflora, Comes (N. commutata, F. and M.).

Section Petunioides.

Nicotiana sylvestris, Speg. and Comes.
———— alata, Lk.
———————— var. grandiflora, Comes.
———— acuminata, Grah.
———————— var. grandiflora, Comes.
———— longiflora, Cav.
———————— var. acutifolia, St. Hill.
———— plumbaginifolia, Viv.
———— viscosa, Lehm.
———— forgetiana, Hort. Sand.

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* It is therefore only proper to mention that all the varieties obtained from the garden at Upsala were correctly named so far as I am able to judge.

The position of N. langsdorfii in the recognized classification is open to criticism. Its nearest ally appears unquestionably to be N. viscosa, and it seems worth while to consider the advisability of removing N. langsdorfii from the Rustica to the Petunioides section of the genus. The habit and shape of the leaves of N. langsdorfii are quite different from those of any other member of the former group with which I am acquainted. Hybrids have been obtained between N. langsdorfii and N. paniculata and between N. langsdorfii and N. glauca. Both are quite sterile, and the latter is said to be difficult to raise. Plants of the former hybrid were raised by the present writer, and the same was found to be true of them. On the other hand, the cross between N. langsdorfii and N. alata is not only easy to carry out in either direction, but the hybrid plants are almost perfectly fertile. At the same time it is to be remembered that fertility of the hybrid offspring is by no means an infallible test of systematic affinity.

3.—*THE HYBRID OFFSPRING OBTAINED IN F 1.*

Almost every possible combination between the above-named species was attempted, but the following hybrids were all that were raised from parents specifically distinct :—

Parent Species.	Previously obtained by.	Fertility.
Rustica × paniculata	Kölreuter, Gærtner, &c.	Uncovered plants set a few seeds.
Paniculata × langsdorfii	Gærtner	No good seed.
Langsdorfii × alata-forgetiana hybrid	New*	Fertile.
Alata × langsdorfii (var. or hybrid†)	New*	Fertile.
Tabacum × glauca	Naudin	Sterile.
Acutiflora × alata-forgetiana	New	Sterile.
Alata × forgetiana‡	Recent	Fertile (partly).
Plumbaginifolia × acutifolia	New	Fertile.

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* Fertile hybrids between N. alata and N. langsdorfii were obtained by Naudin and Focke.

† Possibly a hybrid between N. langsdorfii and N. viscosa.

‡ Or rather N. Sanderi, which is said to be the offspring of a cross between N. forgetiana and N. alata. The plants used, however, agree very closely with the plate and description of N. forgetiana in the Botanical Magazine (Plate No. 8,006), so that if the described origin is correct, there must have been marked segregation among the offspring of this cross followed by the selection of types very near the parent forms.

Numerous hybrids were also obtained between varieties of N. rustica, N. langsdorfii, and N. tabacum. All such varietal crosses (with one peculiar exception noted below) appeared to be quite fertile with their own pollen.

From the point of view of the student of heredity, completely sterile hybrids are of interest chiefly as combinations to be avoided. On the other hand, hybrids which exhibit partial sterility are worthy of specially careful examination, as being likely to throw light on one of the most important of specific problems. This can only be done, however, where there are facilities available for carefully nursing the seedlings. Under the conditions at present obtaining at Peradeniya, I am able to do little, except with the more fertile forms. I would therefore specially recommend such a cross as N. rustica × paniculata to students of heredity. In spite of the excellence of Kölreuter's work upon this combination, carried out nearly 150 years ago, there is a great deal still to be learnt from an examination of its progeny in the light of modern knowledge.

The first point which strikes an observer familiar with the offspring of crosses between domestic varieties is the intermediate character shown by all the above hybrids. Speaking in general terms of the adult plants, it may be said that practically every character of every hybrid approaches the mean between the corresponding characters of the parents.* The fact that I was at one time doubtful whether my seedlings of N. rustico-paniculata had not arisen by accidental self-pollination of N. rustica (in spite of great care in the manipulation) points to a predominating influence of the mother upon the seedling characters of this particular cross. In the adult state, however, it was impossible to discover a single point in which these hybrids were not intermediate between their parents.

In describing the degree of intermediateness of a hybrid plant a great deal clearly depends upon the individual judgment of the observer. The following quotation in illustration of this point is from Gærtner's Bastarderzeugung, p. 252 :—

"An example of the variety of diverse opinions is afforded by Nicotiana rustico-paniculata, regarded by Kölreuter as occupying

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* There are a few exceptions to be noted later on.

an exactly intermediate position between the constituent species. We, on the other hand, consider the type of N. paniculata to exert a predominating influence both in N. rustico-paniculata and in N. paniculato-rustica.

Whilst, in the opinion of the present writer, N. rustico-paniculata is on the whole distinctly nearer to N. rustica than to N. paniculata.

On p. 256 of the same work Gærtner gives the following further examples of the "prepotency" of one species over another in the genus Nicotiana :—

> The hybrid between N. suaveolens and N. vincæflora is a notable example of this phenomenon ; this when crossed with N. langsdorfii preserves its own type so closely that the only points in which a difference can be found are a separation in the stamens from the tube of the corolla, the blue colour of the anthers, the greenish colour of the corolla, and the curvature of the tube. In the hybrid suaveolenti-macrophylla, on the other hand, suaveolens is not recognizable, and macrophylla strongly predominates. One of the most remarkable examples of the predominance of one type and of transformation (Verwandlung) is shown by the hybrid paniculato-vincæflora, in which N. paniculata is so completely transformed into the type of vincæflora that the hybrid only shows slight differences in its smaller greenish flowers, the rounded, markedly smaller, white limb, the partial separation of the stamens from the straight tube, the rather wider leaves and the weaker branching ; whilst no marked difference is to be seen either in the general growth and habit of the plant or in the general form of the leaves with their wrinkled surface. On the other hand, in the hybrid between this species and N. quadrivalvis (N. quadrivalvi-vincæflora) the influence of the seed parent is unmistakable.

To a smaller degree the influence of the pollen parent is said to predominate in N. rustico-quadrivalvis and in N. glutinoso-quadrivalvis, and that of the seed parent in N. grandifloro-glutinosa. None of the hybrids here mentioned by Gærtner have come under my personal observation.

4.—*IMPOSSIBLE COMBINATIONS.*

Taking the flowering plants as a whole, Gærtner found, in attempting various species crosses, every possible degree of resistance to the normal effect of the act of fertilization.

From pollen, which is said to have an actually toxic effect, through pollen to which the female organs of the intended mother species are entirely indifferent, one arrives at a series of cases in which (1) a slight swelling of the pistil is initiated; (2) some ovules swell, but develop no embryo; (3) embryos are produced, but these are incapable of germination; (4) seeds are obtained capable of germination, but the hybrids cannot be reared so as to reach the flowering stage; (5) an increasing number of perfect seeds is formed—very seldom, however, reaching the full number which would have been produced by normal fertilization. Most of these stages are to be observed in the genus Nicotiana.

Contrasting the combinations which do and those which do not give rise to hybrid offspring, a certain "common sense" relationship seems, so far as my experience goes, to be observable. That is to say, in general terms, types between which it is comparatively easy to picture an intermediate form beforehand often give rise to hybrids when crossed together; whereas in cases where an intermediate form is difficult to imagine, it is often apparently impossible to obtain cross-bred offspring.

So rough an observation would be hardly worth recording, except for the purpose of pointing out that the above assertion is not identical with the common statement that more nearly related species are easier to cross than more remote species. Numerous exceptions undoubtedly occur to both rules, if rules they can be called.

5.—*THE EFFECT OF CONDITIONS UPON THE FORMS OF THE HYBRIDS.*

The effect of external conditions upon the growth and appearance of plants is well known to be often very considerable, but the full extent of this effect is seldom realized. It is highly important to get an idea of the amount of change which can be induced in this way before one begins to base any conclusion upon the comparison of individual plants with one another. Plate 18 shows two F 1 individuals of Nicotiana tabacum × glauca. The plants represented were grown from seeds sown at the same time and reared under approximately identical conditions until the seedlings were about 2 inches across. The larger plant (A) was one of a number of similar individuals, which were then set out in ordinary garden soil at intervals of 18 inches by 24. At the same time the other plant (B) was potted, and continued to grow in a greenhouse until the time when the photograph was taken.

The flowers of the two plants differ very slightly, those of B being a little the smaller. On the other hand, the difference in habit and inflorescence may readily be estimated from the photograph. In size and shape the leaves of A are closely similar to those of the parental variety of N. tabacum grown side by side with it, whilst the leaves of B are nearly of the same size and shape as those of N. glauca when similarly grown in a greenhouse. The texture of the leaves was more or less intermediate, but decidedly different in A and B.

All the F 1 plants resulting from crosses between various species carried out in 1906 were grown in 1907. Some of each kind were kept in a greenhouse, and others were planted out in the open air, precisely in the same manner as has just been described in the case of the cross N. tabacum × glauca. Differences similar to those mentioned in the case of the differently treated individuals of that cross were to be seen in every case, though usually less pronounced. All the illustrations to this paper, with the exception of the larger plant shown in Plate I., were taken from specimens grown under glass throughout. On the other hand, the descriptions of the F 1 plants were taken in every case from the presumably more " normal " individuals grown in the open air after germinating under glass. The seed from which the plants described in the F2 generation were grown was taken in nearly all cases from greenhouse plants, because with these the greatest certainty with regard to parentage was obtainable. Seed was also taken from open air plants for comparison, but no appreciable difference was found between the offspring of parents which showed the most marked " acquired " differences. Nor could any differences of importance be recognized between plants of similar constitution grown in the open at Cambridge in 1907 and at Peradeniya in 1908.

6.—*STERILE HYBRIDS.*

N. tabacum × glauca. (Plates 18 and 19.)

Though intermediate in many respects, this plant is, in my opinion, considerably more like N. tabacum than N. glauca. In one point—the annual as opposed to perennial duration—the character of N. tabacum may be said to be fully dominant. And the shape and texture of the leaves and general habit of the plant as grown in the open decidedly recall N. tabacum. These characters are entirely different from the same features of N. glauca as shown by plants which I was able to grow in the open air in Ceylon the year following the growth of the hybrids. In every detail of shape and structure, however, so far as my observation went, there were small differences from the tabacum type, which were clearly referable to the glauca parent. Thus in the flowers the red pigment of tabacum only partly obscured the yellow pigment of glauca, both these colours being therefore dominant (though probably both reduced in amount as compared with either parent—a point I had no means of estimating accurately). The leaves were more markedly stalked than those of N. tabacum, and the bases of the young leaves showed a pigmentation like the same parts in N. glauca, but paler and redder in tint. The form of the inflorescence and the shape of the flowers also show obvious influences from the glauca parent. Both in the open and under glass all the flowers fell off without producing fruits.

According to Focke, Naudin obtained two examples of the cross N. (tabacum angustifolium × glauca) × tabacum macrophyllum. One of these plants closely resembled the primary hybrid and the other resembled N. tab. macrophyllum. This statement strongly suggests segregation.

N. acutiflora × alata (hybrid). (Plate 20.)

N. acutiflora has very long narrow leaves and flowers, the corolla being a pale yellowish white. The leaves are greatly undulated, and the whole plant is very scabrous, being covered with stiff, hooked, multicellular bristles.

The pollen parent was one of the recently produced coloured garden hybrids of N. alata with N. forgetiana, but showed very little trace of the influence of the latter parent, except in the colour of the flowers (mauve). The plant was covered with the soft, sticky, glandular hairs so common in the genus, and specially characteristic of N. alata.

Nine hybrid plants were raised and flowered in the open, and were in all respects closely similar to one another. Two others raised under glass differed chiefly in the very much reduced growth. In form and habit the hybrids occupied an intermediate position between the two parents, though considerably exceeding either in stature. The most interesting point about these hybrids is that they exhibited side by side a mixture of the two kinds of hairs characteristic of the two parent species. Each kind of hair, however, was present in considerably smaller numbers than on the parents.

In the case of the similar phenomenon described by Macfarlane* upon the hybrid between Ribes Grossularia and R. nigrum, the two kinds of hairs were said to be about half as large upon the hybrid as upon the parents, but appear, from the published figures, to be quite as numerous as in either.

In the hybrid tobacco the hooked bristles were decidedly smaller than those of N. angustifolia. But the glandular hairs appeared to be of nearly the same size as those of the N. alata hybrid.

The discovery of a similar phenomenon in a fertile hybrid, so as to allow of the examination of a further generation, may be expected to lead to results of considerable theoretical interest, but I am not aware that any example of the kind is known at present.

N. paniculata × langsdorfii. (Plate 21.)

The most remarkable point about this hybrid was the extreme slowness of its growth. Sown under glass on March 12, 1907, at the same time as the parents, the plants never reached a suitable size for transplanting to beds in the open air. The first flower was produced on October 5. At this date several plants still showed no disposition to blossom.

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* Trans. Royal Soc., Edin., 1892, p. 274.

Plants of the two parent species grown under identical conditions flowered, N. paniculata on July 13 and N. langsdorfii a few days earlier.

The great majority of Nicotiana hybrids produce flowers some days earlier than the mean flowering period of the parents.

The hybrids were very small and stunted. The flowers were perhaps somewhat nearer to N. paniculata in shape and colour ; the habit so stunted as compared with either parent that it was difficult to ascertain the relative indebtedness of the hybrid in this respect. The oval, nearly sessile, leaves were puckered at the base, as if in an attempt to become stalked and cordate.

Fruits were produced with a few apparently perfect seeds, but none of the latter germinated.

7.—*PARTLY FERTILE HYBRIDS.*

Nicotiana rustica × paniculata. (Plates 22 and 23.)

This hybrid and its offspring have been described in great detail by Kölreuter and other excellent observers. For this reason, and also because only a small number of plants was obtained in F 2, and these of uncertain parentage, it will be unnecessary to give a minute description of the first generation of hybrids.

The intermediate character of the hybrid may be recognized from an inspection of Plates 22, 23, and 27. In most respects their aspect appears to be decidedly nearer that of N. rustica than that of N. paniculata. The accompanying tables contain details with regard to the size and proportions of the flowers.

The 22 hybrid plants of F 1 grown in the open were all very much alike, and showed to the eye no more variation than either of the parents. This conclusion is borne out by the few measurements which were taken of the flowers (see Tables I. and II.). The hybrids showed only a slight increase in size and vigour as compared with the parents, though their sterility led to much longer and more profuse flowering. The plants began to flower a week before the parent strain of N. rustica and three weeks before plants of N. paniculata sown at the same time. No self-fertilized seeds were obtained under cover, but in the open, where the plants were freely pollinated by bees, a small amount of good seed was obtained—usually not more than three or four seeds from a capsule. The pollen parent of the great majority of these seeds was almost certainly a strain of N. rustica similar to, but not identical with, the original parent form, since plants of this strain grew near at hand and were also freely visited by bees.

F 2 grown at Peradeniya consisted of some 21 plants derived from these seeds. These plants exhibited a very remarkable diversity in size, habit, infloresceuse, and in the shape and texture of the leaves. The flowers appeared to vary in shape and size between those of the primary hybrid and N. rustica. F 1 plants (N. rustica × paniculata), grown under similar conditions at Peradeniya, showed no such diversity, which would therefore appear to depend upon the segregation of characters in the gametes of the primary hybrid. Since, however, the parentage of this generation was not controlled, no definite deduction must be drawn from its appearance. The drawing of deductions would be a difficult matter in any case, since no two plants out of the 21 were alike, nor was any one of them quite like either the primary hybrid, or any form of N. rustica with which I am acquainted. The differences were of the sort, which one would be naturally disposed to associate with mutations from a natural species, as described by de Vries.

From the measurements of the flowers of these plants as set out in Tables I. and II., it seems fair to conclude that the careful examination of 50 plants, or so, of the cross (N. rustica × paniculata) × paniculata would be likely to yield results of considerable interest. I obtained a few apparently perfect seeds of this parentage in 1907, but on arrival in Ceylon they failed to germinate. N. paniculata suffers considerably from heavy rain even in England. A few tropical downpours proved altogether too much for it, and I have not been able to repeat the cross.

TABLE I.

Name.	No. of Plants.	No. of Flowers.	Length of Tube in *Mm.*																
			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
N. rustica . .	8	41	4	12	15	7	2	1	—	—	—	—	—	—	—	—	—	—	—
N. paniculata . .	7	63	—	—	—	—	—	—	—	—	—	—	—	—	2	16	26	17	2
N. rustico-paniculata . .	22	197	—	—	—	—	4	36	80	71	6	—	—	—	—	—	—	—	—
Rustico-paniculata × rustica . .	19	19	1	5	2	2	6	2	—	1	—	—	—	—	—	—	—	—	—

TABLE II.

Name.	No. of Plants.	No. of Flowers.	Length of Tube divided by Breadth of Limb.																	
			1·0	1·2	1·4	1·6	1·8	2·0	2·2	2·4	2·6	2·8	3·0	3·2	3·4	3·6	3·8	4·0	4·2	4·4
N. rustica . .	8	41	11	28	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. paniculata . .	7	63	—	—	—	—	—	—	—	—	—	—	—	2	3	22	17	13	4	3
N. rustico-paniculata . .	22	197	—	—	26	99	53	16	3	—	—	—	—	—	—	—	—	—	—	—
Rustico-paniculata × rustica	19	19	2	8	4	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—

8.—*FERTILE HYBRIDS.*

In describing the offspring of those hybrids where the progeny presented no difficulty in the way of raising families of considerable size, it will be most convenient to deal with the simplest characters first, and afterwards to pass on to those features which appear to present phenomena of greater complexity. In the case of all the fertile hybrids, of which it is proposed to give a description in the present paper, one of the parents at least was represented by some form of N. langsdorfii. Several supposed varieties of this species were used, and of these it will be well to give some description.

The typical Nicotiana langsdorfii has small greenish yellow flowers (see Table VII. for measurements) and dark-blue pollen. The flowers are greenish yellow, and have a markedly inflated or bulged throat (not funnel-shaped), and the margin of the corolla is very obscurely lobed. This brief description includes all the features with which we are at present concerned.

In addition to the above a series of marked varieties were grown, all of which were apparently fully fertile *inter se*, and must be supposed to belong to the same species. The most markedly distinct form had a much larger, funnel-shaped corolla—white on the inside of the limb—with well marked lobes and white pollen.

Most of the other forms seen can probably be obtained by crossing these first two types together, and some of those originally used may have actually so arisen, since there is evidence that blue and white pollen, yellow and white corolla colour, and the inflated and funnel-shaped throat of the corolla respectively represent three separate pairs of Mendelian characters. Indeed some of the plants first raised from seed of unknown ancestry were obviously of hybrid nature in respect of some of these characters.

The following forms were utilized as parents in several hybrid combinations :—

A.—N. langsdorfii—typical form. Seed of this species yielding plants which bred quite true for three generations was received from Upsala and from Bremen. In the latter case the name supplied was N. noctiflora. Clearly an error.

Aa.—A form closely similar to the above having rather larger and more distinctly lobed flowers. From seed ripened the previous summer at Cambridge. This form also bred true.

B.—This variety was received from Upsala under the name N. commutata (= N. langsdorfii, var. grandiflora, Comes). Rather small plants with small leaves and rather larger flowers than the last variety. Corolla, pale-yellow in colour, bulged and clearly lobed. Pollen white. This also came quite true to seed.

C.—Received from Budapesth with the name N. viscosa. Is possibly a cross between N. langsdorfii and N. viscosa. Corolla large, funnel-shaped. Some plants had white flowers and others yellow, and the pollen of some was white and that of others pale-blue. Otherwise this variety closely resembled the typical N. langsdorfii in growth and habit. A plant which had white flowers and pollen came true to seed.

D.—This form was received from Kolozsvar as N. viscosa, but in all visible characters it appeared to be a variety of N. langsdorfii with large lobed flowers. The flower were still larger and more deeply lobed than those of Aa. Corolla yellow, throat bulged, pollen blue. Self-fertilized seed from one of these plants yielded 7 plants with bulged and 2 with funnel-shaped corollas. It seems therefore quite possible that the original plants may be the result of a cross similar to that which is suggested as the origin of C.

E.—A plant which made its appearance as a solitary individual in a row of plants similar to Aa may be provisionally designated as a variety of N. langsdorfii. The plant was of a dwarf habit, the foliage that of N. langsdorfii on a small scale, and the inflorescence similar, but condensed and crowded. The flowers were markedly funnel-shaped, but distinct in shape from those of C; white inside, the outside of the corolla slightly veined with purple. The stamens were very short—not half the length of the style, pollen white. No seed was produced by this plant, but its pollen gave good seed when applied to several of the above varieties of N. langsdorfii.

The results of crosses between the above-mentioned varieties will first be recorded in tabular form under the heads of the several characters involved.

I.—COLOUR OF POLLEN.

Blueness of the pollen appears to behave as a Mendelian dominant to the absence of blue (white or faintly grayish pollen). The heterozygote is, however, invariably of a distinctly paler blue colour than the homozygote. The evidence for this statement regarding Mendelian behaviour appears in Table III.

TABLE III.

Langsdorfii Crosses Pollen Colour.

No. of Experiment.	Parentage.	Pollen Colour of Parents.	Generation.	Plants with Blue Pollen.	Plants with White Pollen.
61/07	N. langsdorfii (A) × N. paniculata	w b	F 1	4	—
67/07	N. langsd. (var. B) × N. langsd. (A)	w b	F 1	10	—
68/07	N. langsd. (A) × var. E	b w	F 1	10	—
69/07	N. langsd. (A) × var. E (another)	b w	F 1	10	—
75/07	N. langsd. (A) × N. alata (hybrid)	b w	F 1	10	—
39/08	N. langsdorfii (A) × N. viscosa	b w	F 1	6	—
41/08	N. langsd. (var. D) × N. viscosa	b w	F 1	6	—
44/08	N. langsd. (var. B) × N. langsd. (A)	b w	F 1	6	—
Crosses with N. langsdorfii, var. D (plant with blue pollen).					
70/07	D 2 × var. E	b w	—	3	7
72/07	D 2 × var. E	b w	—	5	7
76/07	N. alata × D	w b	—	8	2
64/08	67/1/07 self-pollinated	b	—	18	4
73/08	75/07 self-pollinated	b	—	9	3
74/08	76/5/07 self-pollinated	b	—	7	4
103/08	75/07 × N. alata	b w	—	6	6
104/08	76/2/07 (white pollen) × N. alata	w w	—	—	37
105/08	Reciprocal of 104/08	w w	—	—	41

In every case where a variety of N. langsdorfii was crossed with a species or variety in which the pollen was white, the blue colour appeared, more or less diluted, in the pollen of all the F 1 plants. In F 2 there was sharp segregation into whites and blues. In some cases a notable distinction could be drawn between the shades of blue shown by the pollen of different F 2 plants, some being nearly as dark as the original N. langsdorfii pollen, and others again being more like the primary hybrid in this respect. No case was observed of the appearance of blue pollen in the offspring of plants with white pollen only.

II.—COLOUR OF THE COROLLA.

Here again, so far as the evidence goes, it would appear as if the presence of a yellow pigment in the corolla were a simple dominant to the absence of this colour. But the shade of yellow shown by the heterozygote is distinctly paler than that of the homozygote.

It may be noted here that the phenomena of colour inheritance seen in the offspring of crosses between N. forgetiana and other species appear to be complex. A whole series of reds and purples segregates out in F 2. So far a sufficient number of plants have not been grown to establish any definite numerical relationship between the various shades.

Table IV. relates simply to the inheritance of the yellow colour derived from N. langsdorfii.

TABLE IV.

Langsdorfii Crosses Corolla Colour.

No. of Experiment.	Parentage.	Flower Colour of Parents.	Generation.	Plants with Yellow Flowers.	Plants with White Flowers.
68/07	N. langsdorfii (A) × var. E.	y w	F 1	10	—
69/07	N. langsdorfii (Aa) × var. E.	y w	F 1	10	—
70/07	N. langsd. var. D × var. E.	y w	F 1	10	—
71/07	N. langsd. var. D 2 × var. E.	y w	F 1	10	—
75/07	N. langsd. (A) × N. alata (hybrid)	y w*	F 1	10†	—
65/08	68/07 self-fertilized	y	F 2	8	4
66/08	69/07 self-pollinated	y	F 2	8	4
69/08	70/07 self-pollinated	y	F 2	3	2
70/08	71/07 self-pollinated	y	F 2	17	4
73/08	75/07 self-pollinated	y	F 2	9	3
103/08	75/07 × N. alata	y w	F 2	6	10

* *I.e.*, no yellow pigment, purple pigment was present.

† Some contained purple pigment.

Yellow flowered offspring were never seen to originate from white flowered parents. The cross between yellow and white usually showed a corolla of a distinctly paler shade of yellow than that of the yellow parent. Considerable differences in the shades of yellow were to be observed in F 2.

III.—SHAPE OF THE COROLLA.

The distinction between a bulged or inflated and a funnel-shaped corolla has already been mentioned as one of the features separating certain of those varieties of Nicotiana which have been referred more or less provisionally to N. langsdorfii. The two types reappeared among the offspring of several crosses. In such cases it seemed to be always possible, with a little trouble, to refer every plant definitely to one class or the other. Individual blossoms might baffle this attempt, but in the case of each plant a typical flower could be chosen, which could be described as either funnel-shaped or bulged.

There were other considerable differences in the shape of the flowers in addition to this one. But no other feature was observed in respect of which two definite classes could readily be separated. In addition to considerable differences in size, which will be dealt with later, there were notable variations in the shape of the lobes of the corolla and in the degree of flatness or hollowness of the limb. But these and other similar characters were not sufficiently easy of definition to permit of any conclusion being arrived at as to whether segregation took place in their case or not. The character breadth of limb divided by length of tube, of which some preliminary measurements were taken, was found to show only a very small variation in the different strains.

The distinction between funnel-shaped and bulged corollas is shown (with a slight exaggeration) in text figs. 2 and 3. Fig. 1 shows the profile of a flower of variety E. The same type reappeared in a few cases in F 2 from crosses in which E represented the pollen parent. The plants which bore flowers of this kind were always dwarfs with crowded inflorescence just like the original specimen. My impression is that this form of flower is to be regarded as the funnel-shaped type modified by association with a second factor. The latter may be a simple factor of dwarfness (or absence of tallness), since dwarf plants with bulged corollas were seen in F 2 from a cross between E and a tall variety having bulged corollas, whilst the particular form of corolla under discussion never appeared upon a tall plant. On this supposition funnel-shape and dwarfness are separate recessive allelomorphs. The bulged character was never seen to arise among the offspring of exclusively funnel-shaped parents.

Fig. 1.

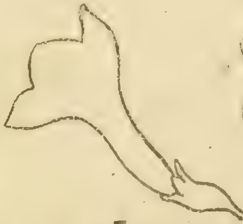

Fig. 2.

Fig. 3.

TABLE V.

Langsdorfii Crosses—Shape of Flowers.

No. of Experiment.	Parentage.	Flower Shape of Parent.	Generation.	Plants with Bulged Flowers.	Funnel-shaped.
68/07	N. langsdorfii (A) × var. E.	b f	F 1	10	—
69/07	Same repeated	b f	F 1	10	—
71/07	N. langsd. (D 1) × var. E.	b f	F 1	10	—
76/07	N. alata, N. langsd. × var. D.	b f	F 1	10	—
70/07	N. langsd. (D 2) × var. E.	b f	—	1	9
72/07	Same repeated	b f	—	8	4
102/08	76/07 × var. C.	b f	—	16	11
10/07	Var. D (No. 2) self-fertilized	b	—	7	2
96/08	10/07 (bulged) × 71/07	b b	—	18	9
65/08	68/07 self-fertilized	b	—	8	4?
70/08	71/07 self-fertilized	b	—	17	4
71/08	72/1/07 (bulged) selfd.	p	—	5	2
72/08	72/2/08 another selfd.	b	—	5	4?
74/08	76/07 self-fertilized	b	—	9	3
67/08	70/5/07 self-fertilized	f	—	—	24?

b = bulged corolla. f = funnel-shaped corolla.

? includes one or more specimens of type E.

We find, then, both in crosses between varieties of Nicotiana langsdorfii, and in those between N. langsdorfii and N. alata, three pairs of characters—one of shape and two of colour—which show marked segregation. And we find moreover in F 2 ratios, which at least suggest that this segregation is taking place in characteristic Mendelian fashion numerically. The characters segregate independently, and all possible combinations of them have been seen.

IV.—GENERAL FEATURES OF N. LANGSDORFII CROSSES.

A.—CROSSES WITH OTHER SPECIES.

These are of special interest as affording evidence with regard to the behaviour of the progeny of crosses between forms of unquestionable specific distinctness, in which the hybrids appear to be almost perfectly fertile.

Evidence with regard to the segregation of certain characters has already been given.

(1) **N. alata × N. langsdorfii, var. C.** (No. 76/07.)

Except that one plant had white pollen (the remainder pale-blue), all the 10 hybrids reared were closely similar to one another. They were decidedly intermediate in general habit and appearance, but considerably taller than either parent. The corollas showed a marked bulge, but were otherwise intermediate in shape and size.

In F 2 the following were grown to the flowering stage:—

No. 76/07 self-fertilized = No. 74/08, 11 plants.
No. 76/07 × N. langsd. var. C = No. 102/08, 28 plants.
N. alata × No. 76/07 = No. 104/08, 38 plants.
No. 76/07 × N. alata = No. 105/08, 40 plants.
No. 76/07 × N. langsd. (A) = No. 101/08, 36 plants.

[For Table VI., see p. 219.]

In the accompanying Table (VI.) the length of the tube of a typical flower of each of the above plants is recorded. The thoroughly intermediate character of the cross-bred type is here clearly indicated. There is certainly no evidence of segregation in this table. We may go further, and point out that, if there is any segregation in size, that segregation must be of a decidedly complex kind.

The few plants obtained in F 2 from self-fertilization were upon the whole decidedly different from F 1. A new character—the presence of markedly reflexed petals—made its appearance in several of them. One plant only was noticed as having a flower decidedly like that of N. alata, though smaller. There was no plant which approached the other parent form at all closely.

The hybrid crossed with N. langsdorfii, var. C, yielded a series of plants, in which little sign of segregation could be observed, except in the characters bulged and funnel-shaped corollas, where there was clear segregation in the sense that every plant could be referred with confidence to one or the other category. Still there was considerably more diversity among the plants than in F 1, though all were more or less intermediate between F 1 and var. C.

In the case of the two reciprocal crosses between the hybrid and N. alata, among a total of 78 plants which blossomed, the flowers were all closely similar in general shape—like N. alata, but with a narrower limb. Both the reciprocal series showed great diversity in habit and in time of flowering, and a considerable number (14) were overtaken by severe drought whilst still in the rosette stage and never flowered at all. Although the foliage and habit varied beyond the possibility of a complete classification, it was thought that the following five types could be distinguished. They are recorded in the order of the frequency of their occurrence—of the last two only two or three plants each were seen :—

1. Plants with rather small narrowish flat leaves. This was the form which most nearly approached the original hybrid.
2. Plants with wider leaves, considerably wrinkled and wavy.
3. Plants with very large flat leaves.
4. A much-branched type, the main axis being obscure, with unusually leafy branches.
5. Giant plants, 6 feet high or over, the average height of the remaining plants being about 3 to 4 feet.

Thirty-six plants were obtained from the cross between No. 76/07 and a typical N. langsdorfii (A). These plants were all closely similar in habit and the shape of the flowers. In these respects typical N. langsdorfii would appear to be almost completely dominant over the hybrid type. From Table VI. it may be seen that the size of the flowers is again intermediate.

(2) N. langsdorfii typical (A) × N. alata (of hybrid origin—with mauve flowers). (No. 75/07.)

Of 11 plants, 6 had corallas of a yellowish colour tinged with purple, whilst in 5 the corallas were pale-yellow without any trace of a purple tinge. The hybrid origin of the alata parent is thus clearly indicated. In other respects the 9 plants grown in the open were all closely alike. The shape of the flowers was somewhat nearer that of N. alata than that of the other parent. Plate IX. shows one of two very stunted plants grown under glass.

The following plants were raised in F 2 :—

No. 75/07 self-fertilized = (No. 73/08), 12 plants.
No. 75/07 × N. langsdorfii (A) = (No. 99/08), 4 plants.
N. langsd. A × No. 75/07 = (No. 100/08), 29 plants.
N. alata (of hybrid origin, but with white flowers) × No. 75/07 = (No. 103/08), 16 plants.

The tube lengths of one flower from each of these plants are recorded in Table VII. The same remarks apply as in the preceding case.

[For Table VII., see p. 220.]

TABLE VI.

No. of Experiment.	Plants.	Year	Length of Corolla Tube in Mm.																													
			18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76
25 06	N. alata ..	1907	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	3	2	—	1	—	1
46 06	N. langsd.. var. C. ..	1907	—	—	—	—	7	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
76 07	N. alata × N. L. C.	1907	—	—	—	—	—	—	—	—	—	—	1	2	1	4	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
74 08	No. 11 selfd. ..	1908	—	—	—	—	—	1	1	—	—	—	1	1	2	1	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—
102 08	No. 11 × N. L. C...	1908	—	—	—	—	1	—	2	4	9	5	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
104 & 105 08	No. 11 × N. alata and recip. ..	1908	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	6	11	6	10	11	4	11	5	4	4	2	—	—	—

Every measurement in this table relates to a separate plant. One flower—as representative as possible—being chosen from each.

TABLE VII.

No.	Plant.	Year	Length of Corolla Tube in Mm.																													
			18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76
26/06	N. alata hybrid ..	1907	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3	2	—	2	2	1
24/06	N. langsd. typ. ..	1907	1	6	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
75/07	N. L. typ. × N. alata hy. ..	1907	—	—	—	—	—	—	—	—	—	—	—	5	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
73/08	No. 8 selfd. ..	1908	—	—	—	—	—	1	3	—	1	1	—	1	1	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
99/08	No. 8 × N. langsd.	1908	—	—	—	1	2	9	6	7	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
100/08	No. 8 × N. alata hybrid ..	1908	—	—	—	—	—	—	—	—	—	—	—	2	2	1	1	2	1	3	3	1	—	—	—	—	—	—	—	—	—	—
—	No. 11 × N. langsd. typ. ..	1908	—	—	—	—	1	3	15	11	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Every measurement in this table relates to a separate plant. One flower—as representative as possible—being chosen from each.

The offspring of self-fertilized F 1 plants appeared to show clear signs of segregation in floral characters. The range in shape was much more marked than that in size ; in fact the 12 plants showed a series ranging from almost the shape of N. alata to almost the shape of N. langsdorfii. In 11 of the plants the style projected very slightly beyond the throat of the corolla ; in the twelfth it projected considerably—to an extent varying from $\frac{1}{3}$ to $\frac{1}{4}$ of an inch. In habit the plants were all very much alike.

In the case of the cross with typical N. langsdorfii, the recorded measurements of tube length agree fairly closely with the observations of corolla shape. That is to say, the majority of the plants had flowers which differed little from those of N. langsdorfii, except in being somewhat larger, whilst a minority showed a more marked influence from the alata grand-parent. One plant, which flowered late, had a markedly succulent winged stem—a habit unlike that of all its brethren.

The 16 plants obtained by crossing the hybrid with N. alata were all practically alike in habit and in the shape of the flowers, the latter being like those of N. alata, but having a less spreading limb. The segregation in colour, however, was clearly marked (see Table II).

B.—CROSSES BETWEEN SUPPOSED DIFFERENT VARIETIES OF N. LANGSDORFII.

The greatest interest relates to the crosses in which the remarkable type E was concerned.

No self-fertilized offspring have so far been obtained from this variety. Seed was, however, obtained from other varieties of N. langsdorfii when fertilized with pollen from this type. The reciprocal crosses failed. Not much stress is to be laid upon the last-named fact, since the experiments were confined to a single small plant.

Hybrids were raised between this plant and N. langsdorfii, vars. A and Aa, and with 3 different plants of var. D. All the plants thus obtained appeared perfectly fertile.

The cross with var. A yielded 10 plants, all closely similar and very near the typical N. langsdorfii. They had rather larger paler yellow flowers and paler blue pollen, bulged throats to the corolla and a rather flat limb. Habit practical identical with var. A.

The cross with var. Aa showed hardly any describable difference from the last.

The crosses with the obviously hybrid var. D showed segregation in colour of pollen and bulge of corolla. But all the plants —32 in all—were similar in habit, and showed no sign of any of the other characteristic features of var. E. Plate 25 shows the bulged type of flowers.

Among 91 plants of F 2 obtained by self-fertilization from 7 of the above plants, the var. E type reappeared in 6 individuals, one other plant differed from these in one respect only. This plant had long stamens and a short style, instead of short stamens and a long style. Want of knowledge of the previous history of this strain makes it impossible to decide whether this sudden and discontinuous appearance of heterostylism is novel or " reversionary " in nature.

A brief note may be added as to the offspring of each of the 7 F 1 plants under discussion.

65/08 : Offspring of 68/07. One plant of type E is included in the w and f groups in Tables IV. and V. It is also included among the dwarfs in the classification of these 12 plants into 9 tall and 3 dwarfs. There is some doubt, however, whether dwarfing is not due to disease in all the cases observed, except those represented by plants of type E. If this is so, the figures suggest that the disease (or liability to the disease) causing the stunted appearance of certain plants is itself a recessive character.

66/08 : Offspring of 69/07. Among 12 plants, one was noted as dwarf with a bulged tube. In the remaining plants b and f were not distinguished. No representative of type E was seen.

67/08 : Offspring of 70/07 (plant with funnel-shaped corolla and white limb and pollen). Among 24 plants, there were two exact replicas of E and one apparently representing the short styled form of it. The latter produced seed in fair abundance, whilst the former produced none. The remaining 21 plants were of normal size, all had white limb and pollen, and funnel-shaped flowers all very much alike.

69/08 : Offspring of another similar plant of 70/07, which differed from the last in having yellow flowers. Only 5 plants raised, 3 yellow and two white, otherwise like the parent.

70/08 : Offspring of 71/07. See Tables IV. and V. 2 dwarf plants (yellow bulged).

71/08 : Offspring of 72/07. See Table V. The three f plants include one of type E. All had white petals and white pollen.

72/08 : Offspring of 72/07, another plant which like the last had bulged flowers and white corolla and pollen. Among 9 plants there were 2 of type E.

V.—OTHER CROSSES.

A considerable number of F 2 plants was raised from crosses in which N. forgetiana was concerned as one of the parents. Some of these crosses, especially those in which N. langsdorfii took the place of a second grand-parent, appear likely to give rise to interesting novelties from a horticultural point of view. The colour of the flowers in several of these crosses showed signs of segregation into a redder and a bluer series, both of which included several different shades. The colours seen recall to some extent those shown by certain hybrid primulas. The number of plants seen is not sufficient at present to warrant any definite numerical conclusion, except that the red series was more numerous than the blue.

A single plant with varigated flowers arose from one of these crosses, and its progeny will be watched with interest.

A long series of coloured drawings of the flowers of these crosses has been prepared by Mr. A. de Alwis, Draughtsman to the Royal Botanic Gardens, so that it should be possible to make a close comparison with the characters of the next generation.

9.—*CONCLUDING REMARKS.*

The experiments described in the preceding pages are only a selection from a series of pioneering attempts to throw light upon a branch of the science of heredity, to which statistical observations have not hitherto been applied. One of the principal objects of these experiments was to ascertain how far crosses between thoroughly distinct species could be used as a source of evidence bearing upon the problems of heredity. This object may be said to have been in some measure accomplished. It has been clearly shown that a patient study of the more fertile crosses is likely to yield evidence of considerable value. Such work will be both tedious and expensive, since long series of drawings or photographs of F 2 plants will be required for comparison in the case of characters other than the very simplest.

So far it has been possible to demonstrate the existence of Mendelian proportions in the case of a few simple characters. There is no evidence that Mendel's laws are transgressed by any character of colour. A curious character of shape was observed to behave in the same way, namely, the funnel-shaped or inflated throat of the corolla tube. This point is one of some interest, because the difference between the two types is one which the earnest seeker after adaptations might suppose to be specially suited for determining the preference of two different kinds of insects. Such an one would suppose that the difference between the two types of flowers had arisen through the extinction of a series of intermediate forms of lesser degrees of fitness. I am not aware of the existence of any evidence in favour of this view. On the contrary, everything points to the conclusion that an intermediate type would be just as fit for existence as either of the extreme forms observed. As a matter of fact the most frequent insect visitor in Ceylon appeared to be a sphinx moth, which sipped the honey without ever alighting upon the flowers; yet the ripe capsules were full of perfect seeds.

On the other hand, the fact that in experiment one of the types was observed to arise from the other at a single step—in the case of funnel-shaped offspring of inflated hybrid parents—may be regarded as evidence to show that it is at least possible that the original differentiation may have taken place in a similar discontinuous fashion.

Leaving out of account the simple characters already mentioned, the casual observer might conclude that chaos reigned among the offspring of these crosses. But experience of natural processes generally, and of genetic research in particular, forbids our accepting this conclusion as a true description of the phenomena. It is legitimate to hope that future experiment will reduce some parts at least of this apparent chaos to some kind of order.

In certain cases it appeared that a more or less intermediate form or character persisted in the second generation from the cross. Apparent blended inheritance of this kind was only seen in the case of characters of general habit or shape, which are very difficult of exact definition, although in other cases signs of segregation in shape or habit were not wanting. The phenomenon is one which has to be reckoned with, and it will be useful to enumerate the reasons for hesitation in assuming that such apparent blended inheritance must be due to the production by the hybrid of germ cells containing a true and permanent blend of character-determinants.

The delayed segregation described in the case of certain seed characters in other plants is hardly likely to help us here. Two important considerations remain :—

1. The possibly very complicated nature of the characters in question has to be considered. It is reasonable to suppose that such a " character " as habit or the general shape of a flower may depend upon the co-operation of quite a number of allelomorphic factors, even though we may never be able to distinguish between the individual factors.

Where two such factors are concerned, in cases where the heterozygote form is intermediate, we should expect 1 out of 16 F 2 individuals to resemble each parent form, and the remaining 14 plants to be more or less intermediate.

With three factors we should expect only 1 of each parent type out of 64 individuals.

There seems to be no reason for doubting that the total number of visible factors even which go to make up the total shape of a flower may be considerably greater than this.

2. The second consideration lies in the possibility of a differential fertility among the possible allelomorphic combinations. The possibility has to be borne in mind that among the offspring of a hybrid between two widely different species those individuals which nearly resemble their immediate parent may have a better chance of survival than the forms which

have more characters in common with either grand-parent. In the absence of evidence it would be unwise to labour this point further.

Among other phenomena of special interest, we may briefly recall in conclusion the strictly intermediate nature of the first crosses between species. This may be contrasted with the apparent dominance shown by a limited number of (possibly varietal) characters.

It is not suggested, however, that this classification (due to de Vries) holds good with any degree of strictness, and it seems to be quite clear that segregation frequently takes place in cases where dominance is absent.

A curious case which affords an exception to the general rule of an intermediate F 1 is worth recalling. So far as can be ascertained from the evidence available the form E* appears to be a recessive type. This type is specially remarkable inasmuch as a whole series of external features seem to behave in heredity as if they depended upon a very limited number of internal factors. It is suggested that two principal factors are concerned, one for dwarfness and one for the shape of the flowers. If this anticipation proves correct, it appears that in some cases the inheritance of shape and habit are much simpler matters than would have been expected at first sight. It is hoped that it may be possible to investigate further the inheritance of this remarkable type, which exhibits two further points of interest in its sterility, and in the suggestion of incipient heterostylism which it exhibits.

The very remarkable range of stature shown by F 2 plants in certain cases is noteworthy—far transcending in both directions the dimensions of the original parents.

F 2 from crosses with N. forgetiana showed a remarkable range of colours, which at first sight certainly suggested an explanation by some such formula as that put forward by Bateson in his first report to the Evolution Committee of the Royal Society (1902) to describe the complex phenomena shown by sweet peas. There is no reason for supposing that

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* Of unknown origin, but supposed to be an offshoot of N. langsdorfii (see p. 211).

To face p. 226.

Note added March 22, 1909.

Since writing the above I have had the opportunity of reading an extremely interesting paper by De Vries (Uber die Zwillings bastarde von Œnothera nanella. Berichte d.d. Bot. Ges. XXVI.a, No. 9). From this it appears that two forms of Œnothera, which originated in a cross, and are distinguished as Laeta and Velutina respectively, possess female gametes, half of which bear the tall and half the dwarf characters. All the functional pollen grains of Laeta bear the tall character, and all the functional pollen grains of Velutina bear the dwarf character. De Vries does not offer the obvious suggestion that half the total number of pollen grains in each case are impotent. If this suggestion should prove to represent the truth, Œnothera laeta would afford a case of a hybrid which breeds true in spite of the fact that typical segregation takes place among its germ cells. In the light of these facts it is clear that non-segregation cannot be asserted in any given case, until the hybrid has been crossed with each of the parent forms on a considerable scale.—R. H. L.

Plate 27.—N. paniculata. Height, $20\frac{1}{2}$ in.

Plate 28.—N. alata. Height, 28 in.

Plate 29.—N. tabacum.

shown by sweet peas. There is no reason for supposing that

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* Of unknown origin, but supposed to be an offshoot of N. langsdorfii (see p. 211).

a similar purely Mendelian explanation to that which was subsequently discovered for the sweet peas will not be found to meet the case of Nicotiana.

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11.—*DESCRIPTION OF PLATES.*

Plate 18.—Nicotiana tabacum × glauca. Plants grown in open ground and in a pot under glass for comparison.

Plate 19.—N. tabacum × glauca. Pot plant. Height, 24 in.

Plate 20.—N. acutiflora × alata (hybrid). Height, 28 in.

Plate 21.—N. paniculata × langsdorfii (A). Height, 11 in.

Plate 22.—N. rustica × paniculata. Height, 16 in.

Plate 23.—N. rustica (on left); height, 24 in. N. rustica × paniculata (on right); height, 27 in.

Plate 24.—N. langsdorfii, var. B × var. A. Height, 24 in.

Plate 25.—N. langsdorfii, var. C. × var. E. Height, 20 in.

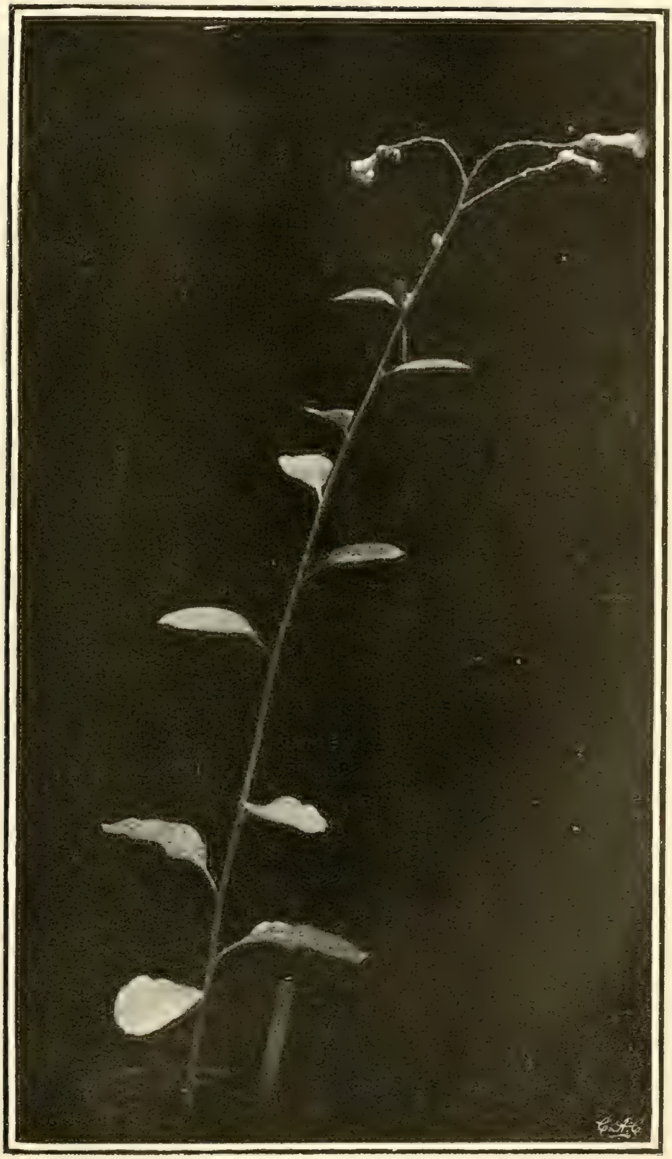
Plate 26.—N. langsdorfii, var. A. × N. alata (hybrid). Height, 22 in.

Plate 27.—N. paniculata. Height, 20½ in.

Plate 28.—N. alata. Height, 28 in.

Plate 29.—N. tabacum.

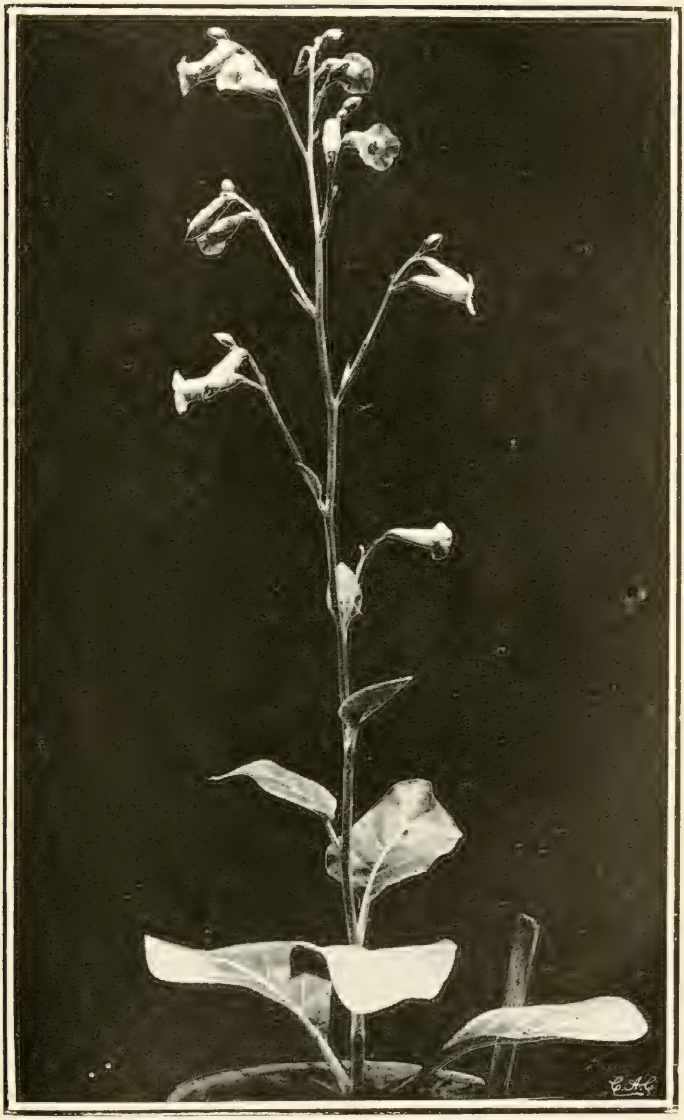
B NICOTIANA TABACUM × GLAUCA. A



N. TABACUM × GLAUCA.

N. ACUTIFLORA × ALATA (HYBRID).

N. PANICULATA × LANGSDORFII.



N. RUSTICA × PANICULATA.

N. RUSTICA. N. RUSTICA × PANICULATA.

N. LANGSDORFII, VAR. B. × VAR. A

N. LANGSDORFII, VAR. D. × VAR. E

N. LANGSDORFII, VAR A. × N. ALATA (HYBRID).

N. PANICULATA.

N. ALATA.

N. TABACUM.

On the Internal Temperature of Leaves in Tropical Insolation, with Special Reference to the Effect of their Colour on the Temperature; also Observations on the Periodicity of the Appearance of Young Coloured Leaves of Trees growing in Peradeniya Gardens.

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PART I.

PART II.

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PART I.

INTRODUCTION.

VERY little attention has previously been paid to the ascertaining of the internal temperature of leaves exposed to natural illumination. For succulents Askenasy (1) has shown that high internal temperatures up to 49° C. occur. Keeble (14) took some temperatures of leaves of *Amherstia nobilis* at Peradeniya by the method of placing a mercury thermometer in contact with the leaves. His object, however, was not to find the internal temperature of the leaves, but to estimate how much heat was transmitted and how much reflected. Stahl (28) used a thermo-electric method of determining the internal temperature of succulent leaves exposed to artificial illumination, with the special object of finding whether there was a difference in temperature between red and non-red parts of the leaves. His spatula-like thermojunction, however, was too large to be placed in thin leaves.

Ewart (8) took one or two isolated observations on the temperature of *Hoya* leaves by using a mercury thermometer in contact with the leaf.

Ursprung (29) in the course of his work on the heat and light relations of leaves took some temperatures of both succulents and thin leaves exposed to natural illumination. He deliberately abandoned the thermo-electric method on the ground that it was difficult to get the instrument sufficiently sensitive over a large range. Since he did not use artificial light, he required an easily portable and yet sensitive galvanometer, and this he could not obtain. In fleshy leaves he made a small hole just big enough to contain the thermometer bulb. In thin leaves he placed the thermometer on the upper surface, and then folded the leaf upwards over its midrib and fastened it, thus folded and insulated by a pad of wadding in a clamp supported on a stand. His results agreed with those previously obtained for succulents, and he found some very high temperatures occurring in them, *e.g.* :—

Opuntia Rafinesquii	43·3° C.
Mammillaria fulvispina	43·5° C.
Sempervivum tectorum	49·6° C.
Saxifraga crassifolia	35·9° C.

For thin leaves, however, he got much lower temperatures, *e.g.* :—

Betula alba 28·3° C.
Ulmus montana 29·3° C.

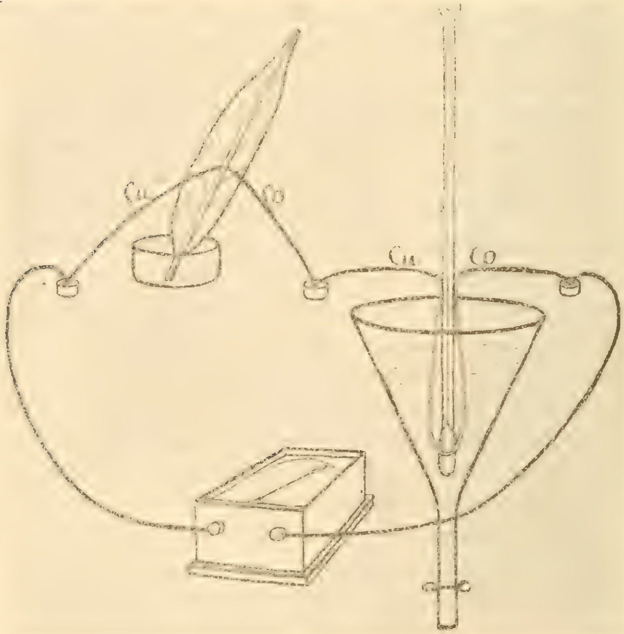
Blackman improved the thermo-electric method by reducing the size of the junction until it was small enough to be inserted in the midrib and even in the lamina of thin leaves. He also arranged that the junction, threaded through the leaf in the open air on the roof of the laboratory at Cambridge, should be electrically connected with a sensitive reflecting galvanometer in one of the rooms of the laboratory. By the use of this apparatus, described by Matthæi (18) and again by Blackman and Matthæi (3), he was for the first time able to overcome the difficulty of taking the internal temperatures of thin leaves in natural illumination. These were obtained by a sensitive instrument to a high degree of accuracy. Though the main object of their use of the apparatus was to obtain the internal temperature of the leaves in their assimilation apparatus, yet they obtained figures which showed that, in natural illumination in the open air, thin leaves attained higher temperatures than had been previously recorded, and more closely approximating to the figures obtained previously only for succulents, *e.g.*, a leaf of Cherry Laurel reached 44–45° C. when the temperature of the surrounding air was 27° C.

The subject of internal leaf temperature was incidentally touched on by Brown and Escombe (4) in a research dealing with the interchange of energy between a leaf and its environment. Their conclusions are quantitatively different from those found by direct experiment by Blackman and Matthæi (3). Their research had, however, a very different primary object from that of ascertaining the internal temperature of the leaf, and little significance perhaps is to be attached to the actual figures on this point, which was quite a side issue in the investigation. It must be pointed out too that their figures are obtained in an indirect manner by an elaborate calculation based on several different observations, in each of which a small error may have occurred.

On going out to Ceylon in 1905, the present writer took a supply of thermo-electric junctions similar to those used by Blackman and Matthæi (3). By means of these and a galvanometer and using substantially the method described by Blackman and Matthæi (3), the following investigation into the temperatures of leaves in tropical insolation was carried out. It seemed likely that on a subject so far so little investigated, results of interest and importance might follow from a more extensive study of the facts in the quite different environment afforded by the tropical climate of Ceylon.

Description of Apparatus.

The apparatus used differed in some slight respects from that described by Blackman and Matthæi (3).



At Dr. Blackman's suggestion, the wooden frame in which his experimental leaves were fastened was abandoned. The wooden base of this frame was close beneath the leaf, and when heated by the sun's radiation it gave out reflected thermal rays, which may have affected the leaf temperature. In the new form of the apparatus the leaf was placed with its petiole in water in a small beaker, while the upper end of the lamina was fixed on the hooked ends of two glass rods projecting from a retort stand. By this means the leaf was suspended so as to be freely exposed to the air on all sides, and so as to be raised some eighteen inches above the wooden stand on which the whole apparatus was placed. The whole apparatus was shaded behind a wooden screen, in which a square hole was cut, which could be closed to shade the leaf or opened to illuminate it, by a movable shutter. In this way no part of the apparatus but the leaf was illuminated, and errors due to reflected radiation from the parts of the apparatus were reduced to a minimum.

The mercury cups were cut in corks held in position by clamps attached to the retort stand, to which the funnel and glass rods and thermometer were also attached. In all cases the leaf was placed approximately normal to the sun's rays. Absolute accuracy in this particular was not always attained, especially in the case of thin flaccid leaves. The position, however, was never departed from to any considerable extent.

The thermo-junction, whose temperature was under control, was placed inside a rubber tube and close to the bulb of a thermometer which was immersed in water in the funnel attached to the retort stand. A glass rod was used as a stirrer to ensure an even temperature throughout the mass of water in the funnel.

The galvanometer used was a direct reading suspended coil ammeter, manufactured by R. W. Paul, London. Its resistance was 9·2 ohms. at 16° C. This instrument was found very convenient, as it could be carried about with the apparatus to different parts of the gardens and used on the spot where the observations were taken. Each scale division corresponded with the apparatus set up, as usual. to 5° C., and since $\frac{1}{10}$ of a division could be easily read off, it was possible to read with accuracy to ·5° C.—an accuracy more than sufficient for the purpose.

PRELIMINARY TESTS OF THE ACCURACY AND SENSITIVENESS OF THE METHOD.

Some blank tests were first performed to test the accuracy and sensitiveness of the apparatus. The first of these was carried out in shade in the laboratory, and was designed to find out what reading of the galvanometer scale corresponded to 1° C. difference in temperature between the two junctions: one junction in air, the other in rubber tube in water; whole apparatus in the laboratory.

TABLE I.—January 16, 1906.

Temperature of Air. C.	Temperature of Water. C.	Deflection.	Deflection per Degree of Temperature Difference.
25·6	39·5	2·8	·20
25·7	36·7	2·3	·21
25·8	33·4	1·7	·22
25·8	55·0	6·0	·20
25·8	50·6	5·0	·20
25·8	44·8	3·8	·20

Average deflection per degree, C ·20.

Thus, within a wide range of temperature, the readings of the galvanometer agree in registering the temperature at ·20 scale divisions per degree C. of temperature difference between the two junctions. An attempt was made to find out if the junction itself when exposed to full sunlight was raised above the temperature of the surrounding air by absorption of heat. For this purpose readings were taken with the apparatus on the verandah of the laboratory. It was set up as before, and the whole apparatus exposed to direct sunlight. A piece of pith, about $\frac{1}{3}$ in. wide, was then interposed so as to cast a shadow on the junction in the air, and the effect noted. The pith was removed and replaced several times.

In Table II. at first some slight difference (*cf.* readings at 11.45 and 11.50) of about ·5 C. seems to be caused by shading the junction in air, but even this is probably due to the fact that changes of temperature taking place in the water and the air are not quite coincident in their effects on the junctions, for when air temperature and water temperature have settled down to a steady state, it is seen in both tables that the shutting out of direct sunlight from the junction by the pith or *vice*

The following were the results :—

Table II.—January 18, 1906.

Time.	Conditions.	Zero.	Deflection.	Shade Air Temperature.	Temperature of Junction in Water.	Temperature of Junction in Air (calculated).
A.M.						
11.30	Both junctions in sun	2·3	2·1	27·7	27·2	28·2
11.40	Air junction shaded by pith.	2·3	2·7 to 2·8	27·4	29·2	27·2 to 26·7
11.45	Do.	2·3	2·9	27·2	30·2	27·2
11.50	Shade taken away	2·3	2·9	27·2	30·7	27·7
11.51	Shaded	2·3	3·0	27·2	30·7	27·2
11.52	Shade taken away	2·3	3·0	27·2	30·7	27·2

Table III.—January 19, 1906.

Time.	Conditions.	Zero.	Deflection.	Temperature of Junction in Water.	Shade Temperature of Air.	Calculated Temperature of Junction in Air.
A.M.						
10.35	Whole apparatus in shade	·15	·4	25·0	26·4	26·25
10.37	Do.	·10	·4	25·0	26·5	26·5
10.45	Both junctions in sun	1·3	1·1 to 1·05	26·3	27·4	27·3 to 27·5
10.55	Air junction only shaded	1·3	1·4	28·0	27·3	27·5
11. 0	Air junction shaded	—	1·2	—	—	—
	Shade taken away	—	1·2*	—	—	—

* And thus for next 2 or 3 minutes.

versâ has no effect whatever. An important conclusion from this is that the rise of temperature of a junction registered when it is placed in a leaf exposed to direct sunlight must all be due to the absorption of radiation by the leaf, and no part of it to the absorption of radiation by the junction itself.

The method of ascertaining the temperature by reading the deflections of the galvanometer was checked on several occasions, *e.g.*, January 22, 27, and 29, and November 16, by using hot water in the funnel containing the control junction. In this way the temperature of the junction in water was made equal, or nearly equal, to that of the junction in the exposed leaf. The deflection obtained under these circumstances was either zero or was quite small. When the deflection is zero, the accuracy of the method is a maximum, and in all cases the readings thus obtained were confirmatory of the results obtained by the more usual method. The following figures are an example of this :—

TABLE IV.—January 25, 1906.

Junction in leaf of *Tradescantia discolor.*

Time	11.18 A.M.	11.21 A.M.
Conditions	Exposed to sun	Exposed to fairly strong breeze
Zero	·1	·1
Deflection	—2·9	—2·8
Temperature of junction in water ..	27·4	27·4
Shade temperature of air ..	27·5	27·5
Calculated temperature of junction in leaf ..	42·4	41·9

Hot water was then added until the junction in water was at a temperature of 42·8, and the following readings were obtained:—

Time : 11.24 A.M.
Conditions : Exposed to sun.
Zero : ·1.
Deflection : ·2.
Temperature of junction in water : 42·8.
Shade temperature of air : 27·5.
Calculated temperature of junction in water : 42·3.

Thus the temperature registered when the control junction was at 27·4 and the galvanometer showed a large deflection agreed very closely with the temperature registered immediately afterwards when the control junction was 42·8 and the deflection only ·1.

The following results were obtained :—

TABLE V.—January 22, 1906.

Time.	Conditions.	Zero.	Deflection.	Temperature of Water Junction.	Shade Air Temperature.	Calculated Temperature of Junction in Leaf.
A.M.						
10. 9	Junction in midrib exposed to sun ; no breeze	1·0	—1·5 to —1·7	25·9	25·5	38·4 to 39·4
10.33	Do.	1·0	·3	37·0	26·3	40·5
11. 8	Junction beneath side vein ; exposed to sun ; no breeze	—1·9	—4·1 to —4·3	29·2	26·7	40·2 to 41·2
11.19	Do.	—1·9	—4·7	29·3	26·7	43·3
10. 8	Junction in lamina ; no prominent veins ; exposed to sun ; slight breeze	·8	·8	38·3, Jan. 23	25·5	38·3

TABLE VI.—January 22, 1906.

Time.	Conditions.	Zero.	Deflection.	Temperature of Junction in Water.	Shade Air Temperature.	Temperature of Junction in Leaf.
A.M.						
10. 4	Junction shaded leaf in sun.	1·0	—·2 to —·4	25·8	25·4	31·8 to 32·8
10. 9	Shade taken away	1·0	—1·5 to —1·7	25·9	25·5	38·4 to 39·4
10.13	Junction shaded again	1·0	—2	26·2	25·5	32·2
11. 8	Leaf in sun	—1·9	—4·1 to —4·3	29·2	26·7	40·2 to 41·2
11.13	Junction shaded	—1·9	—2·7	29·1	26·7	33·1
11.19	Shade away	—1·9	—4·7	29·3	26·7	43·3

It appears from the blank tests that the apparatus is quite capable of registering the internal temperature of a leaf to an accuracy of ·5° C. Experiments were then devised to see if different temperatures were obtained when the junction was threaded through different parts of the leaf. For this purpose a leaf of *Magnolia sphenscarpa* with fairly prominent midrib and side veins was used. The junction was placed first of all in the midrib, then through one of the side veins, then in the lamina where there were no prominent veins.

In considering tables V. and VI. it must be borne in mind what difficulties present themselves in getting accurate comparison. In the first place, as will be shown more fully later, the breeze was a most powerful factor in reducing the temperature of the leaves. No attempt was made to measure it accurately, but it has been roughly indicated in the tables as slight, moderate, or strong. It was not often possible to get readings in still air. On January 22, for example, the interval between 10.9 A.M. and 10.33 A.M. was filled up in taking observations when some amount of breeze was blowing, and the two readings given were the highest obtained in still air. On January 23 no reading in still air was obtained at all, and the reading given was the highest temperature obtained during the observations, though even then some breeze was felt. Again, as the morning advanced, the sun got more powerful, and under similar cloudless conditions in still air the highest readings were always obtained near to noon. The differences in the above table between the temperatures registered in the three positions of the junction can all be ascribed to these changes of conditions, and it seems that no change due to the change of position can be discerned. The readings from 10.9 A.M. to 11.19 A.M. are progressively higher as time goes on, and are just what we should expect from the more powerful sunlight, so that the change from midrib to side vein seems to have had no effect. The lower temperature of 38·3 obtained at 10.8 A.M. on the following morning with the junction in the lamina itself is very near to the 38·4 obtained at 10.9 A.M. on the previous morning, and there seems no reason to doubt that, if the air had been quite still and the experiment continued later, temperatures as high as those of the previous day would have been registered. It seems reasonable for the future, therefore, to take the temperature of the midrib as being the temperature of the whole lamina, and this was accordingly done.

In considering the experiments as a whole it must be remembered that though a good deal of sunshine was vouchsafed, yet there were times when clouds appeared, obscured the sun, and caused the experiment to be abandoned. Though this is not always stated, it is often the cause of the abrupt conclusion of the experiments.

Later, temperatures were registered by dry and wet bulb thermometers to obtain humidity of air and by the black bulb thermometer to give the intensity of solar radiation, and these will be inserted where they seem to bear on the argument.

It is perhaps worth while recording the results of an experiment intended to give some idea of the conductivity of heat of a green foliage leaf. For this purpose a leaf of *Magnolia sphenscarpa* was exposed to direct sunlight with a thermo-junction in the midrib. After the temperature in sunlight had been observed, the junction alone was shaded by a small piece of pith. The temperature attained by the junction under these conditions was not due to absorption of direct radiation by the part of the leaf in which the junction was placed. but was due chiefly to conduction of heat from the illuminated parts all round. That leaf substance is not a perfect insulator, and at the same time not a good conductor is shown by the temperatures attained.

Thus, while in full sun, the leaf attains a temperature of from 13·9 (10.9 A.M.) to 16·6 (11.19 A.M.) above the surrounding air, shading only the junction reduces the temperature to 6·7 (10·13 A.M.) and 6·4 (11.13 A.M.) above the surrounding air. It is thus seen how large a part in the high temperatures produced is played by the absorption of radiation by the restricted area immediately surrounding the junction.

HIGH TEMPERATURES REACHED BY ILLUMINATED LEAVES.

Tables will first be given showing the temperatures to which green foliage leaves of different kinds attain under still air conditions in direct bright sunlight.

Table VII.—January 22, 1906.

Mature leaf of *Magnolia sphenocarpa*. (A rather thick stiff leaf.)

Time.	Conditions.	Zero.	Deflection.	Temperature of Junction in Water.	Shade Air Temperature.	Calculated Temperature of Junction in Leaf.
A.M.						
10. 9	Full sun ; air still	1·0	—1·5 to —1·7	25·9	25·5	38·4 to 39·4
10.33	Do.	1·0	·3	37·0	26·3	40·5
11. 8	Do.	—1·9	—4·1 to —4·3	29·2	26·7	40·2 to 41·2
11.19	Do.	—1·9	—4·7	29·3	26·7	43·3
11.36	Do.	—1·9	—4·9	29·0	27·0	44·0
11.35	Do.	·7	—2·2	27·0	27·1, Jan. 24	41·5
11.45	Do.	·7	—2·1	27·2	27·3	41·2

Note.—The wooden screen for the whole apparatus was first used on January 24, and was used afterwards in all the experiments.

Table VIII.—January 25, 1906.

Leaf of *Rhœo discolor*, not detached from the plant. (A thick fleshy leaf with water storage tissue.)

Time.	Conditions.	Zero.	Deflection.	Temperature of Junction in Water.	Shade Air Temperature.	Calculated Temperature of Junction in Leaf.
A.M.						
9.27	Full sun ; air still	·65	—1·7	25·5	25·5	37·2
10. 2	Do.	·60	—1·8	26·2	26·1	38·2
10.13	Do.	·6	·2	37·8	26·5	39·8
11.18	Do.	·1	—2·9	27·4	27·5	42·4
11.25	Do.	·1	—·1	41·0	27·5	42·0

TABLE IX.—January 27, 1906.

Variegated (green and white) leaf of *Acalypha tricolor*.
(A thin leaf which soon wilts in direct sunlight.)

Time	11.46 A.M.	11.56 A.M.
Conditions	Junction in green part ; full sun ; still air	Junction in green part ; full sun ; still air
Zero	—·4	—·4
Deflection	—3·4	—·7
Temperature of junction in water	27·9	42·0
Shade air temperature	28·1	28·0
Calculated temperature of junction in leaf	42·9	43·5

In Table VII. (first part) and in Table VIII. the gradual increase of intensity of the sun's radiation is well seen. Although no black bulb thermometer was used, the gradual increase of intensity of radiation is reflected to some extent in the gradual rise of shade temperature of the air. Parallel with this is the gradual rise of temperature of the leaf, *e.g.*, January 25 air temperature rises 25·5 to 27·5, while the leaf temperature rises 37·2 to 42·0.

TABLE X.—November 14, 1906.

Amherstia nobilis.—Mature leaf, intermediate in thickness between *Magnolia sphenscarpa* and *Acalypha tricolor*.

Time	10.44 A.M.	10.55 A.M.	10.4 A.M.
Conditions	Full sun ; still air	Full sun ; still air	Full sun ; still air
Zero	0·0	0·0	0·0
Deflection	2·9	3·0	3·0 to 3·2
Water junction temperature	27·8	27·8	26·8
Shade air temperature	26·6	27·2	26·4, Nov. 15
Leaf temperature	42·3	42·8	41·8 to 42·8

TABLE XI.—December 14, 1906.

Mature leaf of *Saraca indica*.

Time	10.27 A.M.	10.58 A.M.
Conditions	Sun, still	Sun, still
Zero	0·0	0·0
Deflection	3·3	3·0
Temperature of junction in water	23·4	24·4
Shade air temperature	24·9	25·8
Temperature of junction in leaf	38·1	38·0

TABLE XII.—December 22, 1906.

Green leaf of *Codiæum variegatum.*

Time	11.40 A.M.	11.41 A.M.
Conditions	Sun, still	Sun, still
Zero	0·0	0·0
Deflection	2·0	2·2
Temperature of junction in water	29·0	29·0
Shade air temperature	27·9	27·9
Temperature of junction in leaf	39·1	39·9

TABLE XIII.—February 4, 1907.

Mature Green Leaf of *Mangifera indica.*

Time	10.3 A.M.	10.15 A.M.	10.20 A.M.
Conditions	Sun, still	Sun, still	Sun, still
Zero	0·0	0·0	0·0
Deflection	3·2	3·0	3·3
Temperature of junction in water	25·1	25·6	26·0
Shade air temperature	25·9	26·2	27·0
Temperature of junction in leaf	39·4	39·2	40·6

It is seen from these tables, representing experiments done at different times of the year, that mature green leaves of various species, varying in thickness and texture from thick and fleshy (*Rhœo*) to quite thin (*Acalypha*), attain a temperature, when normal to full sunlight and in still air, of from 12° C. to 16° C. above that of the surrounding air. They attain an actual internal temperature of from 38° C. to 43° C. under such circumstances.

That the greater part of this large rise of temperature is due to the absorption of direct sunlight is seen in the following tables, which show that in the shade the temperature is always much lower :—

TABLE XIV.—November 14.

Time.	Conditions.	Zero.	Deflection.	Temperature of Junction in Water.	Shade Temperature of Air.	Calculated Temperature of Junction in Leaf.
A.M.						
10.32	In shade	0·0	—0·2	27·2	26·2	26·2
10.39	In sun	0·0	2·9	27·3	26·6	41·8
10.44	Do.	0·0	2·9	27·8	26·6	42·3
10.48	In shade	0·0	0·0	27·9	26·8	27·9
10.51	In sun	0·0	2·5	27·8	26·8	40·3

Thus the leaf, which in direct sunlight attained a temperature of 42·3°, was immediately brought down to 27·9° by being shaded, and this is a sample of what normally occurred. It is noteworthy, however, that very rarely did the leaf temperature sink in the shade to that of the surrounding air. Readings, such as those given in Table XIV., where the leaf in the shade has a temperature of 1·1° C. above the temperature of the surrounding air (10.48 A.M.), are typical. The usual shade reading was between 1° and 2° C. above the surrounding air. On certain occasions it rose higher than this, the highest reading recorded in the shade being 4·1° C. above that of the surrounding air. This occurred on January 27, 1906, when the shade temperature of the air was 28·2 C., almost the highest temperature recorded during the whole of the observations. Thus, this high temperature in the shade was on a very cloudless morning when the reflected radiation was very bright. On one occasion only, October 31, 1906, did the temperature in the shade sink below that of the surrounding air. This was the case of the young flaccid red leaf, with little chlorophyll, of *Amherstia nobilis*, a special case which will be dealt with later.

It seems then in general that, in direct sunlight, green leaves of various thicknesses and textures attain a temperature of from 11°–15° C. above that of the surrounding air, while in the shade they are usually 1°–2° C., and sometimes as much as 4° C. higher than the air. The heating up is no doubt due to the absorption of radiation by the colouring matter of the leaf. Part of this is used up to provide energy for transpiration and assimilation, but in direct sunlight much more is absorbed than can be used, and the excess raises the temperature of the leaf. Further, in the open air on bright sunny days there is, as a rule, sufficient reflected radiation (direct sunlight being shut off) to raise the temperature of the leaf 1°–2° C., and sometimes more above the surrounding air. Only on dull or wet days does the leaf temperature remain the same as that of the surrounding air.

EFFECT OF THE THICKNESS OF A LEAF.

It seems somewhat surprising that the thickness and texture of the leaf should have so little influence on this result. There is one important respect, however, in which thick succulent leaves differ from thin leaves in their absorption of radiation, and that is with regard to the time taken to attain the maximum temperature after exposure. The following experiments bear upon this point :—

TABLE XV.—January 25, 1906.

Leaf of *Rhœo discolor.*

1 Time.	2 Conditions.	3 Shade air Temperature.	4 Leaf Temperature.	5 Difference between 3 and 4.
A.M.				
9.27	In full sun	25·5	37·2	11·7
9.28	Shaded	—	—	—
9.30	Do.	25·6	31·5	5·9
9.32	Do.	25·6	29·4	3·8
9.34	Do.	25·6	28·6	3·0
9.42	Do.	25·8	27·5	1·7
9.50	Do.	25·8	27·4	1·6

TABLE XVI.—January 25, 1906.

Time.	Conditions.	Shade Air Temperature.	Leaf Temperature.	Difference.
A.M.				
9.50	In shade	25·8	27·4	1·6
9.54	Sun on	—	—	—
9.56	Do.	25·9	33·5	7·6
9.58	Do.	26·0	36·7	10·7
10. 0	Do.	26·1	37·6	11·5
10. 2	Do.	26·1	38·2	12·1
10.10	Do.	26·3	38·5	12·2
10.12	Do.	26·4	39·5	13·1
10.13	Do.	26·5	39·8	13·3
10.15	Do.	26·5	39·3	12·8
11. 0	In shade	27·2	28·7	1·5
11. 3	Exposed to sun	—	—	—
11. 5	Do.	27·4	34·2	6·8
11. 7	Do.	27·4	37·9	10·5
11. 9	Do.	27·4	38·4	11·0
11.18	Do.	27·5	42·4	14·9
11.21	Moderate breeze	27·5	41·9	14·4
11.24	Air still	27·5	42·3	14·8
11.25	Do.	27·5	42·0	14·5

If from these tables curves of the fall or rise of temperature with the time are plotted, it will be seen that, in the case of this succulent leaf, at least ten minutes must pass after exposure or shading before the leaf takes up the temperature corresponding to the new conditions. For comparison with this the following results with thinner leaves are given :—

TABLE XVII.—January 22, 1906.

Magnolia sphenocarpa.

Time.	Conditions.	Shade Air Temperature.	Leaf Temperature.	Difference.
A.M.				
11.32	In shade	27·0	29·3	2·3
11.33	Exposed to sun	—	—	—
11.33	Do.	27·0	34·0	7·0
11.34	Do.	27·0	38·5	11·5
11.36	Do.	27·0	44·0	17·0
11.37	Shaded again	—	—	—
11.37	—	27·0	40·1	13·1
11.38	—	27·0	34·1	7·1
11.39	—	27·0	32·6	5·6
11.40	—	27·0	30·6	3·6
11.42	—	27·0	30·6	3·6

* Immediately after exposure.

In this case we find that in three minutes after shading or exposure the leaf takes on the temperature corresponding to the new conditions.

TABLE XVIII.—January 27, 1906.

Acalypha tricolor.—Variegated leaf.—Junction in green part.

Time.	Conditions.	Shade Air Temperature.	Leaf Temperature.	Difference.
A.M.				
11.56	In full sun	28·0	43·5	15·5
11.57	Shaded	—	—	—
11.58	—	28·0	33·3	5·3
11.59	—	28·1	32·8	4·7
12. 1	—	28·2	32·5	4·3
12. 3	—	28·2	32·3	4·1

In this, the thinnest leaf used, the fall during the first minute was more rapid still. In three minutes the leaf had practically attained the temperature of the new conditions. Thus, in the contrast between the ten minutes taken by the succulent leaf and the three minutes taken by the thinner leaves, we seem to have a purely physical effect due to the greater value in the former of the proportion $\frac{\text{Volume}}{\text{Surface}}$. Where there is a greater mass to be heated up in proportion to the surface receptive of radiation, a longer time is taken to reach the higher temperature and the same holds for the reverse process of cooling. If the mass is small in proportion to the surface, both higher and lower temperatures are reached more quickly. These facts, however, do not seem to produce any permanent difference between the two classes of leaves with respect to the temperature to which they attain even under varying conditions of sunshine and shade, as in the case of the thinner leaves the more rapid cooling is balanced by the more rapid heating. It will be shown later what a powerful agent in reducing leaf temperature movement of air is, and it is important to notice that in this respect succulent leaves are much less affected by the breeze than thinner leaves. (See Table XVI., 11.21 A.M.) This difference must be of considerable importance under natural conditions, since a slower cooling during air movements must tend in the direction of keeping the succulent leaf at a higher temperature than that of the thin leaf.

ESTIMATION OF EFFECT OF TRANSPIRATION ON TEMPERATURE.

Theory indicates (for a full discussion of the point, see Brown and Escombe (4)) that the loss of water by transpiration is a most important factor tending to lower the temperature of transpiring leaves. In order to get some idea of this effect quantitatively, the internal temperature of a dead and brittle leaf of *Magnolia* was ascertained. This leaf does not, it will easily be seen, present the same case as a living leaf, minus the transpiration effect. The colour is quite changed from green to a dark brown, and no doubt the dead leaf is less transparent to radiation on that account. It may nevertheless be of some interest to give the figures obtained.

TABLE XIX.—January 23, 1906.

Dead Leaf (brown and brittle) of *Magnolia sphenocarpa.*

Time.	Conditions.	Shade Air Temperature.	Calculated Temperature of Leaf.	Difference.
A.M.				
10.42	Leaf in sun (little breeze)	26·1	45·5	19·4
11. 2	Do.	26·3	48·7	22·4
11. 7	Leaf in sun (air still)	26·5	50·0	23·5
11.25	Leaf in sun (little breeze)	26·6	49·2	22·6
11.29	Do.	26·6	49·7	23·1
11.34	Junction only shaded	26·8	35·7	8·9
11.40	Do.	27·1	43·1	16·0
11.43	Shade removed	27·0	48·8	21·8

It is thus seen that such a leaf attains in the sun a temperature of 23° C. above that of the surrounding air, and reaches 50° C. This is a temperature which would be injurious to the living leaf, and the fact that the living leaf does not attain to it may be put down to two causes : (i.) the living leaf, on account of its colour being green, not dark brown, absorbs less of the sun's radiation, *i.e.*, it is more transparent ; (ii.) the living leaf is cooled by the loss of water in transpiration.

An attempt was made to estimate the effect of transpiration in another way. This consisted of placing the thermo-junction between two leaves placed one on top of the other with their edges bound together in a cardboard frame fastened with clips. The small space between the leaves in which the thermo-junction lay was thus a closed space.

When the leaves were placed with their stomatal surfaces facing each other, transpiration was largely diminished. It was difficult to fit up the leaves, so that their edges should be closely pressed together all round forming a quite closed inner space. In actual experiments the leaves were only approximately so placed, so that a small amount of communication between the inner air space and the outer air was possible. The leaves so placed were contrasted with a pair of leaves, whose stomatal surfaces faced outwards, thus allowing of free transpiration from these surfaces. On the whole the contrast is between pairs of leaves, alike in other respects, in one of which there is free stomatal transpiration, and in the other this transpiration is very largely diminished.

The following are some of the results obtained :—

Table XX.—November 21, 1906.

Amherstia nobilis.

Conditions.	Black Bulb Thermometer.	Humidity in Saturation. Per Cent.	Shade Air Temperature.	Leaf Temperature.	Difference.
Stomata inwards in shade	—	63	26·6	27·5	0·9
Stomata inwards in sun	60·4	66	26·7	41·0	14·3
Stomata inwards, with strong breeze	—	—	—	—	—
Stomata inwards in sun (still)	60·7	64	26·7	43·5	16·8
Stomata inwards, strong breeze	60·7	63	26·6	39·4	12·8
Stomata inwards in shade	—	64	26·9	28·7	1·8
Stomata outwards in shade	—	64	26·8	28·5	1·7
In sun, strong breeze, but highest temperatures are reached in lulls	61·3	61	27·0	39·6	12·6
In sun	61·7	63	27·2	40·6	13·4
In sun	61·8	63	27·2	41·7	14·5
In sun, air still for a time	62·0	63	27·1	42·8	15·7
In sun, strong breeze	62·0	63	27·1	37·8	10·7
Stomata inwards in shade	—	62	27·5	29·4	1·9
In sun (air still)	62·4	62	27·7	46·5	18·8
In sun (moderate breeze)	62·4	62	27·7	41·0	13·3

Breeze was so constant that the highest temperature (46·5) was not reached again.

The readings of the black-bulb-in-vacuum thermometer are given and show a slight progressive increase in the intensity of the sun's radiation. Readings of the humidity are given, as change in this factor is likely to affect transpiration considerably. These readings show fairly uniform conditions throughout, though on the whole the humidity decreases a little. It will be seen that the conditions with respect to movement of air vary considerably, so that it is only on two or three occasions that still air conditions were obtained. This renders comparison of the results difficult. To get a reliable comparison it would be best to take the average of a series of readings in each case. Since, however, no attempt was made to measure the conditions as to rate of air movement, it might be misleading to do so, because the amount of breeze in one series might not be comparable to the amount in another. It seems best to compare the readings obtained in still air. If we do so, we get stomata inwards 16·8 C. above surrounding air, stomata outwards 15·7 C. above surrounding air, stomata inwards 18·8 C. above surrounding air. The increase from 16·8 to 18·8 may be put down to the increase in intensity of radiation (see figures for black bulb thermometer) as the morning advanced. Taking the average of these two 17·8, it is 2·1 above the highest reading for stomata outwards. This difference may be fairly attributed to the diminishing of the transpiration in the former case. It will be seen that a difficulty occurred, with the apparatus used, in comparing two leaves or sets of leaves, in that the conditions of air movement and intensity of sun's radiation often changed very rapidly, and in a way which could not easily be measured. It might occur, therefore, that during the time occupied in setting up a leaf for comparison with one previously used the conditions had changed considerably. For instance, a breeze may have sprung up or the sun have become more or less obscured. Under such conditions comparative experiments were useless. In order to get over this difficulty, two sets of apparatus were henceforth used. The leaves to be compared could be set up side by side, and thus conditions were equalized. Since only one galvanometer was available, the readings could not be absolutely simultaneous, and the method was to take a reading of the temperature of one leaf, and then transfer the connecting wires of the galvanometer to the mercury cups of the other apparatus and take a reading of the temperature of the other leaf.

This transference occupied only a very short space of time, and it was thus possible to take readings of both leaves under similar conditions. The wires could easily and quickly be transferred back again, and in this way it was possible to take a series of readings crossing from one leaf to the other several times—a series from which a reliable average temperature could be obtained.

The two sets of apparatus were first carefully compared and standardized. This was done with one junction of each in air and the other in water in a room of the laboratory. It was attempted to make the two sets as much alike as possible, special care being taken that the very thin wires composing the thermo-junctions should be of equal length. The resistance of these wires is so high that any change in their length alters the deflection per degree very considerably. In spite of this attempt, the two sets did not register the same temperature when the temperature of the air in which they were placed was the same. Their deflection per degree was the same, but one apparatus registered ·8° C. higher than the other all through. A curve was made of the galvanometer readings of both plotted against the air temperatures as registered by an accurate thermometer. All subsequent readings of the galvanometer were referred to this curve, and thus the proper correction was always applied.

The following table gives the results for mature leaves of *Amherstia nobilis* : (*a*) with stomata inwards, (*b*) with stomata outwards, obtained by using this double apparatus :—

TABLE XXI.—January 26, 1906.

Time.	Black Bulb Thermometer.	Humidity of Air.	Temperature of Leaves with Stomata outwards above Shade Temperature of Air.	Temperature with Stomata inwards.
A.M.		Per Cent.		
11.41	55·2	55	7·0	8·6
11.45	55·2	55	10·7	11·9
11.57 to 12 noon	58·7	58	11·1	11·2
—	—	—	10·7	11·2
—	—	—	11·6	12·3
—	—	—	11·6	12·6
—	—	—	11·1	12·0
		Average	10·5	11·4

The numbers in the fourth and fifth columns represent the excess of the temperature inside the leaves over that of the surrounding air. The readings opposite to each other were taken almost at the same time, and are comparable with each other.

Amherstia nobilis.—December 6, 1906.

Time.	Black Bulb Thermometer.	Humidity.	Outwards.	Inwards.
A.M.		Per Cent.		
11.32	52·7	69	7·2	11·2
—	—	—	7·0	10·7
11.43	Dull sun	74	7·8	10·2
11.45	58·2	73	12·3	13·1
—	—	—	13·7	17·1
11.47	63·0	73	15·9	17·0
11.52	64·7 (breeze)	—	10·9	15·7
11.54	65·7	69	13·8	16·9
P.M.				
12. 1	61·7	70	9·6	12·0
12. 3	—	—	9·6	13·2
—	—	—	10·8	14·1
		Average	10·8	13·7

Amherstia nobilis.—December 7, 1906.

			Outwards.	Inwards.
A.M.		Per Cent.		
11.16	47·7	77	9·2	10·9
11.32	—	75	12·7	16·2
		Average	10·9	13·5

Thus the first day shows on the average the leaves with the stomata inwards ·9° C. hotter than those with stomata outwards. The second day shows 2·9° C. difference, and the third day 2·6° C. I am not able to account for the smaller difference on the first day. The only marked difference from the second and third days is in the humidity, which was much lower, but it is not obvious that this should tend to equalize the temperatures. If we take the average of the whole twenty readings on the three days, we get stomata outwards 10·7° C., stomata inwards 12·9° C., a difference of 2·2° C., and this is very near to the 2·1° C. obtained by readings with the single apparatus.

We may take it that in direct sunlight of this intensity and for still air the loss of water by transpiration cools the leaf from 2°–3° C. at least. Most probably greater differences would be obtained if the edges of the leaves were accurately fitted together all round so that no water vapour could escape. One of the leaves with stomata inwards, which reached a temperature of 45° C., was turned brown on each side of the lower portion of the midrib for a distance of 1–2 cms. Drops of water stood plentifully on the inside of these leaves when they were taken apart. The same experiments were also performed on two pairs of the young red flaccid leaves of *Amherstia nobilis*, and gave the same general results. These are set out in Table XXII.

TABLE XXII.—December 27, 1906.

Two pairs of young red flaccid leaves of *Amherstia nobilis* : one pair with stomata outwards, the other with stomata inwards.

Time : 11.53 A.M.

Black bulb : 62·2.

Shade temperature : 26·4.

Humidity : 69 per cent.

Leaf temperature : *39·2*, 36·9, *38·8*, 37·2, *39·6*, 38·6, *41·3*, *43·7*, 41·9, 40·6, *43·7*, 40·6.

Conditions : Bright sun. No breeze when highest temperatures are recorded ; slight breeze for lower.

The figures in *italics* are the temperatures of the leaves with stomata inwards. The observations are placed exactly in the order in which they were made. They occupied about five minutes in taking. Taking the average of the six observations with each apparatus, we get stomata inwards 14·6°, stomata outwards 12·9° above the temperature of the surrounding air—a difference of 1·7° C.

Effect of Air Movement.

The internal temperatures reached by thin foliage leaves placed normal to bright tropical sunlight and in still air are, we have seen, from 38–43 C. Such temperatures as these have hitherto often been considered injurious to the leaf. It is worth while, therefore, to notice how far leaves are subjected to such conditions in nature. The statement has been made (Ewart 8) that in the tropics plants very rarely expose their leaves so as to be normal to the sun's rays when the sun is overhead. This statement is open to doubt, and would require a large amount of detailed evidence to substantiate it. Full evidence on this point, either for or against, is not at my command. Apart from this, there is one condition, that of air movement, which is most important in this connection, upon which evidence will be brought forward. Even at Peradeniya where strong winds are of very rare occurrence, there are very few times when the air is quite still. During the present experiments, which were all carried out on days which were sunny and bright, a certain amount of fitful breeze varying in strength was usually present. In all the tables the highest readings were only obtained in certain still intervals, which were in many cases very short. As has previously been remarked, any air movement, however slight, is a most powerful factor in reducing the internal temperature, at any rate of thin leaves. No attempt was made to measure the velocity of the movement of air, but the condition of the air was roughly classified as (1) still, (2) slight breeze, (3) breeze with an occasional special note when the breeze was strong.

The following table gives the reduction of temperature brought about by breeze of varying velocity on January 22, 1906 :—

TABLE XXIII.—January 22, 1906.

Mature leaf of *Magnolia*.

Time.	Conditions.	Internal Temperature of Leaf.	Excess over Shade Air.
A.M.		C.	C.
10. 9	Air still, bright sun	38·9	13·4
10.19	Breeze do.	34·0	8·5
10.21	Do. do.	34·5	9·0
10.24	Slight breeze do.	37·6	11·9
10.26	Do. do.	38·2	12·4
10.30	Do. do.	38·8	12·7
10.33	Still do.	40·5	14·2
11.19	Still do.	43·3	16·6
11.24	Slight breeze do.	39·3	12·6
11.50	Breeze do.	35·6	8·5
11.52	Do. do.	34·5	7·4
11.53	Do. do.	35·3	8·2
11.54	Slight breeze do.	37·6	10·5
11.55	Do. do.	38·3	11·3
11.56	Do. do.	38·2	11·2
January 23, 1906.			
9.25	Breeze, bright sun	34·3	10·0
9.28	Do. do.	34·7	10·3
10. 5	Slight breeze do.	37·3	12·0
10. 8	Do. do.	38·3	12·8
10.10	Strong breeze do.	34·2	8·8

An observation on the fleshy leaf of *Rhœo discolor* shows that this leaf is not so much affected by breeze as a thin leaf.

TABLE XXIV.—January 25, 1906.

Leaf of *Rhœo discolor*.

Time.	Conditions.	Temperature of Leaf.	Excess over Air.
A.M.			
11.18	Still, bright sun	42·4	14·9
11.21	Fairly strong breeze, bright sun	41·9	14·4
11.24	Still, bright sun	42·3	14·8

One or two further examples are given with leaves of other species.

TABLE XXV.—January 27, 1906.

Leaf of *Acalypha tricolor.*

Time.	Conditions.	Temperature of Leaf.	Excess over Air.
A.M.			
11.46	.. Still, bright sun ..	42·9 ..	14·9
11.47	.. Fairly strong breeze, bright sun ..	35·9 ..	7·8
11.54	.. Still, bright sun ..	41·7 ..	13·7
11.56	.. Do. ..	43·5 ..	15·5

TABLE XXVI.—January 21, 1907.

Mature leaf of *Theobroma Cacao.*

Time.	Conditions.	Temperature of Leaf.	Excess over Air.
A.M.			
10.55	.. Still, bright sun ..	37·2 ..	10·7
10.56	.. Strong breeze, bright sun ..	30·9 ..	4·4

Young red leaf of *Theobroma Cacao.*

Time.	Conditions.	Temperature of Leaf.	Excess over Air.
10.55	.. Still, bright sun ..	40·3 ..	13·8
10.56	.. Strong breeze, bright sun ..	30·0 ..	3·5

The last example furnishes the extreme case of effect of breeze, 10° C. difference in temperature being caused in the young red leaf of cacao by a sudden strong gust of wind. Summing up, it may be said that breezes of various strengths reduce the temperature in thin leaves immediately from 2°–10° C. below what they attain in still air. It only remains to point out how important such air movement is in natural conditions in reducing leaf temperature. There are few days when some sort of breeze is not present, and even on comparatively still days the occasional light airs which spring up have an important effect in reducing leaf temperature.

EFFECT OF COLOUR (HISTORICAL).

A large number of observations were made on the internal temperature of leaves of different colours, especially on those coloured red with anthocyan. The subject of the significance of such red colouring matters has attracted considerable attention. The method followed by observers on this matter has almost always been to regard the presence of anthocyan as an adaptation advantageous for some purpose, and then to bring forward arguments from its distribution and the conditions of its occurrence, in favour of some particular advantage being the one really obtained. Thus, the history of the question of anthocyan can be conveniently summarized by dividing the researches into those which support the "screen theory," *i.e.*, the theory that the anthocyan absorbs the rays which are destructive to chlorophyll, and those which support the theory that the anthocyan by raising the temperature of the leaf favours transpiration and also in colder climates translocation. Overton's (22) researches stand apart from the rest in that they show the red colour to be a product formed under certain conditions by chemical processes going on in the leaf whenever those conditions are realized. Thus, it is not necessary, Overton's (22) results being known, to suppose the anthocyan to be an advantageous adaptation at all in itself. It is only necessary to suppose that its disadvantages, if they exist, are not so great as to imperil the life of the species in the struggle for existence. The foundation of the screen theory was laid by Pringsheim (24), 1880. He performed experiments showing the destruction of chlorophyll by intense light in *Nitella*, *Elodea*, &c., and showed also that under a red screen, a solution of iodine in carbon bisulphide, this destruction did not occur. His general conclusion from the whole of his experiments was the theory that the protoplasm does the actual work of carbon assimilation and that the function of the chlorophyll is to act as a screen to prevent oxidation of the protoplasm in too strong a light. This theory is, of course, now quite discarded. Nevertheless, the particular experiments here quoted are quite possibly a good foundation for the screen theory as applied to anthocyan, and have been so used by later writers, *e.g.*, Ewart (7).

Reinke (25), 1883, expressed conclusions in opposition to Pringsheim's results. For us his most important result is that exposing chlorophyll and other colouring matters to concentrated light, with heat rays cut off by passing through alum solution, he obtained no bleaching in leaves of *Elodea* and *Impatiens* or in petals of *Papaver* and *Rosa* until the light intensity became 800 or 1,000 times the usual intensity of sunlight. These experiments are directly opposed to those of

Pringsheim, and would seem to indicate that the destructive effect of light on chlorophyll had been over-estimated by him.

Engelmann (5), 1883, using the bacterial method, showed in opposition to Pringsheim that the green colouring matter, and that only, did the work of assimilation. He went on to show that in all coloured cells red, green, blue-green, and yellowish-brown there is a general parallellism between absorption of light and assimilation. This he did by investigating the assimilation of blue-green, brown, and red algæ by the bacterial method. He even conjectured, though his work does not here afford a sufficient foundation for proof, that assimilatory value $A = n E$ where E is the actual energy of a wave-length and $n =$ co-efficient of absorption of that particular wave-length.

Reinke (26), 1885, attempted to trace the relation between absorption of the different parts of the spectrum and the destruction (oxidation) of the colouring matter by these parts of the spectrum. He used his well-known spectrophore to correct for unequal dispersion. His figures showed that the amount of destruction of chlorophyll for the different wave-lengths showed the same sequence of effects as the course of absorption of these different wave-lengths by the chlorophyll.

It seemed to be established by these researches that the effects of the different parts of the spectrum on the chlorophyll, whether in causing assimilation or oxidation, varied in intensity according to the absorption by the chlorophyll of these particular wave-lengths. It followed that rays not absorbed by the chlorophyll did not have any effect on it. When, therefore, Engelmann (6) in 1887 showed by the use of the microspectral-photometer that the course of absorption of the rays of the different wave-lengths in anthocyan was almost exactly complementary to that in chlorophyll, the following argument arose :—If the anthocyan only absorbs those colours which are not absorbed by the chlorophyll and allows the others to pass unchanged, how can it have a screening effect ? To be of any use as a protection against chlorophyll destruction it should absorb some of those rays which would otherwise be absorbed by the chlorophyll, for it is these which produce the destructive effect. Really to protect the chlorophyll, Engelmann pointed out, a green screen would be the best, as it would absorb those rays which would otherwise be absorbed by and destroy the chlorophyll. It will be seen that to this argument no adequate reply has yet been forthcoming.

Meanwhile, Kerner (15), 1883, had carried on experiments in the Alps on the growth of plants brought from lowland districts. He found that of the varieties he transferred, those grew best which had red colouring matter, while ordinary green-leaved species did badly. He explained this by supporting the screen theory, and supposed that those without the red colouring matter suffered by the exposure to the intense light of the higher Alpine regions. He interpreted the red colour as a protection against the destruction of the chlorophyll, and also against the oxidation of assimilated products of the leaf. His experiments are of special importance, because they are constantly quoted, as we shall see, by later writers on both sides of the controversy.

Pick (23), 1883, brought forward the idea that the red colouring matter was useful in furthering translocation, as it screened from those rays which tend to dislocate the machinery of translocation. His work has been adversely criticised by Ewart, Stahl, and Overton, and it may be concluded that his experiments were crude, although he collected many useful facts.

Hassack (11), 1886, devoted the greater part of his paper to an anatomical investigation into the position and distribution of the coloured sap in coloured leaves. In his general conclusions he supported the screen theory of the function of anthocyan, resting his argument on Kerner's results with plants in Alps and the general occurrence of red and of intenser colours in plants much exposed to sunlight. Up to this point then, when Engelmann (6) in 1887 made his attack upon the screen theory, most writers had favoured it. We now come to Wiesner's (31) paper, 1894. He assumed that chlorophyll, especially while developing, needed protection and supported the screen theory of the function of anthocyan. This he did from a consideration of the results of other researchers, especially prominent among them being Kerner. He was inclined, however, to minimise somewhat the protective effect of anthocyan, and stated it to be only a link in a chain of protective measures.

Keeble (14). 1895, in a paper dealing with the hanging foliage of certain tropical trees also dealt with the question of the function of anthocyan, since it was present in *Amherstia nobilis*, the tree upon which most of his experiments were made. He supported the protective function of anthocyan, and performed an experiment tending to show that chlorophyll in young leaves of *Amherstia* was to some extent destroyed if fully exposed to sunlight, and therefore stood in need of a protection. He, however, put anthocyan as a protection in a somewhat minor position, because of the fact that it is not universally distributed in plants in those positions in which the exposed chlorophyll needs a protection. He thought it to be, however, an efficient protection in the somewhat limited number of cases where it is present in such positions. He obtained temperatures registered by thermometers placed both above and below such red leaves and compared them with those obtained with green leaves. From his somewhat rough experiments he drew the novel conclusion, which has been adversely criticized by later authors (Stahl, &c.), and is exactly the opposite of the conclusion logically to be drawn from his observations, that the red colour is a protection against too great heating up of the leaf, *i.e.*, that it ends to keep down the temperature of the leaf.

In 1896 Stahl (28) published a most important paper and brought forward, in a long survey of the distribution and structure of plants with coloured and variegated leaves, the idea that the chief value of anthocyan was to raise the temperature of leaves by absorption of the sun's rays. This favoured, he thought, in temperate and cold climates translocation and in tropical climates transpiration. He emphasized the argument of Engelmann (6), which had been lost sight of by later writers, that since anthocyan lets through just those rays which are absorbed by the chlorophyll, its function cannot be protective. His view of the screen theory is that while it plausibly explains certain facts, chiefly of distribution, yet these facts can be explained on his theory also, and that so far there have been no decisive experiments made to settle the matter between the two theories. The chief value of his paper is that he supports his theory by experimental data, showing that it is, at any rate, true that the presence of red colouring matter does raise the temperature of a leaf. His proof of the supposition that this higher temperature does really aid transpiration is of a different kind. It consists in showing that the red colour is usually found in places where transpiration is difficult, and that other contrivances, such as silver-flecked and velvety leaves, are also found in such situations, and can be explained as being adaptations for the same purpose. The importance of increasing transpiration is that then the salts necessary for translocation and anabolic changes are not withheld from the plant even at night. He considers Kerner's results, and tries to show that they can be explained on the supposition that the red colouring in the Alps may by raising the temperature of the leaves protect them from the very low temperature, which would otherwise be the result of the excessive radiation going on at night at high elevations. From the experiments already brought forward in the earlier part of the present paper, showing how quickly leaves lose the high temperatures caused by the absorption of sunlight, we can at once dismiss this explanation of Stahl's, for it depends upon the supposition that the red leaf for an appreciable part of the night retains a temperature higher than that of the surrounding air. We have seen that even in bright diffuse light a thin leaf only takes three minutes and a fleshy leaf not more than fifteen minutes to sink to the temperature of the air when it is screened from direct sunlight. That a leaf should in the dark retain a temperature above that of the air for any length of time seems therefore impossible.

Stahl's most important work was that he showed, by well-devised experiments both with a thermo-junction and with cacao-butter smeared on the leaf, that red leaves did attain a temperature in sunlight 1–2° C. higher than the temperature reached by green leaves, and that the same is true for a red part of a leaf compared with the green part of the same leaf.

Ewarts (7), 1896–7, favours the protective theory of anthocyan, but interprets it not so much as a protection against the destruction of chlorophyll as against assimilatory inhibition which he had shown to follow on too strong illumination. He states, however, that this protection is not necessary in plants which are accustomed to exposure, and that it is seldom, except in shade plants, that healthy and mature green leaves suffer more than a slight weakening of assimilation even after twelve hours' exposure to sunlight. He mentions the distribution of red colour, and quotes Johow (13) as having shown that the presence of anthocyan is called forth directly by exposure to light. In 1897 Ewart (8) in a further paper supports the protective theory of the function of anthocyan and adversely criticises Stahl. His view is still founded on Pringsheim (24), who, he says, showed that the rays most destructive to chlorophyll were the blue and green, and these are those most absorbed by anthocyan. Against Stahl's theory of anthocyan, as an aid to transpiration, he brings forward a new statement that red leaves or parts of leaves have generally fewer stomata, showing that the extra transpiration due to the higher temperature caused by the anthocyan is a disadvantage which has to be provided against. As opposed to the idea that young leaves (often red in the tropics) require greater transpiration to provide mineral salts to the growing organs, he looks upon the young leaf not as an organ requiring copious mineral food, but as one supplied with food already formed and presented to it in a concentrated and soluble form.

Overton (22), 1899, in a paper of striking value offered evidence of a different character on the problem of anthocyan. He accidentally observed that the leaves of *Hydrocharis*, a plant on which he was experimenting with quite a different object in view, turned red when cultivated in 3–5 per cent. solution of cane sugar. New leaves formed in this solution were all red. Travelling in the Alps, where such colour is abundant, brought back the point to his mind and suggested that perhaps the low temperature of those elevations favoured the presence of sugar at the expense of starch. He quotes as supporting this (1) Sachs, who showed that low temperature hinders translocation and therefore increases the amount of sugar; (2) observations of Müller-Thurgau (21) on potatoes to the effect that low temperatures tended to change their starch into sugar; (3) Fischer (9) on the reserves in trees in winter; and (4) Lidforss (17) on sugar in evergreen leaves in winter. Overton himself made observations and found more sugar in Alps in autumn than in the same species in summer. He then performed a large number of experiments and came to the following conclusions from them :—(1) In a large number of species the presence of red cell sap stands in an exact relation with the richness of the sap in sugar; (2) a lower temperature favours the red colour; (3) greater light intensity shares in the effect. He considers the chemical nature of the pigment and from the probability that the grape sugar molecule is not much changed in forming the pigment and from other considerations he supposes the pigment to be a glucoside, of which a constituent is a tannic acid. Red colours are, however, probably not all alike in chemical composition. In reviewing the history of the question, he is inclined to support Stahl in his view of the function of the red pigment.

The chief supports therefore of the screen theory are Kerner's Alpine experiments, Pringsheim's experiments on the destruction of chlorophyll by strong light, and the general fact of distribution, namely, that the red colour is favoured by exposed situations and is developed in specimens in strong light when others of the same species in the shade are without it, or even, as is often the case in the Copper Beech, that one individual has its exposed leaves coloured and its shaded leaves green. Against this screen theory are Reinke's experiments tending to minimise the destructive effect of light on chlorophyll, and Engelmann's careful analysis of the absorption spectrum of anthocyan, showing that it is complementary to that of chlorophyll and only absorbs those rays which would otherwise pass through the chlorophyll, not those rays which would be absorbed by the chlorophyll. It is likely that a screen which had the effect of protecting chlorophyll would absorb some of those rays which would be absorbed by the chlorophyll without such a screen. An effective screen should have a similar, not a complementary, absorption spectrum to that of chlorophyll. It is significant that later supporters of the screen theory have never shown experimentally that anthocyan does protect the chlorophyll. Pringsheim's red screen which protected the chlorophyll was iodine dissolved in carbon bisulphide and had quite a different absorption spectrum from anthocyan, especially at the more refrangible end. Even if the destructiveness of strong light to chlorophyll under normal conditions has not been over-estimated by them, yet it is not enough to show that chlorophyll needs a screen, it must also be shown that anthocyan actually affords the protection needed.

The chief supports of Stahl's position are: (1) that he has shown by experiments that the internal temperature of red leaves or parts is higher than that of green leaves or parts; (2) that he has shown that red colour does often exist in shade plants; and (3) that he has suggested an interpretation of Kerner's results which is compatible with his own theory. Overton's work bids us be chary of arguing on the assumption that if a particular advantage might accrue from the presence of anthocyan, therefore that advantage is probably the one which does accrue, for it is quite possible that anthocyan is a product necessarily formed in the leaf under certain chemical and physical conditions and that its presence is of no advantage to the plant at all. In this paper therefore no such conjectural evidence will be brought forward, but experimental results on the actual temperatures attained by red leaves compared with yellow, white, and green leaves. Further evidence will be brought forward in a later part of the paper on the actual time and conditions of appearance of red colouring matter in young leaves of certain tropical trees. It may meanwhile be remarked that Stahl's explanation of Kerner's results does not hold good in the light of experimental results in the earlier part of this paper, and that there is a considerable body of evidence by observation to the effect that anthocyan is by no means confined to, even if it is prevalent in, shady moist situations, where transpiration is difficult; but that, on the other hand, it is very prevalent in open situations exposed to the strongest tropical sunlight.

Effect of Colour (experimental).

The leaves used in this part of the investigation were of various kinds, and in some cases had, besides their colour, other differences, *e.g.*, of texture, from ordinary green leaves. These will, however, be described in each case. In the following experiments the temperatures of young leaves of

Amherstia nobilis and of *Saraca indica* were compared. Both these trees belong to the group whose young foliage hangs flaccidly downwards (see Keeble). In *Amherstia nobilis* the young leaves are brownish-red in colour and are folded along the midrib in the earlier stages. The anthocyan producing the colouration is present in the spongy mesophyll. In the earlier stages the chorophyll is very feebly developed, so that when the anthocyan is dissolved by hot water the leaf becomes very pale and almost white. The leaf of *Saraca indica* is smaller and not folded, and in colour is almost white. It very often contains no pigment other than a little chlorophyll, but faint purplish areas on the whitish ground are not uncommon. The prevailing colour ought really to be described as a greenish-white, for a very small amount of chlorophyll is present and gives a green tinge to the leaf. As the leaf grows older this green tinge gets deeper, and by development of the chlorophyll the leaf gradually changes first to a light green and then to a darker green. The two leaves approach similarity as nearly as possible, except in the matter of colour. They are both thin and flaccid, and, as far as can be roughly judged by the eye, have a similar development of chlorophyll. In both it is almost absent in the earliest stages and gradually developes later. The great difference is that in *Amherstia nobilis* anthocyan is present, giving the leaf a deep brownish-red colour, which disappears when the chlorophyll is developed, and *Saraca indica* being without this colour is almost white in the earlier stages, and gradually changes to green.

TABLE XXVII.—December 14, 1906.

Time.	Black Bulb Thermometer.	Humidity.	Internal Temperature of *Amherstia nobilis* above Shade Air Temperature.	Internal Temperature of *Saraca indica* above Shade Air Temperature.
A.M.	C.	Per Cent.		C.
11.24	59·6	53	11·0	8·7
			11·3	10·0
11.27	59·6	53	13·4	10·7
11.42	59·9	54	13·2	10·7
			13·2	11·5
11.58	58·7	52	10·3	8·5
	Sun slightly obscured		11·1	9·4

Average of 7 = 11·9 C.; average of 7 = 9·9 C.

Here the coloured leaf of *Amherstia* reaches a temperature 2° C. higher than the leaf of *Saraca*.

In the next table results are given of experiments with the young red leaf of *Mesua ferrea* compared with the young leaf of *Saraca indica*. The young leaf of *Mesua ferrea* is a little stiffer than the leaf of *Amherstia nobilis* and is of a brighter red, tending to pink rather than brown.

TABLE XXVIII.—December 18, 1906.

Time.	Black Bulb.	Humidity.	Internal Temperature of *Mesua ferrera* above Shade Temperature of Air.	Internal Temperature of *Saraca indica* above Shade Temperature of Air.
A.M.	C.	Per Cent.	C.	C.
11.27	58·0	68	6·5	4·2
11.30	58·4	69	9·5	4·7
—	—	—	10·9	8·9
11.35	59·0	67	11·2	7·4
—	—	—	8·1	7·0
11.39	59·0	67	9·0	5·9
		Average of 6 =	9·2° C.	6·4° C.

Here again the red leaf attains a higher temperature than that of the pale leaf, this time to the extent on the average of 2·8° C.

In Table XXIX. are given the results of a comparison of green and yellow leaves of *Codiæum variegatum*. This plant as it grows in Peradeniya Gardens has some leaves almost devoid of chlorophyll and of a bright yellow colour, others green with chlorophyll, and there are leaves which show proportions of the two colours, which form all the intermediate stages between these two extremes. The cross sections of the green and yellow leaves are of the same thickness, the cuticle is of the same thickness and the cell arrangement is the same. The difference is that the yellow leaves have few chromoplasts, and these are yellow, with a slight green tinge when seen under the microscope, not green as in the green leaf.

Table XXIX.—December 22, 1906.

Codiœum variegatum.

Time.	Black Bulb Thermometer.	Humidity.	Yellow Leaf (above Shade Temperature of Air).	Green Leaf (above Shade Temperature of Air).
A.M.	C.	Per Cent.		
11. 7	61·4	64	10·1	11·8
—	—	—	7·7	—
11.14	61·1	63	7·1	8·0
11.19	60·0	63	8·3	10·4
—	—	—	8·7	—
Here the junctions and apparatus were changed over to the other leaf.				
11.40	62·1	58	8·2	11·2
—	—	—	7·4	12·0

Average of 7 = 8·2° C.; average of 5 = 10·7° C.

During this experiment the two sets of apparatus were interchanged, No. 1 apparatus with its junction being changed from the green leaf to the yellow leaf and *vice versâ* for No. 2. This was done to test the accuracy of the two sets of apparatus, and to see if they gave comparable results. The readings after the change show somewhat greater differences between the two leaves, and the average result is decidedly that the green leaves reach a higher temperature. It amounts on the average to 2·5° C. higher for the green leaf.

Table XXX. gives the results of experiments with the variegated leaves of *Caladium*, sp. The species was a common border plant in the gardens. Two varieties were used. One was green and white, the other green and red. The green and white variety had very little chlorophyll. The chlorophyll present was usually along the main veins. The junction was placed beneath a small side vein where there was scarcely any chlorophyll. The green and red variety had a thicker leaf. It was red over nearly its whole area, and especially along the veins. The junction was placed beneath a side vein.

TABLE XXX.—January 19, 1907.

Time.	Black Bulb. Thermometer.	Humidity.	Temperature of Green and White Leaf above that of surrounding Air.	Temperature of Green and Red Leaf above that of surrounding Air.
A.M.	C.	Per Cent.	C.	C.
11.40	58·8	58	10·2	12·6
—	—	—	9·8	14·5
—	—	—	6·4	11·1
—	—	—	6·1	—
11.55	64·4	50	7·3	11·2
—	—	—	6·0	8·0
		Average of 6 =	7·6 C.	11·5 C.

In this case the red leaf shows a more striking difference, attaining a temperature of 3·9° C. above that of the white leaf. This great difference may perhaps be to some extent correlated with the presence of two pigments in the leaf, chlorophyll and the anthocyan masking it. The general result which seems to be clearly indicated by these experiments is that the presence of any pigment raises the internal temperature of the leaf whether the pigment be red (anthocyan) or green (chlorophyll). A yellow or white leaf remains at a lower temperature on account of the lack of pigment. The experiments in fact seem to show more clearly a purely physical effect, similar to what would be obtained with inorganic bodies, than was perhaps to be expected.

The fact that the red pigment does cause a higher temperature than that attained in leaves lacking it is now clearly established for thin leaves, as it had previously been for succulent leaves by Stahl. Attention was now paid to the question of the internal temperature of young flaccid and coloured leaves compared with the mature green leaves of the same tree. Here the question is complicated by the fact that besides differences in colour in the leaves compared there are great differences of texture. In the case of *Amherstia nobilis*, for example, the mature leaf is green, stiff, with fairly thick cuticle, while the young leaf is thin, flaccid, and pliable with scarcely developed cuticle, red in colour and almost without chlorophyll.

In *Theobroma Cacao* the section of a young dark red leaf was 120 μ thick, while a mature green leaf was 174 μ thick and had a thicker cuticle.

Table XXXI. gives the results of a comparison of the young leaf of *Saraca indica* with the mature leaf. In this case the young leaf is thin, flaccid, and almost white, while the mature is thick and green.

TABLE XXXI.—December 14, 1906.

Time.	Black Bulb.	Air Movement.	Humidity.	Mature Leaf above Air.	Young Leaf above Air.
A.M.			Per Cent.		
10.27	58·5	Still	53	13·2	7·5
10.58	59·7	do.	53	12·2	9·4
11. 3	59·4	Breeze	49	5·3	5·2
11. 5	59·2	do.	48	8·6	6·6

Unfortunately the breeze became so constant that further readings in still air could not be obtained. The readings obtained show that the mature leaf was decidedly higher in temperature, to the extent of about 4° C., than the young leaf. This, of course, considering the difference in pigmentation, was to be expected.

Table XXXII. gives the results of a similar comparison for the leaves of *Theobroma Cacao*. The young leaf contains a large quantity of anthocyan. The mature leaf is green.

TABLE XXXII.—January 21, 1907.

Time.	Black Bulb.	Air Movement.	Humidity.	Mature Leaf above Air.	Young Leaf above Air.
A.M.			Per Cent.		
10.29	61·8	Still	66	9·7 8·9	14·2 13·0
10.50	63·5	do.	65	11·8 9·9	13·8 13·5
			Average	10·1	13·6

For the young leaf another younger one was substituted, which differed in being rather more densely pigmented with anthocyan.

but owing to breeze only one reading was obtained in still air as follows :—

TABLE XXXII.—January 21, 1907.

Time.	Black Bulb.	Humidity.	Air Movement.	Mature Leaf above Air.	Young Leaf.
A.M.		Per Cent.			
—	—	—	Still	10·7	13·8
11.29	64·9	66	Slight breeze	6·4	13·4

Here it is seen that the young pigmented leaf has a higher internal temperature than the mature green leaf. This is in contrast to what occurs in the case of *Saraca indica*, and the suggestion is obvious that this difference is due to the anthocyan in the young leaves of *Theobroma*, this colouring being absent, or almost so, from the leaves of *Saraca indica*. It seems that in the case of this species *Theobroma Cacao*, the anthocyan in the young leaves is more effective as an absorber of radiation than the chlorophyll of the mature leaf, as is shown by the higher temperature reached by the young red leaves.

Lastly, a very large number of observations were made on the temperature attained by the young leaf of *Amherstia nobilis* compared with that attained by the mature leaf under the same conditions. The young leaf is brownish-red, flaccid with thin cuticle. The mature leaf is green and stiff and has a thicker cuticle.

TABLE XXXIII.—November 14, 1906.

Amherstia nobilis.—Mature leaf.

Time.	Black Bulb.	Humidity.	Air Movement.	Internal Temperature above Air.
A.M.		Per Cent.		
10.39	56·0	83	Still	15·2
10.44	59·7	83	do.	15·7
10.51	58·9	70	do.	13·5
10.55	58·9	76	do.	15·6
November 15.—Fresh leaf.				
9.58	59·7	71	Still	15·9
10. 4	59·7	71	do.	15·5
				Average = 15·2° C.

A. nobilis.—Young flaccid leaf.—November 14.

Time.	Black Bulb.	Humidity.	Air Movement.	Internal Temperature above Air.
A.M.		Per Cent.		
9.24	51·9	79	Still	9·4
10.15	45·7	79	do.	10·4
11.15	56·7	72	do.	10·3*

* Fresh leaf.

November 15.—Fresh Leaf.

Time.	Black Bulb.	Humidity.	Air Movement.	Internal Temperature above Air.
9.37	56·4	72	Still	11·5
11. 8	62·2	74	Very slight breeze	11·4
11.27	58·4	75	Still	11·3

Average = 10·7

So far the figures show the young leaf decidedly cooler than the mature. The conditions, though similar, are not exactly the same, as will be seen by comparing the readings of the black bulb thermometer and the humidity in the two cases.

An attempt was made to get readings under more closely comparable conditions in the following way. Thermo-junctions were placed in two leaves, one, young, the other mature, and a reading was taken of one of them. This with its junction was then taken out, and the other one put in its place and a reading taken. Thus, the readings followed one another pretty closely, only the time required to replace one leaf by the other intervening between. This method gave the following results :—

TABLE XXXIV.—November 16, 1906.

Amherstia nobilis.

Time.	Black Bulb.	Humidity.	Air Movement.	Mature Leaf above Air.	Young Leaf above Air.
A.M.		Per Cent.			
9.58	57·2	80	Still	14·7 13·2	11·7 10·7
10. 0	57·2	80	do.	9·7	9·7
10. 2	57.2	80	do.	10·2	10.2
10. 4	57·2	77	do.	—	10·8
10.49	57·5	72	do.	14·2	14·2
10.54	60·2	74	do.	12·8	12·8
11. 4	60·2	74	do.	—	12·2
11. 6	60·4	74	do.	12·7	—
			Average	12·5	11·5

This series, especially in the later readings, shows that the two kinds of leaves were nearly equal in temperature. The whole apparatus, except the galvanometer, was now duplicated, so that readings of the two kinds of leaves could be taken consecutively, only the very short interval necessary to change the wires of the galvanometer from one apparatus to the other intervening between the readings. Though a breeze sometimes sprang up or the sun was obscured during the changing of the wires, yet, as a rule, the leaves were measured under the same conditions by this method. The two apparatuses were carefully compared and calibrated previous to observations.

The following results were obtained :—

TABLE XXXV.—December 8, 1906.

Time. A.M.	Black Bulb.	Humidity. Per Cent.	Air Movement.	Mature Leaf above Air.	Young Leaf. above Air.
10. 3	53·0	79	Still	7·5	8·2
10.25	42·2	75	do.	7·5	6·3
10.27	—	73	do.	9·2	8·4
10.33	57·5	72	do.	10·1	9·0
10.36	59·0	71	do.	11·5	9·7
10.40	59·7	72	do.	12·0	13·3
10.41	59·9	72	do.	12·0	12·8
10.42	60·0	71	do.	11·4	10·0
10.45	60·0	71	do.	11·0	10·4
10.48	59·9	69	do.	13·9	12·8
			Average	10·6	10·1

The result here is in agreement with that of the last table in showing a slightly higher temperature in the mature leaf. The flaccid leaf has a midrib, which projects considerably on the under side. The junction was now placed further back in this midrib, so as to be further away from the lamina of the leaf. The results are now not strictly comparable with those for the mature leaf in which the junction is in its original position. The following readings show that the junction in this position is considerably cooler, and thus illustrate the delicacy of the manipulations and the care necessary to obtain exactly equal conditions :—

TABLE XXXVI.—December 8, 1906.

Time. A.M.	Black Bulb.	Humidity. Per Cent.	Air Movement.	Mature Leaf.	Young Leaf.
11. 0	60·0	66	Still	11·2	7·5
—	—	—	—	11·5	7·9
—	—	—	—	12·2	7·5

Another set of readings was taken on December 27 as follows :—

TABLE XXXVII.—December 27.

Amherstia nobilis.

Time.	Black Bulb.	Humidity.	Air Movement.	Mature Leaf.	Young Leaf.
A.M.		Per Cent.			
11. 5	63·2	71	Still	16·9	12·2
11.13	62·4	73	Some breeze	12·6	10·8
11.21	61·5	75	Still	16·5	13·8
11.25	—	—	do.	16·9	14·6
11.27	—	—	do.	16·4	14·7
			Average	15·9° C.	13·2° C.

Here as in Table XXXIII. there is a decidedly higher temperature in the mature leaf. It must be remembered in considering the differences shown in these tables that the leaves used have their individual differences. Some of the young leaves are more intensely coloured with anthocyan than others, and differences no doubt occur according to age in the amount and vitality of the chlorophyll in different mature leaves, but on the whole the result is clear that the mature leaves do attain a slightly and occasionally considerably higher temperature than the young ones. Thus, it seems, that we have a series beginning with *Saraca indica*, in which anthocyan is almost absent, and in which the mature leaf is always higher in temperature than the young leaf. Then comes *Amherstia nobilis* with a brownish-red colour, in which the mature leaf is, as a rule, only slightly higher in temperature than the young leaf. Lastly, we have *Theobroma Cacao* with the young leaf an intense pinkish-red and the mature leaf lower in temperature than the young leaf.

No doubt the relative temperatures of mature and young leaves are to be correlated with the amount of anthocyan in the young leaf. The young leaves, without this pigment, would be always cooler than the mature leaf, as is the case in *Saraca indica.* The presence of more or less authocyan produces a temperature in the young leaf, which almost reaches (*Amherstia*) or exceeds (*Theobroma*) the temperature of the mature leaf. Thus the general tendency of these results is to confirm and extend Stahl's conclusion that the presence of anthocyan tends to raise the internal temperature of the leaf. What biological advantage, if any, is gained by the plant in this way is quite another question, but it is well to have this physical effect definitely established.

PART II.

The second part of the paper will be occupied with an account of some observations on the periodicity of growth of certain trees at Peradeniya, and, as it suggests a theory which may throw further light on the question of the biological advantage of high internal leaf temperature, the final discussion of that question will be reserved to the end of the paper.

Periodicity Observations.

Many of the evergreen trees of Ceylon, and also some trees in Peradeniya Gardens which are not indigenous to the Island, produce new growth during a very restricted period of the year, and then rest from growth in length for a considerable period. Observations were made of the frequency of this growth period and the time of year when it occurred. In the most typical cases the young foliage borne by the new shoots is of different colour from the mature green leaves, usually red or brown, occasionally white. The new growth is thus sharply marked off from the old, and is at once noticed on a casual inspection. In some cases the young foliage only differed in being very much lighter green than the mature. It was at first intended to make an inspection of the whole Garden at Peradeniya once a month and note the names of the species which were producing new growth. Owing to the fact that the writer spent four months at Hakgala this could not be carried out in full, but nine separate tours of the Gardens were made extending over twelve months, and on each occasion a record was made of all the species showing new growth at the time. The table thus obtained shows to a certain extent the frequency of this new growth and the months in which it is most abundant.

A large number of the trees in the Gardens are not labelled, and it was often necessary to bring in twigs and carefully compare them with herbarium specimens before the species could be established. This work was much facilitated by the help of Don Miguel de Silva, Plant Collector at Peradeniya, whose thorough knowledge of the trees of the Gardens was invaluable. When new growth was occurring in a large number of species in all parts of the Gardens, the tour of observations was spread over more days than one; when the amount of new growth was small, the whole was done in one day.

The following is a tabulated list of species showing new growth as each period :—

December 10–14, 1905.

Rhodamnia trinervis
Aglaia Roxburghiana
Pachira aquatica
Duabanga moluccana
Cleidion javanicum
Eugenia grandis
E. Gardneri
E. jambolana
E. operculata
Butryospermum Parkii
Persea gratissima
Pometia pinnata
P. eximia
Bassia butyracea
Memecyclon capitellatum
Brownea grandiceps
B. coccinea
Anacardium occidentale
Joannesia princeps
Pittosporum undulatum
Garcinia terpnophylla
Mesua ferrea
Barringtonia speciosa
Gustavia insignis
Calophyllum tomentosum
Polyalthia coffæoides
Caraipa guineensis
Pentadesma butyragea
Chicrassia, sp.
Melisoma simplicifolia
Hydnocarpus venenata
Turpinia pomifera
Amoora Rohituka
Bocagea Thwaitesii
Odina Woodier
Adenanthera bicolor
Achras sapota
Celtis cinnamomifolia

January 12–15, 1906.

Garcinia Morella
G. terpnophylla
Vateria acuminata
Sterculia Thwaitesii
Eugenia Gardneri
E. caryophyllata
E. grandis
Persea gratissima
Duabanga moluccana
Caraipa guineensis
Pentadesma butyragea
Cullenia excelsa
Polyalthia coffæoides
Pometia eximia
Humboldtia laurifolia
Anacardium occidentale
Citrus decumana
Mimusops Elengi
Diospyros affinis
Butyrospermum Parkii
Amoora Rohituka
Turpinia pomifera
Adenanthera bicolor

February 14–17, 1906.

Eugenia Gardneri
E. caryophyllata
Ixocarpus edulis
Aglaia Roxburghiana
Mangifera indica
Garcinia xanthocarpa
G. morella
Saraca indica
Brownea grandiceps
Flacourtia inermis
Anacardium occidentale
Cynometra cauliflora
C. ramiflora

Diospyros embryopteris
Mesua ferrea
Polyalthia coffæoides
Nothopegia Colebrookiana
Ormosia, sp.
Cinnamomum zeylanicum
Butyrospermum Parkii
Sterculia Thwaitesii
Carycar narthecium
Gustavia insignis
Turpinia pomifera
Calophyllum tomentosum
C. inophyllum
Bocagea Thwaitesii
Cyclostemon macrophyllus
Mimusops erythroxylon
Duabanga moluccana
Pometia eximia
Theobroma Cacao
Humboldtia laurifolia
Pithecolobium bigeminum
Canarium commune
Walsura Piscidium
Mitrephora macrantha
Caraipa guineensis
Pentadesma butyragea
Kurrimia zeylanica
Connarus monocarpus
Mischodon zeylanicus
One unnamed sp.

May 6, 1906.

Brownea macrophylla
Saraca indica
Amherstia nobilis
Cynometra polyandra
C. caulifolra
Turpinia pomifera
Amoora Rohituka
Semecarpus obscura
Cinnamomum zeylanicum
Pometia pinnata
P. eximia
Eugenia caryophyllata
Sterculia fœtida
Caraipa guineensis
Duabanga moluccana
Humboldtia laurifolia
Podadenia sapida
Connarus monocarpus
Anacardium occidentale
Vateria acuminata
Aglaia Roxburghiana
Doona, sp.
One unnamed sp.

June 8, 1906.

Flacourtia inermis
Humboldtia laurifolia
Saraca indica
Amherstia nobilis
Brownea grandiceps
Anacardium occidentale
Pometia eximia
Duabanga moluccana
Cinnamomum zeylanicum
Diospyros Gardneri
D., sp.
Walsura Gardneri
Mitrephora Heyneana
Calophyllum tomentosum
Talauma Hodgsoni
Eugenia Gardneri
E., sp.
E. aquea
Caraipa guineensis
Polyalthia coffæoides
Turpinia pomifera
Amoora Rohituka
Connarus monocarpus
Adenanthera bicolor
Dicellostylis axillaris
Doona macrophylla
D. cordifolia
Hemigyrosa canescens
Theobroma Cacao

July 17, 1906.

Pometia eximia
P. pinnata
Turpinia pomifera
Amoora Rohituka
Cullenia excelsa
Duabanga moluccana
Mimusops Elengi
Brownea grandiceps
Dicellostylis axillaris
Connarus monocarpus
Eugenia operculata
E. Gardneri
E., sp.
E. caryophyllata

Hopea, sp.
Memecylon rostratum
Humboldtia laurifolia

August 23–31, 1906.

Eugenia Gardneri
E. caryophyllata
Mischodon zeylanicus
Durio zibethinus
Theobroma Cacao
Cryptocarya Wrightiana
Vateria acuminata
Alphonsea lutea
Turpinia pomifera
Cinnamomum zeylanicum
Mangifera indica
Caraipa guineensis
Cullenia excelsa
Meliosma simplicifolia
Doona macrophylla

September 23–October, 1906.

Dimorphandra Mora
Dillenia retusa
Nephelium longana
Eugenia zeylanica
E. Gardneri
Mesua ferrea
Mischodon zeylanicus
Duabanga moluccana
Garcinia terpnophylla
Cinnamomum zeylanicum
Pometia eximia
Diospyros, sp.
Mesua Thwaitesii
Caraipa guineensis
Eugenia, sp.
E. malaccensis
Joannesia princeps
Walsura piscida
Turpinia pomifera
Mangifera indica
Theobroma Cacao

November 12, 1906.

Brownea ariza
Aglaia Roxburghiana
Caraipa guineensis
Barringtonia speciosa
Pometia eximia
Mesua Thwaitesii
Saraca indica
Brownea grandiceps
Amherstia nobilis
Amoora Rohituka
Turpinia pomifera
Theobroma Cacao

The method pursued in making this table was to note the name of any tree showing new growth, unless this was very slight in amount occurring, say, in only six to twelve twigs. The trees catalogued were those in which the new growth was sharply marked off from the old, indicating that growth was not continuous, but resumed after an interval. The test for this was the colour of the new leaves. If these were any shade of red, or brown, or were white, or even very light green, so as to stand out from the dark green mature foliage, the species was recorded.

Before going on to make certain reservations about this table, it is to be noticed that, roughly speaking, it gives in the number of species growing in a particular month a test of the amount of new growth made in that month. The months of March and April were missed owing to the writer's absence up-country. The case of October, for which there is no record, is different. The writer was at Peradeniya and in different parts of the Garden at various times during the month, and no instance of new growth was observed, except a few species, such as *Saraca indica*, on which new growth is to be found at almost all times of the year, so that the absence of names for October means that there was no new growth or very little.

The total number of species showing new growth in each month recorded is as follows :—

December, 1905	38	July, 1906	17
January, 1906	23	August, 1906	15
February, 1906	43	September, 1906	21
May, 1906	23	October, 1906	(?) 6
June, 1906	29	November, 1906	12

The following is a record of the average rainfall for the years 1884–1906 inclusive at Peradeniya :—

December, 1905	8·03	June, 1906	10·30
January, 1906	3·34	July, 1906	7·93
February, 1906	1·76	August, 1906	5·76
March, 1906	4·33	September, 1906	2·41
April, 1906	9·03	October, 1906	14·32
May, 1906	7·02	November, 1906	10·18

Average number of rainy days in each month for the same period—

December, 1905	13	June, 1906	15
January, 1906	6	July, 1906	19
February, 1906	4	August, 1906	16
March, 1906	7	September, 1906	15
April, 1906	13	October, 1906	20
May, 1906	11	November, 1906	16

The outstanding fact with regard to this record is that the month of February, the driest month of the whole year, had the largest number of growing species ; September, another rather dry month, had a considerable number ; November and July, wet months, had very few growing species ; while October, the month with the highest rainfall, had the fewest of all.

There thus seems to be a rather surprising correlation between amount of growth and lack of rain. There is probably some deduction to be made from the number recorded in December, 1905. This was the first time of making the record, and the writer had scarcely appreciated the limits of the phenomenon under observation. The impression left on the writer's mind is that he was rather more strict in later months and did not record certain species, whose new foliage was not very sharply differentiated and which were included in December. The number to be deducted for this personal factor cannot be estimated, but it probably renders the results for December less reliable than the later ones.

Closer analysis showed that there were a number of species in which growth was almost continuous, and these appeared in nearly all the records.

CLOSER ANALYSIS OF THE PHENOMENON OF PERIODIC GROWTH.

On considering the subject more closely the phenomenon of rapid periodic growth was seen to be very varied in its nature. Roughly speaking, as is indicated by Wright (32) in his paper on foliar periodicity, the species exhibiting this phenomenon may be divided into three classes.

In the *first class* is included a number of species in which growth is almost continuous in point of time, taking the tree as a whole. These trees, such for example as *Duabanga moluccana* and *Saraca indica*, appeared in nearly all the records made. In these cases the growth is not, as a rule, general over the whole tree. Any particular branch axis passes through a resting period before growth begins again. The different branches, however, elongate at different times, so that, taking the tree as a whole, there was some new growth to be observed on it at all or nearly all the times of observation. The amount of new growth in such trees varies, sometimes it occurs in only a few twigs, sometimes in a considerable number, but not, as a rule, over the whole tree.

In the *second class* we may place those trees which show new growth four, five, or six times in the year. Examples are *Eugenia Gardneri* and *Theobroma Cacao*. As the periods of new growth are fewer so the growth is correspondingly more general when it does occur. Sometimes the whole tree shows it, sometimes only part of it, but it is not restricted to a few twigs as in trees of the first class.

In the *third class* those species are to be placed which grow, as a rule, only once or twice annually, *e.g.*, *Mangifera indica*, *Cinnamomum zeylanicum*, *Mischodon zeylanicus*. In these cases the new growth is usually general over the whole tree. These are the species in which this phenomenon of rapid growth at restricted periods is seen at its fullest development. In them the phenomenon is the most striking to the observer, as the new shoots are usually most sharply marked off from the old. The simultaneous covering of the whole tree with a bright pink canopy, as in *Mesua ferrea*, or golden brown, as in *Mangifera indica*, cannot fail to attract attention. We can therefore get a little nearer to a true estimate of the difference probably caused by difference of climate in the different months by eliminating the first class, namely, those which show some growth in all or almost all the months of the year. The following species may be included in this class :—

Aglaia Roxburghiana.
Saraca indica.
Brownea grandiceps and other species of Brownea.
Anacardium occidentale.
Butyrosperumum Parkii.
Turpinia pomifera.
Duabanga moluccana.
Pometia eximia.
Humboldtia laurifolia.
Eugenia caryophyllata.
Caraipa guineensis.
Connarus monocarpus.
Amherstia nobilis.
Amoora Rohituka.

In all these the growth at one time is only partial and does not involve the whole tree, and each of them recurs many times in the records, in fact in some months the list consists chiefly of these, *e.g.*, November, 1906.

Excluding these, we shall have left those species which more fully illustrate the phenomenon of periodicity, and the monthly results come out as follows :—

December, 1905	28
January, 1906	14
February, 1906	31
March, 1906	—
April, 1906	—
May, 1906	9
June, 1906	18
July, 1906	9
August, 1906	12
September, 1906	17
October, 1906	0
November, 1906	3

In this table the dry month of February again stands out with the largest number of growing species, the month of December being next, though about it, as has been said, certain reservations are to be made. July, in the height of the south-west monsoon, when there was very little sunshine, and

October and November, in the height of the north-east monsoon, show the smallest number of growing species.

A question which affects our treatment of these results is whether the phenomena observed in any year are to be correlated with the weather of that particular year or with that of a long series of years. We know that leaf-fall in temperate climates, though it occurs with regularity sometime during autumn, yet varies as to its actual date with the kind of weather experienced. If the autumn is fine and warm, the leaf-fall will be later, while if there are early frosts and rough weather, it will be earlier. It is not known how far such temporary variations of weather in the tropics affect the growth periodicity, nor, in fact, whether they do so at all. The writer did not stay in Ceylon long enough to obtain records for more than one year, so that there is no evidence as to how far the records of that year represent the usual occurrence of the phenomenon. It cannot be stated how far the records reflect only the general periodicity established as a result of average climatic influences, or to what extent they show the influence of the rather special variations of rainfall during that particular year.

It is possible that the large number of growing species in February and the fairly large number in September represent the two normal growth periods of the year, corresponding to the two drier periods ; and that the fairly large numbers in December, 1905, and June, 1906, are not usual, but represent the effect of the abnormally dry weather of those two months in the particular years in question. On this view the practical absence of growth in October may also be due to the exceedingly wet weather of that month in 1906. The following are the figures of rainfall for December, 1905, to November, 1906, with the number of rainy days in each month :—

RAINFALL IN INCHES.

December, 1905	.. 3·00	June, 1906	.. 4·87
January, 1906	.. 2·75	July, 1906	.. 11·01
February, 1906	.. 2·22	August, 1906	.. 6·60
March, 1906	.. 3·51	September, 1906	.. 2·26
April, 1906	.. 4·26	October, 1906	.. 19·09
May, 1906	.. 1·94	November, 1906	.. 7·15

NUMBER OF RAINY DAYS.

December, 1905	2	June, 1906	19
January, 1906	4	July, 1906	24
February, 1906	6	August, 1906	21
March, 1906	6	September, 1906	9
April, 1906	8	October, 1906	24
May, 1906	12	November, 1906	18

The average rainfall is given again for comparison, 1884–1906—

December, 1905	8·03	June, 1906	10·30
January, 1906	3·34	July, 1906	7·93
February, 1906	1·76	August, 1906	5·76
March, 1906	4·33	September, 1906	2·41
April, 1906	9·03	October, 1906	14·33
May, 1906	7·02	November, 1906	10·18

The truth of the reasoning of the above section can, however, only be tested by further observation. At present it is only put forward tentatively as a suggestion.

It seems more certain from the evidence so far obtained that there is a rough correlation between small rainfall and number of growing species. This is seen in the very large number in young leaf in February, the driest month of the year, and in the almost complete absence of growth in October, the wettest month.

The matter may be put in another light by chosing a few species in which the phenomenon is most marked and stating the months in which they grow. The species are here chosen for the striking way in which they exhibit this phenomenon. They are those in which after a period of rest of varying duration the whole tree quickly, almost suddenly, becomes covered with a new growth bearing leaves strikingly different in colour from the mature leaves. In the following table the attention will therefore be confined to a small number of species exhibiting this periodicity phenomenon in its most marked form.

A complication arises here from the fact that while young and in vigorous growth a tree usually shows new growth much more frequently than it does later in its life. It takes a few years for it to settle down into the periodicity characteristic of its species. Thus, in the following table there is growth noted for certain months for a certain species which record would not occur but for the fact that the irregular growth of a young specimen has been included. To get some idea of the extent to which this factor affects the results, it would be necessary to make a note of the age of each tree, at least so far as to divide the trees observed into younger and older. It would also be desirable to make an estimate of the number of individuals of each species showing new growth at each record, so as to show whether the record is one of general growth for the species or confined to a few isolated trees. This could not, as a rule, be done in the limited time devoted to these records, but in spite of this the following table shows some broad results :—

Name.	General Colour of Young Foliage.	Dec.	Jan.	Feb.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Mangifera indica ..	Brown ..	.	.	+	.	.	.	+	+	.	.
Garcinia xanthocarpa ..	Light brown ..	.	.	+	.	.	.	.	+	.	.
Mesua ferrea ..	Light red ..	+	.	+	.	.	.	.	+	.	.
Cinnamomum zeylanicum	Pink ..	.	.	+	+	.	.	+	+	.	.
Sterculia Thwaitesii ..	Red ..	.	+	+	.	.	.	.	.	.	.
Mischodon zeylanicus ..	Brownish-red..	.	.	+	.	.	.	+	+	.	.
Vateria acuminata ..	Dark red ..	.	+	.	+	.	.	+	.	.	.
Doona macrophylla ..	Red ..	.	.	.	.	+	.	+	.	.	.
Theobroma Cacao ..	Red ..	.	.	+	.	+	.	+	+	.	+

It will be noted how the growing period of these species, many of them indigenous, coincides with the two drier periods. The greater number of them have their chief growing season in February in the midst of the longer dry period. The other chief time for growth among these species is September, the August observations, being made during the last week in August, may be bracketed with those of September. In the cases where an attempt was made to estimate the relative prevalence of new growth in each of the months recorded, the February growth was most abundant.

For *Mangifera indica* (mango) I have the following notes :—

February : Every mango seen was in young leaf.
August : One tree recorded.
September : A good many were noted in the district, only three or four in the Gardens.

For *Theobroma Cacao*—

February : Very full of young leaf.
June : Fair amount, not general.
August : Fair amount.
September : Rather full.
November : Fair.

For *Cinnamomum zeylanicum*, a planter at Negombo—a place which has similar incidence of monsoons and similar dry periods to those at Peradeniya—informed me that on his estate there were two certain periods for the "flush" of the cinnamon, the most general one being in February, and another somewhat less so in September. Besides these there were occasional very partial irregular "flushes" in June and July. Thus the evidence seems to point in these species to a correspondence between the period of new growth and the dry periods, the most general period for a large number of species being February in the midst of the longest dry period occurring in this part of the Island. Species which grow once a year usually do it in February, species with two growth periods usually grow in February and September, and species with more frequent periods almost always have February as one of them, and that usually the one in which the growth is most general.

CONCLUSIONS AND THEORETICAL SUGGESTIONS FROM THE OBSERVATIONS.

This general result is somewhat surprising. The only previous results bearing on this point are those of Wright (32), who has worked out the periodicity of deciduous trees in Ceylon in a very thorough manner. His results are given on a period of observation extending from 1900 to 1905. His general conclusion is that the largest number of leafless species coincides with the longest dry period of the year, namely, January to March. He interprets this as an adaptation to check transpiration, and there is evidence that for certain species this is probably the case. He notes, however, certain exceptions which make it impossible to draw the general conclusion at all rigidly, and it is significant that these exceptions agree very closely with the results of the present paper, and, in fact, extend its scope to deciduous species. The following extracts from Wright's paper show this :—He states on p. 452, "Holtermann (12) proved that transpiration was greater from young leaves than from old ones, and greater during the hot dry period at Peradeniya than during other parts of the year. *Yet there are many trees*, e.g., *Albizzia procera*, *with thin tender foliage*, *which retain all their leaves during the period when transpiration is at the maximum*, and, on the other hand, trees, such as species of *Ficus*, with tough leathery leaves coated with a thick cuticle, and, therefore, probably losing less by transpiration, become leafless."

After mentioning *Bombax malabaricum* and *Cratœva Roxburghii* which remain leafless during the whole of the dry period and therefore avoid transpiration, he goes on to say : "But when species, such as *Phyllanthus indicus*, *Careya arborea*, *Ficus Tsjakela*, *Sterculia Balanghas*, *Terminalia belerica*, *Chickrassia tabularis*, and many others, are studied, it is seen that though they become leafless during the hot months for one or two days or weeks, *they always produce their complete outfit of new tender foliage while the hot dry season is prevailing.*

"For these reasons one must assume that checking transpiration is only a consideration to certain species, and that others may, by passing through their foliar stages, like those last mentioned, actually lead to *an increase of transpiration at a time when the minimum quantity of water is available in the soil.*"

The case of these latter species, which, according to Wright are numerous, is closely comparable to the case of the evergreen species studied in the present paper. They too, by putting on their new outfit of tender leaves at the dry period of the year, lead to an increase of transpiration at that time. There is not much doubt that one explanation will apply to both cases. The evidence of the present paper, though not complete, is, as far as it goes, fairly decisive and, strengthened as it is by the numerous examples of deciduous trees mentioned by Wright, is sufficient to justify a search for the cause of the evident connection between dry periods and the production of new growth.

Of course, such rapid growth as occurs makes much greater calls upon material than can be supplied by the assimilation carried on by the mature leaves during the actual period of growth. Anatomical investigations showed that in every case, just before the new growth appeared, and, indeed, at any time when the tree had had considerable rest after a growth period, the branches and twigs were crowded with starch in the pith, cortex, and parenchyma generally. In the period immediately after growth, the older portions of the twigs, from which the new growth had come out, were quite devoid of starch. Thus it was easily shown that this new growth was, as far as starch is concerned, growth from reserve. It may give some idea of the demands made upon this reserve if the rate of growth in length observed in two instances is recorded.

A young shoot of *Brownea ariza* gave the following measurements :—

December 17, 10.45 A.M., 20·5 cms. in length;
,, 18, 2.30 P.M., 25·2 cms. in length;
,, 19, 10.50 A.M., 25·6 cms. in length;
,, 21, 12 noon, 25·9 cms. in length;
,, 22, 3 P.M., 25·7 cms. in length;

and this length was never afterwards exceeded, though measurements were taken up to January 31. This shoot has evidently been measured just towards the end of its short growth period, but the increase of about 5 cms. during the first day shows the rapidity with which this new growth occurs when at its height. It is interesting too to note that, as far as length growth is concerned, the growth period is of comparatively short duration, and a length is soon reached which does not increase at all during the long period of rest which follows.

The following are the lengths of certain new shoots of *Theobroma Cacao* measured on three different dates :—

	January 31, 6.5 P.M. Cms.	February 7, 12 noon. Cms.	February 15, 5.50 P.M. Cms.
1	15·6	26·0	30·5
2	8·8	21·2	33·0
3	13·5	22·6	32·7

An increase in length of 10–12 cms. in one week is thus common in strongly growing new shoots of *Theobroma.*

When we consider that in many cases trees, such as *Theobroma, Mesua, Mangifera,* &c., are putting on over their whole periphery new growth at this rate, we can understand how great a supply of reserve food is necessary at this period. In working up the reserve starch into plastic material for new growth of leaf and stem, there must be a correspondingly great demand for the mineral foods which are needed to form the protoplasm.

Very little is known as to how far nitrogenous organic reserves are stored up by trees, and no investigations on this point have been made on the particular trees here in question. Beyond the fact that trees do in some cases store up certain amounts of proteids and amides, scarcely any reliable information is to be obtained. Turning to the case of reserves stored in seeds we know that proteids form a part of such reserves in many cases. But in general the proteid and carbohydrate are not in the proportions in which the young plant makes use of them. In germination the radicle, as a rule, is the first organ to elongate, and the development of the other parts does not occur until the radicle is at such a stage that it can supply mineral foods to the young plant to be worked up along with carbohydrate into plastic materials for growth.

Godlewski (10), 1879, showed that development of *Raphanus* seedlings in the dark took place far more vigorously when he supplied them with nutrient salts than when they had distilled water only. If in the rapid growth of the trees under consideration a similar state of things holds good, then a copious supply of mineral salts from the soil will be required *at the time of growth.*

It must be repeated that whether this is the case or not, whether the growth takes place from reserves of carbohydrate, nitrogenous organic material, and minerals, all stored up in the tree and in the right proportions, or whether special demands are made upon the mineral supply from the soil at the time of growth, is not known.

Shibata (27) has investigated the nitrogenous and other reserve present in the rhizomes of bamboos previous to the very rapid elongation of the young culm in the growing season.

In this reserve, though starch is the principal material, yet proteid material is present in large amounts. The following analysis by Shibata of the two-year old rhizomes of *Phyllostachys mitis* may be given :—

	Percentage of Dry Weight.
Starch	24·01
Reducing sugar	0·95
Non-reducing sugar	4·31
Proteid	5·41
Fat	0·61
Fibre	47·32
Ash	8·74
Undetermined (difference)	8·65
	100·00

We see from this analysis that proteid material is present in considerable amount, and also ash containing, as shown by another analysis, all the necessary minerals. Thus, although we do not know the proportions in which these reserves are required by the growing culm, it is probable that in bamboos the growth may go on entirely from reserve and no limiting of the growth from lack of necessary mineral foods may occur. In a previous paper by the present writer (19) it is shown how varied the different cases of growth are. In some the moisture, in others temperature, in others food supply are limiting factors, and in some cases each of these factors may become limiting in turn. We cannot therefore deduce from the reserves in one case what are the reserves and the conditions of growth in another, and some definite knowledge not only of the carbohydrate, but also of the proteid reserve in the trees under consideration in this paper, is greatly to be desired.

Failing this knowledge it may be said to be fairly probable that when in these trees rapid and general growth takes place, large demands are made upon the mineral supplies obtained from the soil. If this is the case, the trees will require a copious and constant transpiration stream during their growth period to supply the minerals required. That the case of these trees with regard to mineral food supply is quite different from the case of the bamboo is indicated by the fact that at Peradeniya the bamboo growth takes place in the season of highest humidity during the south-west monsoon, while the growth of the tree occurs most abundantly during the period of lowest humidity.

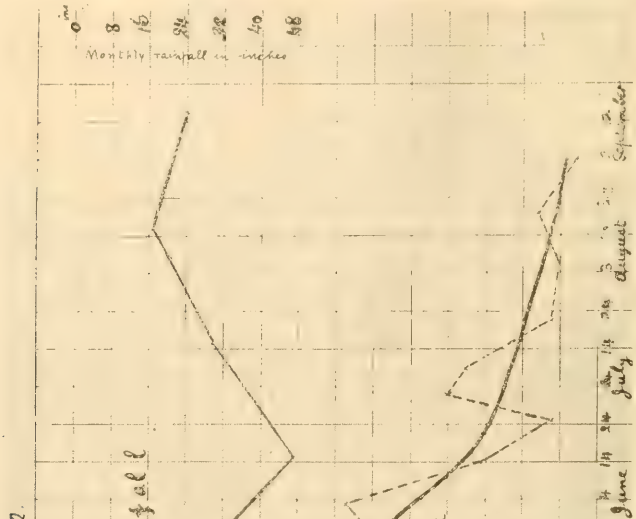
It is in the demand for a large transpiration stream to bring up the necessary minerals that a clue is perhaps to be found to the close relation between dry weather and rapid growth in these trees. May it not be that it is only in this drier period that the humidity is low enough to promote the necessary copious transpiration stream ? It must be remembered in this connection how high a humidity prevails at Peradeniya during some of the wetter months of the year. From July 4 at 10.40 P.M. to July 7 at 3.28 P.M. the humidity taken at 2-hour intervals did not at any time sink below 74 per cent. of saturation, while even in the middle of the day very much higher humidity than this was often registered. Thus, at 11.22 A.M., July 5, the humidity was 80 per cent., at 11.25 A.M., July 6, it was 91 per cent., and at 11.18 A.M., July 7, it was 81 per cent. This occurred during a rather light south-west monsoon. There is no doubt that in the usual monsoon weather, all through June, July, and the greater part of August at Peradeniya, the humidity rarely falls below 75 per cent. and values of 80 per cent. to 90 per cent. in the day are the rule, while 100 per cent. is often reached at night. The same may be said generally of October and November, the months of heaviest rain in the north-east monsoon, though towards the end of November there is beginning to be a good deal of sunshine in the morning. There are sometimes a few days in November when rather dry winds cause the humidity to fall, and records were taken of humidity of 53 per cent. in the middle of the day on November 3. Such days are not frequent, as may be expected, considering the large rainfall of November in normal years. In the dry period, beginning in December and lasting through January, February, and March, there are an increasing number of days in each month up to February, on which the humidity of the air is low, and in February, with the lowest rainfall of the whole year, there is an almost continuous period of fairly low humidity. For example, on February 4, 1907, the humidity was 57 per cent. at 10 A.M. and at 11 A.M. had gone down to 48 per cent.

The following figures, taken from Wright's paper, show the average mean monthly relative humidity for Kandy (three miles from Peradeniya) :—

January ..	77	July ..	81
February ..	71	August ..	81
March ..	71	September ..	80
April ..	77	October ..	82
May ..	78	November ..	79
June ..	81	December ..	81

It is therefore quite likely that only in the drier period is there a transpiration active enough to bring up to the growing periphery of the tree a supply of salts sufficient to meet the demand of the large amount of new material manufactured. At least it may be said that the species growing at this drier period are doing so under more favourable conditions for the promotion of the new growth.

The experience of tea planters in the wetter regions of Ceylon, where during the south-west monsoon the monthly rainfall reaches 40–50 inches, and the days are continuously cloudy with high humidity, is confirmatory of these observations. During the wet humid months the growth of the tea as measured by the amount of leaf plucked falls off considerably. It has been possible, by the kindness of the Superintendent of the Abergeldie estate belonging to the Scottish Ceylon Tea Company, to give a curve showing the number of pounds of green leaf plucked from one of the fields of that estate during 1905. The rainfall is also given for each month. The figures are given in average number of pounds of tea grown per day, and are obtained by dividing the total number of pounds obtained at each plucking by the number of days from the end of the previous plucking to the end of the one in question. This average number is placed in the curve at a date corresponding to the middle of the period from one plucking to the next. Thus the record supplied to me gives June 15–20 2,673 lb. plucked, June 21–30, 1,477 lb. plucked. Thus 1,477 lb. has grown between June 20 and June 30, *i.e.*, in 10 days. This gives an average growth per day of 148 lb., and this has been placed in the curve on the date June 25. This procedure has been necessary on account of the irregularity of the periods of plucking. I have selected for representation in the curve the period from March 1 to August 31. The rainfall for each month is given in inches. The continuous line in the curve representing the growth of tea is obtained by taking roughly the mean values of the figures given by the dotted line. It is put in in order to smooth out the rather large fluctuations of the actual readings.


Text Fig. 2.

The month of March is dry, with less than 4 inches rainfall, and the rainfall increases in April and May. In April there is still a good deal of sunshine, and a moderate amount in May. In June the character of the weather changes. With the breaking of the "big monsoon," as it is called, not only is there a large increase in the amount of rainfall reaching the large total in June of 47 inches, but it becomes more continuous with scarcely any sunny intervals. This type of weather continues through July and August. Though the rainfall is less in these months, yet the rain is fairly continuous and only falls off in intensity. The most striking point in the curve is the falling off of the yield of tea during the end of May and through June. The lower value is continued through July and August. The falling off coincides approximately with the break of the monsoon about the end of May and the consequent ushering in of almost sunless weather. If the figures of relative humidity of the atmosphere were available, they would no doubt be even more to the point than those of the rainfall. But the correspondence between the falling off of the amount of tea plucked in June and the increase in the rainfall sufficiently illustrates the point. In this case the factor limiting the growth is not moisture, nor is it temperature, as the average temperature during these months is slightly higher than in the drier periods. It seems justifiable to suppose that in this case the limiting factor is mineral food supply, as the transpiration stream bringing the dissolved salts is almost absent. If this is the case for a shrub-like tea, which under suitable conditions is making some new growth at all periods of the year, it would apply with special force to those species in which the habit of rapid growth for a very limited period has been evolved.

Those species, whose growth period occurred in the wet months, would have their growth checked by lack of mineral food. Any variation toward a drier season would produce a more vigorous growth and a larger tree, other conditions being equal. Thus the habit of growth in the dry season would be confirmed, and the habit of growth in the wet season checked, until of the prevailing indigenous trees a majority grew in the dry season. On this view we must suppose that those species which do leaf out in the wet months find this habit a disadvantage, but one which other compensating advantages are sufficient to counterbalance. Now, if once this general result be granted, we come upon a point of view which enables us to connect the two investigations of this paper under one general heading. For just as the necessary copiousness of transpiration stream for the rapid growth is only to be obtained in the dry season, so the increase of internal leaf temperature caused by the presence of a red colouring matter in the young leaves would tend to increase the transpiration. The higher the internal temperature of the leaf the more rapid the loss of water from the leaf tends to be, and, if a sufficient supply of water is forthcoming from the soil, the more copious the transpiration stream becomes. Thus though the young red leaf may not be any higher in temperature than the mature green leaf, yet it is distinctly higher, as has been shown, than such a young leaf would be without the anthocyan. The work of the present paper has shown that a young leaf with anthocyan, in bright sunlight on a fairly still day, is at a temperature 3° or 4° C. higher than such a leaf without anthocyan. Although this may not seem a very large difference, yet when the whole periphery of a large tree is covered with leaves, all of which are at this increased temperature, the increase in the transpiration stream must be considerable. This explanation is in complete accord with that of Stahl, who points out how in the tropics the raising of the internal temperature of leaves promotes the transpiration stream. In the earlier part of the paper reasons have been given for casting doubt upon the function of anthocyan as a light screen for the chlorophyll, on the ground that it does not, on the whole, screen from those rays which the chlorophyll absorbs the only ones presumably which can destroy the chlorophyll. One of the chief supports of the light screen theory has been the type of general distribution of anthocyan.

It is contended by Stahl that in the tropics leaves containing anthocyan are often found in moist situations, *e.g.*, in damp forests, where it is an advantage that the transpiration stream should be increased. No one who has visited the tropics can doubt that they are also abundant in sunny and exposed situations, and, taking a general view, it has been rightly contended that on the whole the red colour is abundant in exposed situations, where presumably a screen from intense light would be useful. The distribution would thus fit in with the idea that anthocyan is a protective screen. When, however, it is shown from the habits of trees in Peradeniya that even in what seem exposed sunny situations, the increase of the transpiration stream may be an advantage; it is at once evident that the argument against Stahl's explanation on the ground of distribution becomes invalid. It may be that plants in the open also find it an advantage for their transpiration stream to be increased just as they do in those dark damp forests, where live many of the plants cited by Stahl. In any case there is a big logical gap between the proposition "Anthocyan is distributed in such situations as make it possible for it to be a light screen" and the proposition "Anthocyan does act as a light screen." This gap does not up to the present seem to be filled. In opposition to the view expressed in this paper the cases may be cited of those trees, such as *Humboldtia laurifolia* and *Saraca indica*, whose young foliage contains very little anthocyan, and is almost white. These are shade trees, as pointed out by Keeble, and it may be said that these are the trees whose transpiration needs increasing the most, and yet they have not developed the red colour. In reply it may be said that this paper has shown that the red colour of young leaves leads to a higher internal temperature, and has suggested that this higher temperature may have the incidental advantage of promoting the transpiration stream, and thus of rendering possible the development of the habit of general rapid growth during a short period followed by a long rest. It is no part of the purpose of this paper to show that the red colour has always been developed in places where it would be advantageous or that it has been most developed where it would have been most advantageous. All that can be said is that where it has been developed, it may be of advantage. It might be incidentally noted that the trees coming under the present writer's notice, whose young foliage is almost white, are among those whose growth is not general over the whole tree, but takes place nearly all the year round in a few branches at a time, thus making only a small demand upon the mineral food supply at any one time. The causes of the development of anthocyan in the young leaves of so many tropical plants are not yet known. Investigation upon the lines of Overton's paper seems most hopeful, and it is possible that a suggestion of explanation on those lines can even now be put forward. Owing to the absence of chlorophyll in the young leaf, the very rapid growth which at first takes place must go on at the expense of material translocated from the stem, since the leaf itself does not form food at all. It may be that the proportion of sugar in the food thus being rapidly translocated into the leaf is high, and that the young rapidly growing leaf contains a higher proportion of sugar than the mature leaf does. If so, according to Overton, the effect of light on a tissue richer in sugars is to form anthocyan, and this would be only a special case of a general law deduced by him from other instances. When chlorophyll was developed in the mature leaf, and starch thereby formed and accumulated during the day, the condition of preponderance of sugar being absent, the anthocyan would no longer be formed and the leaf would lose its red colour, which is, of course, what actually does occur.

It is possible that the sugars brought into the young leaf, which are not products of its own activity may be deposited as starch when they reach a certain amount. If so, it may be that the young leaf is not richer in sugars than the mature leaf, and some other explanation is to be looked for. The question can only be settled by direct chemical investigation, which it is now impossible for the present writer, who has left the tropics, to carry out.

What has here been shown is that by the absorption of radiation the red leaf tends to have a higher internal temperature than the leaf without anthocyan, that trees bearing such red leaves have the habit of growing rapidly for a restricted period, and that at Peradeniya this growth takes place profusely at the driest period of the year. It has been suggested that these facts receive an explanation on the supposition that only at such periods is there a possibility of sufficient transpiration to provide the necessary mineral foods for such rapid growth. The higher internal temperature of the young leaves caused by the anthocyan would aid in promoting this transpiration. Much of what has been suggested in the latter part of the paper is tentative and provisional. In two directions especially the evidence is in great need of further extension; namely, (1) in the extension of observation of the facts of new rapid growth in evergreen trees in the tropics, and (2) in further chemical investigation of the reserve stores in such trees. The former investigation is now impossible for the writer of this paper, but with regard to the latter, at any rate, so far as relates to the relative distribution of the chief mineral foods in new twigs and older branches, he hopes to bring forward some evidence in a subsequent paper.

In conclusion, I wish to express my thanks to Dr. F. F. Blackman for suggestions and help in this investigation, especially with regard to Part I., to Dr. J. C. Willis, at whose suggestion the investigation forming Part II. of the paper was undertaken, and to Mr. H. F. MacMillan, Curator of the Botanic Gardens at Peradeniya, for placing at my disposal the resources of the Gardens in various ways.

SUMMARY (PART I.).

1. By the aid of specially designed thermo-electric apparatus the internal temperature of any leaf could be obtained to an accuracy of ·5° C.

2. In still air, with black bulb vacuum thermometer at from 55°–62° C., the air temperature in the shade being from 25°–28° C. and the humidity about 70 per cent. of saturation, leaves, whether thick and fleshy, or thinner and somewhat coriaceous, or quite thin and pliable, when placed normal to the sun's rays, reach a temperature of 15° C. above that of the surrounding air. They attain, in fact, a temperature of 40–43° C.—a temperature hitherto often considered injurious to the functions carried on in the leaf.

3. In the shade such leaves have an internal temperature varying from 1·5° C. below to 4° C. above that of the surrounding air under different conditions.

4. Though the thickness of the leaf did not affect the temperature finally reached in the sunlight, yet it did affect the time taken to reach that temperature. The thickest leaf used took ten minutes to attain its steady temperature after exposure, while the thinnest leaf only took three minutes.

5. An attempt was made to estimate the magnitude of the cooling due to transpiration. Two leaves with stomata outwards were consistently lower in temperature than two with their stomatal surfaces facing each other. The difference was on an average 2·5° C.

6. Of factors tending to reduce the high temperature reached in sunlight, the movement of the air is the most important. Breezes of various strengths reduced the temperature attained in sunlight by amounts varying from 2° C. to 10° C.

7. A historical survey of the subject of anthocyan in leaves is given, in which previous work is summarized as supporting either (1) the screen theory of the function of anthocyan or (2), the theory that anthocyan promotes transpiration and translocation by raising the temperature of the leaf.

8. It is shown experimentally—

(*a*) That a red leaf attains a higher temperature than a white or pale leaf of the same thickness and texture.

(*b*) That immature thin coloured leaves of various tropical trees may be either higher or lower in temperature than mature thicker green leaves of the same species. This probably depends on the amount of anthocyan in the young leaf.

SUMMARY (PART II.).

9. Observations were made at intervals of the number of trees showing new growth, the leaves of which were sharply marked off in colour from the mature leaves.

10. Analysis of the results showed that this new growth was most prevalent in the driest season and almost absent in the wettest months. This agrees with some observations on deciduous trees at Peradeniya made by Wright (32).

11. It is suggested that probably in a climate of high humidity, like that at Peradeniya, it is only in the dry period that a sufficient transpiration stream is obtained to supply the large amount of mineral substances required in the formation of the copious new growth.

12. If this be the case, then the higher internal temperature attained by the colouration of the young leaves would promote the same object, viz., the increase of the transpiration stream.

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New Ceylon Fungi.

BY

T. PETCH.

Hymenomycetes.

Armillaria fuscipes, Petch, n. sp.—Pileus up to 6 cm. diameter, at first broadly convex, then plane, margin recurved; centre obtusely umbonate with an encircling depressed zone, sometimes umbilicate; brown or yellow brown in the centre, becoming pale brown outwards, shading off to pure white in the outer half; centre corrugated; the central half covered with minute distant brown warts, elsewhere glabrous; margin striate. Flesh thin, white, turning brownish when cut.

Stalk up to 10 cm. long, usually almost horizontal at the base and then curving upwards, up to 9 mm. diameter at the base, attenuated upwards and 5 mm. diameter at the apex; blackish brown, clothed with grayish flocci, becoming paler and longitudinally fibrillose towards the ring; longitudinally striate and reddish above the ring; solid, outer layers dark brown in section, inner tissue brownish white; in clusters of six to nine, arising from a cushion-like mass, each stalk surrounded at the base by a narrow, white, tomentose ring.

Ring, near the apex, dependent, ample, rather thick and floccose.

Gills white, rather crowded, narrow (3–4 mm. broad), decurrent, attenuated outwards.

Spores white, oval, or subglobose, smooth, 6-8 × 5–7 μ.

On roots of *Acacia decurrens*, which it kills. Mycelium between the wood and bark of the host plant in reddish plates. Rhizomorphs, 2–3 mm. diameter, at first reddish, then black. Uda Pussellawa, Ceylon.

Paxillus russuloides, Petch, n. sp.—Pileus 7–8·5 cm. diameter, plane and obtusely umbonate, or infundibuliform, viscid, with a separable purplish red, brick-red, or pinkish

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part V., March, 1909.]

cuticle, somewhat mottled; margin incurved, finally expanded, not striate. Flesh white, thick.

Stalk 3·5–4 cm. high, 1–1·4 cm. diameter at the base, expanding upwards into the pileus, solid, red, or red-brown, minutely scurfy, the scurf extending over the lower edges of the gills.

Gills rather distant, decurrent, narrow, cream-coloured, becoming brownish when old, separating as in *Paxillus involutus*, not brittle.

Spores ochraceous, verrucose, narrow-oval, with a stout apiculus, 11–12 × 6–7 μ.

On the ground among *Strobilanthes*, sp., in jungle at Hakgala.

Boletus rubescens, Petch, n. sp.—Pileus broadly convex, soon undulating and margin repand; at first reddish or yellow brown, minutely tomentose, then with the cuticle broken into polygonal yellow brown or red brown areolæ, showing the pale yellow flesh between, dry; 6–15 cm. diameter; flesh thick, pale yellow. Pore surface at first pale yellow, then greenish yellow; pores angular, aculeate, up to 3 × 2 mm., decurrent, terminated on the stem by a well defined line, which is at first translucent, then dark gray.

Stalk 3·5–5·5 cm. high, 1·5–2·5 cm. diameter, attenuated at the base, grayish white, minutely tomentose, not reticulated, solid, internally white at first, then pale yellow.

Spores pale olive brown, obliquely ovate, 6–7 × 4 μ.

The flesh of the pileus changes slowly when cut first to blue, then red; the pores turn slightly blue where bruised, and become red-brown in drying; the stalk becomes red-brown when handled; the mycelium is white, but turns brick-red on exposure.

On the ground, among grass, Peradeniya.

Irpex destruens, Petch, n. sp.—Resupinate, spreading in large patches, then producing horizontal pilei, either at the margin or anywhere on the resupinate patch. Resupinate portion indeterminate, or bordered by a broad white sterile margin. Pilei elongated, or orbicular, or flabelliform, attached by their whole length, or narrowed behind, confluent or solitary, often imbricated, up to 2 cm. wide. At first white and soft, then coriaceous, pale ochraceous with a pinkish tinge, with broad ochraceous zones, minutely tomentose, and radiately fasciato-rugose ; thin, internally white ; margin thin, entire, incurved when dry. Hymenial surface pale ochraceous, teeth up to 4 mm. long, triangular, flattened. Spores not seen.

Parasitic on tea (*Thea*, sp.) entering through the pruned main stem, and killing the branches as it proceeds downwards. The diseased wood is yellow. Uda Pussellawa, Ceylon.

Exobasidium cinnamomi, Petch, n. sp.—On *Cinnamomum zeylanicum*, Bl., and *Cinnamomum cassia*, Bl., Peradeniya. Causing outgrowths, up to 8 cm. long and 1 cm. thick, slightly flattened laterally, sometimes longitudinally ridged, square or triangular in cross-section, with short conical branches here and there like a stag's horn, rough, parenchymatous, pale brown at first, finally covered with a white bloom, arranged in lines along the branches, or in clusters up to 15 cm. diameter on the main stem.

Basidia 25 μ long, 13 μ diameter, ovate and rounded at the apex, or cylindric and truncate, 4-spored ; spores white, oval, minutely spinulose, 5–6 × 3–4 μ

Exobasidium zeylanicum, Petch, n. sp.—Causing galls on the under surface of the leaf of *Rhododendron arboreum*, Sm. Hakgala, Ceylon.

Galls spherical, up to 3·5 cm. diameter, on the under surface of the leaf, attached by a narrow base, soft, constantly white or greenish white, then covered with a white bloom. Spores cylindric, straight or slightly curved, 10–15 × 2–3·5 μ, white.

Apparently differs from the species recorded on other species of *Rhododendron* in the colour of the gall and the size of the spores.

Uredineæ.

Melampsora acalyphæ, Petch, n. sp.—Sori irregularly circular, or elongated and curved, surrounded by the torn epidermis, encircling small black spots on the lower surface of the leaf, the upper surface marked with corresponding black spots with a white centre. Uredospores pale brown in mass, almost hyaline when magnified, pyriform or subglobose, verrucose, 27–34 × 24–28 μ. mixed with immature (?) teleutospores, dark gray, oblong, curved or straight, 40–50 × 10–14 μ.

On leaves of *Acalypha fruticosa*, Forsk. Peradeniya, May, 1908.

Æcidium elæagni-latifolæ, Petch, n. sp.—Hypophyllous, gregarious, without evident spots, minute, about ·2 mm. diameter, pseudoperidium white, mass of spores pale ochraceous. Pseudoperidial cells up to 30×20 μ, polygonal, hyaline, strongly verrucose ; spores irregularly oval or globose, verrucose, almost hyaline, slightly tinged ochraceous, 18–21 × 13–17 μ.

On leaves of *Elæagnus latifolia*, L. Peradeniya, December, 1908.

Æcidium parsonsiæ, Petch, n. sp.—Hypophyllous, arranged in circles on circular spots, which are slightly bullate, at first pale yellow, becoming purple ; æcidia orange yellow, ·25–·3 mm. diameter, pseudoperidium white and well developed. Pseudoperidial cells hyaline, thick-walled, verrucose, polygonal or quadrate, slightly larger than the spores. Spores ovoid, minutely and closely warted, 15–20 × 11–14 μ.

On leaves of *Parsonsia spiralis*, Wall. Weligama, March, 1908 ; Dikwella, May, 1908.

Æcidium cajani, Petch, n. sp.—Forming minute galls about 1 mm. diameter, on the under surface of the leaf along the veins and on the leaf stalks and stems ; these galls rupture at the apex when ripe, leaving a deep cavity, which contains the orange red mass of spores. Pseudoperidium absent. Spore contents orange, epispore hyaline, very faintly warted, subglobose, 20–45 × 20–23 μ.

On *Cajanus indicus*, Spr. Peradeniya, June, 1908.

Æcidium atylosiæ, Petch, n. sp.—Hypophyllous, circular, about ·5 mm. diameter, orange red, deeply sunk in the tissues and hidden by the hairs of the leaf, or forming small galls along the veins. Pseudoperidium absent. Spores sub-globose or spherical, orange, wall hyaline, smooth, 25–32 × 24–28 μ

On *Atylosia candollei*, W. &. A. Hakgala, March, 1907 ; September, 1908.

Æcidium paramignyæ, Petch, n. sp.—Æcidia hypophyllous, crowded, on pale green circular patches 1–2 cm. diameter with a broad pale green margin, yellow, ·2 mm. diameter, tubular, ·2 mm. high, flaring at the top. Pseudoperidium white, of polygonal, strongly verrucose cells; spores irregularly oval or subglobose, strongly verrucose, 20–25 × 17–19 μ.

On leaves of *Paramignya monophylla*, Wight. Kandy, June, 1907.

Æcidium toddaliæ, Petch, n. sp.—Forming yellow spots on the leaves; unopened æcidia spherical, visible from both sides; spots ultimately thickened, forming galls 2–4 cm. diameter on the under surface, the æcidia opening on the under surface only. Æcidia peritheciiform, minute, about ·5 mm. diameter. Spores orange, verrucose, irregularly oval, 50–57 × 27–34 μ.

On *Toddalia aculeata*, Pers. Nuwara Eliya, April, 1908; August, 1908.

Uredo uguressæ, Petch, n. sp.—Sori dark orange, minute, up to ·25 mm. diameter, crowded in circles on circular blackish spots; spores brownish yellow, pear-shaped or ovoid, covered with large blunt spines, except at the narrower end which is smooth, 24–28 × 15–19 μ.

On unripe fruits of Uguressa (*Flacourtia ramontchi*, Sher.). Galle, July, 1907.

Uredo chasaliæ, Petch, n. sp.—Sori minute, circular, ochraceous, clustered, on blackish spots, hypophyllous, surrounded by the upturned epidermis; spores subglobose or elliptical, strongly echinulate, thick-walled, 22–31 × 17–23 μ

On leaves of *Chasalia curviflora*, Thw. Hakgala, March, 1907; September, 1908.

Uredo dregiæ, Petch, n. sp.—Causing minute dark spots on the under surface of the leaf. Sori hypophyllous, pale grayish brown, clustered, circular or linear, surrounded by the upturned epidermis; spores very pale brown or almost hyaline, oval, or pyriform, thick-walled, with coarse scattered spines, 30–37 × 20–22 μ, a few spherical spores 23–25 μ intermixed.

On leaves of *Dregia volubilis*, Benth. Peradeniya, May, 1908.

Ustilagineæ.

Ustilago andropogonis-aciculati, Petch, n. sp.—In the unexpanded inflorescence; spores spherical, olivaceous, smooth, 5 μ diameter.

In inflorescences of *Andropogon aciculatus*, Retz. Peradeniya.

Ustilago anthisteriæ, Petch, n. sp.—In ovaries; spores, globose, spinulose, blackish olivaceous, 6–7 μ diameter. In ovaries of *Anthisteria tremula*, Nees. Peradeniya.

Pyrenomycetes.

Physalospora neglecta, Petch, n. sp.—Perithecia about ·3 mm. diameter, gregarious, embedded in the cortex and raising and cracking the epidermis, slightly flattened, with a small abrupt papilla, ·08 mm. diameter and ·08–·12 mm. high, protruding through the epidermis, black, smooth. Asci 140–160 × 35 μ, clavate, appearing thick-walled at first, eight-spored, spores biseriate; paraphyses numerous, septate, shorter than the asci; spores hyaline, thick-walled, inequilateral, cymbiform, 32–40 × 12–16 μ.

On living branches in *Thea*, sp., causing at first slightly sunken areas, from which the cortex afterwards splits off. These wounds are then surrounded by a callus and form large open "cankers." Kadugannawa, Ceylon.

Metasphæria cocoes, Petch, n. sp.—On the mid-rib of decaying fronds of *Cocos nucifera*, L. Ceylon.

Perithecia ·3 mm. diameter, spherical, gregarious, membranous, black, produced beneath the epidermis and raising it in irregular grayish confluent blisters, which usually form a raised network; ostiola penetrating the epidermis, minute, scarcely visible. Ascus 260 × 15 μ, attenuated towards either end, apex rounded, shortly stalked, eight-spored, spores obliquely uniseriate; paraphyses absent. Spores fusiform, curved, ends obtuse, hyaline, multiseptate, 85–100 × 5 μ.

Myxomycetes.

Physarum crateriforme, Petch. n. sp.—Sporangia stalked, with occasional plasmodiocarps; head crateriform, ·5–·75 × ·3–·4 mm., or spherical, ·5 mm. diameter, sometimes flattened as in *Didymium clavus*, white with dense scattered lime deposits, or gray with scanty lime deposits on a thin iridescent wall, or iridescent when the lime deposits are absent.

Stalk opaque, conical, black below, white above, ·3–·7 mm. long, up to 200 μ diameter at the base, 80 μ diameter at the apex, projecting into the head and continuing as a dense white columella to the apex in crateriform examples, but usually terminating at the base of the head in spherical examples. The stalk changes from black to white either below or inside the head. Lime knots forming a dense massive columella extending to the apex of the sporangium, giving off horizontal spine-like points 80–100 μ long, 20–40 μ broad, which end in slender hyaline threads united to the sporangium wall, or in spherical forms, rod-like and forking, springing from the base of the sporangium, often extending to the apex, with few hyaline threads, and usually not forming a columella. Sporangium wall membranous, colourless, with innate lime deposits. Stalk containing refuse matter, usually collapsing when mounted. Spores 11–15 μ, spherical, closely spinulose, violet brown.

On the bark of living jak trees (*Artocarpus integrifolia*); occasionally on decaying branches of the same. Peradeniya.

Perichæna pulcherrima, Petch. n. sp.—Sporangia spherical, ·3 mm. diameter, or elongated, ·7 × ·3 mm., sessile, crowded on a netted, shining, irregular hypothallus; or scattered, shortly stalked, with globose heads up to 4 mm. diameter; stalks sometimes connate, with two or three sporangia on a common stalk. Sporangium wall glossy, purple red, or red brown, double, consisting of an outer granular, purple red layer and a delicate hyaline inner layer, often hexagonally reticulated. Stalk ·3 mm. long, ·1 mm. diameter, furrowed, brown, or red brown, containing granular matter. Capillitium of pale brown, irregular, branching threads, 4 μ diameter, inflated here and there, rough with minute warts and scattered blunt spines. Spores brownish, spinulose with close set spines, 15–17 μ diameter.

On dead branches of *Theobroma cacao* and *Erythrina lithosperma*, about 4 feet from the ground. Ukuwela, Ceylon.

In mass the capillitium appears the same colour as the sporangium, the spores paler. The reticulation of the sporangium wall is not a constant feature, but it is certainly not due to immaturity.

Deuteromycetes.

Septoglœum limoniæ, Petch. n. sp.—On leaves of *Limonia crenulata*, Roxb. Dikwella, Ceylon.

Pustules minute, gregarious, black, on dry pale brown patches on the under side of the leaf; spores slightly clavate, straight or curved, 4–5 septate, hyaline, ends obtuse, 36–45 × 3–4 μ.

Helminthosporium albizziæ, Petch, n. sp.—On leaves of *Albizzia Lebbek*, Benth. Peradeniya.

Spots minute, black, about ·5 mm. diameter, consisting of several tufts of conidiophores surrounding a minute, central, clear spot. On the under surface of the leaf.

Conidiophores united at the base, up to 70 μ long, 7 μ diameter, with usually one septum near the base; nodulose; upper part covered with dark circular patches, 3 μ diameter, with a minute central hyaline spot (the points of attachment of spores); fuliginous; spore terminal.

Spores, clavate, ends rounded, 42–56 × 12 μ, tapering to 4 μ diameter at the lower end, rough with minute warts, fuliginous, terminal cell paler, straight or curved below, 3–4 septate, septa 3–4 μ thick, wall 2–3 μ thick, not constricted at the septa.

Cercospora zizyphi, Petch. n. sp.—On leaves of *Zizyphus œnoplia*, Mill. Peradeniya.

Spots yellow at first, then brown with a yellow margin, circular or oval, up to 4 mm. diameter.

Pustules minute, on either side of the leaf, about 40 μ diameter, black. Conidiophores 16–20 × 4 μ, straight. Spores 40–75 × 4 μ, the smaller equal, the larger clavate and tapering to 2 μ diameter, often nodular, straight, ends obtuse, 3–8 septate, greenish hyaline.

Cercospora bruceæ, Petch. n. sp.—On leaves of *Brucea Sumatrana*, Roxb. Kandy, Ceylon.

Forming gray or black patches on the under side of the leaves. Hyphæ fuscous, creeping and intertwined, somewhat felted together, 3–4 μ diameter. Spores multiseptate, somewhat clavate, straight or curved, 45–65 × 5 μ.

Cercospora ternateæ, Petch. n. sp.—On leaves and pods of *Clitoria ternatea*, L. Peradeniya.

Leaf spots rounded, black, centre brown, then gray, with a yellowish or pale green border, 3 mm. diameter, conidiophores amphigenous. Spots on the pod, up to 5 mm. diameter, or confluent, black with a brown margin, sunk.

Conidiophores olivaceous, arising from a minute stroma, septate, at first smooth, up to 90 × 5 u, bearing a single spore at one corner of the apex, then up to 200 μ long, nodular with old spore attachments. Spores hyaline, 80–120 μ long, curved, tapering from 4 μ to 2 μ, multiseptate, with septa about 8 μ apart.

Apparently differs from *Cercospora clitoriæ*, Atk., in the longer curved spores and the longer conidiophores.

Cerebella anthisteriæ, Petch, n. sp.—Stroma about 6 mm. long, 3 mm. broad, somewhat flattened, the surface consisting of brain-like, generally transverse, convolutions, dark olive, then black. Spores united, 3 to 7 together, into more or less spherical balls, constricted at the septa, 14–20 μ diameter, with a short thick hyaline pedicel. Separate spores tetrahedral with a rounded base, 8–12 μ across the widest part, olivaceous, smooth.

In inflorescences of *Anthisteria imberbis*, Retz. Peradeniya.

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ANNALS

OF THE

ROYAL BOTANIC GARDENS, PERADENIYA.

EDITED BY

R. H. LOCK, M.A.

ACTING DIRECTOR.

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A List of the Mycetozoa of Ceylon.

BY

T. PETCH, B.Sc., B.A.

THE earliest collections of Ceylon fungi, made by König and Gardner, consisted of the more obvious forms only, and apparently did not include any Mycetozoa. On the other hand, Thwaites devoted considerable attention to the collection of microscopic species, and the number of Mycetozoa enumerated by Berkeley and Broome in their "Fungi of Ceylon"—seventy-four—forms rather a large percentage of the 1,200 species of fungi recorded. Of these seventy-four, seven do not belong to the Mycetozoa, and, judging from the description, the same is true of another, *Reticularia fuliginosa*, the type specimen of which appears to have been lost. Berkeley and Broome were particularly unfortunate in their diagnoses of *Reticularia ;* the specimens of four of the five species recorded from Ceylon are still in existence, but only one of these is a mycetozoon, and it is not a *Reticularia*. Out of the remaining sixty-six species, twenty-six were described as new, but twenty of the supposed novelties have since been proved to be species previously described. *Trichamphora pezizoidea*, Jungh., was re-described under two new names, and *Dictydiæthalium plumbeum* under three. Six of Berkeley and Broome's new species, therefore, hold good ; and, moreover, the collection contained two other new species, since described from America, which Berkeley and Broome did not recognize as such.

The re-examination of the Ceylon specimens in the herbaria at Kew, the British Museum, and Peradeniya has reduced the sixty-six recorded species to fifty-two, in spite of the fact that Berkeley and Broome included three species under the name *Stemonitis fusca* and three under *Arcyria punicea*. *Hemitrichia*

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part VI.* Jan., 1910.]

Karstenii, Lister, is included in this fifty-two, but it seems very probable that it was an Australian, not a Ceylon, gathering; there are undoubted instances of the inclusion of Australian species in the "Fungi of Ceylon," and it appears as if, when a fungus originated East of Suez, the exact locality was of minor importance.

I give below a copy of the records in the "Fungi of Ceylon," with re-determinations of the species. The initial numbers are those of Berkeley and Broome's list, while those in brackets are the numbers of Thwaites' collection. I am indebted to the late Mr. Arthur Lister for the information with regard to the Kew and British Museum collections. The measurements given by Berkeley and Broome are in decimals of an inch.

732. *Lycogala affine*, B. & Br. Globosum, punctatum, sporis minutis leviter echinulatis (No. 82). On dead wood. Spores ·0002 in diameter, whereas those in *L. epidendrum* are ·00028–·0003.

No specimen in Herb. Peradeniya: not found by Lister in Herb. Kew, or Herb. British Museum: type in Herb. Berk. Kew, No. 10702, is *L. miniatum*, Pers., fide Massee, Mon., p. 121.

733. *L. epidendrum*, Buxb. (Nos. 314, 315, 316). On dead wood. Nuwara Eliya, 6,000 feet. Spores ·0003 in diameter.

314 apparently is not in any herbarium.

315 is *Lycogala flavofuscum*, Rost., in Kew 1732.

316 is immature *Lycogala miniatum*, Pers., in Herb. Peradeniya

734 *L. nitidum*, B. & Br. Peridio tenerrimo griseo nitido, ore stellatim rupto, sporis pallidis (No. 313).

313 is *Lycogala conicum*, Pers., in Kew 1729, and in Herb. Peradeniya.

735. *L. atropurpureum*, B. & Br. Peridiis ovatis atropurpureis apice pallidis, sporis globosis hyalinis (No. 254). On dead wood. Nuwara Eliya, 6,600 feet. Placed provisionally in this genus. Fixed at the base by an orbicular stratum of sarcode, of which there is often a trace on the truncate apices: rather rough or furfuraceous. About the size of *Sphæria bombarda*. Probably a new genus.

254 is *Lycogala conicum*, Pers., in Kew 1730, and in Herb. Peradeniya.

736. *Reticularia lurida*, B. & Br. Depressa, olivacea, ex hypothallo niveo oriunda, floccis erectis ochraceis, sporis concoloribus (No. 259). On dead wood. Flocci abundant even : spores ·0005 in diameter.

259 is *Dictydiæthalium plumbeum*, Rost., in Kew 1664, and in Herb. Peradeniya.

737. *Reticularia apiospora*, B. & Br. Effusa, dendritica, fulva : peridio fibroso-sericeo : sporis obovatis, basi breviter auctis hyalinis (No. 266). On dead wood. Resembling when young *Hymenochæte dendritica* : spreading widely : peridium consisting of branched silky fibrils : spores ·0003 long, ·00015 wide.

This species is a Hyphomycete and has been re-described by Massee as follows:—*Trichosporium apiosporum* (B. & Br.), Massee, Jour. Myc., 1889, p. 186, t. XIV., fig. 5.—Late effusum fulvum : hyphis agglutinatis in fasciculos dendritice radiantes : conidiis ex apice subpiriformi ramulorum oriundis, ellipsoideis, minute verrucosis, subhyalinis, 8–9 × 5. An ob colorem lætum, potius *Sporotrichi* species. (Sacc., Syll. X., p.583.)

266 in Herb. Peradeniya, consists of a red-brown, rather compact, mass of mycelium and spores. In the centre it is about 2 mm. thick, thinning out to the dendritically radiating margin. The largest piece measures 3·8 cm. by 1·6 cm., but it is evidently only part of a much larger specimen. The hyphæ vary from 2 to 4 μ in diameter, and are hyaline : they appear to be loosely interwoven everywhere, and bear the conidia on very short lateral pedicels, either scattered or crowded. The conidia are yellow-brown when magnified, oval, or subpyriform, with short scattered spines, and measure 6 to 8 by 4 to 5 μ : at one end there is a slight collar, showing the attachment to the pedicel, and this, with the colour and spinules, makes the spores resemble those of a *Fomes*, *e.g.*, *Fomes lucidus.*

738. *R. atrorufa*, B. & C., Jour. Linn. Soc., X., p. 347 (No. 17). On bark covered with moss. Peradeniya, Nov., 1867. Spores globose, ·0002 in diameter.

Fide Massee, this is *Trichosporium Curtisii*, Massee, Jour. Myc., 1889, p. 185, t. XIV., f. 3.

739. *R. venulosa*, B. & C., *l.c.* (No. 84). On dead wood and mosses, Nov., 1867.

Fide Massee, this is also *Trichosporium Curtisii.* In Saccardo, Vol. X., p. 583, the names of this and the last species are given as

R. verruculosa and *R. atrofusca*, while in Vol. VIII., No. 739 appears as *R. venosa*. In Herb. Peradeniya, the two species are on the same sheet, without any distinguishing mark. There are four pieces of bark. One of them measures 4·5 by 2 cms., and has the roots of some epiphyte, up to 6 cms. long, adhering to it ; the bark is covered with a dark brown film, consisting of stout, pale brown, creeping hyphæ, 3 to 4 μ in diameter, sometimes agglutinated into strands ; mixed with these are irregularly oval or globose, pale or dark brown spores, 3 to 5 by 4 to 7 μ ; on the bark at one end, and along the adhering roots, is a purple-black horny crust which at first sight looks like a dried plasmodium, but examination shows that this is an immature, effused, gelatinous fungus. The second piece measures 5 by 3·5 cms. ; it has the same brown film in the centre, and the purple-black horny crust in a band from 5 to 15 mm. wide along each edge ; on one side this band is interrupted by a pulverulent purple-black mass of spores ; these spores are the same size and shape as those among the creeping hyphæ, but somewhat blackish brown ; nearly all the spores are distorted. The third piece measures 3 by 1·5 cms. ; it has a slight film of brown hyphæ, on which are three pulvinate masses, each about 5 mm. diameter, of blackish brown spores. The fourth piece bears a circular horny patch about 1·5 cm. diameter, purple black in the centre, becoming brown and membranous towards the edge : it is radially and transversely cracked. According to the descriptions, the first three should be *Reticularia atrorufa*, and the fourth *Reticularia venulosa*. They are certainly not *Reticularia*, and it does not seem possible that they are *Trichosporium*. From the dried material, it is not possible to decide whether there is only one species, or to what group it belongs. The immature gelatinous form appears to be the same on all four specimens, and it is identical with Thwaites' 989, which was named *Thelephora atropurpurascens*, B. & Br., Fungi of Ceylon No. 580.

740. *R. fuliginosa*, B. & Br. Effusa, tenuis, ex olivaceo fusca, sericea : sporis magnis globosis floccisque atropurpureis lævibus (No. 247). On leaves of some palm. Spores like of those of *R. lurida*. Accompanied by a *Helicoma*.

347 is apparently not in any herbarium. The type specimen of the *Helicoma*, *H. binale*, B. & Br., No. 897, is not in Herb. Peradeniya.

741. *Æthalium septicum*, Fr. (*a*, Nos. 196, 261), (*d*, Nos. 136, 218). On various decaying substances. *A*, *flavum*, Nuwara Eliya : *d*, *violaceum*, Nov., 1867.

196, 261, 136, 218 are apparently not in any herbarium.

742. *Diderma sublateritium*, B. & Br. Congestum, collabens, deplanatum, glaberrimum ; peridio exteriore pallide lateritio, intus candido furfuraceo ; interiore cinereo ; columella conformi ; floccis pallidis ; sporis dilute brunneis (No. 26). On dead leaves. Peradeniya, Nov., 1867. Looks at first sight like the eggs of some moth. Spores ·0003 in diameter. Allied to *D. testaceum*.

26 is *Chondrioderma testaceum*, Rost., in Kew 1454, and in Herb. Peradeniya.

743. *D. deplanatum*, Fr. (No. 40). On dead leaves, &c. Peradeniya, Nov., 1867.

40 is *Chondrioderma reticulatum*, Rost., in Kew 1439, and in Herb. Peradeniya.

744. *D. depressum*, Fr. (No. 75). On dead leaves, &c. Nov., 1867. Spores ·00035 in diameter.

75 (and 40) are *Chondrioderma reticulatum*, Rost., in Kew 1438 ; Kew 1442 ; British Museum 514 ; and Herb. Peradeniya. They are in the same packet in Herb. Peradeniya.

745. *Didymium clavus*, A. & S. (No. 117). On various decaying substances. Peradeniya, Nov., 1867. An almost stemless form.

117 is *Didymium clavus*, Rost., in Kew 1482. No specimen in Herb. Peradeniya.

746. *D. commutabile*, B. & Br. Stipite sursum attenuato, albo, subtiliter pulverulento, demum pallescenti lævi vel substriato tortoque ; peridio subtus cupulæformi, utrinque farinoso, demum circumcisso (No. 120). On dead herbaceous substances. Nov., 1867. A small species.

120 is *Didymium clavus*, Rost., in Kew 1490, British Museum 537, and Herb. Peradeniya.

747. *D. neglectum*, B. & Br. Stipite pallido, sursum, attenuato, sulcato ; peridio subgloboso umbilicato albo-farinaceo ; columella concolori, floccis albis ; sporis atris (No. 25). On

bark. Peradeniya, 1867. Spores ·0003 in diameter. Allied to *D. squamulosum.*

25 is not in Herb. Peradeniya, nor in any herbarium under B. & Br., 747, but the same Thwaites' number is given under B. & Br., 759, and this in Kew 1407 is *Physarum nicaraguense*, Macbride. Rostafinski examined the type specimen of *D. neglectum*, and found that it was *D. effusum.*

748. *D. farinaceum*, Schrad. (Nos. 76, 118). On dead leaves, &c. Nov., 1867. Flocci white: spores ·00035–·0004 in diameter.

76 is *D. nigripes*, Fr., var. γ in Kew 1503, and British Museum 559, 560; no specimen in Herb. Peradeniya. 118 is *D. nigripes*, Fr., var. *genuinum* in Herb. Peradeniya.

749. *D. nigripes*, Lk. (No. 573). Dolosbagey, May, 1868.

573 is *Lamproderma arcyrionema*, Rost., in Herb. Peradeniya.

750. *D. leoninum*, B. & Br. Stipite conico fulvo levi, basi orbiculari, concolori; peridio subgloboso corpusculis fulvis echinatis crystallinis sparso (No. 21). On dead leaves. Peradeniya, Nov., 1867. Clearly allied to *D. tigrinum:* but the corpuscles, instead of being mere scales, consist apparently of a number of crystals resembling somewhat those of lithic acid; the base when seen under the microscope is of a bright yellow.

21 is *D. leoninum*, B. & Br., in Kew 1554, and Herb. Peradeniya.

751. *D. melleum*, B. & Br. Stipite conico albo: peridio globoso melleo subtiliter pruinoso; columella e stipite intruso oriunda; floccis albis (No. 63). On dead leaves. Peradeniya, Nov., 1867. Flocci reticulated; spores ·0004 in diameter. Allied to *D. xanthopus* and *D. Iridis.*

63 is *Physarum melleum* (B. & Br.), Massee, in Kew 1256, British Museum 411, and Herb. Peradeniya.

752. *D. leucopus*, Lk. (No. 68). On dead leaves and bark. Nov., 1867. A large form.

68 is *Physarum compressum*, α and γ, in Kew 1245, 1351; it is marked *Ph. lividum* var. *conglobatum* by Rostafinski in Kew 1245, and *Ph. affine* by Rostafinski in Kew 1351: it is *Physarum compressum* in Herb. Peradeniya.

753. *D. bulbillosum*, B. & Br. Stipite conico albo lævi, basi bulbilloso; peridio globoso farinaceo; sporis floccisque nigris conglomeratis (No. 21 in part). On dead leaves. Peradeniya, Nov., 1867.

There is no specimen of this in Thwaites' 21 in Herb. Peradeniya. It occurs in British Museum 592, and Kew 1514, under the supposed Thwaites' number 1854. But there is some error here, since Thwaites' numbers did not exceed 1250; 1854 is probably a date. The specimens are *Diachœa bulbillosa* (B. & Br.), List.

754. *D. zeylanicum*, B. & Br. Stipite elongato, sursum attenuato, rufo; peridio globoso umbilicato candido; capillitio pallido vel candido; sporis nigris. On dead wood. Ceylon, 1851. Threads pale or entirely white: spores ·0004 in diameter.

This is one of Thwaites' earlier consignments; it has therefore no collection number, and is not in Herb. Peradeniya. The specimens under this name in Kew 1520, and British Museum 576, are *Trichamphora pezizoidea*, Jungh., but through some confusion they are under Thwaites' number 1046, which is B. & Br. 1190, *i.e.*, *Badhamia nitens*. A previous description of *Didymium zeylanicum* was given by Berkeley in Hooker's Journal of Botany and Kew Gardens Miscellany, Vol. 6 (1854), p. 230.—"*Didymium zeylanicum*, n.s. Peridio lenticulari subtus umbilicato cretaceo demum fatiscente subtiliter pulverulento; stipite sursum attenuato elongato sulcato fulvo; capillitio candido; sporis nigris. On dead wood. Ceylon (G. H. K. Thwaites). Stem 1 line high, tawny, incrassated below, attenuated above, sulcate, attached to a shining hypothallus. Peridium lenticular, umbilicate beneath, chalky, white, at length cracking, delicately pulverulent. Capilitium white, branched, anastomosing here and there, stained with a fuliginous tinge, very variable in thickness. Spores globose, 1/2500 of an inch in diameter. This species resembles in some respects *Phy. nutans*; but not only is the stem sulcate, but the peridium is decidedly pulverulent, like a leaf covered with *Oidium*. When the powdery coat is rubbed it appears rugged, like the surface of an egg." There is no doubt that both descriptions refer to the same gathering.

755. *D. effusum*, Lk. (No. 1024). On dead leaves. Peradeniya, Jan., 1869.

1024 is apparently not represented at Kew or the British Museum: in Herb. Peradeniya it consists of two pieces of wood bearing a minute hyaline fungus (*Sphæronema ?*), with hyaline spherical spores.

756. *D. cinereum*, Fr. (Nos. 55, 135). On various decaying substances. Nov., 1867. Spores ·0005 in diameter. No. 135 is a very gregarious form, with larger spores, ·0006. Substratum farinaceous.

55 is *Physarum compressum*, ∝ in British Museum 419: it is *Physarum compressum*, ∝ and *Physarum nicaraguense* in Kew 1244, where it is named *Physarum lividum* var. *conglobatum* by Rostafinski: no specimen of 55 in Herb. Peradeniya.

135 is *Physarum nicaraguense* and also *Physarum didermoides*, Rost., in British Museum 420, and is *Physarum didermoides* in British Museum 421; it is *Physarum nicaraguense* and *Physarum didermoides* in Herb. Peradeniya.

757. *D. croceoflavum*, B. & Br. Gregarium, sessile, extus flavum farinaceum, intus croceum; floccis flavis; sporis fulvis (No. 143). On dead leaves, &c. Nov., 1867. Spores ·00045 in diameter. A very pretty species, easily breaking up, and leaving behind a saffron cup dotted with the yellow flocci.

143 is *Physarum inæquale*, Peck., in Kew 1268, 1269, British Museum 414, and Herb. Peradeniya.

758. *Angioridium sinuosum*, Grev. (No. 129). On dead bark. Nov., 1867. Spores ·0005 in diameter. Peridium reticulated.

129 is *Physarum bivalve*, Pers., in Kew 1349, British Museum 451, and Herb. Peradeniya.

759. *Physarum nutans*, P. (No. 25). On various decaying substances. Nov., 1867. γ *aureum* (Nos. 73, 574). On decayed *Polypori*, &c. Dolosbage, May, 1868.

25 is *Physarum nicaraguense*, and is marked by Massee *Tilmadoche echinospora*, in Kew 1407.

73 is *Physarum viride*, Pers., in Kew 1420, and in Herb. Peradeniya.

760. *P. roseum*, B. & Br. Stipite gracili, peridio globoso, capillitio sporisque roseis (No. 1037). On dead bark, &c. Peradeniya, Jan., 1860. Stem attenuated upwards: spores ·00025 in diameter. Near *P. pulcherrimum*, which, however,

has a much more rigid and darker stem. It greatly resembles *Cribaria purpurea*, but is much smaller.

1037 is *Physarum roseum*, in Kew 1758, and Herb. Peradeniya.

761. *P. virescens*, Ditm., var. *flavum* (No. 271). On various dead substances. Flocci sulphur coloured or white

271 is *Physarum variabile*, Rex., in Kew 1272, and Herb. Peradeniya. Another specimen, marked "B. & Br. 761, ? 271," is weathered *Craterium leucocephalum*, Ditm.

762. *P. rufibasis*, B. & Br. Stipite rufo sulcato, e basi parva orbiculari scariosa concolori oriundo ; peridio flocisque luteis ; sporis atropurpureis (No. 1045). On dead leaves.

1045 is *Physarella mirabilis*, Peck., in British Museum 44, and Herb. Peradeniya.

763. *Craterium leucocephalum*, Ditm. (Nos. 101, 119). On dead leaves, herbaceous stems, &c. Peradeniya, Nov., 1867. Spores ·00035–·0004 in diameter.

119 is *Craterium leucocephalum*, in Kew 1376, British Museum 480, and Herb. Peradeniya. 101 is apparently not in any herbarium.

764. *Craterium pedunculatum*, Trent. (No. 1036). On lichens, dead leaves, &c. Peradeniya, Dec., 1868.

1036 is *Craterium pedunculatum*, in Kew 1358, British Museum 472, and Herb. Peradeniya.

765. *Diachea elegans*, Fr. (Nos. 16, 263). On dead leaves, &c.

16 and 263 are *Diachœa elegans*, in British Museum 591, 593, and in Herb. Peradeniya.

766. *Stemonitis fusca*, Roth. (Nos. 47, 64). On various decaying substances.

47 is *Stemonitis fusca*, in Kew 1615, and in Herb. Peradeniya.

47 is *Stemonitis herbatica*, Peck, in Kew 1592, 1624.

64 is *Stemonitis splendens*, Rost., in Kew 1593, and in Herb. Peradeniya.

767. *Stemonitis ferruginea*, Fr. On various decaying substances. Madamahanuwara, 2,000 ft. Spores ·0002–·00025 in diameter.

No Thwaites' number : not in any herbarium, unless it is British Museum 646, *Stemonitis ferruginea*, Ehr.

768. *S. typhoides*, D. C. (No. 575). On rotten wood, Dolosbagey.

575 is not in any herbarium.

769. *Dictydium umbilicatum*, Schrad. On decayed wood, Madamahanuwara.

Dictydium umbilicatum in British Museum 670 : no specimen in Herb. Peradeniya.

770. *Arcyria punicea*, P. (Nos. 20, 12, 21, 22, 70, 126). On dead wood. Spores ·00045 in diameter. In No. 20 the capillitum is not so bright as in the normal form.

20 is *Arcyria punicea*, Pers., in Herb. Peradeniya.

21 is *Didymium leoninum*, B. & Br., in Herb. Peradeniya, and in Kew 1554.

22 is *Hemitrichia rubiformis*, List. in Herb. Peradeniya.

70 is *Arcyria punicea*, Pers., in British Museum 709*b*, but is *Arcyria stipata*, List., in Kew 1719, British Museum 709, and Herb. Peradeniya.

12 and 126 are apparently not in any herbarium.

771. *Arcyria incarnata*, Fr. (No. 115). On dead wood, &c. Nov., 1867.

115 is apparently not in any herbarium.

772. *Arcyria nutans*, Fr. (No. 1035). On various decaying substances. Central Province, Dec., 1868.

1035 is *Arcyria flava*, Pers., in Herb. Peradeniya.

773. *A. umbrina*, Schum. (No. 24). On decayed wood. Nov., 1867.

24 is *Hemitrichia clavata*, Rost., in Herb. Peradeniya.

774. *A. cinerea*, P. (No. 116). On decayed wood.

116 is *Arcyria albida*, Pers., in Herb. Peradeniya.

775. *Trichia pyriformis*, Hoffm. (No. 436). On decayed bark, wood, &c. Habgalla, Dec., 1867. Spores ·0004 in diameter, tuberculated.

436 is *Trichia botrytis*, Pers., var. *lateritia* in British Museum 762, and in Herb. Peradeniya.

776. *Trichia Thwaitesii*, B. & Br. Stipite brevi cylindrico ; peridio tenui fulvo, demum sursum evanescente ; floccis concoloribus (No. 22). On very decayed wood. Nov., 1863.

Spores globose, ·0003 in diameter, sometimes elongated as if two had coalesced. At first sight resembles a little ovate *Arcyria.*

22 is *Hemitrichia clavata*, Rost., in Kew 1765, but is *Hemitrichia rubiformis*, List., in Herb. Peradeniya (see also B. & Br. 770).

777. *T. serpula*, P. (Nos. 83, 130, 139, 119 bis). On various decaying substances. Nuwara Eliya. Threads hispid. Spores papillate, ·0005–·0006 in diameter.

83 is *Hemitrichia serpula*, Rost., in British Museum 802, and in Herb. Peradeniya.

130 is *Hemitrichia serpula* in British Museum 804.

139 is immature *Hemitrichia serpula* in British Museum 803, and in Herb. Peradeniya.

119 bis is not in any herbarium: 119 is *Craterium leucocephalum*, Ditm., and the specimens in Herb. Peradeniya, marked "B. & Br. 777, Thwaites 119," contain *C. leucocephalum* only.

778. *T. chrysosperma*, D. C. (No. 272). On decayed wood.

272 is *Trichia scabra*, Rost., in Herb. Peradeniya.

779. *Licea cylindrica*, Fr. On dead wood.

B. & Br. 779 (Thw. 10, 857*a*) is *Dictydiæthalium plumbeum*, Rost., in Kew 1666: no specimen in Herb. Peradeniya: it is the type of *Clathroptychium Berkeleyi*, Massee, in Kew 1666.

780. *L. fragiformis*, Nees. (Nos. 132, 1018). On dead wood. Peradeniya, Nov., 1867, Dec., 1868.

132 is *Tubulina stipitata*, Rost., in Herb. Peradeniya.

1018 is not in any of the quoted collections.

781. *L. reticulata*, B. & Br. Adnato-serpula, reticulata, opaca, umbrina; sporis subconcoloribus (No. 429). On bark. Peradeniya, Dec., 1867, 1868. Flocci few, wavy, sometimes forked and uniting again so as to leave an elliptic open space. Spores ·0005–·0006. Allied to *L. serpula*, which appears to be much darker both as to the spores and peridia.

429 is *Perichæna variabilis*, Rost., in Kew 1708, and in Herb. Peradeniya.

782. *L. cinnabarina*, B. & Br. Depressa, tenuis, irregularis, superficie minute papillata, coccinea; spores globosis levibus concoloribus (No. 663). On bark. South of the Island.

Hypothallus white, distinct; spores ·0005–·0006. Resembling in habit *L. applanata*, B.

663 is immature *Dictydiœthalium plumbeum*, Rost., in Herb. Peradeniya.

783. *L. tenuissima*, B. & Br. Tenuissima, rufa, nitida, glaberrima, minutissime reticulata; margine primum byssoideo; floccis aculeatis; sporis globosis hyalinis (No. 324). On dead bark. Spores ·0003 in diameter.

324 is *Dictydiœthalium plumbeum*, Rost. (bases only), in Kew 1665.

ALWISIA, B. & Br.

Peridium subcoriaceum, fusiforme, glabrum, demum apice stellato-fissum vel plura in apice stipitis communis insidentia flocci irregulares, deorsum dilatati, sursum angustiores furcati; sporæ subglobosæ, nucleo magno lævi.

784. *A. Bombarda*, B. & Br. (No. 626). On decayed wood. Gongolla forest, July, 1864. A highly curious fungus with the habit of *Trichia rubiformis*, with, however, very different flocci, some of which are obtuse, resembling those of *Rhinotrichum*, and apparently bearing the spores about 1/10 of an inch high. Peridia seated on six or eight together on the top of the common stem, dark purple, black, or brown.

626 is *Alwisia bombarda*, in Kew 1000, and in Herb. Peradeniya.

874. *Ceratium arbuscula*, B. & Br. Niveum, e basi simplici fastigiato-ramosum sporis latis ellipticis (No. 159). On very rotten wood. It occurs also in Bombay. Quite simple below, and then fastigiate and laterally confluent; spores ·0004–·0006 long.

159 is *Ceratiomyxa mucida*, Schrœt., β *flexuosa* in British Museum 1581, and in Herb. Peradeniya.

875. *C. hydnoides*, A. and S. (Nos. 51, 141, 225). On rotten wood. Nuwara Eliya. Spores ·0005 long. In other specimens ·0004–·00045.

51 is *Ceratiomyxa mucida*, Schrœt., var ∝ in British Museum 1572.

225 is *Ceratiomyxa mucida*, β in Herb. Peradeniya.

141 is not in any of the quoted collections.

876. *C. filiforme*, B. & Br. Elongatum, filiforme, tenuissimum, flexuosum (No. 584). On rotten wood. Dolosbagey, May, 1868. Spores ·0004 long by ·0003.

584 is *Ceratiomyxa mucida*, β in British Museum 1578, and in Herb. Peradeniya.

* *Diderma depressum*, Fr. (No. 1044).

1044 is *Chondrioderma Michelii*, Rost., in Kew 1440, and in Herb. Peradeniya.

1189. *Didymium squamulosum*, Fr. (No. 1039). On bark. Peradeniya, Jan., 1869.

1039 is *Didymium effusum*, Link., in British Museum 456, and in Herb. Peradeniya.

* *D. microcarpon*, Fr., var. *xanthopus*, Ditm. (No. 76) = *D. farinaceum*, No. 748.

76 is *Didymium nigripes*, Fr., var. γ in Kew 1503, and British Museum 559, 560.

1190. *D. reticulatum*, B. & Br. Adnatum, reticulatum, peridio sulfureo, furfuraceo; floccis pallide citrinis; sporis nigris (No. 1046). Amongst short moss. Peradeniya, Dec., 1868.

1046 is *Badhamia nitens*, Berk., in Kew 1521, British Museum 574, and in Herb. Peradeniya.

* *Physarum nutans*, P. (No. 1038). On thin bark. Peradeniya, Dec., 1868.

1038 is *Physarum nicaraguense*, Macbride, in Kew 1406, and is marked *Ph. reniforme* by Massee: it is *Physarum nicaraguense* in Herb. Peradeniya.

1191. *P. didermoides*, P. (No. 135). Placed doubtfully under *Didymium cinereum*, 756.

135 is *Physarum nicaraguense* and also *Physarum didermoides*, Rost., in British Museum 420, and is *Physarum didermoides* in British Museum 421; it contains both species in Herb. Peradeniya. Probably Thwaites 135 and 55 were mixed during examination (see B. & Br. 756).

1192. *P. lividum*, Rost., var. *conglobatum*, Fr. (No. 55). On various decaying substances.

55 is *Physarum compressum*, ∝ in British Museum 419: it is *Physarum compressum* ∝ and *Physarum nicaraguense* in Kew 1244.

1193. *P. Mülleri*, B. (No. 1043). On dead wood. Peradeniya; Crocodile Creek, Queensland. Looks just like *Trichamphora paradoxa*, but the spores are quite different. We cannot at present give the characters of this species, as the specimens are at Strasburg.

> 1043 is *Trichamphora pezizoidea*, Jungh., in Kew 1432, and in Herb. Peradeniya.

1194. *Dictydium ambiguum*, Schrad. On decayed wood. Peradeniya, Jan., 1869.

> Thwaites 1041, B. & Br. 1194, is *Cribraria tenella*, Schrad., in Kew 1684, and in Herb. Peradeniya; it is the type of *Cribaria elata*, Massee, type in Herb. Berk. Kew No. 10871.

1195. *Stemonitis dictyospora*, Rost. Mon., p. 195 (No. 47). On bark. Nov., 1867.

> 47 is *Stemonitis fusca*, Roth., in Kew 1622 (Rostafinski's type specimen).

1196. *S. scintillans*, B. & Br. Peridio globoso, subviridicupreo; stipite setiformi, aterrimo, nitidissimo; floccis ramosis sporisque globosis fuscis (No. 1042). On the underside of dead leaves. Peradeniya, Jan., 1869. Spores ·0003 in diameter.

> 1042 is *Lamproderma irideum*, Massee, in Kew 1634, and in Herb. Peradeniya.

1197. *Ophiotheca Wrightii*, B. & C., Cuba, 544 (No. 1047). On slender herbaceous petioles. Peradeniya, Dec., 1868. Spores ·0004 long, granulated.

> 1047 is *Perichæna chrysosperma*, List., in Kew 1712, and in Herb. Peradeniya.

1198. *O. bicolor*, B. & Br. Peridio globoso, rubro, minute granulato, sporis flavis pulverulentis (No. 350). On the rind of *Nephelium lappaceum*, Rambootan. Spores ·0002 long.

> 350 is not in Herb. Peradeniya. The specimen at Kew has been re-described by Cooke and Massee as *Zythia bicolor* (B. & Br.), Cooke and Massee, Grev. XX., p. 106—subsuperficialis, rufo-aurantiaca; peritheciis subglobosis, fragilibus, levibus; sporulis ellipticis, minutis, continuis, hyalinis, 3 × 1·5. "Rambutan" is the native name of *Nephelium lappaceum*.

1199. *Hemiarcyria Karsteni*, Rostaf. Mon. (No. 49). On dead wood. Peradeniya.

49 is *Hemitrichia Karstenii*, List., in Kew 1773, but it is *Perichena depressa*, Libert, in Herb. Peradeniya (see B. & Br. 1201).

1200. *Trichia clavata*, P. (No. 24). On bark. Central Province, Dec., 1868.

24 is *Hemitrichia clavata*, Rost., in Herb. Peradeniya (see B. & Br. 773, where the same specimen was named *Arcyria umbrina*, Schum.).

1201. *Perichæna marginata*, B. & Br. Congesta, pallide cinerea, circumcissa, angulata, intus castanea, margine distincto circumdata; sporis floccisque elasticis flavis (No. 49). On dead wood. Peradeniya.

49 is *Perichæna depressa*, Lib., in Herb. Peradeniya (see B. & Br. 1199).

1202. *Licea cinnabarina*, B. & Br. Applanata, cinnabarina, papillosa, e strato membranaceo hyalino oriunda; sporis subglobosis lævibus (No. 663). On bark. South of the Island, July, 1868. Spores ·0005–·0006 in diameter.

663 is immature *Dictydiæthalium plumbeum*, Rost., in Herb. Peradeniya (see B. & Br. 782).

ENDOCALYX, B. & Br.

Peridium calyciforme, pedunculatum, villosum, demum ruptum, e basi crassi oriundum; sporæ subglobosæ echinulatæ.

1203. *Endocalyx Thwaitesii*, B. & Br. Ore insigniter laciniato, laciniis elongatis; stipite gracili, elongato (No. 1048). On dead sticks. Peradeniya, Jan., 1869. Spores varying from globose to oval, ·0006–·0008 in diameter. Tab. II., fig. 2. Plant and spores magnified.

1204. *E. psilostoma*, B. & Br. Ore primum integro, dein fisso; stipite brevi crassiore. With the last. Spores ·0008–·001 in diameter. This curious genus is evidently closely allied to *Alwisia*. The spores, however, are very different, and not half the diameter.

1048 in Herb. Peradeniya contains both these, which are only forms of one species; it does not belong to the Mycetozoa (see Annals of Botany, Vol. XXII., pp. 389–400).

The total number of species now known to occur in Ceylon is 102. In addition, there are records of three more Ceylon species, but as no specimens are in existence and they have not been re-discovered during the last four years, the records must be considered doubtful. The number compares favourably with that recorded from Java, viz., 82, but many Javan species have not yet been found in Ceylon; these include *Enerthenema elegans*, *Badhamia fasciculata*, *B. hyalina*, *B. macrocarpa*, *Physarum citrinum*, *P. polymorphum*, *P. penetrale*, *P. Gulielmœ*, *Chondrioderma subdictyospermum*, *Didymium farinaceum*, *Cribaria argillacea*, *C. purpurea*, *Licea flexuosa*, *Trichia favoginea*, *T. verrucosa*, *Arcyria incarnata*. Systematic collecting has been restricted hitherto to Peradeniya and Hakgala, though many specimens have also been gathered in the low-country in the course of disease investigations. It is probable that other species might be found in the wet low-country jungles, or in the dry zone. In the latter localities it might be possible to meet with new species; the up-country species are for the most part identical with those of temperate climates.

Although the majority of the Ceylon species are to be found in Europe, there is a marked difference in their relative abundance. *Comatricha obtusata* and *Didymium difforme*, for example, are rare; and *Physarum nutans*, though occurring on damp walls and flower pots fairly frequently, is rarely found on decaying wood. *Badhamia* is poorly represented, the only species being the somewhat atypical *Badhamia nitens*, while no representatives have yet been found of *Liceaceæ*, *Margaritaceæ*, or *Amaurochœtaceæ*. *Trichia* shows a distinct distribution according to elevation; the only species at lower elevations are *T. affinis* and *T. persimilis*, but at Hakgala (5,600 feet) four more species are found. The commonest Ceylon species are *Didymium effusum*, *D. nigripes*, *Physarella mirabilis*, *Hemitrichia serpula*, and *Hemitrichia clavata*. *Physarella* becomes a nuisance when it develops, as it frequently does, on logs kept in the laboratory for the growth of other fungi. The genera *Cribaria*, *Arcyria*, and *Perichœna* are especially well represented. *Alwisia bombarda* and *Erionema aureum* appear to be strictly tropical species, and have been found only in low-country jungles and rubber plantations in the wettest district.

During the first three months of the year, in which the total rainfall (at Peradeniya) is about 9 inches, Mycetozoa are practically absent. The heavy showers of that period run off the surface of the leaf heaps without wetting more than the outer layer, and fail to penetrate the dead stumps. In April a rainfall of about 9 inches rouses *Diachæa elegans* and *Didymium effusum*, and thenceforward there is a constant harvest until the end of the year, the diminution of rainfall in August and September being insufficient to check growth. The greater rainfall and humidity produce two results which appear abnormal to one who has collected Mycetozoa in Europe, viz., the greater tendency of the plasmodium to " wander " and the greater height from the ground at which species are found. *Diachæa elegans*, *Diachæa subsessilis*, *Physarum gyrosum*, and *Stemonitis herbatica* apparently always have the wandering habit, but in Ceylon it is occasionally found in *Stemonitis fusca*, *Craterium pedunculatum*, *Physarum calidris*, *Didymium effusum*, and *Didymium nigripes* also. *Craterium pedunculatum*, *Didymium effusum*, and *Physarum calidris* have been collected on green stems of *Strobilanthes*, having apparently climbed up after the manner of *Diachæa*, while the other two species have been found on earth and stones in flower beds and gravelled footpaths. *Stemonitis herbatica*, *Physarella mirabilis*, *Didymium effusum*, and *Cribraria intricata* have been gathered from the crowns of palm trees, 20 feet from the ground, and *Stemonitis splendens* at about the same height on rotten mango branches. *Perichæna chrysosperma* might almost be said to adopt such a habitat normally ; it is frequently found on rotten Bombax branches which have fallen from a height of some times over 50 feet. Of course, these statements are based on cases in which the branch has been seen to fall, and has been examined immediately afterwards. After such examples it will be understood that dead erect tree trunks or the dead leaf bases on the stems of living palms are always worth examination, and, up to a height of 10 feet, provide almost as many species as dead trunks lying on the ground. *Chondrioderma rugosum* and

Physarum crateriforme are practically confined to the dead patches of bark on living jak trunks.

In the following list I have not attempted to draw up complete descriptions of all the species, but have noted chiefly departures from the normal which occur in the Ceylon forms. The nomenclature followed is that of the "Synopsis of the Orders, Genera, and Species of the Mycetozoa," A. & G. Lister, Jour. Bot., Vol. 45 ; the application of the Vienna rules will necessitate several obvious changes, but I have preferred not to anticipate more authoritative work which is already in the press. The synonyms given represent merely the names which have been bestowed upon Ceylon specimens ; many of them are not synonyms but only errors. I owe more than I can express to the late Mr. Arthur Lister, who generously gave me the benefit of his exceptional knowledge of this group and examined nearly all the gatherings enumerated ; and my thanks are also due to Miss G. Lister for the same invaluable assistance.

SUB-CLASS I.—EXOSPOREÆ.

ORDER I.—CERATIOMYXACEÆ.

Ceratiomyxa mucida, Schrœt.

Ceratium hydnoides, Alb. & Schw, in B. & Br. Fungi of Ceylon, No. 875.

∝ **genuina** : branches of sporophores short, free.

β **flexuosa** : sporophores much branched, stout, and erect, or thin and flexuose, not anastomosing. *Ceratium arbuscula*, B. & Br., in Fungi of Ceylon, No. 874. *Ceratium filiforme*, B. & Br., in Fungi of Ceylon, No. 876.

The Peradeniya herbarium specimen of *Ceratium arbuscula*, B. & Br., consists of crowded sporophores, 2·5–5 mm. high, simple at the base, but soon dividing above into a tree-like structure with numerous branches which form a somewhat rounded head : the branches are somewhat interlaced, but do not anastomose. The specimen of *Ceratium filiforme*, B. & Br., consists of branched sporophores of the same type, but with thinner, more flexuose branches, the whole lying horizontally and interlacing. Fresh specimens of *C. arbuscula* have been collected at Peradeniya; the sporophores in these are 5–8 mm. high, and up to 1 mm. in diameter at the base; the stalk is transparent and rigid when fresh, but shrinks to a thin white thread in drying; some sporophores are 5 mm. in diameter at the top; the bases are rather widely separated, but, owing to the repeated branching, the outer branches of adjacent sporophores are in contact, and the whole group forms a fleecy, white sheet, completely covering rotten wood, or bamboo culms, for a length and breadth of several feet: the spores measure 10–12 × 8 μ. This is the common form of *Ceratiomyxa* at Peradeniya (1,500 feet); at Hakgala (5,600 feet) *genuina* only occurs, with simple or slightly branched sporophores; while a gathering from Talawakele (4,000 feet) includes both forms together.

On rotten wood, — α Hakgala (5,600 feet), Pattipola (6,200 feet). β Peradeniya (1,500 feet), Talawakele (4,000 feet), Badureliya (low-country), Yatiyantota (low-country).

SUB-CLASS II.—ENDOSPOREÆ.

COHORT I.—AMAUROSPORALES.

SUB-COHORT I.—CALCARINEÆ.

ORDER I.—PHYSARACEÆ.

Badhamia nitens, Berk.

Didymium reticulatum, B. & Br., in Fungi of Ceylon, No. 1190. *Lepidoderma reticulatum*, Mass. Mon., p. 252.

The specimen in Herb. Peradeniya (Thwaites' 1046) consists of winding plasmodiocarps, 2 to 4 mm. long and ·3 to ·5 mm. broad, or subglobose sporangia ·5 to 1 mm. diameter, in one part crowded into a convoluted mass measuring 6 × 4 mm.: the spores are in clusters of 3 to 10. Four recent gatherings have been made, all at Peradeniya, on sticks, and on the fallen spathe of a coconut. They consist of small, subglobose sporangia, and elongated, winding, and netted plasmodiocarps. In one gathering the sporangia are purple, with dense wart-like yellow patches, bronze towards the base ; some appear whitish, and others quite yellow through the number of lime deposits ; lime knots yellow, irregular, with few hyaline connecting threads ; spores 14 μ diameter, some elliptic or subglobose, 12 × 14 μ, coarsely warted all over, free or in clusters of 4 to 8 : part of this gathering has scanty lime deposits, and almost black sporangia. In another gathering, from the same place, the sporangia are pale yellow, in some cases darker towards the base ; lime knots as above ; spores 13 to 14 μ diameter, in clusters of 4 to 6, spinulose, but equally spinulose all over. A third gathering has orange-yellow lime warts, and a yellow wall between them ; spores 13 μ diameter, clustered or free.

Peradeniya.

[**Badhamia varia,** Mass.

This species is recorded for Ceylon by Massee in Mon., p. 319. According to Lister, *Badhamia varia*, Mass., includes *Badhamia utricularis*, Berk., *B. hyalina*, Berk., and *B. magna*, Berk. : none of these occurs in the Ceylon collections, and there is no missing number which could be assigned to any of them. The scarcity of *Badhamia* is a marked feature of the Ceylon mycetozoa.]

[**Physarum leucopus,** Link.

Recorded for Ceylon by Berkeley and Broome, No. 752, and by Massee, Mon., p. 287, but all the herbarium specimens under this number are *Physarum compressum*, A. & S.]

Physarum pulcherrimum, Berk. and Rav.

In a single gathering of this species, the sporangia are 0·4 mm. diameter, on stalks 1·5 mm. high : the stalk is purple, subulate, and contains lime ; the sporangium wall is pale purple with innate purple or hyaline lime globules, scattered or crowded ; lime knots small, 20–40 μ in longest diameter, reddish purple, connected by a hyaline network of small mesh, expanded at the axils : spores 8 μ diameter ; in some parts of the specimen there is a purple hypothallus running in narrow bands over the bark.

Rare. On a rotting log in jungle, Hunugalla, Kegalla.

Physarum variabile, Rex., var. **sessile,** Lister.

Physarum virescens, Ditm., var. *flavum*, B. & Br. Fungi of Ceylon, No. 761.

Ceylon specimens of *Physarum variabile* are all var. *sessile.* That in Herb. Peradeniya consists of sessile, scattered or clustered, subglobose sporangia, 0·6 to 0·7 mm. diameter, yellow with dense yellow scattered lime deposits : wall cracking into scales ; lime knots white or yellowish ; spores pale violet-brown, faintly spinulose, 9 to 10 μ diameter. Of this gathering (Thw. 271) Mr. Lister wrote : "The Kew specimen of this number is minute and too immature to admit of examination. That which you now send is not quite ripe, but the yellow sporangium wall and white lime knots, and the violet-brown spores, 9 μ diameter, can be quite well made out." A recent gathering consists of small rounded sporangia, 0·25 mm. diameter, and long winding plasmodiocarps up to 6 mm. × 0·25 mm. : the wall is membranous with scattered innate lime granules and dense yellow warts ; when the denser deposits are wanting, the sporangia appear white ; the plasmodiocarps often split along the top : the lime knots are large, rounded, granular, yellow or white, with slender hyaline connecting threads ; spores pale violet-brown, closely and minutely warted, 9–10 μ diameter.

Peradeniya, on dead leaves. Thwaites' specimen is on moss and lichen.

Physarum melleum (B. & Br.), Massee.

Didymium melleum, B. & Br. Fungi of Ceylon, No. 751. *Physarum Schumacheri*, Rost. Massee, Mon., p. 275.

The type specimen in Herb. Peradeniya consists of a few yellowish-white stalks and detached heads, mostly immature. It is one of the commonest species on dead leaves, more rarely on wood, at Peradeniya, and exhibits considerable variation, especially in colour. Normal specimens have ochraceous sporangia, white stalks, and white lime knots. The ripening sporangium is translucent orange-red, then black, and finally ochraceous ; immature specimens are usually red when dried. One gathering contains, together with the normal form, pale yellow sporangia on yellow stalks, with yellow lime knots ; when mounted some of the stalks are yellow and translucent, others opaque with a yellow edge; the white stalks of the normal specimens are brownish at the base. Another gathering contains yellow-brown sporangia on stalks of the same colour, orange-red (mature) sporangia on white stalks, and yellow-brown sporangia on white stalks. From a large gathering, chiefly of the normal form, sixty specimens were picked out which had sulphur-yellow sporangia, white stalks, and faintly yellow lime knots; and in another set of the same colour the lime knots varied white or yellow in the same sporangium. A small gathering on a single dead leaf shows minute yellow sporangia, 0·3 mm. diameter, sometimes with orange blotches, scaly: stalks yellow-brown, fluted, sometimes twisted, somewhat expanded upwards, 0·5 mm. high, 0·1 mm. diameter, not containing lime; lime knots generally yellowish, but a few white. The spores are usually 8 to 9 μ in diameter. Plasmodium watery ochraceous yellow.

Peradeniya, Talawakele, Gangaruwa, &c. Apparently not at Hakgala (5,600 feet).

Physarum tenerum, Rex.

A gathering from a decaying stump at Peradeniya has pale yellow stalks 1·5 mm. high, containing lime or refuse matter in discontinuous lengths; the sporangia are 0·4 mm. diameter, iridescent, or gray with white lime deposits; capillitium, a regular network of small mesh with greenish-yellow lime knots; spores violet-brown, minutely spinulose, 8 to 10 μ diameter. Another gathering from Urumuwella has sporangia with white or yellow lime deposits, stalks yellow or whitish, and lime knots varying from yellow to white in the same sporangium.

On decaying wood. Peradeniya, Urumuwela.

Physarum compactum, Lister.

This species has been gathered on one occasion in Ceylon. It occurred in fairly large numbers on small twigs cemented together by earth. The sporangia are fairly typical, gray, with circular white dense lime deposits; capillitium almost entirely composed of hyaline threads; spores pale violet-brown, minutely warted, 9 μ diameter. The stalks are white, blackish at the base, either slender, ·8 mm. high, or shorter and stout.

Gangaruwa.

Physarum roseum, Berk. & Br.

Plasmodium maroon. In two gatherings from the decayed leaf bases of *Phœnix reclinata* the rose-coloured sporangia are 0·5 mm. diameter, on red-brown, striate, slender stalks 0·8 mm. high, arising from a brown hypothallus; spores reddish-lilac, 7 μ diameter. It has also been found on the decaying stump of an areca palm, and on the decaying stem of a liane. In the latter gatherings there is no hypothallus, and some of the sporangia are minutely umbilicate at the apex.

Peradeniya, Teldeniya.

Physarum psittacinum, Ditm., var. **fulvum,** Lister.

Plasmodium orange, creeping over dead leaves. Sporangia which developed in the laboratory in contact with wet blotting paper stained the paper yellow. In a gathering from Peradeniya the sporangia are purple, iridescent, with red patches or irregular red markings; total height about 1 mm.; stalks 0·5 to 0·75 mm. high, twisted and furrowed, pale yellow or orange, conical, arising from a circular hypothallus; lime-knots orange-red, conspicuous, with fine, rigid, yellow connecting threads; the whole capillitium looks Didymium-like; the spores are 7 μ diameter, and have a yellow tinge, which may be due to the colouring matter from the capillitium.

Physarum viride, Pers.

Physarum nutans P. var. *aureum.* B. & Br., in Fungi of Ceylon, No. 579.

Fairly common. Specimens from Badureliya are 2 mm. high, nodding; stalk 80 μ diameter at the base, 20 μ at the apex, opaque below, transparent yellow above; sporangium wall containing large yellow lime masses; capillitium rigid; lime knots fusoid, orange; spores violet-brown, smooth, 8 μ diameter. A gathering from Pattipola has bright yellow lenticular sporangia. Yellow specimens left exposed to the sun in the laboratory for a fortnight were bleached white, and might have then been classed as var. *incanum.*

On dead wood and decaying Polypori. Peradeniya, Gangaruwa, Yatiyantota, Hunugalla, Kegalla, Badureliya, Talawakele, Pattipola, Yatipauwa.

Physarum Berkeleyi, Rost.

This species has been collected on six occasions at Peradeniya, generally on decaying palm fronds. In one gathering the sporangia are yellow, rugose, 0·4 to 0·5 mm. diameter, either nearly sessile or on stalks up to 0·7 mm. long; the stalk and lower part of the sporangium are dark brown when viewed as opaque objects; on dehiscence, the lower part of the sporangium persists as a cup in the long-stalked forms, but this is not evident in the more sessile; wall membranous with innate lime deposits, cartilaginous towards the base, which is yellow-brown in glycerine jelly; lime knots yellow, with hyaline connecting threads; spores pale violet-brown, very minutely spinulose, 9 to 10 μ diameter. In another gathering the total height varies from 1·5 to 1·75 mm.; the sporangia are 0·6 mm. diameter, orange, with large warted lime deposits; stalk and lower part of the sporangium almost black, the latter clear yellow, with yellow-brown folds in glycerine jelly; lime knots large, yellow, granular, containing spherical granules, 1 to 2·5 μ diameter, which are also present in the sporangium wall; hyaline threads short; spores 10 to 12 μ diameter, minutely spinulose.

Peradeniya.

Physarum nucleatum, Rex.

On dead wood, and on old leaf bases of *Phœnix reclinata* attached to the tree. The sporangia are white, 0·5 mm. diameter, on long stalks 1·75 to 2 mm. high: stalks translucent above, yellowish at the base; the lime globule in the centre of the capillitium reaches 0·25 mm. diameter, and is frequently found on the substratum, having dropped out of the sporangium.

Peradeniya, Gangaruwa.

Physarum nutans, Pers.

Rather rare. The specimens recorded by Berkeley and Broome in Fungi of Ceylon, No. 759, are *Physarum nicaraguense*, Macbride. A sessile form, in minute subglobose sporangia or small elongated plasmodiocarps (spores 8 to 10 μ), occurs fairly frequently on the green coating of algæ on damp walls and flower pots, but the usual stalked forms are seldom met with. Var. *genuinum*, from Badureliya, has stalks 1 to 1·25 mm.

high, 160 μ diameter at the base, 30 μ diameter at the apex; capillitium of hyaline threads with few lime knots; wall containing somewhat rounded, white lime deposits; spores 8 μ diameter, minutely warted. Var. *leucophœum*, from Ukuwela, has cernuous stalks, typical flattened sporangia, abundant white lime knots, and closely warted spores, 12 to 13 μ diameter; another gathering of this variety, from Gangaruwa, has dark furrowed stalks with white ridges. Var. *robustum*, on moss on the trunk of a jak tree, Peradeniya, consists of plasmodiocarps with spinulose spores, 9 to 11 μ diameter.

Peradeniya, Gangaruwa, Ukuwela, Badureliya, Pattipola, Hakgala.

Physarum calidris, Lister.

Fairly common. Sporangia usually typical, but in one instance very shortly stalked, almost sessile. Spores violet-brown, 10 μ diameter. "The specimen in Broome's herbarium, named *Physarum elephantinum*, B. & Br., MS. from Ceylon (B. M. 453), is a somewhat large form, but appears to be the same species, with capillitium and spores similar to those in the English gatherings" (Lister, Mon., p. 52). This name was not published in Berkeley and Broome's Fungi of Ceylon, and there is no specimen in Herb. Peradeniya. The specimens would appear to be similar to those of recent gatherings at Hakgala, in which the sporangia are 0·75 mm. diameter, total height up to 2·3 mm.; the upper two-thirds of the sporangium is covered with large, dense lime deposits, the lower third being smooth and dark; spores 10 μ diameter, minutely spinulose.

In various localities, usually on twigs, at Peradeniya, Bandarawela, Hakgala, Pattipola.

Physarum compressum, Alb. and Schw.

"*Didymium leucopus*, Lk.," in Berk. and Broome, Fungi of Ceylon, No. 752. *Physarum lividum*, Rost., var. *conglobatum*, Fr., in Berk. and Broome, Fungi of Ceylon, No. 1192. "*Didymium cinereum*, Fr.," in Berk. and Broome, Fungi of Ceylon, No. 756. *Physarum affine*, Rost.

Thwaites' specimen No. 68, which was at first named *Didymium leucopus*, Link., by Berkeley and Broome, and which furnished the type specimens of *Physarum affine*, Rost., and *Physarum lividum*, var. *conglobatum*, consists of typical compressed sporangia on black or gray furrowed stalks in Herb. Peradeniya. This is a common species at Peradeniya, occurring in abundance on dead leaves. The sporangia are always of the typical compressed form, on white, or black, or gray stalks ; spores usually 12 μ in diameter. In one gathering the sporangium wall is purple, without lime deposits, or with scanty deposits in a few instances.

Peradeniya, Teldeniya, Hakgala.

Physarum nicaraguense, Macbride.

" *Didymium cinereum*, Fr.," in B. & Br., Fungi of Ceylon, No. 756. " *Physarum nutans*, P.," in B. & Br., Fungi of Ceylon, No. 759. *Tilmadoche reniformis*, Mass., Mon., p. 336. *Didymium echinosporum*, Mass., Mon., p. 239.

Thwaites, 1038, B. & Br., 759 (in part), consists, in Herb. Peradeniya, of lobed, or bolster-shaped, white sporangia, 0·5 to 1 mm. long, on yellow-brown stalks, darker towards the base, 1 to 1·5 mm. high ; total height 1·5 to 2 mm. ; stalks furrowed and twisted, 220 μ diameter at the base, 50 μ at the apex ; wall of sporangium membranous, with dense lime deposits, yellowish at the base ; lime knots white, large, angular, connected by short hyaline threads, or confluent, forming a pseudo-columella ; spores 13 to 15 μ, strongly spinulose, dark purple-brown ; this Thwaites' number at Kew is the type of *Didymium echinosporum*, Mass. Thwaites, 135, B. & Br., 756 (in part), includes two species in Herb. Peradeniya ; one of these is *Physarum didermoides*, Rost., the other is *Physarum nicaraguense*, with either sessile or yellow-stalked lobed sporangia ; the same mixture occurs in British Museum 420. Thwaites, 25, B. & Br., 759 (in part), is the type of *Tilmadoche reniformis*, Mass., in Kew 1406, and, *fide* Lister, Mon., p. 54, is the same species as *Didymium echinosporum*. " It is a form with compressed reniform sporangia on long buff stalks ; capillitium with large fusiform or branching lime knots and short hyaline threads ; spores dark purple-brown, spinose, 13 to 15 μ " (Lister, *loc. cit.*).

A fairly common species at Peradeniya, usually in considerable quantity on almost sound logs. One gathering consists entirely of stalked sporangia ; stalks 1 mm. high, furrowed and twisted, brownish at the base, grayish-brown above, and, in glycerine jelly, brownish yellow at the base, enclosing a little refuse matter, clear yellow or straw-coloured above; sporangia white, with dense white lime deposits, either spherical, 0·4 mm. diameter, or elongated bolster-shaped, 0·6 × 0·2 mm., often lobed; capillitium with large white lime knots; spores dark purple brown, strongly echinulate, with some of the spines in clusters, 14 to 17 μ diameter. Another gathering consists of globose or elongated plasmodiocarps, white, yellowish towards the base; spores 14 to 17 μ, densely spinulose. In another extensive development the stalks were yellow-brown, red-brown, or blackish-brown below, gray or yellow-brown above; total height up to 2·5 mm.; sporangia lobed and convoluted, 0·75 to 1·5 mm. across, or fused into white contorted masses, up to 5 mm. broad, on distinct or confluent stalks, sometimes almost sessile; the clusters of stalks supporting the confluent sporangia spring from a blackish hypothallus which is sometimes not developed where the sporangia are isolated; stalks furrowed and twisted; base of the stalk opaque, upper part translucent; sporangium wall membranous, with dense white lime deposits, colourless, except at the base, which is yellowish; lime knots white, large, angular, connected by short hyaline threads; spores dark purple-brown, spinulose, 10 to 12 μ diameter. Another gathering agrees exactly with the last, except that the stalks are darker, and appear red-brown in glycerine jelly, and some of the lime knots are tinged yellow. Another variation occurs in a small gathering of about a dozen sporangia, in which the capillitium consists of narrow rigid threads; spores, 13 μ diameter.

Peradeniya.

Physarum didermoides, Rost.

"*Didymium cinereum*, Fr.," in B. & Br. Fungi of Ceylon, No. 756.

Thwaites' No. 135, B. & Br. 756, in Herb. Peradeniya, contains crowded sessile sporangia of *P. didermoides*, in addition to *Physarum nicaraguense*. A typical gathering from Ukuwela consists of crowded, sessile, grayish-white, subglobose or elongated sporangia on a scanty white membranous hypothallus, in patches covering several square inches; sporangia covered with loose lime granules; lime knots small, rounded, with rigid hyaline connecting threads; spores dark purple-brown, spinulose, 11 to 13 μ diameter. In another gathering, with the typical sporangium wall and purple areolated inner layer, there is no hypothallus, and most of the sporangia have a strongly developed pseudocolumella; the spores, however, show that the development has been irregular, for, while some are 11 to 13 μ diameter and strongly warted, others are undivided spore masses up to 60×30 μ; or hour-glass-shaped double spores. Out of four occurrences, it grew on dead dadap (*Erythrina* sp.) in three instances.

Peradeniya, Ukuwela.

Physarum cinereum, Pers.

The specimens included in Fungi of Ceylon, No. 756, under the name "*Didymium cinereum*, P." (Thwaites' 55, 135), are *P. compressum*, *P. nicaraguense*, and *P. didermoides*. There is a supposed Ceylon specimen of *P. cinereum* in Kew 1284. It has been taken recently on several occasions; sporangia white or grayish-white, with a smooth, single, membranous wall charged with globular lime granules; capillitium of rounded white lime knots with abundant hyaline threads; spores light violet-brown, minutely warted, 8 to 9 μ diameter.

Peradeniya.

Physarum crateriachea, Lister.

Plasmodium white, creeping over dead leaves, ripening there and on the stems of living plants, as in *Diachœa*. Collected twice; sporangia ellipsoid, upright, typical.

Peradeniya.

Physarum crateriforme, Petch. Ann. Perad., IV., p. 304.

Sporangia stalked, occasionally sessile: crateriform or clavate, 0·5 to 0·75 mm. high, 0·3–0·4 mm. diameter, or spherical, 0·5 mm. diameter, sometimes flattened as in *Didymium clavus*, white, with dense scattered lime deposits, or gray, or iridescent from absence of lime; stalk opaque, conical, black below, white above, 0·3 to 0·7 mm. long, up to 200 μ diameter at the base, 80 μ diameter at the apex, projecting into the sporangium and continuing as a dense columella to the apex in crateriform examples, but usually terminating at the base of the sporangium in spherical examples. The stalk changes from black to white either below or inside the sporangium. Lime knots forming a massive white columella extending to the apex of the sporangium, giving off horizontal spine-like points 80 to 100 μ long and 20 to 40 μ broad, which end in slender hyaline threads united to the sporangium wall; in the spherical forms, stalked and sessile, the columella is usually absent and the lime knots are rod-like and forking, springing from the base of the sporangium, often extending to the apex, with few hyaline threads; sporangium wall membranous, colourless, with innate lime deposits; stalk containing refuse matter, usually collapsing when mounted; spores 11 to 15 μ diameter, closely spinulose, violet-brown.

This species occurs in fair abundance on the bark of living jak trees, up to a height of about 5 feet from the ground, at Peradeniya. As a rule, the sporangia are stalked, about half of them being crateriform, and the remainder globose. Stalked globose sporangia have also been collected on small fallen twigs of the same tree, but these collection never include more than a dozen sporangia. In two gatherings all the sporangia are spherical and sessile. The capillitium of these sessile forms is in many cases almost that of a *Badhamia*. When the sporangia are broken, the black stalks, changing to white above and crowned by the white columella, persist for a long time.

The occurrence of both spherical and clavate sporangia on the living jak trunks, while only spherical sporangia were found on twigs on the ground, gave occasion for suspicion that the clavate or crateriform examples were abnormal because of their position. However, the two most productive trees were felled in July, 1909, and all the examples collected from them during that month while they were lying on the ground were of the clavate form.

Physarum bivalve, Pers.

Angioridium sinuosum, Grev., in B. & Br. No. 758.

Rather rare. One recent gathering on living stems of *Strobilanthes* at Hakgala; white, elongated, winding, compressed plasmodiocarps, simple or branched, up to 1 cm.

long and 0·3 mm. broad; outer coat white, charged with roundish lime deposits, longitudinally ridged at the sides; inner wall covered with dense lime deposits, which fill up the longitudinal crack in the outer wall; spores violet-brown, almost smooth, 8 μ diameter; not quite mature.

Physarum bogoriense, Racib.

A gathering, on chips, consists of globose sporangia, 0·5 mm. diameter, or winding flattened plasmodiocarps, 2·25 mm. long, 0·4 mm. broad, pale ochraceous, reticulated with white lines of dehiscence; outer wall breaking away in scales or revolute lobes; inner wall gray or iridescent; lime knots white, small, generally rounded; spores pale violet-brown, minutely warted, 8 μ diameter. In another gathering the plasmodiocarps are smaller; some have the outer wall areolated and breaking away in scales, while in others it is recurved as in *Physarum bivalve*, disclosing the grayish inner wall; some of the plasmodiocarps are flattened, others bolster-shaped. The latter connects with two gatherings on dead leaves, in which the plasmodiocarps are not areolated nor flattened: they are up to 3 cm. long, yellow, winding, sometimes slightly laterally compressed, 0·25 to 0·3 mm. wide, with a narrow irregular raised ridge running along the top; this ridge is formed by the outer wall only; as in *Physarum bivalve*, dehiscence occurs along the ridge, and the outer wall separates widely from the unbroken inner sporangium, but does not fall off in flakes; outer wall white internally, up to ·05 mm. thick, consisting of a dense deposit of minute white or yellow spherical granules on the inner surface of a thin membrane; inner wall appearing gray or iridescent; lime knots white, granular, rounded or somewhat angular, with numerous hyaline threads; spores pale violet-brown, faintly warted, 8 to 9 μ diameter. In the general structure of the sporangium, *P. bogoriense* would appear to be connected with *P. bivalve* by the occurrence of forms referable to both in the same gathering.

Peradeniya; on wood and on dead leaves.

Physarum inæquale, Peck.

Didymium croceoflavum, B. & Br. Fungi of Ceylon, No. 757.

Plasmodium orange-red, among dead leaves. Fairly common at Peradeniya. The sporangia vary from pale yellow to orange-red, sometimes yellow-brown, or red-brown. The red centre of the lime knots is also a variable feature ; some have red centres, others are tinged red throughout, while in many cases they are entirely pale yellow or nearly white ; all these variations may occur in a single sporangium. The occurrence of spherical granules in the lime knots is not peculiar to this species, but appears to be a fairly common phenomenon in tropical forms.

Peradeniya.

Physarum gyrosum, Rost.

This species was found developing on the surface of soil fairly rich in vegetable refuse. The plasmodium when first observed, in the evening, formed white columns projecting from the surface. Next morning these had collapsed and formed a flattened crust consisting of masses of contorted plasmodiocarps, or isolated small rosettes, gray with a reddish tinge, on a reddish hypothallus. Another plasmodium was found ripening on the side of a hole which had been dug to receive a cacao seedling, and as it was thought that the first might have been damaged by rain, the hole was covered with large leaves. The projecting columns of plasmodium were up to 1·5 cms. high, but they collapsed into rosettes, sometimes confluent, as before. The sporangia are gray with a reddish tinge, sometimes blotched with red, or lilac from absence of lime ; wall single, membranous, with dense clusters of spherical lime granules in rounded masses ; capillitium of rigid, hyaline threads, sometimes forming a net, with large white irregular lime knots ; spores minutely spinulose, 8 μ diameter.

Peradeniya.

Physarella mirabilis, Peck.

Physarum rufibasis, B. & Br. Fungi of Ceylon, No. 762.

The type specimen of *Physarum rufibasis* in the Peradeniya herbarium is in bad condition, but consists of rather broad and flattened sporangia of *Physarella mirabilis*.

This species is rather common at Peradeniya. It frequently occurs in large numbers on diseased specimens of tea, rubber, cacao, &c., kept on the laboratory verandah, or in glass dishes containing similar specimens in the laboratory. On one occasion it developed in a museum jar containing resin in a natural state, *i.e.*, mixed with fragments of bark : the jar had been in the museum for some years before the plasmodium appeared, but in all probability the lid had been recently taken off.

The plasmodium is pale yellow or orange-yellow. The cylindrical, umbilicate, stalked sporangia are subject to considerable variation, and some of the forms might be considered distinct species if they had not been seen to hatch from the same plasmodium as the normal form. In the "perfect" form the umbilicus is continuous with the hollow stem, and is about 0·1 mm. wide, but it may be as much as 0·75 mm. wide, without affecting the general shape of the sporangium. But further increase in width usually involves a broadening of the stalk also, so that the sporangium becomes pezizoid, or even sessile, on a red-brown hypothallus ; in the last case it imitates exactly the rosettes of *Physarum gyrosum*. In both *Physarum gyrosum* and *Physarella mirabilis* the plasmodium rises in columns which produce a ring-shaped sporangium on a red-brown hypothallus, but while the hypothallus in the former always collapses and thus produces sessile rosette-shaped sporangia, in the latter it remains, as a rule, erect, and forms a hollow stalk. The stalk of *Physarella* varies from a rigid hollow stalk to a sessile hypothallus.

The pezizoid stalked sporangia may attain a diameter of 2·5 mm. ; the sessile forms are sometimes 6 mm. diameter, and consist of either a red-brown plate of hypothallus fringed by the wavy, almost horizontal sporangium, or a continuous laterally compressed sporangium forming a closely reticulated pattern. The colour of the sporangium is greenish-yellow, reddish-yellow, or deep ochraceous ; they are bleached to gray on prolonged exposure to sunlight. One lot, hatched in the laboratory, has olive sporangia studded, especially at the top, with *white* lime deposits ; most of the sporangia are stalked (up to 3 mm. high), but some are rosettes.

On dead wood and decaying fungi. Peradeniya, Gangaruwa, Edangoda.

Trichamphora pezizoidea, Jungh.

Didymium zeylanicum, Berk., Hooker's Journal of Botany, Vol. 6 (1854), p. 230. *Didymium zeylanicum*, B. & Br., Fungi of Ceylon, No. 754. *Physarum mülleri*, Berk., in Berk. and Broome, Fungi of Ceylon, No. 1193.

The spores of this species vary much in size. Berkeley and Broome's specimens, 754 and 1193, have pale spores, 9 to 10 μ diameter. In three recent Ceylon gatherings the spores are dark violet-brown, spinulose, and measure 11 μ, 11 to 12 μ, and 15 to 18 μ respectively, but there are no other characters by which the last could be separated as a distinct species. The plasmodium is grayish white, and has been found on decaying *Hirneola polytricha*.

On dead wood. Gangaruwa, Ukuwela, Ratnapura.

Erionema aureum, Penzig.

In a typical gathering of this species, from the under surface of a dead *Hevea* log at Yatipauwa, the strands of cylindric sporangia are up to 5 cm. long and 6 mm. broad, attached to the substratum by a scanty white thread-like hypothallus; the sporangia are yellow or greenish-yellow; spores 6 to 8 μ diameter, minutely spinulose; capillitium typical. Another specimen, on a dead leaf, from Badureliya, consists of yellow, heaped, convoluted sporangia, in a mass about 1·5 cm. broad, instead of hair-like tresses; the sporangia are irregularly bolster-shaped and usually compressed laterally; the sporangium wall is membranous with dense yellow lime deposits in somewhat rounded lumps; the capillitium is typical, a network of rigid, hyaline or yellowish, didymium-like threads, with a few spindle-shaped thickenings and fusiform orange lime knots; the spores are 7 to 9 μ in diameter, with a few large spores 11 to 14 μ.

Badureliya, Yatipauwa.

Cienkowskia reticulata, Rost.

Plasmodium deep orange-red, on and in decaying palm leaves. A plasmodium on the stalk of a decaying palm leaf kept in a damp chamber in the laboratory remained on the upper surface for four days, and then crawled underneath to form a plasmodiocarp on the lower surface. The plasmodiocarps were dark brown when moist, but became yellow-brown when dry. In general, the plasmodiocarps are netted, and in one instance a continuous netted plasmodiocarp covered an area measuring 14 × 8 centimètres. In many cases the plasmodiocarps are empty when found, only the wall remaining ; this suggested that the capillitium might rupture the wall of the plasmodiocarp and be ejected elastically, but this did not occur when specimens were developed in the laboratory. Exposure to sunlight bleached the yellow-brown wall to grayish-brown, and the yellow capillitium to ochraceous, or almost white. This species was fairly common at Peradeniya during April–June, 1905, being gathered on five occasions, but I have not met with another specimen during the last four years.

Fuligo septica, Gmel.

Æthalium septicum, Fr., B. & Br., Fungi of Ceylon, No. 741.

A common species : æthalia up to 20 centimètres in diameter, usually with a strongly developed, red-brown hypothallus ; outer crust yellow, or reddish, or white ; lime knots generally yellow, but white in one gathering ; spores 6 to 8 μ diameter.

Peradeniya, Gangaruwa, Hakgala, Kotmale, Hunugalla, Urumuwela, Yatiyantota.

Fuligo muscorum, A. & S.

Lime knots yellow, with few short hyaline threads, spores 10 to 12 μ diameter, dark, spinulose. On rotten wood.

Peradeniya, Emelina Estate (Maskeliya).

Fuligo ellipsospora, Lister.

A fairly common species, often occurring in abundance on fallen stems of the papaw (*Carica papaya*) and on cacao pods : in the latter case it sometimes occurs on diseased pods still attached to the trees. On one occasion it developed on a cacao pod in a damp chamber in the laboratory, and what is presumably the plasmodium of this species has been observed several times under the same conditions, but the æthalia have not been obtained. The plasmodium is white. The æthalia are pulvinate, white, usually small, up to 1 centimètre in diameter, sometimes irregular, elongated, and flattened, and confluent in masses up to 5 cm. long and 1·5 to 2 cm. broad; lime knots large, white: spores ellipsoid, or irregularly oval, 11 to 14 by 7 to 10 μ, or sometimes almost spherical, 10 to 12 μ diameter.

Craterium pedunculatum, Trent.

Rather rare. The lid in the recent Ceylon forms is sunk below the rim of the cup, and leaves a distinct inner ridge on dehiscence. A ripening plasmodium, found in the jungle at Pattipola, had crept up the green stems of *Strobilanthes* to a height of one or two feet.

Peradeniya, Gangaruwa, Pattipola.

Craterium leucocephalum, Ditm.

Common at Peradeniya on dead leaves. The sporangia are sometimes almost completely white, except at the base. The stalks are often very short, about 0·1 to 0·2 mm. high. The crystalline yellow discs are apparently absent from the sporangium wall of all the Ceylon forms.

Craterium mutabile, Fr.

Found on one occasion in the jungle at Hakgala (5,600 feet) on dead leaves. Stalks furrowed, translucent, red-brown, 0·5 mm. high, 0·1 mm. diameter; head 0·4 mm. high, ovoid or globose, rugose, pale yellow or orange above, orange at the base, splitting irregularly at the top, sometimes leaving a cup with a regular edge; lime granules of the sporangium wall spherical; lime knots yellow, angular, up to 70 × 40 μ, connected by hyaline, rather rigid threads with triangular expansions at the axils; granules of the lime knots spherical (only visible at the corners); spores violet-brown, minutely warted, 8 to 9 μ diameter.

Chondrioderma spumarioides, Rost.

Plasmodium pale yellow, among dead leaves, becoming white; developing sporangia pale yellow. The Ceylon form is fairly typical, but the mature sporangia always have the outer wall cracked into concave, polygonal areolæ, whose edges form elevated ridges. This was at first considered to be due to imperfect development, but it is a constant feature through a series of half a dozen gatherings, one of which developed in wet weather under dense shade, and another in a damp chamber in the laboratory. It is certain therefore that the cracking is not due to premature drying. The plasmodium has been watched for several days on three occasions. The sporangia are sessile, crowded, on a white hypothallus which is often strongly reticulated, white, bluish-white, or pinkish, 0·6 mm. diameter ; outer wall charged with spherical lime granules, inseparable from the membranous inner wall ; columella white ; interior of the sporangium white or reddish ; capillitium of dark, slender threads with paler extremities and a few nodular thickenings, spores 9 to 10 μ, almost smooth ; in another sporangium from the same gathering the spores measure 10 to 12 μ, and some are spinulose, but the majority are almost smooth.

Peradeniya.

Chondrioderma testaceum, Rost.

Diderma sublateritium, B. & Br., Fungi of Ceylon, No. 742.

The type specimen in Herb. Peradeniya consists of two dead leaves bearing crowded, flattened, circular, somewhat umbilicate, sessile sporangia ; on one leaf they are reddish-brown, on the other gray or almost white ; the outer wall falls away from the gray inner layer. Spores 7 μ diameter. This species has not been found recently.

Peradeniya.

Chondrioderma reticulatum, Rost.

" *Diderma deplanatum*, Fr.," B. & Br., Fungi of Ceylon, No. 743. "*Diderma depressum*, Fr.," B. & Br., Fungi of Ceylon, No. 744.

Berkeley and Broome's 743, 744 (Thwaites' 40 and 75) are marked on one packet in Herb. Peradeniya ; this contains only one specimen, a cluster of crowded, irregular plasmodiocarps of *C. reticulatum ;* their bases are covered with large angular crystals similar to those of *C. michelii*. This species is common in Ceylon. One collection, on living leaves of an epiphytic orchid, consists of confluent plasmodiocarps in patches up to

6 cm. long and 1 cm. or more broad, with a few large oval gaps and many minute perforations. In another gathering of small flat elongated plasmodiocarps there is a slight white hypothallus; the outer surface of these is rough, and lined as though with a brush.

Peradeniya, Gangaruwa, Bandarawela, Hunugalla, Talawakelle, Yatiyantota.

Chondrioderma michelii, Rost.

" *Diderma depressum*, Fr.," B. & Br., Fungi of Ceylon, No. 744.

Thwaites' No. 1044, included in Berkeley and Broome's No. 744, consists of shortly stalked sporangia of *C. michelii*, 0·7 to 1 mm. diameter, with a few sessile, in Herb. Peradeniya. A fairly frequent species at Peradeniya on dead leaves; sporangia up to 1 mm. diameter; stalk and under surface sometimes chocolate-brown, or brown with white lines; the outer layer often falls off round the edge of the sporangium and leaves a brown rim.

Peradeniya.

Chondrioderma rugosum, Rex.

Fairly frequent on trunks of jak trees (*Artocarpus integrifolia*), sometimes also on dead twigs. Sporangia typical, grayish-white, areolated, on furrowed black stalks; total height about 0·8 mm.; stalk and base of sporangium red-brown when mounted; columella white or yellowish; capillitium colourless; spores 8 to 10 μ, violet-brown, minutely warted.

Peradeniya, Talawakelle.

With *C. rugosum*, there occurs on the moss and dead bark on the trunks of jak trees a sessile form which is most probably a plasmodiocarp form of that species. The plasmodiocarps are small, elongated, or oval, or circular, from 0·3 mm. diameter to 2 × 0·75 mm., white, strongly wrinkled, base pale brown or reddish-brown internally; capillitium of dark brown threads, 4 to 6 μ in diameter, often nodular, united by broad perforated sheets, and terminating at the outer ends in paler triangular expansions, up to 45 μ broad; spores, 13 to 18 μ diameter, violet-brown, closely and minutely warted.

Chondrioderma lucidum, Cooke.

A gathering from Talawakelle is doubtfully included under this name. It was found on a moss-covered tree trunk at a height of about 4 feet from the ground, and consists of only a dozen sporangia. The sporangia are globose, 0·6 to 0·8 mm. diameter, clustered and sessile, blackish-brown at the base, pale yellow above, the two colours being sharply defined. The dark part of the wall is membranous and free from lime, orange when mounted, while the upper dull yellow part is cartilaginous, charged with minute yellow lime granules. The yellow sporangium wall is pitted. The columella is subglobose or clavate, pale yellow, wrinkled, and calcareous throughout, with yellow rods, usually entire, sometimes fusiform, extending from it to the pits of the sporangium wall. The capillitium consists of dark brown, wavy, coarse threads, with some delicate colourless threads, anastomosing freely and forming netted expansions. The spores are dark purple-brown, closely spinulose, 15 to 17 μ diameter.

In some respects the yellow lime rods resemble the lime knots of *Physarella*. It is probably a new species, but as the material is scanty, and in some respects appears abnormal, it appears preferable to leave it under the above name until more is available. Its resemblance to *C. lucidum* was pointed out by the late Mr. Lister, who presented me with specimens of the latter which show a similarly pitted wall with pockets or spikes filled with lime projecting inwards from the sporangium wall, though they do not meet the columella as in the Ceylon form. The same specimens show also similar spikes arising from the columella. The Ceylon species resembles *C. lucidum* in "the large rough spores, the dark irregular capillitium, and the subglobose, wrinkled columella." It appears to differ in having lime in the sporangium wall. The above description is compiled chiefly from Mr. Lister's observations.

Diachæa elegans, Fries.

Very common at Peradeniya. It is practically the only species which appears after the showers in the dry season, and is the first to appear during the rains. The sporangia are always cylindrical. A group of twenty sporangia grew on the exterior of a flower pot in an insect cage, about 3 feet from the ground: the stalks arose directly from the surface of the pot without any white hypothallus, and gave the impression that the plasmodium had issued through it.

Diachæa subsessilis, Peck.

This species has been found on one occasion in the jungle at Pattipola (6,200 feet) on dead leaves and on the green stems of *Strobilanthes.* The specimens were immature when collected, and had then a white stalk and a bright yellow head. Sporangia, when ripe, dull purple or iridescent, 0·8 mm. diameter; stalk stout, yellowish-white, 0·5 mm. high, 0·2 mm. diameter; columella white, short or scarcely evident; lime in stalk and columella fused into crystalline nodules; capillitium dark purple, colourless at the base; spores pale purple, 10 μ diameter, marked with minute warts arranged in rows to form an irregular reticulation, usually with three or four patches of more definite reticulation on each spore. In some places there is a thin hyaline or iridescent hypothallus, bearing large lime granules round the base of the stalk.

Diachæa bulbillosa, Lister.

Didymium bulbillosum, B. & Br., Fungi of Ceylon, No. 753.

Berkeley and Broome's specimens were immature, as is indicated by their description, "sporis conglomeratis." It was collected again in 1905 at Peradeniya on dead leaves. The developing sporangia were orange-yellow, on a brown horny-looking stalk, and resembled a developing *Trichia. Diachæa subsessilis* when immature looks like a *Physarum.* Total height 0·9 to 1·2 mm.; sporangia globose, 0·5 mm. diameter, iridescent, sometimes bronze, red-brown at the base; stalks conical, red-brown, whitish at the base, 0·1 mm. diameter in the middle, 0·25 mm. diameter at the base, often united by a white netted hypothallus; columella white, globose, about half the height of the sporangium; capillitium dark purple; spores 9 to 10 μ diameter, rather dark purple, spinulose, with large, blunt, scattered spines, with occasionally a single mesh of a network; lime in stalk and columella in angular granules. Half of this was removed to the laboratory, the remainder being left to develop *in situ.* In the sporangia which developed in the laboratory the spores appear greenish.

ORDER II.—DIDYMIACEÆ.

Didymium difforme, Duby.

Rare. A few sporangia have been found at Hakgala (5,600 feet) on moss, dead leaves, and grass, on two occasions, and at Peradeniya, also on two occasions. The total number of sporangia seen does not exceed one hundred, and of these only six have been found at Peradeniya.

Didymium clavus, Rost.

Didymium commutabile, B. & Br., Fungi of Ceylon, No. 746. *Didymium clavus*, A. & S., in Berkeley and Broome, Fungi of Ceylon, No. 745. *Didymium radiatum*, Mass., Mon., p. 229 (in part).

Berkeley and Broome's type specimen of *D. commutabile* in Herb. Peradeniya is *Didymium clavus* with stalks about 1·25 mm. high, furrowed, twisted, white or gray, encrusted with lime deposits ; the sporangia are 0·8 mm. diameter, flattened, grayish-white ; spores 6 μ diameter. This is a fairly common species in Ceylon. In some forms the head is not so much flattened as in the usual European examples ; in others the stalk tapers abruptly near the apex and the head is nodding.

Peradeniya.

Didymium nigripes, Fries.

Didymium microcarpon, Fr., var. *xanthopus*, Ditm., in Berkeley and Broome, Fungi of Ceylon. "*Didymium farinaceum*, Schrad.," in Berkeley and Broome, Fungi of Ceylon, No. 748.

Berkeley and Broome's specimens of *D. farinaceum* in Herb. Peradeniya are *D. nigripes*. The specimens named *D. nigripes* in B. & Br. 749 (Thwaites' 573) are *Lamproderma arcyrionema*, Rost. This species is exceedingly common. In several gatherings the minute warts on the spore tend to be arranged in clusters. In one gathering, on fallen palm nuts, the sporangia are either stalked, sometimes connate, or sessile ; the sporangium wall is yellow at the base ; the columella is white with a yellow tinge in the stalked specimens, or white and thin in the sessile forms ; stalk furrowed, clear yellow-olive in the upper part, but dark and enclosing refuse at the base ; spores, 8 μ diameter, violet-brown, minutely warted, with some warts arranged in clusters, about three clusters showing on the hemisphere; one sessile sporangium was entirely yellow. A gathering from Hakgala has short conical stalks, opaque at the base, clear orange above, up to 0·75 mm. high, arising from large circular hypothalli; sporangia 0·6 to 0·8 mm. diameter, almost flat, superficially resembling *D. clavus;* columella white; capillitium colourless with numerous bead-like thickenings; spores 7 μ diameter. One gathering of var. *xanthopus* has spores 10 to 12 μ diameter. A small group which grew on a dead palm frond at a height of about 15 feet from the ground has short, dark, opaque stalks and suggests *D. farinaceum* var. *minus*, but the columella is white, filled with small nodules of lime; the examples previously described show that *D. nigripes* var. *xanthopus* sometimes has a stalk which contains refuse matter, and is consequently opaque, in the lower half, and it would therefore seem preferable to regard these last-mentioned specimens as forms of *D. nigripes* in which this feature is more strongly developed, since typical *Didymium farinaceum* has not been found in Ceylon. Vars. *genuinum*, *eximium*, and *xanthopus* of *D. nigripes* all occur in Ceylon, the last-named being the commonest form.

Peradeniya, Bandarawela, Hakgala, Badulla, Pattipola, &c.

Didymium effusum, Link.

Didymium squamulosum, Fr., in B. & Br., Fungi of Ceylon, No. 1189. *Didymium neglectum*, B. & Br., Fungi of Ceylon, No. 747.

Berkeley and Broome's specimens named *D. effusum*, Link, Fungi of Ceylon, No. 755 (Thwaites' 1024), consist of two pieces of wood bearing a minute hyaline fungus with hyaline spherical spores, apparently a Sphæronema. *D. effusum* is common in Ceylon on dead leaves, sometimes also on tree trunks.

Peradeniya, Hakgala, Pattipola, &c.

Didymium anellus, Morgan.

Taken on four occasions at Peradeniya. In a gathering on dead leaves the plasmodiocarps are gray, flattened, circular, up to 1 mm. diameter, or elongated, winding, and branching, up to 8 × 1 mm., covered with lime crystals which consist of amorphous masses with projecting points; wall membranous, blotched with orange or yellow, yellow-brown at the base, where it contains rounded lime granules ; capillitium profuse, dark violet, without thickenings ; spores dark violet-brown, minutely spinulose, 8 μ diameter : these were taken with an abundance of typical *D. effusum.* In another gathering the lime crystals are yellow ; wall blotched brownish-yellow ; capillitium of pale violet anastomosing threads ; spores 7 to 8 μ diameter, minutely spinulose, clear violet. In a gathering on lichens on jak trees the plasmodiocarps are bluish-gray, small, with the lime crystals poorly developed : capillitium threads dark, forking, with triangular expansions at the axils, colourless at the extremities ; spores dark, closely warted, 13 to 16 μ diameter. Normal *D. effusum* was found with all these forms. A few of the circular plasmodiocarps are pitted in the centre, but none are really ring-shaped. Similar pits occur in *Chondrioderma reticulatum.*

Didymium leoninum, B. & Br., Fungi of Ceylon, No. 750.

" *Lepidoderma tigrinum,* Rost," in Rostafinski, Mon., App., p. 23.

Berkeley and Broome's type specimen in Herb. Peradeniya (Thwaites' 21) is for the most part immature, but one fragment shows a stalk, capillitium, sporangium wall, and spores agreeing with the following description.

Plasmodium orange-red, among dead leaves ; immature sporangia the same colour. Total height about 1·5 mm. Stalk yellow or yellow-brown, arising from a circular hypothallus about 1 mm. diameter, 0·75 mm. high, 0·25 mm. diameter in the middle, conical or expanding above and below, covered with large angular yellow lime granules, almost opaque when mounted. Sporangium 0·7 to 0·9 mm. diameter, globose, dark purple or almost black, covered by a loosely cohering crust of large, stellate, ochraceous, or yellow, or almost white crystals, which fall off here and there and disclose the purple sporangium. Crystals of the sporangium up to 40 μ diameter. Sporangium wall stout, cartilaginous, red-brown, areolated with pale yellow lines. Columella globose, 0·3 mm. diameter, yellow, thin-walled, filled with yellow lime granule. Capillistium of dark violet, smooth, anastomosing threads, abundant ; spores pale violet-brown, minutely spinulose, 7 to 10 μ.

This species differs from *Lepidoderma tigrinum* in the stellate crystals, the stout areolated sporangium wall, the thin wall of the columella, and the paler, small spores. Of three recent gatherings, the sporangia are ochraceous or yellow in two, and pale tawny to almost white in the third.

Peradeniya.

[**Spumaria alba,** DC.

This species is recorded for Ceylon in Massee, Monograph, p. 256, but it was not recorded by Berkeley and Broome, nor are there any Ceylon specimens at Peradeniya, Kew, or the British Museum.]

SUBCOHORT II.—AMAUROCHÆTINEÆ.

ORDER I.—STEMONITACEÆ.

Stemonitis fusca, Roth.

Stemonitis fusca, Roth., in Berkeley and Broome, Fungi of Ceylon, No. 766. *Stemonitis dictyospora*, Rost., in Berkeley and Broome, Fungi of Ceylon, No. 1195.

A common species, with the usual amount of variation in the capillitium and spores. One Peradeniya gathering shows a feebly developed net with meshes up to 80 μ broad, resembling *S. splendens*, but the spores are reticulated. The spores of the Ceylon specimens range from 6 to 9 μ diameter. On one occasion a large development was found on the surface of a recently-dug flower bed, distributed over an area measuring 4 feet by 3 feet; a few dead leaves were scattered over the surface, but nearly all the sporangia had developed on lumps of earth and on stones. Vars. α *genuina* and β *rufescens* are equally common.

Peradeniya, Hakgala, Ukuwela, Matale, Talawakelle, Badureliya, &c.

Stemonitis splendens, Rost.

"*Stemonitis maxima*, Sz.," in Massee, Monograph, p. 74.

Fairly common. Thwaites' gathering of this species was included under *Stemonitis fusca;* in his specimen in Herb. Peradeniya the meshes of the net are 18 to 60 μ wide, with numerous membranous expansions. In a gathering from Waharaka the stalks attain a length of 4·25 mm., and the sporangium 15 mm., making a total height of 19·25 mm.; the columella is central below, but becomes lateral above, and the capillitium consists of little more than a superficial net with abundant membranous expansions. In another similar gathering from Yatiyantota the columella is lateral, and often spiral; the total height in these is 14 mm. In both these gatherings the spores are 7 to 8 μ diameter. A gathering from Peradeniya, on the other hand, has strongly spinulose spores, 11 to 12 μ diameter, while the sporangia are only 1·25 to 2·25 mm. high.

Peradeniya, Badureliya, Yatiyantota, Pattipola, Hakgala, &c.

Stemonitis herbatica, Peck.

Fairly common, ripening on wood or dead leaves or on stems of living herbaceous plants. The white plasmodium was found on one occasion developing into coral-like masses on dead leaves and on the bare soil. These subsequently formed loose æthalia of convoluted lobes two or more centimètres in diameter, or flattened patches extending over several centimètres, resembling in shape some forms of *Spumaria alba*, but purple-brown with a grayish outer wall. These are var. *confluens*, identical, as Mr. Lister informed me, with those figured on Plate LXXVII. of his Monograph, where they are attributed to *S. fusca*. The wall is membranous, with a purple tint when mounted; the capillitium is a network of coarse violet-brown strands, up to 12 μ wide, with expansions at the axils; the spores are 8 μ diameter, lilac-gray, minutely warted; in parts there is a fairly strongly developed black or brownish-black hypothallus.

Peradeniya, Badulla, Yatiyantota; var. *confluens*, Gangaruwa.

Stemonitis ferruginea, Ehr.

Stemonitis Smithii, Macbride, in Lister, Monograph, p. 115.

Fairly common at Peradeniya. Stalks 1·3 to 5 mm. long; total height 4·5 to 10 mm.; spores 4 to 6 μ diameter.

Peradeniya, Hakgala, &c.

Comatricha obtusata, Preuss.

Stemonitis friesiana, de Bary, in Massee, Monograph, p. 82.

A group of four, with ellipsoid sporangia, was found at Pattipola. A gathering from Hakgala, with stalks 4·5 mm. long, has spores 11 to 14 μ diameter. The Ceylon gathering cited by Massee is not recorded by Berkeley and Broome. This species is rare in Ceylon.

Comatricha longa, Peck.

Not uncommon. Specimens from Neboda (low-country) have sporangia 3 to 4 cm. long, on stalks 3·5 mm. long; spores 10 to 11 μ diameter, strongly spinulose, with the spines arranged in a reticulate pattern and connected by raised bands which form a spore border crossed by the thicker spines. In some gatherings at Peradeniya the sporangia are closely fasciculate, erect, 7 to 12 mm. high; spores 7 to 9 μ diameter, reticulated; the longest sporangia found at this elevation are 2 cm. in length. In an abnormal development from Gangaruwa the sporangia are about 5 mm. high, the free ends of the capillitium are not divided, and the spores measure 9 to 12 μ in diameter. Not found above 1,600 feet elevation.

Peradeniya, Gangaruwa, Neboda, Dewalapola.

Comatricha typhoides, Rost.

Stemonitis typhina, Mass., Monograph, p. 74. *Stemonitis typhoides*, DC., in B. and Br., Fungi of Ceylon, No. 768.

Common, and usually typical. In one gathering from Peradeniya the capillitium has large dark brown spore-like swellings and smaller thickenings. Spores 6 to 7 μ diameter. Var. *heterospora* has been collected at Peradeniya.

Peradeniya, Urumuwela, Talawakelle, Hakgala, &c.

Comatricha persoonii, Rost.

Fairly common, usually on dead dadap (*Erythrina*, sp.), and frequently ripening on the earthen galleries of Termites which overrun the fallen dadap logs. The Ceylon specimens are all var. *gracilis* (*Comatricha gracilis*, Wingate). Total height 1 to 1·6 mm.; stalks 0·3 to 0·6 mm. high; sporangia cylindrical, ovoid, or globose, 0·5 to 1 mm. high, 0·25 to 0·5 mm. diameter; spores 6 to 8 μ diameter, almost smooth, or faintly and closely warted.

Raciborskia elegans, Berl.

Collected on two occasions. Total height 1 to 2 mm.; stalks black, subulate; sporangia globose, 0·5 mm. diameter, purple-brown; columella dividing repeatedly, the ultimate branches forming a slight superficial net, purple-brown; spores violet-brown, 11 μ diameter, with small scattered warts.

Peradeniya, Hakgala. On wood.

Lamproderma arcyrionema, Rost.

Berkeley and Broome's specimens of *Didymium nigripes*, Fungi of Ceylon, No. 749 (Thwaites' 573) are *L. arcyrionema* in Herb. Peradeniya; the specimens are 1·5 to 1·75 mm. high, with typical capillitium, and spores 8 to 9 μ diameter, lilac-gray, faintly spinulose. Fairly common. The total height is sometimes 2 mm. The spores are usually 6 to 7 μ diameter, sometimes 8 μ, sometimes 7 to 9 μ, and the warts are sometimes clustered. The plasmodium, as observed in Ceylon, is white.

Peradeniya, Badureliya, Henaratgoda, Pattipola, Hakgala.

Lamproderma irideum, Mass.

Stemonitis scintillans, B. & Br., Fungi of Ceylon, No. 1196.

Berkeley and Broome's type specimen in Herb. Peradeniya has black subulate stalks, 0·5 mm. long, arising from a red-brown hypothallus; the sporangia are 0·3 to 0·4 mm. diameter, iridescent, bronze. A common species. In one gathering the capillitium is dark, with pale tips, not pale at the base, but the spores are those of *irideum*, not *violaceum*.

Peradeniya, Talawakelle, Pattipola, &c.

Clastoderma debaryanum, Blytt.

Rather common on rotten wood in up-country jungles, but found also at lower elevations. Sporangia 0·1 to 0·16 mm. diameter; total height up to 1·25 mm.; spores brown in mass, pale lilac when magnified, 8 to 9 μ diameter, minutely warted.

Hakgala, Pattipola, Hunugalla, Gangaruwa.

ORDER II.—AMAUROCHÆTACEÆ.

No representatives yet found in Ceylon.

COHORT II.—LAMPROSPORALES.

SUBCOHORT I.—ANEMINEÆ.

ORDER I.—HETERODERMACEÆ.

Lindbladia tubulina, Fries.

Found once, in the jungle at Hakgala (5,600 feet), on dead wood; the issuing plasmodium was black, or bluish-black internally. Æthalia pulvinate, or effused, up to 2·5 cm. broad, umber-brown, shining bronze where the wall is persistent, or black: some pieces had a hypothallus 5 to 6 cm. diameter, but the æthalia were confined to the margins. Spores ochraceous brown, 6 to 7 μ diameter.

Cribraria minutissima, Schwein.

Total height 0·5 to 0·75 mm. Sporangia globose, gregarious, stipitate, nut-brown; cup wanting; nodes of the net flattened, scarcely expanded, slightly broader than the threads, almost without plasmodic granules; spores ochraceous, 7 μ diameter.

Gangaruwa.

Cribraria intricata, Schrad.

Common. Var. β *dictydioides* has been taken on two occasions at Badureliya, and also at Hapugastenne.

Peradeniya, Badureliya, Urumuwela, Pattipola, &c.

Cribraria tenella, Schrad.

"*Dictydium ambiguum*, Schrad.," in B. & Br., Fungi of Ceylon, No. 1194. *Cribraria elata*, Mass., Monograph, p. 61.

Apparently rare. A gathering from Hakgala has sporangia 0·5 mm. diameter, stalks 0·75 mm. high, cup small, nodes rounded or elongated, with few or no free rays. It agrees with Rostafinski's Ceylon type of *C. tenella*.

Peradeniya, Hakgala.

Cribraria languescens, Rex.

Collected once. "It is the first specimen we have seen or heard of from the Old World, and agrees absolutely with Rex's type and Cran's gatherings in Antigua" (A. Lister in litt.). The fresh sporangia appeared pinkish; the length of the stalk varies from 0·75 to 4 mm.; the cup is shining red-brown; spores pale red, minutely warted, 8 μ diameter.

Hakgala.

Cribraria microcarpa, Pers.

Three gatherings. Total height 2·25 to 3·75 mm. Sporangia globose, gregarious, stipitate, erect, or nodding, 0·25 to 0·5 mm. diameter, purple-brown. Stalk slender, 2 to 3·5 mm. high, purple-brown. Cup rudimentary ; nodes of the net globose, charged with purple-brown granules about 1 μ diameter ; threads yellow. Spore mass reddish. Spores pale red, minutely and closely warted, 7 to 8 μ diameter. The Ceylon specimens differ from typical *C. microcarpa* in having larger spores, smaller plasmodic granules, and less red in the sporangium.

Gangaruwa, Hunugalla.

Cribraria violacea, Rex.

Collected once ; ten sporangia, scattered, on very rotten wood in jungle. Total height 0·6 to 1·5 mm. Sporangia spherical, 0·2 mm. diameter, or ellipsoid, 0·12 mm. broad, 0·2 mm. high, dark violet. Cup occupying one-half or almost the whole of the sporangium, with a few perforations at the apex, or with a net of extremely fine threads ; in some cases the " net " consists of large fragments of the sporangium wall united by a few fine threads. Stalk 0·4 to 1·3 mm. high, 25 to 35 μ diameter, subulate, violet-brown, longitudinally striate. Plasmodic granules purple, minute. Spores lilac, 5 to 6 μ diameter, minutely and closely warted.

Hunugalla.

Dictydium umbilicatum, Schrad.

Dictydium umbilicatum, Schrad., in B. & Br., Fungi of Ceylon, No. 769.

Abundant. Total height up to 4 mm. Sporangia usually small, 0·2 to 0·5 mm. diameter. Plasmodic granules on the spores, 1 to 3 μ diameter. In one gathering, in which the sporangia are 0·5 mm. diameter and the total height varies from 1 to 1·5 mm., the length of the " hook " at the apex of the stalk is 0·3 mm. ; this brings the sporangium down almost to the base of the stem.

Peradeniya, Gangaruwa, Hakgala, &c.

ORDER II.—LICEACEÆ.

No representatives yet found in Ceylon.

ORDER III.—TUBULINACEÆ.

Tubulina fragiformis, Pers.

Collected once. Cluster of sporangia 3 cm. long, 1·5 cm. broad, pulvinate. Spores 5 to 6 μ diameter, a few larger and 8 μ diameter.

Urumuwela.

Tubulina stipitata, Rost.

"*Licea fragiformis*, Nees," in B. & Br., Fungi of Ceylon, No. 780.

Berkeley and Broome's specimens (Thwaites' 132) have stalks 1·5 to 2 mm. high, 1·5 to 2·5 mm. broad; the clusters of sporangia are from 1·5 to 2·5 mm. high, but as they have been pressed their original diameter is not ascertainable; the spores are 4 to 5 μ diameter; the sporangium wall is papillose. In a recent gathering the sporangia occur singly, or clustered in groups of three to twelve, or in larger clusters up to 1 cm. diameter; they are rufous-brown, on a dark brown, stalk-like hypothallus, usually free in the upper half in the smaller clusters and resembling a cluster of *Hemitrichia rubiformis*, turbinate, shining; wall membranous, iridescent when magnified. Individual sporangia are 2 to 3 mm. high, circular, not angled, in section; the outer sporangia of a cluster are often reflexed as in *Alwisia bombarda*. In some clusters the "stalk" is 3 mm. high, in others it is almost absent. Spores 4 to 5 μ diameter, some 7 μ diameter, reticulated with narrow lines, pale rufous-brown.

Talawakelle.

Alwisia bombarda, B. & Br.

Prototrichia bombarda, Massee, Monograph, p. 128.

Berkeley and Broome's type specimen in Herb. Peradeniya consists of clusters of two to six sporangia 1·25 to 1·5 mm. high, 0·5 to 0·6 mm. diameter, rufous-brown, cylindrical-ellipsoid, on clustered, longitudinally furrowed stalks, 2·5 mm.

high, ·25 mm. diameter. The stalks readily separate when soaked in water. The sporangia are chiefly immature. In a recent gathering, which unfortunately is much damaged, the sporangia are clustered or scattered ; stalks 3·5 to 4 mm. high, 0·12 to 0·2 mm. diameter, purple-brown, longitudinally furrowed, attenuated upwards ; sporangium wall yellow-brown, membranous; capillitium of tubular threads, 4 to 20 μ diameter, closely beset with slender spines, or smooth, regular, occasionally inflated, sometimes dividing into a brush of narrow tubes at their extremities, running longitudinally down the sporangium and attached to the wall about half way down. Spores 5 to 7 μ diameter, reticulated, brownish-yellow.

Gongolla forest (Thwaites), Badureliya. Gongolla (Gongalla) is a hill near Hayes Estate, on the boundary between Sabaragamuwa and the Southern Province ; Badureliya is near the boundary between Sabaragamuwa and the Western Province, about 30 miles from Gongolla.

The following account of the vicissitudes of the name *Alwisia* may obviate any change which might appear necessary to one who notes the apparent confusion in its present uses. Thwaites (in litt.) suggested *Alwisia minuta* as the name of an orchid which Lindley considered was a *Tæniophyllum ;* this species was named *Tæniophyllum alwisii*, and Thwaites' generic name was not made use of. But Lindley mentions Thwaites' suggestion in his account of that species, and the Index Kewensis cites *Alwisia minuta* as a synonym of *Tæniophyllum alwisii*. This citation is surely an error, for the name was never used, and the case comes under the rule, " Incidental mention of a name is not effective publication " (Vienna Rules, Art. 37). The name *Alwisia* is therefore not preoccupied by Lindley's reference. In 1859 Lindley named another Ceylon orchid *Alvisia tenuis*. From this there has arisen much confusion, more especially at Peradeniya. In English transliterations of Sinhalese names, w and v are practically interchangeable, and as the name was derived from a surname which is usually written " Alwis," Thwaites always refers to this orchid as *Alwisia*. It appears in that form in his " Enumeratio," and in all the Ceylon Catalogues. Trimen's " Flora of Ceylon " (as completed by Hooker) gives the correct name, *Alvisia*, but in Vol. V. of the same work, Professor Boulger returns to Thwaites' spelling, having copied this from Trimen's biography of H. de Alwis Seneviratne in the Journal of Botany, 1894. It appears that the name *Alwisia* has always been used at Peradeniya for the orchid, but it is quite clear from the facts given above that this application is an error. The generic name *Alwisia* has never been "effectively published," except by Berkeley and Broome for the myxomycete, *Alwisia bombarda*, in 1875.

ORDER IV.—RETICULARIACEÆ.

Dictydiæthalium plumbeum, Rost.

Reticularia lurida, B. & Br., Fungi of Ceylon, No. 736. "*Licea cylindrica*, Fr.," in B. & Br., Fungi of Ceylon, No. 779. *Licea cinnabarina*, B. & Br., Fungi of Ceylon, Nos. 782, 1202. *Licea tenuissima*, B. & Br., Fungi of Ceylon, No. 783. *Clathroptychium Berkeleyi*, Mass., Mon., p. 53.

Berkeley and Broome's type specimen of *Reticularia lurida* in Herb. Peradeniya consists of æthalia up to 5 mm. diameter, clay-coloured or blackish, fringed by a white hypothallus; spores greenish-yellow in mass; threads stout. *Licea cinnabarina*, B. & Br., in Herb. Peradeniya, is immature Dictydiæthalium. The Ceylon specimen of "*Licea cylindrica*, Fr.," at Kew is the type of *Clathroptychium Berkeleyi*, Massee (Mon., p. 53). A recent specimen from Hakgala has threads up to 6 μ diameter. In Ceylon the æthalia are usually small, often not exceeding 5 mm. in diameter.

Not uncommon. Peradeniya, Hakgala.

Reticularia lycoperdon, Bull.

Common and typical. Hakgala, Peradeniya, &c.

ORDER V.—LYCOGALACEÆ.

Lycogala flavofuscum, Rost.

"*Lycogala epidendrum*, Buxb." (in part), in B. & Br., Fungi of Ceylon, No. 733.

Under the name *Lycogala epidendrum* were placed three of Thwaites' gatherings (Thw. 314, 315, 316); one of these, 315, is *Lycogala flavofuscum.* This species is evidently rare in Ceylon ; I have found it only twice, on the same stump (*Ficus elastica*), and only one æthalium on each occasion. The first of these was broken, and formed a grayish mass of elaters and spores ; it had apparently measured three or four centimètres in diameter ; the tubes vary in breadth from 10 to 100 μ, have papillose walls, and contain spores ; the spores are 6 to 7 μ in diameter, minutely reticulated over the greater part of the surface. The second æthalium is 2 cm. by 1 cm., pulvinate, ochraceous brown.

Peradeniya.

Lycogala miniatum, Pers.

Lycogala epidendrum, Buxb., in B. & Br., Fungi of Ceylon, No. 733. *Lycogala affine*, B. & Br., Fungi of Ceylon, No. 732 (fide Massee, Mon., p. 121).

A very common species, not differing from the European form. Thwaites' 316 (B. & Br. 733, in part) is immature *Lycogala miniatum* in Herb. Peradeniya ; Thwaites' 18 was named *Peziza ruberrima* by Berkeley and Broome, but in Herb. Peradeniya it consists of twenty-two æthalia of *Lycogala miniatum*, 1·75 to 5 mm. diameter, many of them immature. Massee states that the Kew specimen of *Peziza ruberrima*, B. & Br., is a collapsed *Lycogala* (Journ. Linn. Soc. XXXV., p. 117). At Peradeniya and Hakgala var. *tessellatum* has been collected ; the æthalia measure up to 1 cm. in diameter, but most of them are small, 2 to 4 mm. diameter, black, or olive covered with black warts and reticulated with black bands ; the black warts and bands are chambered (pseudoparenchymatous), the chambers measuring 20 to 40 μ across, and are two layers thick in the middle ; the spores are 5 to 6 μ diameter. In some respects these resemble *L. nitidum* (= *L. conicum*), but they are not conical, and the warts in the latter species are not chambered. Other gatherings of typical *miniatum* from Peradeniya contain examples approaching var. *tessellatum*, in having the scattered warts chambered.

Peradeniya, Teldeniya, Badureliya, Talawakelle, Pattipola, Hakgala, &c.

Lycogala conicum, Pers.

Lycogala nitidum, B. & Br., Fungi of Ceylon, No. 734.
Lycogala atropurpureum, B. & Br., Fungi of Ceylon, No. 735.
Dermodium conicum, Rost., Mon., App., p. 37.

Thwaites' 313 (B. & Br. 734) in Herb. Peradeniya contains small æthalia, 1 to 1·5 mm. diameter; they probably were originally conical, but they are now flattened. In Thwaites' 254 (B. & Br. 735) many have escaped flattening owing to inequalities in the wood; they are black, either spherical, 0·4 to 2 mm. diameter, or conical, about 1 mm. high, and 0·4 mm. diameter; the spores are irregular, apparently not quite mature, ochraceous, 4 to 5 μ diameter. In a recent gathering from Hakgala the æthalia, with one exception, are conical, 3 mm. high, 2 mm. diameter at the base, gray or bronze, with black elongated warts, blackish at the base; the spores are pinkish gray in mass, marked with a faint broken reticulation, 5 to 6 μ diameter. This is evidently an "up-country" species, since Thwaites' specimens were collected at Nuwara Eliya (6,600 feet), and the only recent Ceylon gathering is from Hakgala (5,600 feet).

SUBCOHORT II.—CALONEMINEÆ.

ORDER I.—TRICHIACEÆ.

Trichia affinis, De Bary.

Fairly common, but usually showing an approach to *Trichia persimilis*, either in the colour of the sporangium, or in a slightly broken reticulation of the spores, or sometimes in having spinulose elaters. The sporangia are ochraceous yellow, or golden, or red-brown, sometimes somewhat iridescent; but the red-brown sporangia have the spores and elaters of *affinis*, not of *persimilis*. In one gathering the sporangia are grayish ochraceous, iridescent; the elaters are golden yellow, and contrast strongly with the spores, which are umber in mass and yellow-brown when magnified. In several gatherings the sporangium wall contains yellow spherical granules. The number of bands on the elaters is usually four. The spores are generally 12 to 13 μ diameter, but in two gatherings they are 11 to 17 μ and 15 to 17 μ respectively. The bands on the spore are often somewhat broken, and in many cases it is difficult to decide whether the gathering should be assigned to *T. affinis* or *T. persimilis*.

Peradeniya, Gangaruwa, Bandarawela, Talawakelle, Hakgala, Pattipola.

Trichia persimilis, Karst.

Trichia sulphurea, Massee, Mon., p. 186.

Not so common as *T. affinis*, and in most cases showing an approach to that species in having some spores regularly banded. In one gathering the longest elaters are about 200 , but the majority are only 40 μ, and some only 15 μ long, resembling a spore with three spines.

Hakgala, Pattipola, Wattegama, Hunugalla.

Trichia scabra, Rost.

" *Trichia chrysosperma*, DC.," in B. & Br., Fungi of Ceylon, No. 778.

Berkeley and Broome's No. 778 in Herb. Peradeniya consists of a bright orange-yellow mass of crushed sporangia on a brown hypothallus ; the elaters are spinulose, with bands in many places irregular, and some of them terminate in two or three spreading points ; the spores are 10 to 12 μ diameter, minutely reticulated. In a recent gathering the spores are 10 μ diameter, with scattered warts ; the spore wall appears thicker on one side ; the elaters are 6 μ broad, with five narrow regular bands and short spines, and their tips end abruptly in a short point. In two other gatherings the spores are reticulated, 11 to 12 μ diameter, and some of the elaters have bulbous ends.

Hakgala.

Trichia varia, Pers.

Typical stalked and sessile forms are fairly common in the jungle at Hakgala (5,600 feet). It has not been found at lower elevations.

Trichia fallax, Pers.

Fairly common at Hakgala. Plasmodium rose coloured ; elaters terminating in long tapering points, and frequently giving off similar points laterally ; spores 9 to 10 μ diameter.

Trichia botrytis, Pers.

Trichia pyriformis, Hoffm., in Berkeley and Broome, Fungi of Ceylon, No. 775. *Trichia fragilis*, Rost., in Massee, Mon., p. 176.

Berkeley and Broome's No. 775 in Herb. Peradeniya consists of crushed sporangia of var. *lateritia*, on simple, purple or red-brown furrowed stalks, 1·5 to 2 mm. long ; the mass of elaters and spores is orange-red ; the points of the elaters are short, measuring 20 to 30 μ. The specimen was collected at Hakgala, which is still the only Ceylon station for this species, though it is quite common there. In one recent gathering the stalks are 4 mm. long. All the gatherings are var. *lateritia*. In a gathering which approaches var. *genuina* the sporangia are purple-brown, marked with ill-defined lighter lines of dehiscence ; they are 0·4 to 0·8 mm. in diameter, shortly stalked or sessile ; stalks up to 0·5 mm. high, 0·3 mm. thick, purple-brown ; elaters brownish-yellow, with irregular bands, and points about 20 μ long ; spores 10 μ diameter, minutely spinulose ; in the short points of the elaters it resembles var. *subfusca*, but the elaters are not so yellow as in Rex's type. Ceylon forms of *T. botrytis* are almost always simple, not clustered. In some cases there is a well-developed red-brown hypothallus. The sporangia are usually shining purple-black, with elaters red-brown in mass.

Hemitrichia rubiformis, List.

Arcyria rubiformis, Mass., Mon., p. 158.

Thwaites' 22, in Herb. Peradeniya, is this species ; it was included by Berkeley and Broome under *Arcyria punicea*, Fungi of Ceylon, No. 770 ; the sporangium wall is red-brown, the orange-red capillitium has no swellings, and the spores are spinulose, 10 μ diameter. In two recent gatherings the sporangia dehisce by a distinct lid, and in one the inner threads of the capillitium lack spines ; the spores are 8 to 10 μ diameter.

Peradeniya, Hunugalla.

Hemitrichia intorta, Lister.

A gathering from Hakgala was referred to *H. intorta* var. *leiotricha* by Mr. Lister. The sporangia are shining olive (rose pink when unripe), sessile, scattered, globose, 0·5 to 1 mm.

diameter, or slightly elongated, 1·5 mm. long, and 0·5 mm. broad ; the capillitium is greenish-yellow in mass, a network of threads, 5 to 6 μ diameter, with four or five narrow, close set, regular bands, and bulbous, or merely rounded free ends ; spores 10 to 12 μ diameter, minutely warted, umber in mass ; sporangium wall membranous, with scanty granular deposits. " It agrees with *T. lutescens* in the membranous sporangium wall, and with *H. intorta* var. *leiotricha* in the *Hemitrichia* character of the capillitium " (Lister, in litt.).

Hemitrichia clavata, Rost.

Trichia Thwaitesii, B. & Br., Fungi of Ceylon, No. 776. "*Arcyria umbrina*, Schum.," in B. & Br., Fungi of Ceylon, No. 773. *Arcyria clavata*, Mass., Mon., p. 166. *Trichia clavata*, P., in B. & Br., Fungi of Ceylon, No. 1200.

Thwaites' 22, B. & Br. 776, *Trichia Thwaitesii*, is *Hemitrichia clavata* at Kew, but the same Thwaites' number is *Hemitrichia rubiformis* in Herb. Peradeniya ; the description appears to refer to *H. clavata*. This species is very common in Ceylon, and typical.

Peradeniya, Talawakelle, Hunugalla, Pattipola, Hakgala, Badulla, Urumuwela, &c.

Hemitrichia Karstenii, Lister.

Hemiarcyria Karsteni, Rost., in B. & Br., Fungi of Ceylon, No. 1199. *Arcyria Karstenii*, Rost., in Massee, Mon., p. 168.

" Rostafinski's type specimen from Ceylon (K. 1773) has pale yellow-brown sporangia and rugged capillitium, with faint spirals and many large rounded expansions ; the spores are yellow, minutely warted, and measure 10 to 11 μ diameter " (Lister, Mon., p. 179). This species has not been re-discovered in Ceylon (see *Perichæna depressa*).

Hemitrichia serpula, Rost.

Trichia serpula, P., in B. & Br., Fungi of Ceylon, No. 777. *Arcyria serpula*, Mass., Mon., p. 165.

A common species. The netted plasmodiocarp sometimes extends over an area 4 or 5 cm. long and 2 or 3 cm. broad ; in some specimens it is seated on a red-brown hypothallus. It soon bursts when ripe, and the capillitium is often blown away or dragged out by insects. In a gathering from Hakgala the capillitium threads are practically smooth, and the spiral bands are more numerous and closer together than usual; the spores are badly developed, but they are more closely reticulated than is normal, and have almost no border. In other gatherings the capillitium is spinose with crowded spines up to 8 μ long in some parts, while on other parts they are scarcely visible.

Peradeniya, Hakgala, Yatiyantota, Talawakelle, Hunugalla, &c.

ORDER II.—ARCYRIACEÆ.

Arcyria ferruginea, Saut.

Rare. A single gathering of about twenty, somewhat weathered, sporangia with typical capillitium and cup; spores 8 to 12 μ diameter, minutely warted, pale red.

Peradeniya.

Arcyria albida, Pers.

Arcyria cinerea, P., in B. & Br., Fungi of Ceylon, No. 774.

Thwaites' 116 (B. & Br. 774) is the cylindric ochraceous form; total height, 3 mm.; sporangia 1·8 mm. high, 0·6 to 0·7 mm. diameter. A very common species; usually pale gray, sometimes with a greenish tint when fresh, often ochraceous; generally cylindrical; often with clustered, adhering stalks (= *Arcyria digitata*, Rost.).

Peradeniya, Talawakelle, Hunugalla Pattipola, Hakgala, &c.

Arcyria globosa, Schwein.

A cluster of about a dozen sporangia on a dead leaf at Peradeniya. Total height about 1 mm.; sporangia 0·5 mm. diameter, gray; stalks grayish-brown, 0·4 mm. high, 0·06 mm. diameter, hollow, filled with spore-like cells, minutely furrowed, sometimes arising from a small circular hypothallus; cup, one-quarter to one-half the height of the sporangium, hemispherical, smooth; capillitium attached to the cup, gray in mass, threads 4 μ diameter, spinulose, the spines spirally arranged; spores 6 to 7 μ diameter, with a few minute warts.

Arcyria punicea, Pers.

Arcyria punicea, Fr., in B. & Br., Fungi of Ceylon, No. 770 (see p. 318).

Abundant. In one gathering from Peradeniya the stalks are 1·5 mm. high, 0·1 mm. diameter in the middle; the sporangia are dull red; 0·8 to 1·75 mm. high, cylindric; the cup is small, plaited, and smooth; the cogs on the capillitium are reduced almost to spines in some cases, and the threads in the cup are smooth; the capillitium is united to the cup; spores 6 μ diameter; the sporangia are scattered, and their long thin stalks give them an appearance quite different from that of normal *punicea*. In a gathering from Hakgala the sporangia are ochraceous. A group of *Arcyria* was found at Hakgala developing from lemon-yellow plasmodium; these were brought into the laboratory, but unfortunately were eaten by cockroaches; what remains of them appears to be *Arcyria punicea*, but under the circumstances it is impossible to decide whether *Arcyria punicea* may have yellow plasmodium or whether we are dealing with a new species.

Peradeniya, Hakgala, Pattipola, Talawakelle, Yatiyantota, Urumuwela, Badulla, &c.

Arcyria insignis, Kalchbr. and Cooke.

Abundant on decaying branches of various shrubs in an abandoned garden at Peradeniya in 1905. Fairly frequent elsewhere at Peradeniya. Sporangia pale rose, clustered, usually in small groups; total height about 1 mm.; stalk and cup together about 0·3 mm. high; cup membranous, plaited, and spinulose; capillitium attached to the cup, a delicate network of almost colourless threads marked with faint transverse bars and short spines; spores 7 to 9 μ. In a gathering from Pattipola the sporangia are scarlet and 2 mm. long, though the stalk and cup are only about 0·3 mm. high; in some the capillitium is free from the cup, but in others there are a few attachments; the thickenings are somewhat distant, prominent, acutely ridged half-rings; in these points it differs from typical *A. insignis*.

Peradeniya, Pattipola, Gampola.

[**Arcyria incarnata,** Pers.

This species was recorded by Berkeley and Broome, Fungi of Ceylon, No. 771 (Thwaites' 115). It is also recorded for Ceylon by Massee, Mon., p. 145. Thwaites' 115 is apparently not in any herbarium at the present time ; it was not found by Mr. A. Lister at Kew or the British Museum. At Peradeniya, Thwaites' Nos. 20 and 115 are marked on one packet, which contains *Arcyria punicea* (No. 20) only. Flesh-coloured examples of *Arcyria punicea* are quite common, but although I have examined all the numerous growths of *Arcyria* seen during the last four years, I have not met with *Arcyria incarnata.* I am inclined to believe therefore that the Ceylon record of this species is an error.]

Arcyria stipata, List.

"*Arcyria punicea*, Fr.," in B. & Br., Fungi of Ceylon, No. 770 (Thw. 70).

Thwaites' 70 consists of a bright scarlet mass of crushed sporangia ; the stalks are 0·75 to 1·25 mm. high, and the sporangia 1·75 to 2·2 mm. ; the threads within the cup are smooth, darker than the outer threads, and have a horny appearance ; the cog-like thickenings are almost square and close set. In recent gatherings from Hakgala and Peradeniya the sporangia are bright or dull scarlet ; the spiral bands are only evident in a few places, generally most conspicuous in the lower part of the capillitium, where the threads are almost smooth. The capillitium of this species appears to be more rigid than that of other *Arcyrias.*

Peradeniya, Hakgala.

Arcyria flava, Pers.

Arcyria nutans, Fr., in B. & Br., Fungi of Ceylon, No. 772.

Not common. Thwaites' specimens have rather long stalks measuring, with the cup, about 1 mm. in length. Recently collected at Peradeniya and Hakgala.

Arcyria Œrstedtii, Rost.

A single gathering from Peradeniya. The stalks are weak, up to 0·5 mm. long, and the cup is small ; the expanded cylindrical sporangia are 5 mm., or more, long ; there is a well-developed, white or hyaline, shining, membranous hypothallus; the persistent plates of the sporangium wall are few in number and almost smooth; the capillitium threads bear broad-based spines and acute-edged half or quarter rings.

Perichæna chrysosperma, Lister.

Ophiotheca Wrightii, B. & C., in B. & Br., Fungi of Ceylon, No. 1197 (Thw. 1047).

Thwaites' No. 1047 in Herb. Peradeniya consists of ring-shaped plasmodiocarps, 1·3 to 1·8 mm. diameter, blackish-brown above, red-brown at the sides; spores 10 to 11 μ diameter; spines of the capillitium short, not exceeding 3 μ. It is a fairly common species, but never in large quantity; usually on fallen branches, but it has been found on elephant dung at Hakgala. The sporangia are sometimes globose, about 0·5 mm. diameter, but more usually ring-shaped or horse-shoe shaped, and about 1 mm. diameter. The spines in some gatherings are 8 μ long. In a gathering from Henaratgoda the plasmodiocarps are small, globose, or ring-shaped, 0·3 to 0·5 mm. diameter, brownish-yellow, reticulated with darker lines; the sporangium wall is almost destitute of granular deposits. In another gathering, from Peradeniya, the spines are reduced to slight warts, only here and there arising to about half the usual length.

Peradeniya, Henaratgoda, Hakgala.

Perichæna depressa, Libert.

Perichœna marginata, B. & Br., Fungi of Ceylon, No. 1201 (Thw. 49).

Thwaites' No. 49 in Herb. Peradeniya consists of crowded, polygonal, flat sporangia, 1 to 1·5 mm. diameter, lilac-gray, or almost white, with superficial deposits; in this respect it agrees with the type of *Perichœna applanata*, Massee, from Australia. Mr. Lister found that the same Thwaites' number at Kew was *Hemitrichia Karstenii*, but the description given by Berkeley and Broome evidently refers to the Peradeniya specimens. It seems probable, in view of the fact that *H. Karstenii* has not been found recently in Ceylon, and that the type specimen of *P. applanata* agrees with the Ceylon specimens in Thwaites' No. 49, that there has been some interchange of the Ceylon and Australian gatherings. *P. depressa* is very common in Ceylon. A gathering from Badureliya consists partly of flattened, clustered, polygonal sporangia, as in typical *P. depressa*, and partly of more globose, scattered sporangia, as in *P. populina*; the spores are 9 to 10 μ in diameter. In a collection from Henaratgoda the capillitium forms a loose net, with free ends about 40 μ long, swollen at the extremities. In several gatherings the lids of the sporangia are pale brown almost without any granular deposits, but containing scattered or crowded spherical yellow granules; and in one from Hakgala, which consists chiefly of purple-brown sporangia, a few sporangia have membranous, iridescent, golden lids the outer layer being absent.

Peradeniya, Badureliya, Hakgala, Pattipola, Badulla, Ukuwela, &c.

Perichæna populina, Fries.

Rare. A small gathering from Peradeniya is typical, except that the spores are rather larger than usual, 13 to 16 μ diameter. In another gathering the sporangium wall is apparently single, and the lid is covered by a gray cap of acicular crystals; the spores are small, 11 to 13 μ in diameter, minutely warted; the capillitium threads are 2 to 3 μ in diameter, somewhat nodulose.

Peradeniya.

Perichæna microspora, Penzig and Lister.

Rare; only found once. Plasmodiocarps elongated, sometimes sinuous, 1·25 to 4·25 mm. long, 0·25 mm. diameter, smooth, pinkish ochraceous; wall single, membranous, or thickened with deposits of granular matter towards the base, minutely and closely papillose; capillitium and spores pinkish yellow in mass, almost colourless when mounted; capillitium of branching threads with frequent irregular expansions at the axils, minutely spinulose everywhere, constricted at short intervals so as to appear beaded, with numerous attachments to the sporangium wall; spores almost colourless, minutely spinulose, 6 to 8 μ diameter.

Peradeniya.

Perichæna variabilis, Rost.

Licea reticulata, B. & Br., Fungi of Ceylon, No. 781. *Ophiotheca reticulata*, Mass., Mon., p. 133.

Berkeley and Broome's type specimen of *Licea reticulata* in Herb. Peradeniya consists of netted wide-meshed plasmodiocarps, up to 12 × 5 mm., and small ring-shaped plasmodiocarps, 0·4 to 1 mm. diameter. The latter are immature. The capillitium is scanty. This is not a common species. An extensive gathering from Peradeniya consists almost entirely of a form with white much-netted plasmodiocarps, some of them 5 cm. long; the sporangium wall consists of two layers, the outer thin and smooth, the inner papillose on the inner side, and between these two lie abundant cubic, lozenge-shaped, or acicular lime crystals. These specimens bring *P. variabilis* into line with *P. populina* and *P. depressa*, both of which may have white incrustations in the sporangium wall.

Peradeniya, Kegalla.

Perichæna pulcherrima, Petch. Ann. Perad., Vol. 4, p. 305.

This species has only been found on one occasion. It occurred on cacao branches which had been killed by *Diplodia cacaoicola*, at a height of about 4 feet from the ground, and in a similar position on dead *Erythrina lithosperma*. The branches were brought to Peradeniya and placed under a bush, where they developed a further lot of sporangia in ten to twelve days. As the dry season had now set in, they were transferred to tall glass cylinders in the laboratory, and further specimens were obtained from them in five days. The sporangia are purple-red, or purple-brown, glossy, either sessile or stalked. The sessile forms are globose, about 0·3 mm. diameter, or elongated, up to 0·7 mm. long, and 0·3 mm broad, crowded on a netted shining, irregular hypothallus. The stalked forms are scattered, and have globose heads up to 0·4 mm. diameter; the stalks are about 0·3 mm. high, 0·1 mm. diameter, furrowed, brown or red-brown, containing granular matter, often connate in twos or threes. The sporangium wall is double, consisting of a stout, outer, granular, purple-red layer and a delicate hyaline inner layer. In some examples of both forms the sporangium wall is hexagonally reticulated, but this is not a constant feature; it occurs in specimens collected in the field, as well as in those grown in the laboratory. The capillitium in mass appears the same colour as the sporangium wall; when mounted it is pale brown; it consists of irregular branching threads, 4 μ diameter, inflated here and there, rough with minute warts and scattered, blunt spines. The spores, in mass, are paler than the capillitium; when mounted they are brownish, 15 to 17 μ diameter, spinulose with close set spines, which appear to form a border about 1 μ wide when the profile of the spore is focussed.

Ukuwela.

Order III.—MARGARITACEÆ.

No species yet discovered in Ceylon.

Revisions of Ceylon Fungi.

(PART II.)

BY

T. PETCH, B.A., B.Sc.

THE first instalment of "Revisions of Ceylon Fungi" was published in the "Annals of the Royal Botanic Gardens, Peradeniya," Vol. IV., pp. 21–68; it redescribed twenty species, which had been recorded under thirty-four names. The present contribution deals with fifty-three species, recorded under ninety-one names so far as Ceylon is concerned; it is most probable that other names have been bestowed on them in other countries. Attention may be specially directed to the fact that the generic name *Neomichelia* is antedated by Berkeley and Broome's *Pithomyces*, and that the Ceylon fungus which was included in Cooke's doubtful genus *Glaziella* is a *Hypocrella*.

21.—**Amanita hemibapha** Berk. & Broome.

Agaricus (*Amanita*) *hemibaphus* B. & Br., Linn. Trans., XXVII., p. 149, tab. 33*a*.

Pileus at first cylindric, then hemispherical, finally broadly campanulate or almost plane, convex, smooth, slightly viscid when moist; up to 11 cm. diameter; deep crimson in the centre, becoming paler outwards; with a broad, bright yellow, sulcate, tuberculate margin, sharply defined from the crimson centre; flesh pale yellow, reddish-orange beneath the cuticle, rather thick in the centre, very thin towards the margin. When dry, the pileus becomes orange-red, with the margin slightly paler but retaining the yellow colouration in the furrows.

Stalk yellow, silky-fibrillose, covered with adherent thin adpressed patches which have a reddish tint, slightly attenuated upwards, pointed at the base; flesh yellow; hollow, with diaphragms of white tissue ; 8 to 16 cm. high, 1 to 1·5 cm. diameter. Veil ample, dependent for about 2 cms., yellow, paler beneath, attached near the apex of the stalk, margin striate.

Gills pale yellow, distant, adnate, somewhat ventricose, up to 1·2 cm. broad, outer ends rounded. Spores white, broadly oval or subglobose, 8–11 × 6–7 μ, with a large gutta.

Volva cylindric or ovate, usually bilobed, rounded or pointed below, white, floccose, thick but soft, striate internally at the base, substance white ; up to 5 cm. high, 3 cm. diameter.

On the ground, among grass. A magnificent species, apparently rare. Found recently on two occasions in the same locality at Peradeniya. The pileus is convex, not obtusely umbonate as Berkeley and Broome state ; the margin is not evidently crenate, and the gills are not white. Recent specimens have been compared with Thwaites' original specimens and paintings.

The three figures in Linn. Trans., XXVII., pl. 33, are very poor reproductions of the original paintings. The convex outline of the pileus is altered to show an umbo which does not exist in the originals, and the clear crimson and yellow are represented by muddy colours which entirely fail to convey the beauty of the fresh specimens ; the stalk is too thin, and dirty white instead of yellow with reddish blotches ; and the volva is almost entirely brown instead of being white.

The original description is—" Pileo e campanulato expanso glabro obtusissime umbonato flavo, sursum coccineo, margine sulcato crenato ; stipite farcto (basi excepta attenuata), subæquali, pallide flavo, e volva crassa bilobata oriundo ; annulo supero deflexo striato lato ; lamellis albis segmentiformibus adnexis."

22.—**Amanitopsis endochorda** (B. & Br.) Petch.

" *Agaricus* (*Amanita*) *vaginatus Bull.*," Berk. & Broome in Fungi of Ceylon, No. 2, Journ. Linn. Soc., XI., p. 496.

A. (*Collybia*) *endochorda* Berk. & Broome, Fungi of Ceylon, No. 99, Journ. Linn. Soc., XI., p. 519.

A. (*Volvaria*) *geaster* Berk. & Broome, Fungi of Ceylon, No. 153, Journ. Linn. Soc., XI., p. 530.

Pileus 3 to 9 cm. diameter; at first campanulate, then expanded, the outer half usually horizontal, the remainder deeply depressed but obtusely umbonate in the centre; the horizontal margin regularly tuberculato-sulcate, brown or blackish brown, the depressed area glabrous, light brown, and the umbo dark brown; sometimes wholly purple gray or French gray; sometimes split almost to the centre; viscid when moist; flesh white, extremely thin except in the centre.

Stalk 10 to 18 cm. high, usually strongly attenuated upwards, 9 to 12 mm. diameter at the base, 4 to 5 mm. at the apex, rarely almost equal, lilac gray, purple gray or brownish, clothed with adpressed fibrils, the outer layers splitting irregularly and displaying transverse irregular white bands, but not forming scales, white at the base, brittle, hollow, stuffed with white shining fibres.

Volva white, narrow, loosely sheathing the stem, substance loose and rather thick, lobed, up to 3·5 cm. high, pointed below. Some specimens have an inner collar encircling the base of the stem within the volva.

Gills white, free but reaching almost to the stem, rather narrow, attenuated at either end or slightly rounded outwards, rather crowded; interstices veined. Spores white, globose, with a large apiculus, 10–12 μ diameter.

Thwaites' specimen No. 777 which was named *A. vaginatus* by Berkeley and Broome is uniformly purple gray; the stalk is more equal and shorter than usual, and the outer layer is not split. This form is rather rare. The common form was sent to Berkeley and Broome minus the volva (Thwaites' 703), and it differed so much from the unicoloured example that they did not realize the relationship, but named it *Collybia endochorda.* The painting of this shows the usual depressed centre and horizontal margin of the pileus, the former light brown and the latter blackish-brown, the change of colour occurring abruptly at the ends of the striations of the margin; it has the usual attenuated, transversely-zoned stalk. Berkeley and Broome state that *Collybia endochorda* grows on wood, and has the habit of *A. radicatus:* there is nothing to support either of these statements, either in the specimens or the figures. The specimen of *Volvaria geaster* was immature, so immature that

Thwaites thought it was a geaster until he cut it open ; from its colour and sulcate margin (as shown on the figure) I have no doubt that it must be assigned to the present species.

It differs from *Amanitopsis vaginata* Roze in the colouration of the pileus, the thin elongated stalk, and the globose spores. There are never any remains of the volva on the pileus, and the stem is not scaly. Professor F. von Höhnel, who saw fresh specimens at Peradeniya, agrees that it is distinct from that species.

23.—Lepiota zeylanica Berk.

Agaricus (*Lepiota*) *zeylanicus* Berk., Lond. Journ. Bot., VI., p. 480.

Agaricus (*Lepiota*) *theloides* Berk. & Br., Trans. Linn. Soc., XXVII., p. 150.

" *Agaricus* (*Lepiota*) *subclypeolarius* B. & C.," in Fungi of Ceylon, No. 9, Journ. Linn. Soc., XI., p. 497.

Agaricus (*Lepiota*) *rubicatus* Berk. & Br., Fungi of Ceylon, No. 10 (loc. cit.).

Agaricus (*Lepiota*) *inebriatus* Berk. & Br., Fungi of Ceylon, No. 11 (loc. cit.).

Pileus up to 11 cm. diameter, at first cylindric, then campanulate, finally conico-campanulate, or expanded and strongly obtusely umbonate, often repand ; centre smooth, dark brown, or yellow brown, or buff, elsewhere white covered with minute, sparsely scattered, brown scales ; innately radially silky ; margin strongly sulcate ; flesh thin, white.

Stalk 4 to 11 cm. long, 3 to 8 mm. diameter, subequal, white, or yellowish, becoming brown or reddish brown at the base and also when handled, covered with minute glandular (?) points, otherwise smooth or sometimes slightly silky, base slightly bulbous and sometimes tomentose, hollow, lined with white fibres, turning reddish when cut, especially towards the base. Ring movable, with a sheathing collar 2 or 3 mm. high and a horizontal or semi-erect, spreading, upper margin, white, or pinkish, or with a purple tinge.

Gills white, or pale yellow, reddish in decay, broadly ventricose, free, rather distant, attenuated behind.

Spores elliptic, 7–12 × 5–7 , white or pale yellow, reddish when in contact with the decaying pileus.

Common among grass and in flower beds at Peradeniya; often growing in rings.

This common species was named *Lepiota zeylanica* by Berkeley on specimens sent by Gardner. When it was afterwards sent by Thwaites, Berkeley did not at first recognize it, but published a new description under the name *Lepiota theloides* in a preliminary account of the Ceylon Fungi in the Transactions of the Linnean Society, Vol. XXVII., p. 150. This mistake was discovered before the publication of the complete list of Ceylon Fungi in the Journal of the Linnean Society, but the matter was there further confused by the division of Thwaites' No. 37 into *L. zeylanica*, *L. subclypeolaria*, and *L. rubicata*, while two other collections of the same species (Thwaites' 701, 780) were named *L. inebriata.* In addition, Thwaites' number 819 was said to be a small variety of *L. inebriata*, and Thwaites' 688 is the figure originally named *L. theloides.* We have the paintings of all these numbers; 37 is represented with yellow gills, while 688, 701, 780, 819 have white gills. Now the only distinction which can be made between these forms lies in the colour of the gills, but this character was not relied on by Berkeley and Broome. In the original descriptions, the colour of the gills of *zeylanica* is not stated; *theloides* and *inebriata* are said to have white gills, while *rubicata* is said to have yellow gills. But figure 37 which is named *zeylanica* in Berkeley's handwriting has yellow gills, and 688 which is named *theloides* has white gills, though the two names are, according to Berkeley, synonyms. Further, although figure 37 is cited by Berkeley and Broome as *L. rubicata*, it is marked by them *zeylanica.*

For the last three years I have endeavoured to separate one of these "species" on the basis of the colour of the gills, but I have been finally driven to believe that the difference in colour is merely a weather effect. In very wet weather, the gills are initially white, and then change rapidly (in less than twenty-four hours) to the reddish tint which all these "species" assume when decaying: with a smaller rainfall they are white at first, then pale yellow, and finally reddish; while in drier weather, they remain white for two or three days, and then turn reddish without any intermediate yellow stage. The last two of these changes have been observed in the same ring: in the specimens which came up first the gills turned yellow, but in those which came up one and two days later, when the rain had ceased, the gills were white and then reddish.

Another interesting phenomenon is often observed in this species. The stem is covered with minute points, and these often bear small drops of a red-brown liquid. It appears that this liquid must be exuded from the tissues, since it occurs on that part of the stem above the veil, before the veil is ruptured.

Lepiota subclypeolaria was originally described from Cuban specimens. There is nothing very distinctive in the description, but it was said to grow on dead wood. All that can be said about it here is that the Ceylon specimens attributed to *subclypeolaria* were undoubtedly *zeylanica*.

24.—Lepiota manicata B. & Br.

Agaricus (*Lepiota*) *manicatus* B. & Br., Trans. Linn. Soc., XXVII., p. 150, tab. 33*b*.

Pileus at first hemispherical, margin incurved, then broadly campanulate, convex, obtuse, apex sometimes flattened, 7 to 11 cm. diameter, fleshy; pale tawny, densely covered with readily detachable, soft, conical warts and silky flocci; margin strongly appendiculate with fragments of the veil up to 2 cms. long, which are tawny and floccose externally; flesh white, spongy, up to 1 cm. thick in the centre.

Stalk 13 to 16 cm. high, somewhat inflated at the base, then equal or slightly attenuated upwards, white below and rough there with minute white flocci, becoming tawny above and clothed with shaggy scales of long silky fibrils, densely crowded, and increasing in quantity up to the ring, in more or less annular superposed sheets; the diameter of the stem at the base is 1·5 to 2 cms., that of the actual stem at the "ring" or "muff" is about 1·2 cms., but it is increased to 2 cms. or more by the dense mass of scales; the stem therefore appears obconic, increasing in diameter up to the "ring" as in *Psalliota crocopepla* B. & Br.; the upper part of the stem, from the apex, is clothed with a white, soft, silky, fibrillose layer which slopes downwards and outwards over the lower tawny scales and forms the upper edge of the muff. The stem is white internally, solid, rather brittle, distinct from the flesh of the pileus, but not socketed.

Gills cream coloured at first, then white, up to 1·2 cm. broad, attenuated behind, somewhat ventricose, widely free, margin entire or crenate (on the same specimen). The intermediate gills in my fresh specimens are much narrower (only half the width) than the longer ones ; and in Thwaites' figure, they are only one-half to one-third the length of the longer. Spores white, globose, 7 to 8 μ diameter.

On the ground, Peradeniya. The smell is somewhat disagreeable, resembling that of new tan kid gloves.

There is a very good painting of three specimens in the Peradeniya herbarium, which agrees exactly with the specimens recently collected. The figure given by Berkeley and Broome, in Trans. Linn. Soc., XXVII., Pl. 33, Fig. *b.*, is entirely wrong in colour, and a very poor representation of the shaggy pileus and "muff."

25.—**Lepiota pyrrhaes** B. & Br.

A. (*Lepiota*) *pyrrhaes* B. & Br., Fungi of Ceylon, No. 51, Journ. Linn. Soc., XI., p. 508.

A. (*Lepiota*) *russoceps* B. & Br., Fungi of Ceylon, No. 53, Journ. Linn. Soc., XI., p. 508.

Pileus 2 to 3 cms. diameter, at first cylindric, then conico-campanulate, obtusely umbonate, margin often repand ; deep red-brown and smooth in the centre, elsewhere split into minute red-brown scales, reddish or orange-red between the scales : cuticle sometimes peeling off and showing a striate margin ; margin often appendiculate ; flesh thick below the umbo, white or faintly reddish.

Stalk 2 to 4·5 cms. high, 2 to 3 mm. diameter, slightly bulbous at the base, slightly attenuated upwards, reddish-white, red, or red-brown, fibrillose, or covered with red-brown scales below the ring, orange-red or orange and smooth above ; sometimes quite smooth and shining, without any ring ; hollow, white or orange-red internally, lined with white fibrils. Ring small, fragile, directed upwards, covered externally with red-brown scales. In the larger examples the stem is paler externally and internally than in the smaller.

Gills pale coffee coloured, broad (4 mm.), ventricose, free; spores white, elliptical, 5–7 × 3·5–4 μ.

On the ground, among decaying leaves, &c., usually gregarious.

Lepiota pyrrhaes is the form with a well-developed ring: *L. russoceps* is the same species without a ring, and without scales on the stem. But though Berkeley and Broome made this distinction in the descriptions, they failed to observe that one of the figures in the painting of *L. pyrrhaes* had a smooth ringless stem and matched exactly one of the figures of *L. russoceps.* Earth on which *L. pyrrhaes* was developing was brought into the laboratory and placed in a glass dish: the specimens which developed subsequently had smooth stems with no ring, and were undoubted *L. russoceps.* The veil of this species is covered with red brown scales, of the same colour as the umbo; when the stalk is lengthening, the veil is attached to the margin of the pileus, but sheathes the stem more or less loosely, and as it is pulled upwards along the stem these scales are left adhering to the latter. When, however, it develops in the constantly saturated atmosphere of a double glass dish, the veil separates from the stalk at the beginning of expansion, and forms a horizontal sheet, stretching from side to side of the pileus, with a central circular aperture through which the stalk passes. Therefore no scales are left on the stem, and the whole of the ruptured veil remains attached to the margin of the pileus. This ringless, smooth-stemmed form is *L. russoceps*, and is evidently due to weather conditions.

The name of this species as originally written on the figures is *L. pyrrhaces.* The published name, *L. pyrrhaes*, is probably due to an error of transcription.

In general appearance this species strongly resembles some of the paintings of *Lepiota citrophylla* B. & Br., but the latter has greenish-yellow gills. Apparently *L. citrophylla* was a common species in Thwaites' time, since five of his gatherings were given that name; but I have not been able to find it during the last four years.

26.—Lepiota leprica B. & Br.

A. (*Lepiota*) *lepricus* B. & Br., Fungi of Ceylon, No. 68, Journ. Linn. Soc., XI., p. 513.

A. (*Lepiota*) *pyrrhaes* B., & Br. in Herb. Perad. Icones 1163.*

Pileus 0·8 to 5·3 cm. diameter, broadly campanulate, then expanded and margin repand, obtusely umbonate; centre smooth, dark red-brown, sometimes split into closely arranged red-brown scales, elsewhere covered with flat red-brown scales, arranged more or less concentrically; in some cases the scales are fibrillose; white or pinkish and silky between the scales; margin sometimes appendiculate, not striate; flesh white, becoming reddish or pink, rather thick.

Stalk 1·5 to 5 cm. high, 1 to 5 mm. diameter, base slightly bulbous, almost equal, red below, white above at first, becoming pink when old, fibrillose and sometimes covered with red-brown scales below, silky and shining above the ring, hollow, lined with white fibrils; flesh reddish, especially towards the base. Ring small, evanescent, usually reddish beneath.

Gills white, ventricose, free but close to the stem, rounded at either end, rather distant. Spores white, oval, 4–6 × 2·5–3 μ.

On the ground among decaying leaves, &c.

This species was included under *Lepiota phlyctanodes* by Thwaites, but it is much smaller than the latter, and differs, *inter alia*, in the shape of the warts. Another gathering of the same species was included by Berkeley and Broome under *L. pyrrhaes*, with the note that it differed from that species in being "more strongly umbonate, the stem more scaly, the gills narrower, paler, and not so ventricose or rounded behind." It can be immediately separated from *L. pyrrhaes* by its white, not coffee coloured, gills, and the general pink tinge as contrasted with the orange-red colouration of the last-named. Berkeley and Broome state that the spores are "ninepin shaped," 12·5 μ long, but in the specimens in the Peradeniya herbarium the spores are oval, 4–6 × 3 μ.

Lepiota microspila B. & Br. is represented by a painting in the Peradeniya collection, but the name was not published in the "Fungi of Ceylon." The species was described by Cooke in Grevillea, XVI., p. 106. It resembles a large weathered specimen of *L. leprica*, but if the spores are 8–10 × 5 μ, as stated by Cooke, it does not belong to the latter species.

27.—Lepiota earochroa B. & Br.

A. (*Lepiota*) *earochrous* B. & Br., Fungi of Ceylon, No. 39, Journ. Linn. Soc., XI., p. 505.

A. (*Psalliota*) *erythrospilus* B. & Br., Fungi of Ceylon, No. 270, Journ. Linn. Soc., XI., p. 553.

Pileus 1 to 2 cm. diameter, conicocampanulate, or hemispherical, sometimes obtusely umbonate, frequently expanded and almost plane, smooth, blackish in the centre, elsewhere pink, mottled with deeper pink or red streaks and dots; flesh white, rather thick; margin faintly striate.

Stalk up to 2·5 cm. high, 1·5 mm. diameter, white, slightly fibrillose, turning brown when handled, hollow, white or brown internally. Ring small, erect, upper edge brown.

Gills free, ventricose, rather distant, deep pink becoming brown when decaying. Spores white, obliquely ovate, 6–7 × 4·5 μ.

On the ground, among decaying leaves.

Berkeley and Broome style the pileus "subconical, then convex," and "convex, subconical": these descriptions are taken from the paintings, but some of the herbarium specimens are obtusely umbonate; the same mixture occurs in recent collections. In both species they say that the pileus is pulverulent, but this is a misinterpretation of the red streaks on the pileus in the paintings. The figure of *Psalliota erythrospila* shows dirty brown gills, but the spores on the herbarium specimens are only faintly tinged with brown and have the same shape and size as those of *L. earochroa*. There seems no doubt that *Ps. erythrospila* is an old specimen of *L. earochroa.*

The same species is probably included under "*Lepiota granulosa* var. (No. 1149 cum icone)." This name appears to have been a convenient dumping ground for small Ceylon forms belonging to several species.

28.—**Lepiota phlyctanodes** B. & Br.

A. (*Lepiota*) *phlyctanodes* B. & Br., Fungi of Ceylon, No. 24, Journ. Linn. Soc., XI., p. 501.

Pileus up to 6 cm. diameter, conicocampanulate, then almost plane, often strongly repand, undulating, obtusely umbonate, pinkish brown or pale brown in the centre, shading off to pink or white at the margin, thickly covered with brown or reddish-brown, conical, rather hard warts, slightly fibrillose between the warts ; margin not striate. Flesh rather thick, white.

Stalk up to 8 cm. high, equal or attenuated upwards, 3 mm. to 1 cm. diameter at the base, 3 to 6 mm. at the apex, externally white or pink, fibrillose, scaly or streaked with brown near the base, striate and silky at the apex, hollow, lined with shining white fibrils, white internally when fresh ; base truncate ; pale yellow-brown when old. Veil ample, dependent, white, striate, with a brown warted margin which sometimes forms a thick warted collar on the stem ; in one specimen the veil was chiefly arachnoid with a long tangle of fibres on the stem.

Gills free, narrow, crowded, white then cream coloured, rounded or attenuated behind, edge slightly irregular. Spores white, narrow-oval, 4–7 × 3 μ.

On the ground among decaying leaves.

The typical form of this species is described under the name *L. phlyctanodes*. *L. leontoderes* appears to be a weathered specimen with most of the warts washed off the pileus, and the colour of the pileus and stem changed to yellow brown.

Thwaites' No. 1173*, which has a striate margin, is covered with small brown *scales*, and is cylindrical when young, was considered by Berkeley and Broome to be a variety of *L. phlyctanodes*. It is without doubt a small specimen of *L. zeylanica*.

29.—**Lepiota cepæstipes** Sowerby.

A. (*Lepiota*) *cepæstipes* Sow., in B. & Br., Fungi of Ceylon, No. 19, Journ. Linn. Soc., XI., p. 499.

Gregarious, sometimes connate at the base. Pileus at first ovate, apex flat, then conicocampanulate, finally plane, sometimes slightly umbonate, up to 9 cms. diameter ; centre brown, or deep yellow, with a few small warts or scales, elsewhere pale yellow with a few small brown-tipped scales towards the centre, mealy or floccose along the ridges; strongly plicato-sulcate almost to the centre; flesh thin; margin membranous.

Stalk up to 6 cm. high, strongly inflated below, contracted at the base, attenuated rather suddenly at about half its height, up to 1·2 cm. diameter near the base, and 6 mm. diameter at the apex, pale yellow, powdered with minute yellow granules or flocci, with a few brown scales at the base; solid below, hollow above; flesh yellow, interior of cavity white; base truncate. Ring white or yellow, fragile, free, evanescent.

Gills pale yellow, narrow, not crowded, free, interstices veined. Spores *white*, broadly oval or subglobose, 5–7 × 4–5 μ.

On footpaths; in flower beds, &c.; often in dense clusters with large numbers of immature examples springing up close to the bases of the expanded specimens; the mycelium consists of rather thick white rooting threads. Young specimens are hour-glass shaped, the diameter of the flat-topped, ovate pileus being approximately equal to that of the inflated base.

There seems little doubt that this is identical with the species found in greenhouses in Europe. The lower left-hand figure in Cooke's Illustrations, Pl. 5, gives the shape of the base of the stem of the immature Ceylon form, but that of the pileus does not fit; further, the Ceylon specimens are never white, are not so brown as in Cooke's figures, *are not so strongly umbonate*, and are much more strongly plicato-sulcate. The last difference is probably due to their greater expansion, since they become plane, or nearly so. The description in Saccardo, Syll. Fung., Vol. 5, p. 43, is "Pileo submembranaceo, ex ovato explanato, farinoso et flocculis plumosis secedentibus squamoso, disco carnuloso, late umbonato, margine plicato; stipite cavo, bulboso, floccoso: annulo secedente; lamellis demum remotis, *albis*": this fits the Ceylon form except in the colour of the gills. The spores are said to be 8 × 5 μ, and Saccardo adds the note that it is near *Hiatula.* This comment is completely justified by the Ceylon examples: it would stand almost as well in *Hiatula* as in *Lepiota*, though there are so many Ceylon species which link the two genera that a distinct line can hardly be drawn.

The descriptions in Massee, British Fungus Flora, state that the flesh is thin, the margin semi-transparent, gills whitish with a yellow tinge; whole plant white, sulphur yellow or yellow; disc often brownish; spores elliptic, 7–8 × 4 μ.

But the above views of what constitutes Sowerby's *Agaricus cepæstipes* are apparently not held in all quarters. F. S. Earle, in Bull. New York Bot. Gard., V., No. 18, p. 448, proposes a new genus, *Mastocephalus*, taking as the type *L. cepæstipes* (Sow.), and gives as characters of the genus, "Pileus fleshy, stipe peronate." But the pileus of *L. cepæstipes*, as understood in Ceylon, and apparently also in Europe, is certainly not fleshy, but rather membranous; and the stalk is mealy, but not peronate. If *Lepiota cepæstipes* is removed from the genus *Lepiota*, it can only be transferred to *Hiatula*.

30.—**Hiatula licmophora** (B. & Br.) Petch.

Agaricus (*Lepiota*) *licmophorus* B. & Br., Fungi of Ceylon, No. 20, Journ. Linn. Soc., XI., p. 500.

Pileus 2·5 to 3 cm. diameter, plane, or repand, radially plicato-sulcate almost to the centre, which consists of a slightly convex disc 3 to 5 mm. diameter: disc pale brown or greenish-yellow, smooth; crests of the ridges clothed with sulphur-yellow or greenish-yellow flocci; between the ridges, hyaline, somewhat transversely wrinkled; flesh none except in the central disc.

Stalk 6 to 9 cms. high, attenuated upwards, about 2 mm. diameter at the base, 1 mm. diameter at the apex, very pale greenish-yellow with a few flocci, or white and almost glabrous, sunk into the central disc, hollow, white internally; ring about two-thirds the length of the stalk from the base, small, evanescent, yellowish.

Gills white, transparent, narrow, equal, nearly all reaching and attached to the central yellow disc surrounding the apex of the stalk. Spores broadly oval with an obtuse papilla at the distal end and an apical apiculus at the other, thus appearing biapiculate, or rather limoniform, white, 11–13 × 7–8 μ.

On the ground, among grass. Peradeniya.

This species affords a striking parallel, in yellows, to the brown Ceylon *Coprinus* which was attributed to *Coprinus plicatilis* Fr. In Cooke's Illustrations of British Fungi, Pl. 1179, copies of the original paintings of the Ceylon species by W. de Alwis occupy the upper right- and left-hand corners. Both are represented as sulphur-yellow throughout, but in the original of the left-hand figure, the pileus is brownish-yellow in the centre, greenish-yellow along the ridges, and white in the furrows, while the stalk is white with a tinge of greenish-yellow; and in the original of the right-hand figure, the gills and interior of the stalk are white. Further, the pileus in the original is plicato-sulcate up to the disc, while in the copy it appears to have little more than a striate margin; and the attachment and shape of the gills are also reproduced incorrectly. The remainder of the figures on this plate resemble the Ceylon species which was attributed to *Lepiota cepæstipes* much more than *Lepiota licmophora*. They are certainly not the latter species.

The description of *Lepiota licmophora* in Massee, British Fungus Flora, Vol. III., p. 247, states that it is entirely pale lemon yellow, that it is distinguished from *L. cepæstipes* by the glabrous pileus, and is perhaps only a variety of the last-named species. But it is not entirely lemon-yellow and has not a glabrous pileus. In all probability the species discovered in hot houses in England is not *L. licmophora*; an examination of the spores would decide the question.

It seems probable that *Hiatula licmophora* is identical with *Leucocoprinus flavipes* Pat. (*Hiatula flavipes* Pat., Saccardo, Sylloge Fungorum, IX., p. 40) and *Hiatula fragilissima* Berk. and Rav.

31.—**Armillaria asprata** Berk.

Agaricus (*Armillaria*) *aspratus* Berk., Lond. Journ. Bot., VI., p. 481.

Lepiota asprata Berk. in Saccardo, Syll. Fungorum, V., p. 48.

This species was sent to Berkeley by Gardner in 1844. Subsequently Thwaites sent specimens and paintings which were referred to *Armillaria asprata* by Berkeley and Broome. Berkeley apparently received it also from Carolina, collected by Curtis, but attributed to Mueller in " Fungi of Ceylon." In "Saccardo" it is said to have been collected also in Australia by Beckler. I have not been able to ascertain why it is listed in " Saccardo " as *Lepiota.* It is possible that these collections are not all the same species ; the following description is drawn up from fresh specimens which agree with the figures named by Berkeley and Broome.

The young unexpanded specimens are orange-red, covered with conical orange-red warts, after the manner of *Lycoperdon echinatum.* When expanded, the pileus is 3·5 to 5 cms. in diameter, almost plane, depressed in the centre, margin incurved, pale yellow covered with orange-red conical warts which are large and close-set in the centre and diminish in size towards the margin ; the margin is slightly floccose. The flesh is white and somewhat spongy. The stalk is 3·5 to 5·5 cm. high, 4 mm. diameter, equal, expanding into the pileus, usually curved at the base, covered with floccose down up to the apex, orange below, becoming pale yellow above, stuffed then hollow. The veil is more or less arachnoid, and is not evident after the expansion of the pileus. The gills are white, broad (up to 6 mm.), somewhat ventricose, rather distant, broadly adnate with a small decurrent tooth, or shortly decurrent. The spores are white, subglobose, 7–8 × 5–6 μ.

Gardner's specimens were said to grow on the ground, but Thwaites' examples are figured growing on wood. I have always found it on wood.

32.—**Oudemansiella apalosarca** (B. & Br.) von Höhnel.

Agaricus (*Collybia*) *apalosarcus* B. & Br., Fungi of Ceylon, No. 101, Journ. Linn. Soc., XI., p. 520.

Agaricus (*Collybia*) *magisterium* B. & Br., Fungi of Ceylon, No. 102, Journ. Linn. Soc., XI., p. 520.

Agaricus (*Collybia*) *euphyllus* B. & Br., Fungi of Ceylon, No. 103, Journ. Linn. Soc., XI., p. 520.

Phæolimacium bulbosum P. Henn., Monsunia I., p. 14.

Pluteus macrosporus P. Henn, Monsunia I., p. 155.

Oudemansiella apalosarca (B. & Br.) v. H., Fragmente zur Mykologie, No. 170.

Pileus up to 10 cms. diameter, at first hemispherical, then broadly convex, or almost plane, covered with a thick layer of mucus which sometimes appears reticulated, pale brown, or grayish brown, or livid gray, or white, usually dark brown in the centre, somewhat translucent ; in drier weather the pileus is glabrous, not viscid ; margin smooth, appearing striate when very moist, sulcatostriate when old and dry, slightly incurved at first ; flesh white, up to 5 mm. thick in the centre, thin towards the margin, subgelatinous and translucent when moist, white and spongy when dry. Gills white, becoming cream coloured or brownish when old, appearing pulverulent owing to the large spores, ventricose, narrowed at both ends, of two to four lengths, up to 1 cm. broad, the longer adnate with a decurrent line on the stem, sometimes sinuate behind, the shorter often abruptly truncate behind ; edge entire or crenate, sharp or blunt, up to 0·5 mm. thick or more ; covered with cystidia, either flask-shaped, 120 to 150 μ long, 35 to 40 μ diameter below, narrowing to 10 μ diameter about half way up, or fusiform, 40 μ diameter in the middle, diminishing regularly above and below, thin walled, apex rounded. Stalk usually curved, solid, equal, or slightly attenuated upwards, sometimes slightly excentric, up to 8 cm. long, 3 to 6 mm. diameter in the middle, expanding at the apex and sharply defined from the tissue of the pileus, white, shining, somewhat cartilaginous, feebly hoary with adpressed fibrils, ribbed towards the apex, usually rough with scattered, coarse, white scales towards the base ; internally white and fibrous ; base expanded, sometimes bulbous, truncate, with a thin root arising from the centre and penetrating the wood. Spores spherical, with a short cylindrical apiculus, white, 17 to 24 μ diameter : basidia about 60 μ long, 15–20 μ wide towards the apex, inflated upwards.

This species is fairly common on erect, dead, or dying tree trunks, *e.g.*, nutmeg and mango, and is most probably parasitic. It resembles an *Armillaria*, but lacks a ring, and the stalk is distinct from the pileus. Its general diaphanous appearance recalls *A. mucida.* Young specimens (5 mm. diameter) are usually dark brown, studded with minute white fragments of the thin universal veil. In " Revisions of Ceylon Fungi " (Ann. Perad., IV., p. 33, *et. seq.*) it was stated that owing to the peculiar character of the gills, this species might possibly be related to *Oudemansiella.* The features there referred to, however, are not constant. The edges of the gills may be either sharp or blunt, and when blunt they are generally crenate, but in many cases they do not present any peculiarity. In some specimens, however, the edge is quite different. The gills normally are white, while the trama is subgelatinous and translucent. In these abnormal specimens, the white layers of basidia on either surface of the gills do not meet over the edge, but are separated by a narrow line of the tramal tissue. Consequently, on looking at the edge one sees a central translucent band bordered on each side by the white edge of the hymenium. The hymenial layer curves round on the stalk and unites with that of the adjacent lamella ; consequently the translucent line widens and ends in a triangular patch behind. Further, the white line of rather loose tissue, which generally runs down the stem from the gill in the normal form, begins in these cases on the thick edge of the gill about midway between the margin of the pileus and the stalk, and runs along the middle of the translucent band up to and down the stalk. But in no case is the edge of the gill furrowed.

A further variation consists in the presence of rather large, thin, triangular sheets of loose, white tissue, hanging from the edges of the gills or the margin of the pileus. This tissue appears to be of the same texture as the lines on the upper part of the stalk : the latter run in continuation of the gills, but they are not of the same texture as the gills, being much looser and non-gelatinous.

Rick has stated that *Oudemansiella platensis* Speg. is a *Mycena* parasitized by a *Phycomycete ;* and it has been suggested that the abnormal forms of the Ceylon species are due to the same cause. But I can find no evidence to support this view. It is certain that the exposure of the trama along the edges of the gills is due to weather conditions, *i.e.*, is caused by the absorption of moisture by the subgelatinous inner tissues, and it seems probable that the occurrence of triangular flocci on the gills is due to an abnormal growth of the tissue which forms the lines on the stem, possibly under the same circumstances (see *Oudemansiella subaurantiaca*).

Thwaites' painting of *Collybia apalosarca* shows a greyish brown pileus, 4 cm. in diameter, darker in the centre: it is apparently striate nearly to the centre, owing to the lines of insertion of the gills being seen through the translucent pileus; the gills are white, about 7 mm. broad, adnate in the section, but continued in a line down the stem in the view of the under surface: it is marked, in Thwaites' handwriting, "very tender, and the gills somewhat crenate on the margin." The figure of *Collybia magisterium* is white, with a pileus 11·5 cm. diameter, and gills 1 cm. broad; the expanded base of the stalk has a conical projection on the under side, which indicates the thin root; the figure is marked "soft and tender: gills serrated." The figure of *Collybia euphylla* has a yellow-brown pileus, 4 cm. diameter, and gills 1 cm. broad, turning brown along the margin; they are fringed with the fragments of tissue previously mentioned. The herbarium specimens of all these have been examined, and there is no doubt that they are all the same species.

This species was found by von Höhnel in Java, and the question of its identity is exhaustively discussed by him in Fragmente zur Mykologie No. 170. The description there given agrees with that detailed above. From an examination of the original specimens, von Höhnel has found that *Phæolimacium bulbosum* P. Henn. and *Pluteus macrosporus* P. Henn., both from Java, are identical with the present species. Whether *Oudemansiella platensis* Speg. is also the same species appears to him to be doubtful. The synonyms determined by von Höhnel are quoted above, in addition to those recorded in Revisions of Ceylon Fungi, Part I.

Berkeley and Broome state (*loc. cit.*) that *C. apalosarca* is "undoubtedly allied to *A. magisterium*," and that *C. euphylla* is "a miniature form of *A. magisterium*." The spores are said to look "like a magisterium;" the latter is I believe the receiver of a retort. *Collybia cubistes* B. & Br. is also said by its describers to be "allied to *A. magisterium* and *A. euphyllus*;" the figure looks quite different, and apparently shows a hollow stalk, but unfortunately there is no specimen in the Peradeniya herbarium, and therefore the evidence of the spores and cystidia is not available.

Mucidula alphitophylla (Berk. & Curt.) Pat. [*Agaricus* (*Mycena*) *alphitophylla* B. & C. : *Agaricus* (*Mycena*) *leucoconis* B. & C.] appears to be very near, if not identical with, the present species. Patouillard (Bull. Myc. Soc. France, XXV., p. 9) states that it is " Entièrement blanc pur, parfois fauve plus ou moins bistré ou légèrement rosé. Chapeau lisse, non ecailleux, convexe, visqueux ; lames larges, épaisses, distantes, inégales, pulvérulentes par une couche plus ou moins épaisse de spores ; basides volumineuses, 60 × 15 μ ; spores globuleuses, lisses, 18–21 μ de diamètre, avec une grosse goutelette brillante ; cystides fusiformes, 120–250 × 40–50 μ. Stipe central ou excentrique, droit ou courbé, sans anneau, parfois strié au sommet, glabre sauf à la base qui est villeuse et un peu renflée."

33.—**Oudemansiella subaurantiaca** (B. & Br.) Petch.

Marasmius subaurantiacus B. & Br., Fungi of Ceylon, No. 363, Journ. Linn. Soc., XIV., p. 36.

Marasmius ignobilis B. & Br., Fungi of Ceylon, No. 390, Journ. Linn. Soc., XIV., p. 40.

Marasmius confusus B. & Br., Fungi of Ceylon, No. 391, Journ. Linn. Soc., XIV., p. 40.

Thwaites made two gatherings of this species, Nos. 100 and 397. He illustrated them by two figures, both on the same sheet. The fungus grows in two forms, which occur together indiscriminately; in one form it is orbicular, and the stalk is more or less excentric; in the other it is circular, and the stalk is central; the latter form often grows in clusters from a swollen base. Thwaites' figures give the first form only. Berkeley and Broome divided them into two species, naming the central-stalked, clustered form, *Marasmius subaurantiacus*, and the excentric-stalked, orbicular or reniform examples, *M. ignobilis*. This species grows on small branches, *M. aurantiacus* usually on the upper surface, and *M. ignobilis* curving up from the under surface : the stalks of the latter, being in contact with the soil, soon decay, and leave the pileus lying on the ground near the stick or adhering to other pilei. Thwaites included specimens of these damaged examples in his gathering, and these were separated as *M. confusus*. The type specimens of all these, and the drawings of *Marasmius ignobilis*, are in the Peradeniya herbarium, and the species has been found recently on several occasions. It is easy to ascertain, after the herbarium specimens have been soaked, that *Marasmius confusus* is not a resupinate species, as stated by Berkeley and Broome, but a stalked species whose stalk has been broken off. In describing *Marasmius ignobilis*, Berkeley and Broome quote Thwaites' numbers 100 and 396 ; this is an error ; the figure and specimen of 396 are *Laschia pustulata*, while the figures and specimens of *Marasmius ignobilis* are labelled 100 and 397. *Marasmius confusus* is "397 in part," and *M. subaurantiacus* is "100 and 397 in part." As the fungus is pure white, the enforced adoption of the earliest name is most unfortunate.

The pileus is white, somewhat translucent, thin except over the stalk, orbicular or circular, convex, or hemispherical, radially sulcate, usually depressed over the stalk, up to 1·5 cm. diameter in the circular, central stalked forms, or up to 3 × 2·5 cms. in the orbicular excentric forms. The internal tissue of the pileus absorbs moisture, and is subgelatinous when moist. When grown on sticks piled up under a bell glass the specimens near the ground are translucent, while those which develop from the sticks at the top of the pile are dead white, but become translucent when moistened. All the latter examples have central stalks.

The stalk is white, shining, translucent when moist, glabrous, somewhat pruinose when dry, inflated and tomentose at the base, usually expanding also at the apex, stuffed, central or excentric or almost lateral, from 1 to 3 cms. long, 0·5 to 1·5 mm. diameter, erect in the central-stemmed forms, but strongly curved, often S-shaped, in the excentric forms, solitary or arising in clusters from a swollen tubercle.

The gills are numerous, broad (3 to 4 mm.), arcuate, sometimes ventricose, adnate, or shortly decurrent, white, much crisped when old, sometimes forked, interstices veined, edge thick when moist, thin when dry. The hymenial layer is continued from gill to gill over the surface of the stalk, and hence the gills separate from the stalk in a pseudo-collar when old. The spores are white, broadly oval, 10–14 × 7–8 μ, with some globose spores 6 μ diameter. Cystidia not found.

When decay sets in, the pileus becomes pale ochraceous or brownish; hence Berkeley and Broome's name "*subaurantiacus*," which was derived from the dried specimen. The colour of "*ignobilis*" was taken from the figure, and therefore is more correctly given as "*albidus*." The specimens which develop in dry situations have some resemblance to *Marasmius*, but it is evidently too readily putrescent to be included in that genus. Nor can it be placed in the problematic *Heliomyces*. I have included it, somewhat doubtfully, under *Oudemansiella*. It has exactly the structure of *Oudemansiella apalosarca*, agreeing in the following points. It has a fibrillose universal veil. The internal tissue of the pileus is subgelatinous when moist, hence it is translucent or opaque according to weather conditions. The hymenium is continuous from gill to gill over the stalk. The gills have a thin edge when dry, but if they are moistened the tramal tissue absorbs moisture and the hymenial layers on either side of the gill separate; they then have thick edge with a translucent line of subgelatinous tissue along the middle; this corresponds exactly with the formation of the thick edge of the gill in *Oudemansiella*. It differs from *Oudemansiella*, as redefined by von Höhnel, in the shape of its spores; but it is questionable whether the shape of the spores, in agarics, is of generic importance.

34.—**Omphalia anthidepas** B. & Br.

A. (*Omphalia*) *anthidepas* B. & Br., Fungi of Ceylon, No. 137, Journ. Linn. Soc., XI., p. 527.

Hygrophorus prasinus B. & Br., Fungi of Ceylon, No. 320, Journ. Linn. Soc., XI., p. 563.

Cantharellus stolonifer B. & Br., Fungi of Ceylon, No. 341, Journ. Linn. Soc., XI., p. 567.

Thwaites' 751 was sent with two drawings, one representing the mature fungus and the other a young stage; the former was named *Omphalia anthidepas*, and the latter *Cantharellus stolonifer*. *Hygrophorus prasinus* is a different gathering, but the drawing is a good representation of the immature form, rather more vividly coloured than that which was named *Cantharellus stolonifer*.

The pileus is 2 to 6 cms. diameter, almost plane with a decurved margin at first, then deeply umbilicate with a plane or strongly decurved margin, or sometimes entirely infundibuliform with the margin recurved. In one instance, of two large specimens, connate at the base, one was infundibuliform with a recurved margin, while the other was hemispherical and *umbonate*. The general colour of the whole fungus is greenish yellow, sometimes pale yellow, sometimes almost white, more highly coloured when young, becoming yellowish white in large specimens when full grown. The pileus is thin, radially sulcate when mature, streaked with radial lines of blackish-brown fibrils, blackish in the centre. Some young specimens are so closely streaked that they appear quite black.

The stalk is 2 to 4·5 cm. high, 2 to 4 mm. diameter, greenish yellow, or pale yellow, or white, usually streaked with blackish fibrils or covered with minute black points, but sometimes wholly white ; it is equal, slightly expanded and truncate at the base, stuffed, then hollow, sometimes tomentose at the base.

The gills are greenish yellow, pale yellow, or white, strongly decurrent, rather distant, broad, somewhat arcuate, interstices veined. The spores are white, oval, 6–8 × 4–5 μ.

Specimens of medium size are usually greenish yellow. Large specimens are pallid yellow, and their gills are often white with a yellow tinge near the stalk. In drier weather the stalk and gills are quite white. The figures which Berkeley and Broome named *Omphalia anthidepas* are pallid yellow with a strongly streaked pileus ; the gills are pallid yellow, but the stalks are almost white ; a note by Thwaites written across the figure states " Gills sometimes more yellow." These figures also illustrate the variation in shape ; one is deeply umbilicate with the outer half decurved, another is almost plane and slightly umbonate, while the third, which is shown in section, is plane. The figure of *Hygrophorus prasinus* shows a young specimen with the pileus not fully developed, everywhere yellowish-green ; that of *Cantharellus* *stolonifer* has a rather thicker stalk than usual, in proportion to the size of the pileus, but it is matched in this respect by specimens recently collected.

This species grows in rubbish heaps, often on sticks. It is fairly common on fallen nuts, which it covers with a white film of mycelium or with rather coarse white cords. These white cords are shown in the figure of *Cantharellus stolonifer*, together with the "reproductive knots" mentioned by Berkeley and Broome. It is probable that these irregular white bodies are merely pieces of vegetable matter enclosed by a film of mycelium.

35.—**Clitocybe anomologa** (B. & Br.) Petch.

Agaricus (*Amanita*) *anomologus* B. & Br., Fungi of Ceylon, No. 3, Journ. Linn. Soc., XI., p. 496.

Pileus 3·5 to 5 cm. diameter, almost plane, obtusely umbonate or depressed in the centre, margin usually decurved; blackish-olive in the centre, becoming paler greenish-olive towards the margin, sometimes streaked with radial blackish lines; cuticle separable, strongly viscid or glutinous when moist, puckered in minute areolæ when dry; margin striate beneath the viscid layer; flesh thin, white, soft, brownish just beneath the cuticle when cut.

Stalk 3·5 to 6 cm. high, attenuated upwards, or nearly equal, 4 to 6 mm. diameter, white, silky striate above, stuffed, sometimes slightly glutinous in the middle (? from the pileus) but never entirely glutinous; base slightly fibrillose.

Gills arcuate, white at first, then pale yellow, rather narrow, somewhat distant, adnexed, separating when old. Spores white, pale yellow when shed in contact with the pileus, globose, 3 to 4 μ diameter, or oval, $3 \times 4 \mu$, marked with scattered warts.

On the ground, among dead leaves. Has a strong smell of meal.

There is no sign of a volva, even in specimens only 3 mm. high, and apparently the gluten is derived entirely from the surface of the pileus. The stem is sometimes almost solid.

36.—**Collybia clara** B. & Br.

Agaricus (*Collybia*) *clarus* B. & Br., Fungi of Ceylon, No. 108 bis, Journ. Linn. Soc., XI., p. 522.

Pileus up to 3·5 cm. diameter, broadly convex, depressed or feebly umbilicate in the centre, glabrous, pallid yellow, thin, tough ; cuticle cartilaginous : margin hygrophanous, even, faintly striate when moist. Flesh white.

Stalk up to 3·5 cm. high, equal, 2–4 mm. diameter, pallid yellow, almost white, glabrous, often compressed, externally cartilaginous, stuffed then hollow, white internally ; base white and slightly tomentose.

Gills crowded, narrow, white, adnate or slightly decurrent ; spores white, globose or broadly oval, 4–5 × 4 μ.

Among roots of palms, either in the soil or attached by mycelium to the roots ; Peradeniya.

No figure of this was sent to Berkeley and Broome, and therefore the colours given by them are merely those of the dry specimens, *i.e.*, " pileo fulvo " and " lamellis flavis." The description and figure of *Collybia verticolor* suggest that the latter is the same species, but the specimens of it in the Peradeniya herbarium have an excentric stalk. The latter fact is not mentioned in the description of " *Collybia verticolor*."

37.—**Chitoniella trachodes** (Berk.) Petch.

A. (*Psalliota*) *trachodes* Berk. London Journ. Bot., VI., p. 487.

A. (*Psalliota*) *pedilius* B. & Br., Fungi of Ceylon, No. 344, Journ. Linn. Soc., XIV., p. 32.

A. (*Psalliota*) *poderes* B. & Br., Fungi of Ceylon, No. 345, Journ. Linn. Soc., XIV., p. 32.

Chitonia pedilia (B. & Br.) Sacc., Syll. Fungorum, V., p. 992.

Chitonia poderes (B. & Br.) Sacc., Syll. Fungorum, V., p. 992.

Chitoniella poderes (B. & Br.) P. Henn., Engler-Prantl., Naturl. Pflanzenfam., 1898, p. 240.

In the account of this species published in the Annals of Peradeniya, Vol. IV., pp. 113–122, Hennings' name was adopted ; it was written in 1906, before the present rules of nomenclature had been applied to fungi, and therefore de Candolle's rule was followed. The adoption of the earliest specific name requires an alteration to *Chitoniella trachodes.*

38.—Psathyra ctenodes (B. & Br.) Petch.

Agaricus (*Psathyrella*) *ctenodes* B. & Br., Fungi of Ceylon, No. 296, Journ. Linn. Soc., XI., p. 558.

"*Agaricus* (*Psathyrella*) *disseminatus* P.," in B. & Br., Fungi of Ceylon, No. 297, Journ. Linn. Soc., XI., p. 558.

Gregarious, densely crowded, on the ground or on decaying wood; often in large patches covering several square feet.

Pileus cylindrical or cylindrico-companulate, the apex usually regularly rounded but sometimes obtusely umbonate, 8–10 mm. high, 6–13 mm. diameter, membranaceous, ivory-white, becoming grayish-white, ochraceous in the centre, regularly plicato-sulcate up to the circular smooth centre, sparsely covered with minute spreading hairs; margin crenate. Stalk up to 2·5 cm. high, 1 to 2 mm. diameter, slightly attenuated upwards, often curved, swollen at the base, translucent, hollow, minutely hairy with spreading hairs, fibrillose at the base or strongly strigose in protected situations. Gills rather broad (2 mm.), distant, usually of two lengths, broadly adnate, sometimes slightly decurrent, white, then pale purple or violet. Spores purple-brown in mass, brown when magnified, oval, 5–8 × 3·5–4·5 μ.

The specimens which were named "*Psathyrella ctenodes*" and "*Psathyrella disseminata*" constituted Thwaites' number 942. He sent two drawings, one of which shows the umbonate form; this was named *ctenodes*, while the one with the rounded apex was referred to *disseminata*. There seems to have been no attempt to separate the herbarium specimens; the sheet numbered 942 in Herb. Peradeniya is labelled "*Ag.* (*Psathyrella*) *disseminatus*" in Berkeley's handwriting, though it contains at least one of the specimens from which the drawing of *ctenodes* was made. This species has the same habit as *Psathyrella disseminata*, but it differs in being more cylindric, white, and clothed with minute, scattered, spreading hairs.

39.—Psathyrella achnoa B. & Br.

A. (*Psathyrella*) *achnous* B. & Br., Fungi of Ceylon, No. 292, Journ. Linn. Soc., XI., p. 557.

A. (*Psathyrella*) *auctus* B. & Br., Fungi of Ceylon, No. 295, Journ. Linn. Soc., XI., p. 558.

These two species constituted Thwaites' 774. The figure of *achnous* is also marked *auctus* var. *achnous ;* apparently Berkeley and Broome named *auctus* first, but they published the names in the order given above. The specimens named *achnoa* had lost the scales which characterize *aucta*.

On decaying twigs and leaves ; gregarious ; often connate at the base.

Pileus at first conical, then broadly conico-campanulate with a reflexed margin, up to 2·5 cm. diameter and 1·5 cm. high, membranaceous, white, becoming pale lavender, but constantly white at the apex ; clothed at first with minute, white, pointed, fibrillose scales which disappear leaving the pileus slightly atomate, smooth, appearing faintly radially striate up to the white apex when moist ; margin at first fimbriate with white flocci, afterwards incised. The white apex is accentuated in Thwaites' figures and appears to be a papillæform umbo, but this is not noticeable in fresh specimens. Stalk up to 6 cm. long, 2 mm. diameter, equal, white, shining and slightly mealy above, clothed with rather coarse white flocci below, hollow, white internally. Gills adnexed, ascending, distant, rather broad (4 mm.), rounded below and visible below the margin of the pileus, attenuated upwards, white, then lavender, finally blackish-violet. Spores narrow-oval, slightly inequilateral, 12–14 × 6 μ, dark violet-brown when magnified, violet-black in mass, with a minute hyaline apiculus and a hyaline cap at the distal end.

40.—**Coprinus macropus** B. & Br.

Coprinus macropus B. & Br., Fungi of Ceylon, No. 307, Journ. Linn. Soc., XI., p. 560.

"*Coprinus fuscescens* Fr.," in B. & Br., Fungi of Ceylon, No. 302, Journ. Linn. Soc., XI., p. 559.

"*Coprinus extinctorus* Fr.," in B. & Br., Fungi of Ceylon, No. 305, Journ. Linn. Soc., XI., p. 559.

Gregarious, often connate at the base ; usually round old decaying stumps.

Pileus ovate, then conical, finally broadly conico-campanulate, obtuse, covered at first with a thick, whitish, floccose layer which often forms a smooth cap over the apex, glabrous when old; centre livid brown, elsewhere ashy brown or whitish, becoming darker with age; striate almost to the centre when old; margin striate, finally recurved; up to 7 cm. broad, and 4·5 cm. high; flesh thin.

Stalk, up to 16 cm. long, 4 to 12 mm. diameter, almost equal or slightly attenuated upwards, white, longitudinally fibrillose, sometimes squamulose, hollow, base generally not swollen. Gills slightly adnexed, narrow (3 mm.), attenuated outwards, rather crowded, white, then purple-brown. Spores deep purple-brown in mass when moist, dark-brown when magnified, oval, slightly truncate at one extremity, rounded or pointed at the other, 8–9 × 5 μ. Deliquescent.

There are three drawings of this species in Herb. Peradeniya. One, which shows a small specimen, partly retaining the floccose layer, was named *Coprinus extinctorius* by Berkeley and Broome; another, which shows two larger, connate, glabrous specimens, was named *Coprinus fuscescens;* the third, which shows two, still larger, connate specimens, one of which has a recurved margin, was labelled *Coprinus macropus*, with the alternative name "*Ag.* (*Psathrya*) *spadiceogriseus* Schæff." The specimens which furnished the last two drawings were not preserved; there is a specimen of "*C. extinctorius.*" The thick cottony covering of the pileus removes the possibility of its being *C. fuscescens*, and it lacks the rooting swollen base of *C. extinctorius.*

41.—**Coprinus microsporus** B. & Br.

Coprinus microsporus B. & Br., Fungi of Ceylon, No. 304, Journ. Linn. Soc., XI., p. 560.

Coprinus rubecula B. & Br., Fungi of Ceylon, No. 308, Journ. Linn. Soc., XI., p. 560.

Coprinus rubecula would be the more appropriate name for this species, but *microsporus* has half a page priority. We have paintings of both species, but the specimen of *C. rubecula* was not preserved. The figure of *rubecula* shows more red-brown scales than that of *microsporus*, but the latter appears to have been "weathered."

Pileus ovate, then campanulate, obtuse, densely covered when young with red-brown floccose scales, which are distant and confined to the upper half in older specimens; pale yellow between the scales, whiter towards the margin which is striate when dry; 1·8 to 2·4 cm. high, 1·5 to 2·2 cm. diameter, flesh thin. Stalk up to 3 cm. high, 2 to 3 mm. diameter, slightly attenuated upwards, white, covered with fine red fibrils or points, white and glabrous above, sometimes longitudinally striate, hollow. Gills free, ventricose, broad, (up to 5 mm.) white at first then black. Spores brown, oval, 5–7 × 3–5 μ, black in mass on wood, but brown on glass. On dead wood, usually dadap stumps (*Erythrina* sp.).

Coprinus miniato-floccosus Bres. & Pat. (Lloyd, Myc. Notes, No. 6, p. 49) which is listed in Saccardo as *C. miniato-flexuosus*, would appear from the description to be the same species.

42.—Russula periglypta B. & Br.

Hygrophorus alutaceus B. & Br., Fungi of Ceylon, No. 322, Journ. Linn. Soc., XI., p. 563.

Russula periglypta B. & Br., Fungi of Ceylon, No. 339, Journ. Linn. Soc., XI., p. 566.

"*Russula emetica* Fr.," in B. & Br., Fungi of Ceylon, No. 340, Journ. Linn. Soc., XI., p. 567.

This species was Thwaites' No. 800, and was sent by him with a coloured drawing. It is at first hemispherical and umbilicate, but becomes infundibuliform later. The drawing depicts three specimens, but these are all in the hemispherical stage, and therefore Berkeley and Broome separated the specimens into two species, naming the younger *Russula periglypta*, and the older, fully developed forms, *Hygrophorus alutaceus*. It is fortunate that the name *Russula alutacea* is preoccupied; it would have been most inappropriate for the present species. This species grows in large rings; and here and there in the rings one finds red specimens resembling *Russula emetica*. These are always deformed or irregularly developed, with thick crowded gills; they never bear spores; but always produce the conidial stage of a *Hypomyces*. I have not yet been able to obtain the perithecia of the latter; its conidial form is of the *Verticillium* type.

Russula periglypta has a pileus up to 9 cm. in diameter; it is at first hemispherical, depressed or umbilicate in the centre, then almost plane, finally infundibuliform; the margin is smooth when young, becoming strongly sulcate with the ridges tuberculate; the colour is white, sometimes greyish or greenish in the centre; it is slightly viscid when young, strongly viscid in wet weather, with shining patches when dry; the flesh is rather thin, and white throughout. The stalk is 2 to 7 cm. high, 1 to 1·8 cm. diameter, white, longitudinally striate with innate fibrils, equal, or swollen at the base, or attenuated below, spongy-stuffed, fragile when old. The gills are white, cream coloured or yellowish when old, arcuate at first, then rather ventricose, outer ends rounded, up to 7 mm. broad, adnate with a slight decurrent tooth, becoming free, rather distant, occasionally forked near the stalk; interstices veined. The spores are creamy white, globose, 5–7 μ diameter, or somewhat oval, $8 \times 6\ \mu$, beset with coarse, blunt spines. Taste mild.

Hygrophorus alutaceus was said to have "Pileo umbilicato glabro; margine arcuato striato; stipite obconico; lamellis arcuatis longe decurrentibus alutaceis," while *Russula periglypta* was described as "Candidus; pileo hemisphærico viscido umbilicato sulcato; stipite deorsum angustato solido; lamellis arcuatis postice acutis attingentibus. Interstices reticulate. Spores globose, echinulate, ·00025 inches diameter."

The parasitized specimens measure 2 to 5 cm. in diameter, and usually remain hemispherical, often with irregular undulating swellings; they never become infundibuliform, but are often depressed in the centre; the colour is dull red or pink, sometimes blackish in the centre, often with pale ochraceous patches also, usually somewhat mottled; the pink coloration may extend over the edges of the gills, and sometimes the stalk also is pink; they are viscid when moist; as a rule, the margin is not striate, but in some instances it is striate on one side. The gills are crowded and thickened, usually vertically corrugated: they never produce *Russula* spores. I have no doubt that this represents Berkeley's Ceylon specimens of *Russula emetica*.

43.—Marasmius subcinereus B. & Br.

Marasmius subcinereus B. & Br., Fungi of Ceylon, No. 369, Journ. Linn. Soc., XIV., p. 37.

Pileus convex, then plane, slightly depressed or umbilicate, sometimes infundibuliform in wet weather, sulcate almost to the centre, the sulcæ being sometimes wavy, thin; dark-green when young, then greenish-grey, centre almost black; greenish-brown with a blackish-brown centre when old; 1 to 1·5 cm. diameter.

Stalk, 2 to 2·5 cm. high, 0·3 to 0·5 mm. diameter, rigid, bluish-black or black, but hoary with minute white particles, pale towards the apex, dull, slightly thickened upwards, solid, base either not thickened (insititious), or expanded into a disc up to 1·5 mm. diameter, or arising from a small tuft of white hyphæ.

Gills white when young, then bluish or bluish-gray, rather broad, distant, thick, adnate or slightly decurrent, interstices strongly veined. Spores white, stellate, consisting of four broad-based triangular processes, each about 4 μ long and 3 to 4 μ broad at the base, the distance from point to point being 8 to 12 μ.

On dead branches and leaves.

Berkeley and Broome cite Thwaites' numbers " 782 cum. icone; No. 204 in part." They also state that Thwaites' No. 804 is a variety. 204 was split up into five other *Marasmii*, and this reference is most probably incorrect, since those which have been identified in 204 bear no resemblance to *M. subcinereus.* The figure of 804 suggests *Omphalia anthidepas* rather than *M. subcinereus;* the specimens unfortunately are not at Peradeniya. The figure of *M. subcinereus* in Herb. Peradeniya apparently shows a hollow stem; Berkeley and Broome say that it is " stuffed "; but in my specimens—and it is fairly common—it is solid.

The spores are somewhat similar to those of *Marasmius nigripes* as illustrated by Lloyd, Myc. Notes, p. 46, but they have sharper points and practically no central " spore-like " body. Theissen (Ann. Myc., VII., p. 346) suggests that *M. subcinereus* is identical with *Marasmius membraniceps* Cooke, but there does not seem to be any resemblance between the two species. The descriptions of Ceylon basidiomycetes were in most cases drawn up from figures which were painted from the fresh specimens; they are not in all cases "Trocken-diagnosen."

44.—**Marasmius caryotæ** (B. & Br.) Petch.

Heliomyces caryotæ Berk., Hooker's London Journ. Bot. (1847), p. 491.

Marasmius stramineus B. & Br. in MSS.

In troops, among grass; occasionally fasciculate.

Pileus 1 to 2·5 cms. diameter, rarely up to 5 cms., campanulate, occasionally depressed in the centre, then expanded with a recurved margin, deeply sulcate, with about twelve sulcæ reaching almost to the centre and intermediate sulcæ extending about half way, glabrous, usually wrinkled in the centre, with a waxy appearance when young, somewhat leathery, thin, grayish-yellow, or pale yellow, or pale yellow but grayish in the furrows, becoming ochraceous or pale brown, red-brown when dried. Stalk 4 to 8 cms. high, 1 to 2 mm. diameter, at first yellow-brown below and white above, becoming yellow-brown or dark brown, rigid, hollow, slightly attenuated upwards, almost glabrous, cartilaginous, tomentose at the base. Gills grayish-yellow, brown when old; about twelve broad, somewhat ventricose, and adnexed, with shorter intermediate gills which are often more or less obsolete; rather thick, often forked at the outer ends; edge even or irregularly lobed. Spores white, narrow-oval tapering at one end, rather thick walled, contents granular, 20–25 × 5 μ.

This species is not a *Heliomyces*, since it is not "Coriaceo-tremellosus; stipes sublignosus." Berkeley and Broome's manuscript name would have been preferable for this species, because it has no connection whatever with the palm *Caryota*; it grows abundantly among grass. The figure in Herb. Peradeniya bears both names in Berkeley's handwriting.

45.—**Marasmius nephelodes** (B. & Br.) Petch.

Agaricus (*Collybia*) *nephelodes* B. & Br., Fungi of Ceylon, No. 105, Journ. Linn. Soc., XI., p. 521.

Marasmius ochraceus B. & Br., Fungi of Ceylon, No. 355, Journ. Linn. Soc., XIV., p. 34.

Solitary, or in groups, sometimes fasciculate, on the ground among grass. Berkeley and Broome state that *Marasmius ochraceus* grows on wood, but the figure does not indicate that.

Pileus broadly convex, centre even or irregularly depressed, entirely brick red, or reddish-brown in the centre becoming ochraceous towards the margin, sometimes feebly zoned, margin sometimes whitish ; fleshy, smooth, slightly hoary when young, shining, 2 to 4 cms. diameter ; flesh white, becoming reddish when cut. Stalk, 4 to 5·5 cms. long, 3 to 4 mm. diameter, nearly equal, white, sometimes longitudinally streaked with ochraceous, becoming reddish or ochraceous when handled, pruinose or minutely tomentose, tough, hollow, lined with white fibres, white internally becoming reddish when cut ; base clothed with white tomentum. Gills pallid, distant, up to 1 cm. broad, quadrate, the lower edge almost straight, abruptly truncate behind with the inner edge almost vertical, free or slightly adnexed. Spores white, narrow-oval, contents granular, 9–13 × 4 μ.

The paintings of the two " species " are practically identical.

46.—Marasmius rufescens B. & Br.

" *Cantharellus capensis* Berk." (in part), in B. & Br., Fungi of Ceylon, No. 350, Journ. Linn. Soc., XIV., p. 33.

Marasmius rufescens B. & Br., Fungi of Ceylon, No. 394, Journ. Linn. Soc., XIV., p. 41.

Xerotus tener B. & Br., Fungi of Ceylon, No. 426, Journ. Linn. Soc., XIV., p. 45.

Marasmius campanella Holtermann, Myk. Untersuch. p. 105, Taf. 12, fig. 1.

Berkeley and Broome's confusion in this case involves three of Thwaites' numbers, viz., 90, 684, and 687 ; there was a figure of No. 90 only. The figure was returned, marked *Cantharellus capensis* Berk., but in the published list No. 90 is recorded as both *Cantharellus capensis* and *Marasmius rufescens*. No. 684 was said to be *C. capensis* only, and No. 687 was listed as *Xerotus tener*. Thwaites had considered these so closely alike that he had included them on one sheet, and at the present day they are on one sheet in the Peradeniya Herbarium, marked 90, 684, and 687 in Thwaites' handwriting.

But the sheet is marked "*Cantharellus capensis*" only, in Broome's handwriting. According to the herbarium sheets, therefore, these three numbers consisted of one species only, but according to the published list they contain three: and although 687 is labelled *Cantharellus capensis* in the herbarium, it is listed only as *Xerotus tener*.

There are undoubtedly two species on the herbarium sheet. The confusion is due, therefore, partly to Thwaites, who did not distinguish between them, and partly to Berkeley and Broome who, though they failed to detect Thwaites' mistake, separated as distinct species a colour form of one of them—and named it twice. The resemblance between these two species was noted by Holtermann, who found them in Java (?), and named one of them *Marasmius campanella*, and the other *Favolaschia bispora*. The former is stalked, membranous, dry, and tough; the latter is sessile and subgelatinous internally. Thwaites' figure No. 90, which was named *Cantharellus capensis*, is the sessile species *Favolaschia bispora;* it cannot be *C. capensis*, since the original specimens of the latter (from South Africa) were villous and stalked. The specimen No. 90, however, contained both *F. bispora* and *M. campanella*, if Berkeley and Broome's references are correct. But probably they referred to No. 90, specimens which were really Nos. 684 or 687. Specimen No. 684 was *Marasmius campanella* only; it is not *C. capensis*, since although it is stalked the gills are thin and the pileus is not villous. Specimen No. 687 included a rufous form which furnished the types of both *Marasmius rufescens* and *Xerotus tener*. The "*Xerotus tener*" figured in Cooke's Handbook of Australian Fungi is something quite different; it does not answer to Berkeley and Broome's description, being figured much thicker than *Xerotus lateritius*, for example, and sessile.

For the purpose of comparison I give the original descriptions of *Xerotus tener*, and *Marasmius rufescens*. "*Xerotus tener* B. & Br. Pileo reniformi tenui membranaceo umbrino pulverulento; stipite brevissimo; lamellis concoloribus angustissimis; interstitiis lævibus. Pileus about ½ an inch across, far thinner than in the more typical species." "*Marasmius rufescens* B. & Br. Totus rufescens; pileo suborbiculari glabro;

stipite brevi cylindrico glabro ; lamellis paucis, interstitus reticulatis. Pileus ¾–1 inch across ; stem 1–1½ line high." Specimens answering to both these descriptions are on the herbarium sheet ; *tener*, with smooth interstices, is a younger specimen than *rufescens*. It may be noted that Berkeley and Broome's "pulverulent" means rugose, as in several other cases (*e.g.*, *Marasmius rotalis*).

According to the rules, the *Marasmius* must be called *Marasmius rufescens*. This affords another example of inappropriate nomenclature enforced by the principle of priority, since the rufous form is comparatively rare, the common form being grey. The sessile species was not distinguished by Berkeley and Broome, except incorrectly as *Cantharellus capensis*, and may therefore remain under Höltermann's name, though the latter appears to be a *nomen nudum*.

Marasmius rufescens B. & Br. Pileus circular, orbicular, or reniform, up to 4 cms. diameter, usually about 2 cms., campanulate then convex, edge often recurved, sulcate over the gills and veins, depressed over the stalk, glabrous, slightly rugose, membranous, tough, gray or purple-gray, or gray-brown, blackening slightly when old, sometimes rufous, rarely orange. Stalk short, excentric, curved, 3 to 4 mm. long, 1 mm. diameter, solid, at first the same colour as the pileus, then black, clothed with minute white fibrils at first, glabrous when old, expanding at the apex ; base swollen. Occasionally specimens are found which have a central stalk. Gills few (6 to 12), thin, broad (up to 3 mm.), distant, sometimes forked, united by strong veins or folds when old, slightly paler than the pileus, adnate to the swollen apex of the stalk, sometimes appearing collared. Spores white, oblong-oval, ends rounded : in one gathering, 12–15 × 5–7 μ, in another 7–11 × 4–6 μ. On dead branches, stems of lianes, &c.

47.—Lentinus giganteus Berk.

Lentinus giganteus Berk., Hooker's London Journ. Bot. (1847), p. 403.

Lentinus stenophyllus Berk., Hooker's London Journ. Bot. (1847), p. 495.

Lentinus obnubilus Berk, Hooker's London Journ. Bot. (1847), p. 495.

Lentinus maculatus Berk., Hooker's London Journ. Bot. (1847), p. 494.

This is a fairly common species; it grows among grass, developing from buried wood, usually at a depth of about a foot in the soil, and coming to the surface by means of a long white rhizome, which often extends obliquely through the soil for some distance from its place of origin. As a rule, the rhizome gives rise to only one large specimen, but it may divide near the surface and produce a cluster of three or four. The original specimens were sent to Berkeley by Gardner: *maculatus* appears to have been separated because its stalks were connate, but there is nothing in the descriptions which will differentiate between the other three. The figures sent by Thwaites twenty years later were both assigned to *stenophyllus*. This name was most inappropriate; the gills are much broader than in other Ceylon *Lentini*.

In the unexpanded state, both the stalk and pileus, in fact all the parts above ground, are black, the convex pileus being covered with scattered black fibrillose scales. The veil is black and remains attached in fragments to the margin. Expanded specimens are, typically, infundibuliform, attaining a diameter of 30 centimetres and a height of 28 centimetres. I have found specimens, 11 cms. diameter, which were quite plane; and many expand abnormally and are campanulate, with the outer half directed almost vertically downwards. The ground colour of the expanded pileus is ochraceous, or yellow-brown, or fawn; it is covered with blackish-brown squamules, densely in the centre, more scattered and concentrically arranged elsewhere. In addition to these scales, which are formed by the splitting of the cuticle of the pileus, there is usually a regular ring of large, black, superficial, flattened, polygonal warts, about midway towards the margin; these represent the remains of the veil. The flesh is white and spongy, thin in fully expanded specimens except over the stalk. The margin is striato-sulcate. The stalk is sometimes almost equal and about 1 to 2 cms. in diameter, but in the typical form it expands upwards, measuring from 1·5 to 4 cms in diameter at the ground level, and 2 to 5·5 cms. in diameter at the ends of the gills ; it is densely velvety with brown or blackish-brown, short tomentum, has a strongly cartilaginous outer layer, and is white and spongy internally ; it is 3·5 to 12 cm. high ; the part below ground is white, and either glabrous or fibrillose. The gills are at first white, then cream coloured, decurrent, not crowded, rather broad (up to 13 mm.), attenuated outwards, sometimes slightly anastomosing ; the tomentum of the stalk extends partly over the edges of the gills. The spores are white, broadly oval, 6–8 × 5–6 μ, or globose, 6–7 μ diameter.

Small specimens of this species have the texture of *Lentinus*, but in the larger examples the gills are somewhat brittle, and the attenuated pileus is not so tough. The stalk is always of the *Lentinus* type, and it has the *Lentinus* characters of growing on dead wood, and of producing pilei along its margin when the latter is wounded during expansion. It has been suggested that it ought to be referred to *Paxillus*, but the gills do not separate from the pileus as in that genus, the margin is not permanently inrolled, and the spores are undoubtedly white.

48.—**Merulius eurocephalus** (B. & Br.) Petch.

Polyporus (*Merisima*) *eurocephalus* B. & Br., Fungi of Ceylon, No. 451, Journ. Linn. Soc., XIV., p. 48.

" *Polyporus* (*Merisima*) *sulfureus* Fr.," in Berkeley and Broome, Fungi of Ceylon, No. 450, Journ. Linn. Soc., XIV., p. 48.

Merulius similis B. & Br., Fungi of Ceylon, No. 536, Journ. Linn. Soc., XIV., p. 58.

This species is fairly common at Peradeniya in clumps of living bamboos. The mycelium spreads through the mound of soil at the base of the clumps in thick white strands up to 3 mm. in diameter, and emerges to form a white floccose sheet, about 6 mm. thick, over the surface of the soil and the bases of the bamboo culms. The hymenium is produced on any part of the horizontal sheet and is then the *Merulius similis* of Thwaites' collection ; this is white at first, with a swollen margin, everywhere tomentose, then pale yellow, finally producing ochraceous patches which bear irregular shallow pores, 0·25 to 0·5 mm. diameter, surrounded by a broad, yellow, or white, swollen sterile margin.

The vertical sheets which ascend the bamboo stems give rise to horizontal, imbricated, often confluent, semicircular pilei, up to 10 cms. long, 5 cms. broad, and usually 1 to 2 cms. thick. The upper surface of these is plane or slightly convex, sometimes undulating ; it is densely fibrillose or tomentose at first, but the hyphæ become matted with age, and the surface often becomes more or less glabrous ; the colour is white at first, then pale yellow ; internally it is soft, fibrillose, faintly zoned, white becoming pale yellow. The hymenium is at first pale ochraceous with a network of shallow labyrinthine pores, but becomes deep ochraceous as the pores become more differentiated. The pores ultimately form a stratum distinct and separable from the pileus ; they vary in depth from 2 to 6 mm. In section they are circular or ovoid, 0·25 mm. diameter, or labyrinthiform, 0·25 mm. wide and 1 mm. or more long ; the dissepiments are soft, 0·25 mm. thick, with a rounded edge ; the basidia are borne on the edges of the dissepiments as well as in the tubes. The margin of the pileus is swollen, and exudes drops of water ; there is a broad white or yellow sterile margin on the lower surface. The spores are ochraceous in mass, brownish-yellow when magnified, smooth, oval or subglobose, 5–8 × 3–4 μ ; they have usually a large central gutta, but the larger oval spores may be biguttulate. The pileus turns red or purple when bruised or cut.

In the remains of old bamboo clumps, when all the stems have been cut down, it forms large, yellow, irregular, nodular masses, 10 cm. or more in diameter. These become rather hard and cheesy internally, or almost woody, the outer layers remaining soft and becoming slippery in wet weather. These masses sometimes remain sterile, but in favourable seasons they produce imbricated pilei identical with those described above. Pilei developed at the close of the rainy season frequently remain white above and on the margin.

This species appears to live on the decaying vegetable refuse in the base of the bamboo clump, not as a parasite on the living plant. It is readily separable from the living stems.

It may be noted that the type specimen of *Polyporus eurocephalus* in Herb. Peradeniya is parasitized by a *Hypomyces*, and its tubes are filled with globose spores, 5–7 μ in diameter, covered with close-set spines 1·5 μ long.

49.—Polystictus sanguineus (Linn.) Mey.

The spores of this well known species are white, oval, 3 × 2 μ. There is a white variety of it, which grows with the red specimens.

50.—Lopharia mirabilis (B. & Br.) Pat.

Radulum mirabile B. & Br., Fungi of Ceylon, No. 558, Journ. Linn. Soc., XIV., p. 61.

Thwaitesiella mirabilis (B. & Br.) Massee, Grevillea, XXI., p. 2.

Lopharia mirabilis (B. & Br.) Patouillard, Bull. Soc. Myc. France, XI., p. 14, tab. 1.

Adnate, determinate, waxy when fresh, coriaceous and rather brittle when dry, thin; at first white, then pale ochraceous; substance white, about 0·25 mm. thick; margin sometimes recurved and then displaying a tomentose, obscurely zoned, white lower surface; circular, up to 2 cms. diameter, or irregular and confluent up to 11 cm. long, and 5 cm. broad; hymenium plane at first, then covered with scattered, erect, laterally compressed, triangular teeth, more or less radially and concentrically arranged, which subsequently coalesce into radiating or concentric, anastomosing ridges, usually toothed, laterally compressed, up to 1 mm. high. The ridges are distant and form a network with meshes up to 2 cms. broad, with numerous isolated teeth between. The whole hymenium, *i.e.*, the ridges and the plane surfaces between them, bristles with minute cystidia; these are up to 120 μ long and 20 μ diameter at the base, projecting 50 to 80 μ above the surface, conical, tapering gradually to the usually blunt apex, hyaline, rough, with a central hollow. Basidia clavate, 70 μ high, 12 μ diameter at the apex, 6 μ diameter at the base. Spores from fresh specimens are white in mass, greenish-hyaline when magnified, oblong-oval, 8–12 × 4–5 μ, contents granular, not guttulate.

Peradeniya; Deviturai.

Berkeley and Broome's type specimen of this striking species is not in the Peradeniya herbarium, and I am indebted to Prof. F. v. Höhnel for the identification of recent examples. He states that the spores are 9–10 × 5–6·5 μ, while those of *Lopharia lirellosa* Kalchbr. are, according to Patouillard, 15–17 × 8–10 μ, and expresses his opinion that the two species may be identical [*cf.* spore measurements of *Aleurodiscus peradeniæ* (B. & Br.) v. Höhnel]. The only other species of *Lopharia* is *L. javanica* P. Henn. et E. Nym., Monsunia I., 1899, p. 144; its spores are said to be 5–7 × 5–6 μ, but in other respects it does not appear to differ from *Lopharia mirabilis.*

51.—**Aleurodiscus Peradeniyæ** (B. & Br.) v. Höhnel.

Corticium peradeniæ B. & Br., Fungi of Ceylon, No. 629, Journ. Linn. Soc., XIV., p. 69.

Aleurodiscus javanicus P. Henn., Mousunia, I., p. 139.

Corticium javanicum (P. Henn), Sacc. et Syd., Saccardo, Syll. XVI., p. 189., non *Corticium javanicum* Zimm.

Aleurodiscus javanicus was re-described by v. Höhnel in "Beiträge zur Kenntnis der Corticieen, II.," p. 65. It was evident from this description that it was closely allied to, if not identical with, *Corticium peradeniæ* B. & Br.; and therefore recently collected specimens, with part of the herbarium specimen, were submitted to Prof. v. Höhnel, who states that the two species are identical. He has published the corrected name in "Beiträge zur Kenntnis der Corticieen, III.," p. 16. His description, from the first of the publications cited, is quoted here.

Fungus at first pezizoid, attached only in the centre, circular 0·5 to 1 cm. diameter, afterwards enlarged by confluence; margin always upturned; white and tomentose below, almost waxy or fleshy when fresh, leathery when dry. Hymenium determinate, smooth, pallid or rose coloured, consisting of basidia and dendrophyses. Basidia elongated clavate, about 100 μ long, 16 to 20 μ broad; sterigmata 4, awl-shaped or almost ninepin-shaped with obtuse tips, straight, 10 to 14 μ long, up to 6 μ thick at the base. Dendrophyses cylindrical or irregularly clavate, thin walled, 6 to 18 μ broad, smooth at the apex, furnished in the middle with obtuse, close-set, spinelike processes, 2·3 μ long, 1 to 1·5 μ thick. In addition to these dendrophyses which reach the surface, others may be observed which do not; the latter are generally smaller, and bear closely-arranged spine-like process everywhere. The contents of the basidia and dendrophyses are usually yellowish. Spores ellipsoid, somewhat flattened on one side, tapering at both ends, 16 to 20 μ long, 14 to 16 μ broad, moderately stout-walled, smooth, colourless, with granular contents, often guttulate. Hyphæ inconspicuous, colourless, about 2 to 4 μ thick, loosely woven and somewhat spinose in the subhymenial layer, agglutinated, horizontal, parallel, and smooth in the basal tissue. Clamp connections not seen.

In his correction of the nomenclature, v. Höhnel states that both kinds of dendrophyses may reach the upper surface and that the spores attain a length of 30 μ and a breadth of 18 μ. Measurements made in Ceylon give 32–36 × 15–18 μ as the size of the spores. Hennings gives 16–20 × 15–18 μ.

52.—Laschia Thwaitesii B. & Br.

Laschia Thwaitesii B. & Br., Fungi of Ceylon, No. 535, Journ. Linn. Soc., XIV., p. 58.

Cæspitose or scattered on dead wood. Whole fungus subgelatinous; entirely orange-red or orange; margin and stalk sometimes paler. Pileus reniform, up to 9 mm. broad by 6 mm., usually about 6 × 4 mm., at right angles to, or in the same plane as the stalk, slightly convex or plane, tessellated, pruinose, margin repand and crenate when old. Stalk excentric or lateral, up to 1·5 cm. high, 1 mm. thick, attenuated upwards, translucent, pulverulent, solid. Hymenium plane; pores almost circular, ·3 to ·4 mm. diameter, rather distant; dissepiments thick. Spores white, oval or somewhat oblong, 10–13 × 6–7 μ.

This appears to be identical with *Laschia lateritia* P. Henn., except that the spores of the latter (from dried specimens ?) are said to be yellow and 7–8 × 4–4·5 μ.

The phrase "stipite gracili porisque albis" in the original description has usually been taken to mean that both the stalk and pores were white. "Poris" is probably an error for "sporis."

53.—Laschia pustulata B. & Br.

Laschia pustulata B. & Br., Fungi of Ceylon, No. 534, Journ. Linn. Soc., XIV., p. 58.

This species grows gregariously on decaying palm fronds. The whole fungus is vertical or slightly inclined, the pileus and stalk being in the same plane. The pileus is spathulate or orbicular, convex, 4 to 5 mm. long, 3 to 5 mm. broad, thin, glabrous, tessellated with grooves which correspond with the lines of insertion of the gills, white at first, then cream coloured, finally deep crimson. The pileus merges below into the stalk, which is 2 to 5 mm. high, 0·5 mm. diameter at the base, expanding upwards to 1 mm. diameter, glabrous, white, then cream, finally deep red: the base of the stalk is bulbous, and surrounded by a circular white tomentose disc about 2 mm. diameter. The gills are few in number, usually three running from the stalk, forking at their outer ends, and united by deep veins: they are at first white, then cream coloured with a brownish edge, and finally pink or pale red with a deep red edge. The spores are white, oval, slightly inequilateral, strongly guttulate, pointed at both ends, 9–13 × 7 p, sometimes subglobose, 9 × 7 μ, or 8 μ diameter. The whole fungus is subgelatinous at first, and becomes glutinous when old.

The figure of *Laschia pustulata* in Cooke's Handbook of Australian Fungi bears no relation whatever to this species. The original painting, and the type specimens, are in the Peradeniya herbarium.

54.—Laschia (Favolaschia) bispora Holtermann.

"*Cantharellus capensis* Berk." (in part) in Fungi of Ceylon, No. 350, Journ. Linn. Soc., XIV., p. 33.

Favolaschia bispora Holtermann. Mykol. Untersuchungen, p. 105 (name only); Taf., XI., Fig. *5a–b*.

Thwaites' figure of this species was named "*Cantharellus capensis* Berk." by Berkeley and Broome. The following description is drawn up from fresh specimens which agree exactly with the figure. It is of course quite distinct from the original *Cantherellus capensis* described by Berkeley from South Africa, since it is not villous and not stalked. Holtermann's figure and his comparison with *Marasmius campanella*

(=*M. rufescens*) appear to justify the assumption that his name refers to the species described below, though, as far as I can discover, the name was published without any description.

Pileus 3 to 10 mm. diameter, hemispherical, or broadly campanulate, deeply incised behind, affixed at one side just above the incision, grayish white, or faintly ochraceous, reticulated with sulcæ which correspond with the lines of insertion of the gills, bullate between the furrows, minutely rugose ; margin white, sometimes crenate, sometimes narrowly recurved ; quite sessile ; substance thin, outer layer dry, internally subgelatinous. Gills radiating from a point or a half ring at the apex of the incision, white, consisting of four or five deep primary gills which usually fork several times at their outer ends and are united by numerous narrower gills or ribs which form an intermediate network : edge blunt ; basidia two-spored. Spores white, narrow, oval, 11–13 × 3·5–4 μ.

On dead twigs, and on leaf sheaths of palms.

55.—**Auricularia** (sensu Lindau).

There are two common and one rare species of this group in Ceylon, but there are seven names in the published lists. König collected *Hirneola rufa* (Berk.) Fr. ; Thwaites gathered *Hirneola hispidula* Berk., and *Auricularia lobata* Sommf. ; Beccari collected *Hirneola hispidula* Berk., *Auricularia lobata* Sommf., and *Laschia lurida* Ces. ; Holtermann records *Auricularia* (*Laschia*) *velutina* Lév. and *A.* (*Laschia*) *tremellosa* Fr. ; while Saccardo gives Ceylon as a locality for *Laschia tremellosa* Fr. and *Hirneola polytricha* Mont., the records of which I have not been able to trace.

Holtermann figures (Mykologische Untersuchungen, Pl. 6, Fig. 1*a*) what he considers typical *Hirneola polytricha* Mont. ; the figure represents just as typical *Hirneola hispidula* Berk, somewhat dried, as shown by the incurved edge, and it has a common habit of the latter of growing on rather small branches. *Hispidula* is said to be sessile, *polytricha* stalked ; this appears to be the chief difference ; but *hispidula* may be either stalked or sessile, and I have grown specimens, on tea branches half embedded in damp earth under bell glasses and kept constantly moist, with cylindrical, solid, tomentose stalks up to 2 cms. long and 4 mm. in diameter. I have no doubt that these two names refer to the same species. *Hirneola rufa* does not seem to differ from these; the hairs of *H. hispidula* are often rufous. I regard these three names as synonyms as far as Ceylon is concerned. The descriptions in Saccardo are as follows :—

Hirneola polytricha Mont.—Cupula hemisphærica, expansa, auriculæformi, extus villoso-tomentosa grisea, in stipitem brevissimum obliquum producta; disco levi spadiceo-purpureo.

Hirneola rufa (Berk.) Fr.—Cupularis, sublateralis, sessilis, extus setis brevibus fasciculatis rufis vestita; hymenio subplicato, glabro, nigrofuscescente.

Hirneola hispidula Berk.—Globoso-campanulata, obliqua, sessilis, intus brunneo-atra, extus cervino-colorata pilis lanuginosis, brevibus tecta.

The length of the stalk may be varied by altering the conditions of growth, and therefore this point of distinction vanishes. The difference in shape depends either on the age of the specimen or weather conditions: young specimens are at first deeply cup shaped—indeed, my long-stalked specimens have at first only a small cylindrical umbilicus, about 3 mm. deep, at the apex of the stalk, and they would not, at first, be recognized as *Hirneola* except by their colour and consistency; in moderately wet weather the expanded hymenium is plane, but in very wet weather it remains broadly concave or "auriculæform;" the usual stages of expansion resemble those of a *Peziza*. The differences in colour are unreliable, since none of the recorded colours refer to fresh specimens.

Hirneola polytricha Mont. is either sessile or stalked; usually circular, up to 2 cm. diameter, or oval, up to 4 × 2·5 cm.; hymenium plane, smooth, pruinose; thin, somewhat leathery, densely covered behind with white or brown hairs up to 0·8 mm. long; in very wet weather or in the wetter districts, often concave, or ear shaped, up to 8 cm. × 7 cm., with the hymenium thrown into irregular folds; long-stalked specimens are often umbilicate when expanded; hymenium violet or bluish-purple, purple-brown when old; spores, 12–15 × 5–6 μ, strongly guttulate, white, cylindric, curved.

The other common species is *Auricularia* (*Laschia*) *tremellosa* Fr. In all probability, the Ceylon specimens attributed to *Laschia lurida* Ces., and *Auricularia velutina* Lév. were the same species. *Laschia lurida* Ces., was, according to Cesati, considered by Berkeley to be very close to *tremellosa*, and the brief description does not reveal any point by which it could be distinguished from the latter. Holtermann gives a figure (Pl. VI., 1*b*, 1*c*) of *Auricularia deliciosa* (? an error for *delicata*) which might be taken to represent, with a slight degree of success, the Ceylon species attributed to *A. tremellosa*.

Auricularia tremellosa (*Laschia tremellosa* Fr.), as represented by Ceylon specimens, is orbicular, convex or sometimes almost plane, usually projecting horizontally from tree trunks, joined to the substratum near the margin, sessile, gelatinous, thickened and elevated at the point of attachment, usually about 6 × 4 cms., but in wetter districts sometimes 10 × 8 cms., about 5 mm. thick as a rule, but up to 1 cm. thick in the larger specimens; upper surface glabrous or somewhat granular, brown, yellow-brown, or white; margin entire, thin; hymenium pruinose, brown or purplish, with ribs up to 3 or even 5 millimetres high radiating from beneath the point of attachment and diminishing in height towards the margin, joined by lower ribs, or giving off branches which fork or interlock without anastomosing; spores white, curved, cylindric, 10–12 × 4 μ. Fries himself stated that *Laschia delicata* was not to be distinguished from *Laschia tremellosa*.

We have still to consider the further question which has been regarded as decided by other mycologists who have studied in the tropics, viz., whether all the species mentioned above are really forms of the common European *Auricularia auricula judæ*. Lindau (Engler-Prantl. Pflanzenfamilien) accepts this view, and, stating that *A. auricula judæ* is a cosmopolitan species, illustrates it by three figures, one of which is undoubtedly *Auricularia tremellosa*, a rather poor copy of Möller's figure. Möller, in his " Protobasidiomyceten, Untersuchungen aus Brasilien," appears to have been the first to enunciate this view: he agrees that *A. delicata* is identical with *A. tremellosa*, and joins with it *Laschia velutina* Lév. and *L. nitida* Fr., but he goes further and gives as the result of his researches that these are all identical with *Auricularia auricula judæ.* He gives illustrations of five specimens ; two of these (1*a* and *b*) represent a concave form, with a smooth hymenium, which, like the larger forms of *Hirneola polytricha*, do not differ much in appearance from the European species ; two others (1*d* and *e*) are good figures of *Auricularia tremellosa*, while the intermediate form (1*c*) appears to be a badly developed specimen of the latter. It is evident that his opinion as to the identity of these cannot be transferred to the Ceylon species, since he did not meet with *Hirneola polytricha :* this is an obvious deduction from his statement that, in all the forms he met with, the upper surface is to the naked eye completely smooth when fresh. *Hirneola polytricha* on the contrary is always strongly hairy in all stages of development, in all its varying sizes, and under all conditions of rainfall and elevation. Nevertheless, objection must be taken to his conclusion that *A. tremellosa* is identical with *A. auricula judæ.*

Holtermann (Mykologische Untersuchungen aus den Tropen) has applied the same theory to the species in the Eastern Hemisphere. He groups together, *Laschia velutina* Lév., *Laschia tremellosa* Fr., *Hirneola polytricha* Mont., *Auricularia porphyrea* (Lév.) Fr., *Auricularia tenuis* (Lév.) *Auricularia pellucida* (Jungh.) Fr., and styles them all *Auricularia auricula judæ.* He gives figures of typical *Hirneola polytricha* (Pl. VI., 1*a*) ; the same species with a folded hymenium (1*d*) ; the upper surface of *Auricularia tremellosa*, evidently abnormal (1*b*) ; and a very poor representation of the under surface of *A. tremellosa* (1*c*). Fig. 1*e*, which shows *Hirneola polytricha* growing from the middle of a specimen which Holtermann considers *tremellosa*, can hardly be interpreted without the specimen ; but it may be stated that the phenomenon is fairly common in my cultivations of *H. polytricha*, both specimens being of course typical *H. polytricha* in that case. The differences between the extreme forms, typical *H. polytricha* and typical *A. tremellosa* were so great that Holtermann could not believe that they were the same species ; but by sowing the spores of the tomentose *H. polytricha* he obtained smooth specimens which he regarded as *A. tremellosa.* It is however to be noted that the difference between the two species lies in the structure of the hymenium, and that Holtermann did not succeed in obtaining specimens with the hymenium of *A. tremellosa.* According to his illustrations, his culture produced specimens with a smooth hymenium and the erect habit of *H. polytricha,* not the entirely different hymenium and habit of *A. tremellosa.*

Both *Hirneola polytricha* and *Auricularia* (*Laschia*) *tremellosa* are common in Ceylon, and during the last four years I have examined specimens in many parts of the Island, always with Möller's view in mind. These have included specimens from districts at sea level, at medium elevations, and at 6,000 ft., with rainfalls varying from 60 to 200 inches per annum. But I have never found a specimen which could not be immediately referred to one or the other of the two species. The variations in rainfall, humidity, and climate generally, in the different districts of Ceylon, are without parallel in any other country of similar extent, and it would be expected that such conditions would be extremely favourable for the production of intermediate forms, if the two species were identical ; but from my experience I must certainly deny the existence of anything of the kind.

Hirneola polytricha is always strongly tomentose with hairs nearly a millimetre long, while *Auricularia tremellosa* is always smooth, or minutely granular, to the naked eye. The two species differ also in consistency, *polytricha* being always leathery, while *tremellosa* is gelatinous : in very wet districts *polytricha* may become slightly gelatinous, but under the same conditions *tremellosa* becomes liquid internally. A large specimen of the latter, measuring 10 by 8 cms. and 1 cm. in thickness, was gathered at Hakgala, and left to dry on the laboratory table. Unfortunately the margin was torn, and consequently the liquid middle layer flowed out over the table. With a slight rainfall, the hymenial surface of *polytricha* is plane, becoming concave with wetter weather ; but the hymenium of *tremellosa* is concave, except occasionally in very wet districts where it may be almost plane. The colour too is definitive ; *polytricha* is always violet or bluish-purple *throughout*, whereas *tremellosa* is most often yellow-brown, sometimes white, with only occasionally a tinge of purple on the hymenial surface. The habit of the two species also differs; in *polytricha*, the fungus frequently, one might almost say usually, grows with the hymenial surface directed upwards, though when growing in clusters on dead stumps, it is directed upwards or downwards or laterally indifferently; but *tremellosa* always projects horizontally from the substratum, with the concave hymenial surface directed downwards.

The great difference, however, lies in the structure of the lower surface. In *Hirneola polytricha*, the hymenial surface of small specimens is perfectly smooth, but in the large specimens it is thrown into irregular folds. This is merely the expression of a more vigorous growth, and it is quite evident from an inspection of the fresh specimen that these ridges are merely more or less accidental folds and not a structural feature. Specimens grown under a bell glass persist for several months and pass from the plane to the folded form. Sometimes the folding or pleating involves the whole thickness of the fungus. But the lower surface of *A. tremellosa* is furnished with distinct ribs which are just as much a constant structural feature as the gills of an agaric; and there are no corresponding depressions on the upper surface. When a pleated specimen of *H. polytricha* is dried, the folds contract into sharp ridges, and in this condition they might conceivably be confused with the ribs of dried *A. tremellosa*, but I cannot imagine anyone confounding the two in the fresh state. In colour, consistency, habit, and structure, *H. polytricha* differs entirely from *A. tremellosa*, and Ceylon does not yield intermediate forms.

As far as *Auricularia auricula judæ* is concerned, only *H. polytricha* could be said to resemble that species. It is similar in colour, consistency, and habit, but is apparently sufficiently distinguished by its covering of white or brown coarse hairs.

For six months, I had a succession of crops of *H. polytricha* from tea prunings buried in pots in the laboratory, but although these were constantly deluged with water by an over-zealous attendant, there was no variation in the direction of *Auricularia tremellosa*; some of the specimens were 6 cm. in diameter. Again, both species have been grown for several months on a Hevea log which stood upright in a vessel of water on the laboratory verandah. On one side of the log grew typical *H. polytricha*, on the other side typical *A. tremellosa* ; but there were no intermediate forms.

On the Ceylon evidence, therefore, *Hirneola polytricha* Mont. must be regarded as distinct from *Auricularia tremellosa* Fr., and both of them distinct from *Auricularia auricula judœ.*

Beccari's Ceylon specimen of *Auricularia lobata* was recorded with a query, as it was "vix determinandum." I have collected this species at Hapugastenne in almost the wettest district in the Island. The colouration of the upper surface agrees with Brefeld's figure (Untersuchungen Heft. VII., Taf. IV., Fig. 1*a*), while the hymenial surface of the young specimens matches in configuration and colour his figure of *Auricularia mesenterica* (Taf. IV., Fig. 1*b*). This species is apparently rare in Ceylon.

56.—**Sarcosoma Thwaitesii** (B. & Br.) Petch.

Rhizina Thwaitesii B. & Br., Fungi of Ceylon, No. 920, Journ. Linn. Soc., XIV., p. 102.

"*Rhizina spongiosa* Berk. & Curt." Massee in Journ. Linn. Soc., XXXI., p. 470.

Up to 5 cms. diameter, 1 to 3 cm. thick. With the exception of the thin disc (about 0·75 mm. thick), the whole fungus is strongly gelatinous when fresh, large specimens being semi-liquid internally in wet weather. The general form is subhemispherical, with the flat side uppermost, and the edge rounded ; the disc is sunk into the upper surface for a depth of about a millimetre, leaving a regularly convex swollen margin up to 5 mm. broad. The disc is pale brown or yellow-brown, circular, plane, bordered by a vertical, fawn-coloured, tomentose edge. The margin and under-surface are dark brown, or blackish-brown, almost black at the base, minutely tomentose, regularly convex, not lacunose. It is attached by a central point ; there are no attaching rhizoids. Internally it is almost black and gelatinous.

The asci are up to 520 μ long, 17–24 μ broad, cylindric, with a rounded apex and a slightly curved pedicel, operculate, eight-spored, spores uniseriate. The paraphyses are linear, branched towards the top, slightly thickened at the apices, septate. The spores are hyaline, oval or narrow-oval, continuous, thick walled, ornamented with flattened warts up to 3 μ diameter or with branching ridges, 34–44 × 15–20 μ, sometimes narrower and 46 × 14 μ, sometimes more broadly oval and 39 × 24 μ. The last two measurements were taken from extruded spores from one specimen, in which the majority of the spores were 36–44 × 15–20 μ.

This species grows on the main stem and branches of living *Juniperus bermudianus* up to a height of twelve feet or more from the ground. On the branches it appears to be the cause of "Witches' brooms." The habitat given by Berkeley and Broome, "On twigs covered with lichen," exactly describes the twigs of *Juniperus bermudianus*, and it is probable that the recent specimens have been gathered from the same tree as those collected by Thwaites. On branches which have fallen to the ground the specimens are thicker and more tomentose externally than those on the tree.

Massee (*loc. cit.*) gives *Bulgaria trichophora* as a synonym of *Rhizina spongiosa*, and therefore of *Rhizina Thwaitesii*. But the figure of *Bulgaria trichophora* (Journ. Bot., XXIX., Pl. 300, Figs. 7–10) shows a simple difference which at once serves to distinguish it from the present species. The margin of *Bulgaria trichophora* is inrolled when dry. Now, since the disc of *Sarcosoma Thwaitesii* is rigid, while all the rest of the fungus is gelatinous, the margin does not roll inwards when drying. The whole of the gelatinous portion shrinks underneath the disc, the latter remaining almost plane, or even becoming convex. The disc thus occupies the whole of the upper surface, and the lower surface is thrown into more or less concentric folds. A dried specimen is only about two millimetres thick.

The mycelium of the fungus runs in the bark and emerges as a velvety brown cushion which opens at the apex, exposing a minute disc which gradually increases in size. The disc is directed upwards or downwards or laterally, according to the position of the fungus on the branch, *e.g.*, when it develops on the main stem the disc is parallel to the latter.

Sarcosoma orientale Pat. (Bull. Soc. Myc. France, Vol. XXV., p. 3) from Annam, is closely allied to, if not identical with, the present species. It has the same habit. It differs in having its disc orange-yellow, and its spores 42–50 × 16–18 μ. In other points it agrees with *S. Thwaitesii.*

57.—**Peziza reticulata** (B. & Br.) Petch.

Rhizina reticulata B. & Br., Fungi of Ceylon, No. 919, Journ. Linn. Soc., XIV., p. 102.

Peziza rhytidia Berk. in Massee, Journ. Linn. Soc., XXXI., p. 502.

This species has been re-examined by Massee (*loc. cit.*) who considers that it is identical with *Peziza rhytidia* Berk. His description of *Peziza rhytidia* does not quite fit the Ceylon species, but it is difficult to decide in what degree this is due to the fact that it was drawn up from dried specimens. *Peziza reticulata* appears to differ from *P. rhytidia* in being subgelatinous, in the colour of the disc, in its stouter paraphyses, and in its larger spores.

Gregarious ; ascophore up to 7 cms. diameter, 1 cm. thick, almost sessile, or prolonged into a conical stalk up to 8 cms. high ; entirely subgelatinous ; disc cup shaped, becoming plane or undulating, circular ; margin even, remaining incurved for some time ; externally black, lacunose, slightly velvety, strigose or naked at the base ; internally blackish, strongly gelatinous ; disc at first black, then chocolate. It contracts when dry into a thin horny plate, and is then reticulated underneath, but there are no " raised anastomosing ribs " on the fresh specimens. Asci 400–440 × 15–18 μ, uniformly cylindrical with a slightly curved pedicel, apex rounded and not blue with iodine, eight-spored, spores uniseriate or obliquely uniseriate. Spores hyaline, smooth, oblong-oval, curved, ends obtuse, 25–34 × 13–18 μ, two or three guttulate. Paraphyses stout, up to 4 μ diameter, septate, slightly inflated at the tips, branched. On dead wood, sometimes on Rhododendron leaves ; Hakgala.

P. rhytidia is said to have very slender paraphyses, spores 25 × 10–11 μ, a black disc, and raised anastomosing ribs on the exterior ; it is not said to be subgelatinous.

58.—Peziza epispartia B. & Br.

Peziza (*Discina*) *epispartia* B. & Br., Fungi of Ceylon, No. 922, Journ. Linn. Soc., XIV., p. 103.

Peziza (*Discina*) *radiculosa* B. & Br., Fungi of Ceylon, No. 923, Journ. Linn. Soc., XIV., p. 103.

Peziza (*Humaria*) *flavotingens* B. & Br., Fungi of Ceylon, No. 933, Journ. Linn. Soc., XIV., p. 104.

Sarcoscypha radiculosa (B. & Br.) Sacc., Sylloge Fungorum, VIII., p. 155.

This species grows from termite nests, and has not been found in any other situation. When an old termite comb is placed under a bell glass and allowed to become rather dry, so that the growth of the usual *Xylaria* is inhibited, it develops small subglobose tufts of red or yellow hyphæ; these are about 0·3 mm. diameter, often confluent. In " The Fungi of certain Termite Nests " (Ann. Perad., III., p. 248), it was stated that these tufts were a *Cephalosporium*. This statement is an error; it has since been determined that the tufts are always barren until they produce the *Peziza* and that the *Cephalosporium* is intrusive. With a greater degree of moisture, the red or yellow hyphæ spread completely over the comb and climb up the sides of the bell glass. They then develop small spheres, the upper half of which splits off as a hemispherical cap, leaving a sessile *Peziza*. This *Peziza* has also been found to arise from termite nests after the inhabitants have been killed by injecting sulphur dioxide and arsenical fumes into the nest: the yellow mycelium then spreads upwards through the soil and produces the fructification, in clusters or singly, on the surface. In one instance, where it was found developing from a deserted termite nest in a densely-shaded shrubbery, the yellow mycelium ran freely over and among dead leaves and for a height of about a foot up the trunks of neighbouring trees, covering altogether an area of several square yards. Such an extensive development of superficial mycelium only occurs in very damp situations; in drier situations, as in one instance where it grew from a nest beneath a bungalow verandah, the fructification is formed as soon as the mycelium reaches the surface. It has been found on several occasions, and in no instance was there any doubt about its connection with a termite nest; it must be regarded as a constituent of the fungus flora definitely associated with termite nests, though apparently it does not develop until the combs are old.

Berkeley and Broome described *Peziza radiculosa* as "sending down a long root or threads into the soil." Cooke, in Micrographia, Pl. 28, Fig. 107, figures it with a long, thick, yellow stem, pointed at the base, and apparently considers that it should be classified with such species as *Peziza tricholoma.* Saccardo follows Cooke, and names it *Sarcoscypha radiculosa.* Massee (Journ. Linn. Soc., XXXI., p. 480) correctly states that "the ascophores when expanded lie flat on the soil." Such a specimen as that figured by Cooke is quite abnormal, and could only be produced by the growth of the mycelium either through a worm hole (in which case it would not be rigid) or along a dead twig. There is nothing resembling Cooke's figure among the specimens in the Peradeniya herbarium; all are sessile, with weak basal mycelial strands. *Peziza flavotingens* was said to grow "among fragments of herbs which are bound together by the mycelium;" this describes exactly its condition when growing in damp shrubberies, and Cooke's figure (Micrographia, f. 38) is a good representation of a cluster of such ascophores. Berkeley and Broome's specimens of *Peziza flavotingens* were immature, but Massee (*loc. cit.*, p. 484) state that the spores are 11–12 × 5 μ; that is probably an error, since in all other particulars the immature specimens agree exactly with *Peziza radiculosa.*

The type specimens of *Peziza epispartia* in the Peradeniya herbarium agree with *Peziza radiculosa* in all respects. They have the same asci and spores, the latter measuring 6–7 × 3·5–4 μ, and few paraphyses. Berkeley and Broome state that it is about an inch across, but the largest specimen is only 11 mm. They also state that it is at first cup-shaped, soon expanded, externally "tomentosa-pulveraceo," with spores 7·5 × 3·75 μ, and a mycelium of rather thick cylindrical threads, in all of which points it agrees with *P. radiculosa.* They say that it grows "apparently on very rotten wood," but there is nothing attached to the herbarium specimens, and they might equally well have grown on the ground. The size of the spores, and the mycelium, point strongly to its identity with *P. radiculosa.* Berkeley and Broome do not mention its colour, but state that at first sight it resembles *P. sarmentorum.* Now, *P. sarmentorum* varies from crimson to pale rose, and therefore is quite different from *P. radiculosa* when fresh ; but the former becomes yellowish in drying, and the latter becomes orange-red, so that it is quite possible that the dried specimens might look alike. It is quite impossible to judge colour from the dried specimens. Cooke (in Micrographia) figures *Peziza sarmentorum* dull yellow, and thus affords confirmation of the above explanation of Berkeley and Broome's reference. In Massee's re-description of *P. epispartia* the disc is said to be "brownish with a tinge of flesh colour, or sometimes tinged lilac ;" this is even still further removed from *P. sarmentorum.* Massee also re-describes *P. sarmentorum* twice and states that it is entirely pale tan colour when dry (*loc. cit.*, p. 480), and entirely ochraceous when dry (*loc. cit.*, p. 499). It is evident that all these colour descriptions are inaccurate, and therefore cannot stand in the way of the conclusion that *P. epispartia* is identical with *Peziza radiculosa.*

The ascophores are scattered or clustered, united to the soil by yellow mycelium ; they are at first globose and split off a hemispherical cap which often remains, shrivelled up, attached to one side. The disc when fully expanded is plane or undulating, up to 1·5 cm. diameter, glabrous, pale yellow or bright orange-yellow when fresh, becoming orange-red when dry. It is rather fleshy, and yellow internally. The exterior is paler than the disc and somewhat scurfy. The asci are narrow-cylindric, 85–120 × 6–7 μ, with a slightly curved pedicel, and the spores are obliquely uniseriate. The spores are oval, hyaline, continuous, 6–7 × 3·5–4 μ. The paraphyses are few in number, as long as the asci, filiform, slightly inflated at the tip, septate, and sometimes branched.

Peziza citrina Penz. and Sacc. (Icones Fungorum Javanicorum) appears, from the description and figure, to be the same species.

59.—Ascobolus leiocarpus B. & Br.

Ascobolus leiocarpus B. & Br., Fungi of Ceylon, No. 971, Journ. Linn. Soc., XIV., p. 109.

Gregarious, sometimes connate, fleshy, up to 3 mm. thick; up to 1·2 cm. diameter, circular, margin regular; or up to 2·5 cm. diameter, circular, or elongated, strongly lobed, with incisions extending as much as 6 mm. into the disc. Disc plane, or convex, or undulating in the larger examples, yellowish-green at first, then purple-black; margin white, with a reddish tinge, scurfy; lower surface scurfy, grayish-white, greenish-yellow at the base. Asci cylindric, tapering slightly below, 240 × 25–30 μ; pedicel usually abruptly narrowed, irregularly nodulose, about 30 μ long and 8 μ diameter; eight-spored, spores obliquely uniseriate. Paraphyses linear, tips slightly thicker and 3 to 4 μ diameter, septate, sometimes branched; tips yellow. Spores elliptic-oblong, ends rounded, violet, then pale brown, smooth or faintly areolated with very fine lines, 23–27 × 12–14 μ.

On dung; Peradeniya.

Examples recently collected agree exactly with the herbarium specimens.

60.—Hypocrea fusigera B. & Br.

Hypocrea fusigera B. & Br., Fungi of Ceylon, No. 993, Journ. Linn. Soc., XIV., p. 112.

Effused; when moist, pulvinate, tuberculate, cream coloured or yellowish, somewhat pellucid, marked with scattered fuscous spots (ostiola); when dry, flattened, and more tuberculate, pale reddish-ochraceous; irregularly oval, up to 7 mm. long and 4 mm. broad, or confluent in large patches; oftenwith small outlying stromata which contain only one loculus; margin sometimes tomentose, usually glabrous; ostiola not projecting, sometimes depressed. Loculi globose or ovoid, 0·25 to 0·3 mm. broad, 0·3 to 0·4 mm. deep, rather distant. Asci clavate, apex rounded, 170–180 × 20 μ, eight-spored; spores at first obliquely uniseriate, afterwards irregularly fasciculate. Spores hyaline, fusoid, ends blunt, one-septate, slightly constricted at the septum, not separating into two, contents granular (granules up to 2 μ diameter), straight or slightly curved, 72–110 × 11–13 μ. Paraphyses linear, short, in a dense fringe, about 30 μ long.

Berkeley and Broome state that the spores are 0·003 inches long, *i.e.*, 75 μ long. In Saccardo, Sylloge Fungorum, they are said to be 7·5 μ long. The measurements given above were obtained from extruded spores, all from the same stroma. Specimens recently collected agree with the type in Herb. Peradeniya. It grows on dead stems of *Amomum* spp.

61.—Hypocrella ceramichroa (B. & Br.) Petch.

Hypoxylon ceramichroum B. & Br., Fungi of Ceylon, No. 1059, Journ. Linn. Soc., XIV., p. 120.

Glaziella ceramichroa (B. & Br.) Cooke, Grevillea XI., p. 83.

Berkeley and Broome's type of *Hypoxylon ceramichroum* in Herb. Peradeniya contains twenty-one specimens, measuring from 1·5 to 9 mm. in diameter. The larger are almost spherical, the smaller about two-thirds of a sphere. The colour is red-brown externally, with the exception of one example which is somewhat clay coloured, becoming black. Internally the colour is pale yellow to brownish-red. They are attached to the stem of a *Smilax*, but it is easy to see that the stem was quite sound when collected and that the fungus could not have developed at the expense of its tissues. The specimens are superficial and easily detached, as stated by Berkeley and Broome, and when detached they leave an oval scar, or rather discolouration, on the stem. Examination of the base of the specimens proves that they grew, not on the stem, but on a scale insect, and there is sufficient left of the latter to show that it is *Lecanium nigrum*.

Berkeley and Broome cut sections of the largest specimen, but unfortunately size is no criterion of development in *Hypocrella;* the perithecia in that particular example are all immature, and abnormally arranged somewhat regularly near the periphery. Still, it is possible to find in them asci with parallel spores. The smaller examples bear perithecia and pycnidia at varying depths, and the asci contain large numbers of small spores, identical with those described below. There is no doubt that the fungus is a *Hypocrella.* I have had no opportunity of consulting Cooke's later description in Grevillea.

It appears to be a fairly common form on *Lecanium* in the East. The *Aschersonia* stage is recorded by Parkin in his paper on "Fungi parasitic on Scale Insects" (Ann. Perad., Vol. III., pp. 11–82) under the heading "B.—Forms with rich brown unflattened stromata without paraphyses" (p. 38), and again under the heading "A Fungus with *Aschersonia*-like stromata, but black" (p. 39). Parkin states that the conidia are 4 to 5 μ broad, but an examination of his specimens proves that they are only 1·5 to 2 μ broad. He records the *Hypocrella* stage on pages 29 and 30, the orange-coloured form as No. 1, and the black form as No. 3, but the length of the ascus is said to be 103 μ, whereas his specimens show that it is 170 to 180 μ; there are asci 110 μ in length, but they are immature. Parkin's *Hypocrella* No. 2 was on *Chionaspis*: it was immature, and it is not included among his material at Peradeniya.

The forms recorded by Parkin, and Berkeley and Broome, which are now in the Peradeniya herbarium and have been re-examined, occur on—

Lecanium expansum, on leaves of *Schumacheria alnifolia* (Ceylon).

Lecanium sp., on leaves of *Gelonium lanceolatum* (Ceylon).

Lecanium psidii, on leaves and stems of *Myristica moschata* (Ceylon).

Lecanium hemisphæricum var. *coffeæ*, on tea leaf and stem (Assam).

Lecanium sp., on tea leaf and stem. (Kurseong and Darjeeling).

Lecanium sp., on *Calophyllum Walkeri* (Ceylon).

Lecanium sp., on *Jambosa aqua* (Java).

Lecanium nigrum, on *Smilax* sp. (Ceylon).

To these are to be added the following recent examples on—

Lecanium nigrum, on leaves and stems of *Hevea brasiliensis* (Ceylon).

Lecanium hemisphæricum, on *Schizœa digitata* (Ceylon).

Lecanium sp., on leaf of *Garcinia* sp. (Ceylon).

Lecanium marsupiale, on an undetermined leaf (India).

Lecanium tessellatum, on *Litsea zeylanica* (Ceylon).

Eriochiton theæ, on tea leaf and stem (Assam).

All the examples are on species of *Lecanium* except the last-quoted, and that is on a *Lecaniid*.

The fungus occurs either on the upper or under side of a leaf or on the stem. The position of a *Hypocrella*, though usually included in its description, is immaterial, since it is governed merely by the position of the insect. As a rule the specimens are scattered, but they sometimes occur in crowded clusters, especially on the stem, and are then variously distorted. The colour varies, being bright orange, orange-red, red, buff, or clay-coloured; when growth ceases, it gradually becomes dark slate-coloured, or blackish, sometimes quite black. This change of colour occurs when growth stops, not when the fungus has attained any given stage or size, and it usually begins in patches. The blackening is often intensified by the growth of *Meliola* or *Asterina* over the specimen. Internally the colour varies from pale yellow to orange. The stromata are usually hemispherical or about two-thirds of a sphere; young examples may be pulvinate and flattened. As a rule there is no hypothallus. These subglobose examples vary from 1·5 to 10 mm. in diameter. A marked variation (or stage of growth ?) occurs in some collections where several examples have a pulvinate covering over the scale insect with a conical or rounded elevation in the centre (Parkin, Fig. 43). It is probable that this marks a less luxuriant growth than the subglobose examples. This is exceptionally well marked in the specimen illustrated in Parkin's figure 23; in these, the stromata are circular and up to 7·5 mm. diameter at the base, rising gradually for a width of about 2 mm., and then more abruptly until they attain a height of about 4 mm.; in this case the variation is probably due in part to the scale insect, since the specimens are growing on *Lecanium expansum* which is flattened, almost circular, 5 to 7 mm. long and 4·5 to 6·5 mm. broad, whereas *L. nigrum* is oval, convex, 3 to 5 mm. long and 2 to 3 mm. broad.

Young specimens are almost smooth: old specimens are tuberculate. The pycnidial and perithecial orifices are usually inconspicuous (at first); the former are indicated by darker reddish dots, and do not project; the latter occasionally have a projecting ostiolum for about 50 μ, but generally it is not more than 10 μ or absent altogether. But on old examples, after the conidia have been extruded, the pycnidial orifices form circular openings, about 0·25 mm. in diameter, with an upturned edge: these make the stromata rough. Specimens with projecting ostiola resemble Möller's Fig. 51, *Hypocrella Gartneriana* (Phycomyceten und Ascomyceten).

The perithecia are flask-shaped, 400 to 500 μ deep (including the neck) and about 250 μ diameter: they are situated all over the stroma at various depths, but always near the periphery. In the younger stromata they are found only near the base. The pycnidia are variable; in large specimens they form irregular tubes about 0·2 mm. wide, sometimes forked, often with lateral cavities, descending into the stroma for a length of 2 mm., or often almost to its base; in young specimens they have the same general character, but are shorter, though some are flask-shaped and others vertically compressed. In old stromata the black coloration extends down the pycnidial tube. The conidia are fusiform, with pointed ends, often guttulate, and measure 7–13 × 1·5–2 μ; there are no paraphyses in the pycnidia. The asci are narrow-clavate, 170–180 × 8 μ, with a truncate thickened apex penetrated by a narrow axial canal, and contain eight linear, somewhat spirally-arranged spores which break up into oblong sporules, 6–8 × 1·5–2 μ. As a rule, the stroma forms pycnidia first, and then perithecia, but some large stromata appear to bear perithecia only.

Möller's *Hypocrella Gartneriana* agrees with the present species in the size of its spores and its colour, but it differs in being more lobed, and in having only four primary spores in the ascus, though Möller appears to be doubtful about the latter point; it seems most probable that it is the same species. It is impossible to deduce any conclusions from the descriptions of other species. In very few cases is the scale insect recorded, and in most cases the ascus spores were evidently not mature. When the colour and shape vary so greatly, it is unsafe to establish species on small collections, and it may be found that the species of scale insect on which the fungus grows affords a more reliable determination than either of these two characters. It would certainly be surprising if a species which is known to occur on *Lecanium* in India, Ceylon, and Java did not occur in other parts of the Tropics. Species which might prove on examination to be identical with *Hypocrella ceramichroa*, judging from their descriptions, are *Aschersonia sclerotioides* P. Henn., from Java, *Hypocrella pernettyœ* Pat. from Java, *Aschersonia badia* Pat., from Tonkin, and *Aschersonia marginata* Ell. & Ev., from the Sandwich Islands. From an extensive collection of *Aschersonia* spp. at present under examination, it would appear that the species on *Aleurodidœ* always possess paraphyses, while those on *Lecaniidœ* never have them.

In an account of *Fleischeria javanica* Penz. & Sacc., in Ann. Peradeniya, IV., p. 60, it was stated that that species did not grow on a scale insect. Further examples from the same locality have shown that that statement is incorrect : in one case it was associated with *Lecanium oleœ*, and in another, with an undetermined *Lecaniid*. This species is apparently distinct from *Hypocrella ceramichroa ;* the pycnidial orifices project slightly, and the perithecia are arranged singly in superficial tubercles, so that an old example resembles a group of nectrias on a globose stroma ; it is slightly tuberculate when young and strongly tuberculate when old ; the conidia are broader, 8–14 × 3–3·5 μ and the ascospores, according to Penzig and Saccardo, are 14–15 × 1·7–2 μ though in my Ceylon specimens the largest ascospore is only 10 × 2·5 μ. There is a slight blackening at the base in some specimens. The pycnidia are without paraphyses, and in this respect resemble those of *H. ceramichroa*. The stromata are rather harder than those of *H. ceramichroa*, but this scarcely seems sufficient to warrant its separation as a distinct genus. The name *Fleischeria* ought to be discarded, and the fungus should be known as *Hypocrella javanica*.

I am indebted to Mr. E. E. Green for the determinations of the insects mentioned above.

62.—**Ophiodothis brevis** (B. & Br.) Petch.

Ephelis brevis B. & Br., Fungi of Ceylon, No. 800, Journ. Linn. Soc., XIV., p. 89.

Berkeley and Broome's description of this species is " solida, nigra ; sporis minutis brevibus linearibus. On *Anthisteria* *tremula*, Peradeniya, December, 1862. Spores ·00016 (inches) long (= 4 μ). Looks at first like an Ergot." Examination of the herbarium specimens fails to reveal any spores of these dimensions, or conidia of any description ; all the specimens examined—there are forty-seven in the Peradeniya herbarium —bear immature perithecia.

The fungus attacks an axillary spike of the inflorescence and completely encloses it, forming a black subcylindrical stroma ; the lowest inner bract is not enclosed, but the stroma is adnate to this over nearly the whole of its length, leaving uncovered a free tip about 2 mm. long. The long outer bract is not affected, and the inflorescence thus assumes the appearance of a stem with alternate leaves bearing an ergot-like body in the axil of each leaf. The appearance is similar to that of Möller's *Balansia regularis*, but the stromata are elongated and sessile.

The stromata are elongated, pulvinate, tapering or obtuse at the upper extremity, flattened on the under surface which is adnate to the bract, up to 6 mm. long, 1 mm. broad, 1·25 mm. thick, usually curved, black, rough with slightly elevated ostiola ; internally white, becoming black towards the exterior. The perithecia are pyriform, densely crowded, 0·25–0·3 mm. long, 0·1–0·12 mm. diameter, with slightly projecting ostiola. The asci are narrow-cylindric, 180–220 μ long, 6–8 μ diameter, eight-spored. The spores are arranged in a parallel bundle, almost equal in length to the asci, 2 μ diameter, hyaline, and apparently not septate.

Recent specimens on *Anthisteria* (?) have been found at Thumpalamcholai.

63.—Sphærella cleidii Sacc.

Sphæria cleidionii B. & Br., Fungi of Ceylon, No. 1119, Journ. Linn. Soc., XIV., p. 129.

On leaves of *Cleidion javanicum* Bl.

Spots blackish-brown with a brown radiating margin, about 1 cm. diameter, surrounded by a pale yellow ring : afterwards becoming whitish owing to the elevation of the cuticle. Perithecia minute, spherical or conical, 80 μ diameter, situated in the epidermis and raising the cuticle which falls off in flakes; ostiola about 10 μ diameter, not projecting. Asci at first oval, then broadly clavate, 50 × 13 μ, eight-spored, the spores arranged irregularly in two rows. Spores hyaline, one septate, slightly clavate, ends rounded, 13–15 × 4 μ.

64.—**Rosellinia bothrina** (B. & Br.) Sacc.

Sphæria (*Byssisedæ*) *bothrina* B. & Br., Fungi of Ceylon, No. 1090, Journ. Linn. Soc., XIV., p. 125.

Perithecia gregarious, embedded at first in dark purple-brown mycelium which subsequently weathers away; at first blackish-brown, with a black ostiolum, then black; superficial, carbonaceous, globose, slightly depressed, 1·5 to 2·4 mm. diameter; smooth (fragments of the mycelium adhere at first to the perithecia, but these soon disappear); ostiolum conical, 0·1 mm. high, springing from a base 0·4 mm. diameter; perithecial wall brittle, black throughout, rather thin, about 0·1 mm. thick.

Asci about 300 μ long, 8 μ diameter, cylindrical, spores obliquely uniseriate or almost uniseriate; paraphyses filiform, about 2 μ diameter, as long as the asci. Spores 40–47 × 5–7 μ, guttulate, finally opaque, black, cymbiform, ends pointed and often abruptly narrowed in the last 3 μ.

The mycelium spreads in white strands under dead leaves and in the upper layers of the soil, and forms large patches, white, then smoky gray, then purple, and finally black, on the stems of the trees and shrubs attacked, just above the surface of the ground. On diseased roots it forms coarse black strands composed of hyphæ which exhibit the usual swellings at the septa. Where the hyphæ enter the root, a white star-shaped patch of mycelium is produced between the wood and the cortex. The mycelium on the stem produces innumerable crowded, erect, compound conidiophores, up to 2 mm. high and 0·1 mm. diameter, which give it a velvety appearance: the conidia are hyaline, narrow-oval, 4–6 × 2 μ.

This species is the cause of the Ceylon root disease in *Grevillea robusta*, *Symplocos obtusata*, tea, *Panax fruticosum*, *Cinnamomum camphora*, and dadap (*Erythrina* sp.), which was formerly attributed to *Rosellinia radiciperda* Mass.; it differs from the latter species, which has not been found in Ceylon, in the shape and size of the perithecia and spores. In some cases it originates on *Grevillea* or *Symplocos* and spreads by means of its mycelium to the stems and roots of tea bushes, but it can also originate in heaps of dead leaves, or on dead logs, and spread to the tea or *Panax* from there. Its dissemination through the tea estates is brought about by the conidia; these are always present in abundance, but the perithecia are found only rarely. Thwaites' specimens are not localized. It occurs on tea estates from Peradeniya upwards (*i.e.*, above 1,500 ft.); I have developed the perithecia from material collected on a tea estate at Peradeniya, and have gathered them from a dead jungle tree at Hakgala. There is no doubt that it is a native, not an introduced, species.

65.—**Rosellinia bunodes** (B. & Br.) Sacc.

Sphæria (*Byssisedœ*) *bunodes* B. & Br., Fungi of Ceylon, No. 1088, Journ. Linn. Soc., XIV., p. 125.

Perithecia densely crowded, embedded at first in purple-brown mycelium, superficial, brownish-black, globose, up to 1·6 mm. diameter, carbonaceous, verrucose with close-set, somewhat pyramidal warts arranged more or less concentrically; ostiolum sometimes papillate, sometimes not elevated; wall of perithecium thin, brittle, about 0·1 mm. thick, black internally.

Spores, 80–110 × 7–12 μ, cymbiform, or sometimes lanceolate, ends acute and produced into a thread-like point which in the longer spores may reach a length of 25 μ, brownish-black, opaque. Asci not seen.

Berkeley and Broome's figure of the conidiophore is somewhat imaginary: it is of the usual *Graphium* type, much branched at the apex, as in *Rosellinia bothrina*. The perithecia have been refound recently at Peradeniya, on sticks in a rubbish heap; these agree in all points with the type specimens in Herb. Peradeniya. It has only been found saprophytic in Ceylon, though it has been recorded as parasitic on *Coffea* in Southern India.

F. Theissen, in "Novitates Riograndensis," Annales Mycologici, Vol. VI., p. 350, records *Rosellinia Desmazierii* (B. & Br.) Sacc. var. *acutispora* Theiss., which is said to differ from *Ros. bunodes* (B. & Br.) Sacc. in having the perithecia not verrucose ; it evidently differs also in the size of the spores, which are only 42–50 × 6–7 μ.

F. v. Höhnel, in " Ergebnisse der Bot. Exped. d. k. Acad. d. Wissensch. nach Sud Brasilien, 1901 : Eumycetes et Myxomycetes," p. 25, notes the relationship of *Rosellinia goliath* (Speg.) v. Höhnel to *Rosellinia bunodes* (B. & Br.) Sacc. The latter species apparently differs in its smaller perithecia, which are only warted, not spinous, and in its smaller spores which, although they have the same tapering points, are only two-thirds the size of those of the former. The bases of the warts of *Rosellinia bunodes* are more or less lozenge-shaped, 0·2 to 0·4 mm. across, and the warts are not more than 0·1 mm. high. *Rosellinia echinata* Massee is apparently closely allied to *Rosellinia bunodes.*

66.—**Rosellinia emergens** (B. & Br.) Sacc.

Sphæria (*Byssisedæ*) *emergens* B. & Br., Fungi of Ceylon, No. 1089. Journ. Linn. Soc., XIV., p. 125.

Perithecia gregarious, embedded to about half their height in closely interwoven purple-brown hyphæ, conoid, about 0·8 mm. diameter at the base, 0·9 mm. high, with an abruptly conical ostiolum, 0·1 mm. high, black, smooth, carbonaceous.

Asci clavate, eight-spored, sporiferous part 160 × 30 μ, shortly pedicellate, apex abruptly cylindrical and thickened ; spores obliquely biseriate. Spores fusoid or broadly cymbiform, straight or slightly curved, ends subacute, contents granular, blackish-brown, covered with a thin hyaline film which is most evident as a small cap at each end, 60–70 × 10–13 μ. Paraphyses not seen.

Rosellinia emergens var *bambusicola* Theiss. (Ann. Myc., VI., p. 351) appears to have perithecia of a different shape, " depresse globosis," and much broader spores (15–22 μ). The above description is drawn up from Berkeley and Broome's type specimen in Herb. Peradeniya.

67.—Bivonella chrysomella (B. & Br.) Sacc.

Melanospora chrysomalla B. & Br., Fungi of Ceylon, No. 1125, Journ. Linn. Soc., XIV., p. 130.

Perithecia scattered or gregarious, superficial, each in a yellow globose tuft of hyphæ by which it is attached to the substratum. Perithecia black, globose, 0·4 to 0·5 mm. diameter, clothed with coarse, intertwined, irregular yellow hyphæ, 4 μ diameter, with a black cylindrical ostiolum, 0·4 mm. high, 0·1 mm. diameter. Outer layer of the perithecium wall fuscous, inner layers thick and yellow : wall fleshy, not carbonaceous.

Asci cylindrical with a short abrupt pedicel, 85–90 × 8 μ ; spores obliquely uniseriate, or linear in the lower half of the ascus ; spores 12–13 × 6 μ, fuliginous, oval, with three cross septa and a longitudinal, sometimes oblique, septum in one or both of the two middle loculi ; not constricted at the septa ; the septa appear thicker than the wall. Paraphyses absent.

The perithecia are accompanied by pycnidia surrounded by similar yellow hyphæ, and with walls of the same texture as those of *Bivonella chrysomella.* Pycnidia black, somewhat conical, 240 μ high, 200 μ diameter ; mouth fimbriate with yellow hyphæ ; basidia simple, 12–16 × 1–2 μ, or acutely branched with branches up to 25 μ long ; sporulæ hyaline, 3 × 1·5 μ, oval.

Specimens recently collected on decaying bamboo, at Peradeniya, agree exactly with Berkeley and Broome's type specimens in Herb. Peradeniya.

68.—Nummularia pithodes (B. & Br.) Petch.

Diatrype pithodes B. & Br., Fungi of Ceylon, No. 1081, Journ. Linn. Soc., XIV., p. 124.

Anthostoma pithodes (B. & Br.) Sacc., Syll. I., p. 298.

Widely effused, up to 30 cms. long and 15 cms. broad, or confluent for a length of 1–2 metres, on erect, dead, tree trunks ; developing in the cortex and forcing off the outer layers ; adnate, flattened, 2–3 mm. thick, distinctly margined by the cortex, carbonaceous, black, dull or sometimes shining, here and there slightly undulating but usually plane, smooth or minutely papillate. Perithecia densely crowded, vertically elongated, hexagonal in section, 0·5 mm. diameter, 1·5 mm. high; ostiola usually not projecting. Spores dark brown, broadly cymbiform, or fusoid-elliptic, inequilateral, 25–35 × 14–16 μ. Asci not seen.

The herbarium specimens are merely fragments of a large stroma; some pieces are smooth, others minutely papillate, either shining or dull black; the spores agree with the description given above. This is a common and striking species in upcountry jungles, but I have not yet been able to find specimens young enough to show the asci.

69.—**Pithomyces flavus** B. & Br.

Pithomyces flavus B. & Br., Fungi of Ceylon, No. 900, Journ. Linn. Soc., XIV. (1875), p. 100, Tab. 4, Fig. 18.

Neomichelia melaxantha Penz. & Sacc., Diagnoses Fungorum Novorum in insula Java collectorum, series tertia (1902), p. 46; Icones Fungorum Javanicorum, Tab. LXX., 1.

This species was made the type of a new genus by Berkeley and Broome. Their generic diagnosis is "Flocci erecti, granulati, in massam flavam tenuem congesti; sporæ maturæ quinqueseptatæ doliiformes." Under the name of the species they merely add that it grows on some monocotyledon, forms little yellow or olive-yellow thin soft patches, and has spores 37·5 μ long, 25 μ wide in the middle. They give figures showing a somewhat imaginary spinulose hypha, three- and five-septate dark, spinulose spores, and two specimens of the entire fungus. One of the latter appears to show three perithecia, but these really represent three prominences in the substratum, over which the fungus has grown. The species is fairly well recognizable from the figure and the meagre description, and the type specimen in the Peradeniya herbarium places the present identification of recent specimens beyond doubt.

The fungus grows in thin, irregular, usually angular, often branched, effused, yellow or greenish-yellow, superficial patches. These are sometimes 1 cm. long and 5 mm. broad, but most of them do not exceed half that size; the thickness of the patch is not more than 0·1 mm. When old the patches are olive-yellow. The basal layer consists of creeping, fuliginous, closely-warted, septate hyphæ, of uniform diameter (3–4 μ). From these creeping hyphæ arise thinner (2–3 μ diameter) yellow, minutely roughened hyphæ. These latter are simple or branched, somewhat flexuose, septate; they bear the conidia laterally, either alternately or all on one side, on very short pedicels, but their upper ends are barren. These barren extremities are loosely intertwined and form a loose cover which completely hides the black mass of conidia. To the naked eye this cover appears to be a continuous yellow wall, but under a low magnification it is seen to consist of slightly intertwined free hyphæ: it resembles exactly the mass of elaters of a *Trichia.* The spores are elliptical or oblong-elliptical in general outline, coarsely warted, 3 to 5 septate, ends rounded, fuliginous, black in mass; they are rather deeply constricted at the septa, with the loculi regularly inflated between. In the four- and five-septate spores, the terminal loculi are small, being only one-half or one-quarter the width of the middle loculi, and about 4 μ long. The majority of the spores are four- or five-septate and measure 34–47 × 20–25 μ; but some, in the same patch, are three-septate and measure 22 × 18 μ. Berkeley and Broome's figure of the spore is incorrect in representing it with pointed ends and not constricted at the septa.

In old specimens, the upper half, consisting of most of the yellow hyphæ and the spores, peels away in a continuous sheet, and leaves an olive-yellow patch.

This species is undoubtedly identical with *Neomichelia melaxantha* Penz. & Sacc. described and figured from specimens obtained in Java. The spores of the Javan specimen are said to be three- rarely five-septate, slightly constricted, 30–36 × 18–22 μ. The figure of the entire fungus magnified shows the yellow wall too solid. It may be noted that Berkeley and Broome's specimens were (at least in part) on decaying leaf sheaths of *Oncosperma*; recent examples from Peradeniya are also on the same substratum; and it is evident from Penzig and Saccardo's figure that the Javan specimens are on *Oncosperma* also.

Pithomyces is included by Saccardo among the *Tuberculariaceæ.* Penzig and Saccardo place *Neomichelia* in the

Dematiaceæ. This probably explains why they did not refer their fungus to *Pithomyces.* In their list of the Fungi of Ceylon, Berkeley and Broome place *Pithomyces* between *Zygosporium* and *Graphium,* evidently in *Dematiaceæ.* The lax arrangement of the conidiophores precludes its inclusion in *Tuberculariaceæ.*

Pithomyces Berk. & Br. (Char. emend). Hyphæ steriles repentes; hyphæ fertiles laxe cæspitosæ, simplices v. ramosæ, læte coloratæ, basim versus conidiiferæ, supra steriles, intertextæ. Conidia nigricantia, elliptica vel elliptico-oblonga, septata, pedicillis brevibus, lateralia.

Pithomyces flavus Berk. & Br. Effusa, velutina, superficialis, tenuissima, flava, flavo-aurantia, flavo-viridis, vel flavo-olivacea, intus ob conidia nigra, hinc bicolor: hyphis sterilibus repentibus, septatis, scabris, flavo-fuligineis, 3–4 μ diam.; hyphis fertilibus suberectis, simplicibus v. sæpe furcatis, cylindraceis, 2–3 μ diam., flexuosis, minute scabris, septatis, flavidis, supra sterilibus intertextis; conidiis ellipsoideis v. ellipsoideo-oblongis, utrinque rotundatis, crasse scabris, 3–5 septatis, ad septa constrictis, 22–47 × 18–25 μ, fuligineis, coacervatis nigricantibus.

70.—**Sclerocystis coremioides** B. & Br.

Sclerocystis coremioides B. & Br., Fungi of Ceylon, No. 1183, Journ. Linn. Soc., XIV., p. 137.

Tuber zeylanicum B. & Br., Fungi of Ceylon, No. 975, Journ. Linn. Soc., XIV., p. 110.

In the Annals of Botany, Vol. XXII., pp. 116–117, it was stated that the genus *Sclerocystis* was founded on a sclerotium, and that *Tuber zeylanicum* was another larger sclerotium, which when planted in damp sand produced small sclerotia resembling those of *Sclerocystis coremioides.* The two species have since been found developing together from the same mycelium, and there is no doubt that they are identical. It has not yet been possible to ascertain to what group it belongs, but evidently both names should be discarded. *Sclerocystis* might be revived if it is subsequently found that the complete fungus does not fall into any existing genus.

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On Lasiodiplodia.

BY

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THE genus *Diplodia* forms a huge unwieldy group of weakly differentiated species, and any method of subdividing it into smaller groups would be welcomed. But it is evident that some of the present subdivisions, though they may appear distinct on paper, only lead to confusion in practical mycology.

Saccardo, in "Sylloge Fungorum," Vol. III., adopts the following scheme of subdivision :—

§ Pycnidia discreta.
    † Pycnidia tecta vel erumpentia.
  Diplodia.—Pycnidia glabra ; sporulæ strato mucoso carentes.
  Macrodiplodia.—Pycnidia glabra ; sporulæ strato mucoso obvolutæ.
  Chætodiplodia.—Pycnidia pilosa ; sporulæ strato mucoso carentes.
    †† Pycnidia lignicola, subsuperficialia.
  Diplodiella.—Pycnidia subcarbonacea, papillata.
§§ Pycnidia cæspitosa.
  Botryodiplodia.—Pycnidia cæspitoso-erumpentia.

Except that *Chætodiplodia* may be "*setosa vel pilosa*," no further differences are disclosed by the subgeneric descriptions.

In the "Botanical Gazette," Vol. XXI., No. 2, p. 92 (February, 1896), another subgenus, *Lasiodiplodia*, was described by Miss Ida Clendenin. The fungus for which this subgenus was instituted, *Lasiodiplodia tubericola*, was found on sweet potatoes which had been imported from Java, and was submitted to Ellis, who decided that it was worthy of separate generic rank. Hence *Lasiodiplodia* is attributed, in the article referred to, to Ellis and Everhart. The generic characters

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are—"Perithecia collected in a stroma, clothed with brown mycelium; basidia and sporules with paraphyses intermingled; otherwise as in *Diplodia.*"

Since then other subgenera have been instituted, viz.:—*Microdiplodia*, with distinct pycnidia, and spores less than 15 μ long; *Pellionella*, with subsuperficial pycnidia produced into a beak, "*Est Diplodiella rostrata*"; *Rhynchodiplodia*, which is a beaked *Chætodiplodia*; and *Diplodiopsis*, which is a superficial, granulato-rugulose *Botryodiplodia*. With these last four this communication is not concerned, except that in so far as they are based on the older scheme of subdivision they are open to the same objections.

How this subdivision works in practice is best illustrated by the following example:—

In 1892, Patouillard (1) described *Botryodiplodia theobromæ*, on fruits of cacao from Ecuador. Its pycnidia are 200 μ diameter, more or less villous, united in a black villous stroma; the spores are brown, uniseptate, 25–35 × 12–15 μ; basidia hyaline, 50 μ long. A note in Saccardo adds "ad *Chætodiplodiam* vergit," but this does not appear in the original description.

In 1894, Prillieux and Delacroix (2) described *Macrophoma vestita* on the roots of cacao from Central America. Its pycnidia are 300 μ diameter, with hyaline, non-septate spores, 30 × 15 μ. The pycnidia are figured as simple and isolated.

In 1897, P. Hennings (3) described *Diplodia cacaoicola* on branches of *Theobroma cacao* from the Cameroons. Its pycnidia are scattered, immersed in the cortex; and its spores are 22–28 μ × 12–14 μ. This species was investigated by Howard in the West Indies, and from his account (5) we are able to add more details to Hennings' brief description.

Howard states that the rind of sugar cane is ruptured by the growth of dark bodies underneath, which are arranged in more or less vertical lines. These are colonies of true pycnidia, formed just beneath the rind, in connection with a dark-brown, septate, branched mycelium abundant in the tissues of the plant. His figure 11, which illustrates the growth of the fungus on cacao, shows four adjacent erumpent pycnidia in a basal weft of hyphæ. The pycnidia are said to contain short conidiophores, 20–40 μ in length, and numerous paraphyses. When diseased pieces of sugar cane were placed in a moist chamber, it was observed that there was a considerable development of hairlike processes on the walls and round the opening of the pycnidium, giving the colonies a furry appearance which was never noted in the cane in ordinary circumstances. In plate and flask cultivations there was an enormous development of mycelium, forming a felt up to half an inch thick, in which the pycnidia were embedded. Howard states that the spores are very constant in size and measure 20 × 10 μ; in this respect his description of the fungus differs from that of Hennings. He was able to prove by cross inoculations that the *Diplodia* on sugar cane was identical with that on cacao.

In his discussion of the systematic position of the fungus, Howard writes: "In *Diplodia* the pycnidia are free from each other, occurring singly, and there is no stroma. In *Botryodiplodia*, they are arranged in colonies and a stroma is present. In considering the behaviour of the fungus under discussion under artificial conditions and on the host plants, it will be seen that there is a great variation in the arrangement of the pycnidia, as they sometimes occur alone, at other times in colonies. There is, besides, a good deal of variation in the amount and arrangement of the hyphæ surrounding the pycnidia. In some cases the latter appear to be embedded in a stroma, in others to stand in a web of hyphæ. It would therefore appear likely that the fungus on cacao pods in Ecuador (*i.e.*, *Botryodiplodia theobromæ*) is identical with that which is so common in the West Indies."

In March, 1906, Appel and Laubert (7) described the second known species of *Lasiodiplodia*, viz., *Lasiodiplodia nigra*, which was found on the lower parts of dead stems of *Theobroma cacao* and *Carica papaya* in Samoa. It formed black stromata, 2 to 4 mm. in diameter. The spores in the alcohol material measured 22 × 12 μ, but those developed in cultures were 28–32 × 18–21 μ. The stromata were pilose, and the pycnidia contained paraphyses.

In the same month, the present writer (9) published descriptions of two species of *Diplodia* which occur in Ceylon.

viz., *Botryodiplodia elasticæ* and *Chætodiplodia grisea*. *Botryodiplodia elasticæ* was found on *Hevea brasiliensis* and *Castilloa elastica*, and has since been discovered on *Ficus*, *Thea*, *Albizzia*, *Erythrina*, *Carica papaya*, and *Cocos nucifera*. In the case of *Hevea*, it was first found parasitic on young plants ("stumps") shortly after they had been planted out in the field. It burst through the cortex in linear or rounded masses up to 2 mm. diameter: these were largest when they emerged at the point of exit of the lateral roots. These masses were true stromata, and were glabrous. Higher up on the same stems, the pycnidia occurred singly or in groups, embedded in the bark. The pycnidia were 0·25–0·4 mm. in diameter, with spores 25–30 × 14–15 μ, and abundant paraphyses up to 80 μ long. The hyphæ of the fungus are at first hyaline, then violet black, but become brownish when old or when preserved in alcohol. The course of the hyphæ in fresh specimens is easily recognized by the long blackish streaks extending through the stem of the host. On young *Castilloa* which had been damaged by fire, the soft decaying bark was filled with masses of hyphæ which also ran, more or less free, over the surface of the wounds. In this case, the pycnidia were surrounded by loose hyphæ, and there was no solid stroma. The fungus has since been found to be an almost universal saprophyte on dead *Hevea* stems, but if the stems are not too damp, *e.g.*, when they have been lying in the laboratory for a fortnight, the pycnidia remain embedded in the bark, and there is no outward indication of their presence until the stem is covered with the extruded spores. In these cases the pycnidia may be united by a basal weft of hyphæ. In the soft, watery stems of *Carica papaya*, the loose weft of hyphæ is usually well developed, as in the case of *Castilloa* referred to above.

Appel and Laubert's description of *Lasiodiplodia nigra* was not available when the description of *Botryodiplodia elasticæ* was published, and even if it had been, it is doubtful whether, from the description, the Ceylon species would have been considered identical. Hennings' description of *Diplodia cacaoicola* does not mention the paraphyses (the most striking feature of the fungus), and Howard states that the spores of that species are 20 × 10 μ: it seemed certain therefore that the Ceylon fungus was a different species, and as it did not agree with any of those described in Saccardo, it was considered new.

Diplodia cacaoicola had not been recorded for Ceylon prior to 1906, though the diseases of cacao had been under investigation for several years. In 1906, however, it was found to be fairly common on cacao in the Island, and on comparison with *Botryodiplodia elasticæ*, the two "species" were found to be practically identical, though *D. cacaoicola* has not been observed to form true erumpent solid stromata on cacao. This was recorded in the report of the Mycologist for 1906: "There seemed some probability that this fungus (*i.e.*, *Botryodiplodia elasticæ*) was identical with *Diplodia cacaoicola* Henn., which is parasitic or saprophytic on cacao, or at least with the *Diplodia* on cacao in Ceylon. The descriptions of *D. cacaoicola*, however, are contradictory, and our species does not agree with those of recent writers." It was hoped to decide this point by infections, but pressure of other work made this impossible.

Chætodiplodia grisea Petch was found on decaying cacao pods which had been kept moist. The pycnidia were scattered, and clothed with erect hairs. The spores measured 24–28 × 13–14 μ, and the fungus possessed long paraphyses.

A *Lasiodiplodia* has been recorded by V. K. Charles (6) as parasitic on *Theobroma cacao* and *Mangifera indica* in San Domingo, but apparently it has not been named. This record has given rise, in the West Indies, to the idea that there are two serious diseases of cacao there, one caused by *Diplodia cacaoicola* P. Henn., and the other by *Lasiodiplodia* sp.

Finally, in 1908, a *Chætodiplodia* was recorded by C. J. J. van Hall and A. W. Drost, as parasitic on cacao pods in Surinam (12).

From the descriptions briefly quoted above, the six fungi referred to are clearly all different. *Macrophoma vestita* has hyaline spores; *Diplodia cacaoicola* (according to Hennings' description) and *Botryodiplodia theobromæ* lack paraphyses; *Lasiodiplodia nigra* has spores which attain a *breadth* of 21 μ; *Chætodiplodia grisea* has pilose, scattered pycnidia; and the stromata of *Botryodiplodia elasticæ*, in its most highly developed form, are glabrous. Yet, as the sequel shows, these names all refer to the same fungus!

This chaptor of errors has been partly corrected by Griffon and Maublanc (14). These authors had occasion to investigate a disease of cacao branches and roots from the Congo, and found in the diseased tissue a fungus with pycnidia either simple or grouped in a common stroma ; its spores were ovoid and hyaline, and measured 25–30 × 12–15 μ. This was apparently *Macrophoma vestita*, though the pycnidia of the latter were figured as scattered. An examination of the type specimens, however, showed that the pycnidia were either scattered or grouped, and therefore this apparent difference vanished. Moreover, this re-examination proved that *Macrophoma vestita* is really a *Diplodia*, and a further comparison with the type specimen of *Botryodiplodia theobromæ* showed that it is identical with the last-named species. The supposed *Macrophoma* spores were immature *Diplodia* spores. As a result of this re-investigation, an additional character was added to the description of *Botryodiplodia theobromæ*, viz., that it possesses long paraphyses.

Griffon and Maublanc further conclude that *Diplodia cacaoicola* is the same species. From Howard's account and from the examination of this species in Ceylon, there is no doubt that their conclusion is correct; Howard's spore measurement is unaccountably small, and in this he is followed by Butler (8). They also regard Charles' *Lasiodiplodia* from San Domingo, and *Lasiodiplodia nigra* Appel and Laubert as identical with *Botryodiplodia theobromæ* Pat., both of which conclusions may be accepted.

Griffon and Maublanc's paper reduces three names to synonyms. A further reduction results from a paper by Brick (15). A consignment of young *Hevea* plants ("stumps") was forwarded from Ceylon to German West Africa, *viâ* Hamburg. They were packed in latticed cases, with their roots embedded in damp coconut fibre and earth. On arrival in Hamburg, 87 per cent. of the plants were found to be dead, and the remainder were diseased. Brick, who examined them in Hamburg, found a *Lasiodiplodia* on the dead plants. This he considers is *Lasiodiplodia nigra*, and is identical with

Botryodiplodia elasticæ Petch. From the nature of its occurrence, and the full description given by Brick, there is no doubt that the fungus is *Botryodiplodia elasticæ*, and as he is presumably acquainted with *Lasiodiplodia nigra*, his conclusion as to the identity of these two must be accepted. The Hamburg specimens differ from those recorded from Ceylon in their larger stromata, up to 5 mm. in diameter, embedded in a loose weft of hyphæ, whereas the compact stromata in Ceylon are glabrous. But this difference is just what might be expected if the stromata developed in a constantly damp situation.

A re-examination of the type specimen of *Chætodiplodia grisea* Petch, in the light of the experience gained during the last four years, has convinced me that this is merely *Botryodiplodia theobromæ*, with scattered pycnidia, clothed with hairs as a consequence of its development in a saturated atmosphere. Similarly, A. E. van Hall (18) has arrived at the conclusion that the *Chætodiplodia* sp. recorded on cacao pods in Surinam is only *Diplodia cacaoicola*, *i.e.*, *Botryodiplodia theobromæ*.

As a result of these re-investigations, we must accept the following synonymy :—

Botryodiplodia theobromæ Pat. (1892).
= *Macrophoma vestita* Prill. & Del. (1894)
= *Diplodia cacaoicola* Henn. (1895)
= *Lasiodiplodia nigra* Appel et Laub. (1906)
= *Botryodiplodia elasticæ* Petch. (1906)
= *Chætodiplodia grisea* Petch. (1906)
= *Lasiodiplodia* sp. Charles. (1906)
= *Chætodiplodia* sp. Van Hall & Drost. (1908)

It is scarcely necessary to point out the important bearing which this confusion has upon practical mycology in the tropics. We have been compelled to believe that our cacao diseases were more numerous than those of any other plant cultivated in the tropics, and that each cacao-growing country had its own peculiar parasitic *Diplodia*. The diseases of cacao have recently been monographed by F. C. von Faber (16): in this work nine pages are devoted to the discussion of these Diplodias and their treatment, under the belief that they are all different. Owing to the erroneous descriptions and incorrect identifications of tropical fungi, the diseases of the same plant in different countries are considered quite distinct, and thus the work of a mycologist in one country is thought to be inapplicable to the diseases of another. In actual fact, it is being abundantly demonstrated that plant diseases are identical throughout the tropics, but this state of things has not yet been hitherto perceived for the reasons already mentioned. Even in the same country, an erroneous determination of a known species is liable to cause serious alarm. In the West Indies, for example, the *Diplodia* on cacao has long been known under the name of *Diplodia cacaoicola.* But quite recently, in ignorance of the fact that it was the same thing, a scare has been raised by the discovery on cacao of a *Lasiodiplodia* to whose agency diseases of all descriptions have been attributed.

The distinctions between the various subdivisions of the Sphærioidaceæ-Phæodidymæ are by no means clearly understood. Brick (*loc. cit.*) states: "The genus *Botryodiplodia* Sacc. differs from *Lasiodiplodia* Ell. & Ev. in the absence of the paraphyses in the hymenium." This is scarcely correct. The distinguishing features of *Lasiodiplodia*, as given by its authors, are three, viz., the formation of a stroma, the presence of paraphyses, and the weft of hyphæ surrounding the stroma; and would appear from the name that the latter character was considered the most important. Ellis and Everhart have erred in laying special stress on the occurrence of paraphyses. The presence of paraphyses alone has never been considered a subgeneric character, either before or after the institution of *Lasiodiplodia.* Thus, we have, prior to *Lasiodiplodia*, *Diplodia cococarpa* Sacc., *D. nematospora* Sacc., *D. cactorum* Speg., *D. gongrogena* Temme., *D. guaranitica* Speg., *D. nutans* Speg., *D. ægyptiaca* F. Tassi, *D. paraphysaria* Sacc.; and subsequently, *D. paraphysata* Ell. & Ev., *D. zeylanica* F. Tassi, *D. arthrophylli* Penz. & Sacc., *D. Mangiferæ* Koorders, *D. Wurthii* Koorders, *D. cinchonæ* Koorders, *Chætodiplodia coffeæ* Zimm., *Chætodiplodia vanillæ* Zimm., all with long paraphyses. Of these, *Diplodia paraphysata* Ellis & Everhart is most instructive: it was described in 1897, a year after *Lasiodiplodia tubericola* Ell. & Ev.;

its pycnidia are pilose, scattered or subconfluent, with long internal paraphyses; yet its describers do not consider that it falls within their genus *Lasiodiplodia*. It has two of the characters of that genus, but its pycnidia are not embedded in a true stroma. After this example, we may be quite certain that most of the forms of *Botryodiplodia theobromæ* Pat. would not be considered as *Lasiodiplodia* by the authors of that genus. Nor would *Lasiodiplodia Thomasiana* Sacc., whose pycnidia are "modo solitariis, modo paucis coacervatis."

Bancroft (24) falls into the same error as Brick. In discussing *Botryodiplodia theobromæ*, he states: "But these authors all overlook the presence of paraphyses in the pycnidia, on account of which the fungus must be regarded as a *Lasiodiplodia*." Reference to the characters of the genus will show that this is incorrect, and *Diplodia paraphysata* proves that it was not the authors' idea of their genus. The distinguishing character of *Lasiodiplodia* is the pilose stroma.

The above list of Diplodias which possess paraphyses is in all probability far from complete. Many of the older descriptions include measurements of "basidia," and it appears probable that in some cases these may have been paraphyses. For example, the "basidia" of Patouillard's *Botryodiplodia theobromæ* must have been paraphyses. If the presence of paraphyses is to be considered of subgeneric importance, we are at once beset with difficulties. It would not be at variance with the information available at present, if we were to suppose that very many, if not all, species of *Diplodia* are furnished with paraphyses, but that these attain a length greater than that of the basidium plus its spore only in tropical species. It would be necessary to decide whether a given filament were a paraphysis, or a basidium deprived of its spore, and this would give occasion for endless differences of opinion. The difficulty might be evaded by counting as paraphyses only those filaments which exceeded the length of a basidium plus its spore, but the distinction would be purely artificial, corresponding to that between *Diplodia* and *Microdiplodia*.

The present classification of the Sphærioidaceæ-Phæodidymæ is given in the following table :—

A.—Pycnidia isolated, stroma wanting.	
(*a*) Pycnidia innate or erumpent.	
* glabrous.	
† spores destitute of mucus.	
§ spores exceeding 15 μ	*Diplodia* Fr.
§§ spores less than 15 μ	*Microdiplodia* Alles.
†† spores large, surrounded by mucus	*Macrodiplodia* Sacc.
** pilose or setose.	
† without a rostrum	*Chætodiplodia* Kars.
†† with a rostrum	*Rhynchodiplodia* Br. et Farn.
(*b*) Pycnidia superficial, or sub-superficial.	
† without a rostrum	*Diplodiella* Karst.
†† with rostrum	*Pellionella* Sacc.
B.—Pycnidia united into a stroma.	
(*a*) Stroma glabrous	*Botryodiplodia* Sacc.
(*b*) Stroma pilose	*Lasiodiplodia* Ell. & Ev.
(*c*) Stroma granulato-rugulose	*Diplodiopsis* P. Henn.

This key appears quite definite, but in practice it proves quite unworkable. Brick places the species under discussion in *Lasiodiplodia*, as his specimens were furnished with a stroma, clothed with hyphæ : and as far as his specimens permitted him to judge, his view was quite correct. But it must be remembered.that they had been developed under abnormal conditions. Griffon and Maublanc also place this fungus in *Lasiodiplodia* under the name *Lasiodiplodia theobromæ* (Pat.) Griff. et Maubl., but it would appear doubtful, from their figures, whether the pycnidia were contained in a true stroma. On the other hand, Hennings decided that it was a simple *Diplodia ;* and Howard was of opinion that the fungus should stand as a simple *Diplodia*, not as a *Botryodiplodia*. Butler, however, states that in its natural habitat in Bengal on the sugar cane the fungus must be considered a *Botryodiplodia*, not a *Diplodia*.

If we collect the opinions of those mycologists who are known to have examined this fungus, we find that seven have considered it a simple *Diplodia*, three a *Chætodiplodia*, three a *Botryodiplodia*, and six a *Lasiodiplodia*. If, however, we consider only the independent determinations of the fungus, the number of times it has been assigned to *Lasiodiplodia* is only four, and in none of these four cases has the determination been based on an examination of material in the country of origin.

These differences of opinion cannot be attributed to any fault on the part of the describers. Each classifies the fungus according to the form he happens to have. On *Hevea* stems and cacao branches it is usually a simple *Diplodia*, often united into groups by a basal weft of hyphæ; as Howard decided, one is scarcely justified in placing it anywhere but in *Diplodia* on such material. On cacao and *Hevea* pods it is either simple or grouped, and here it might sometimes be assigned to *Botryodiplodia*, though there is no true stroma, and the pycnidia are best described as subconfluent. When the pycnidia have developed on cacao pods in a saturated atmosphere, they are distinctly pilose, and if scattered they cannot be referred to any group but *Chætodiplodia*. When the fructification emerges from the points of origin of the lateral roots of young *Hevea* plants, it is an undoubted *Botryodiplodia*, with a glabrous solid stroma; but under exceptional conditions this stroma may be surrounded by hyphæ (*fide* Brick), and it is then a *Lasiodiplodia*.

It is evident from this example that the present system of subdivision of the genus *Diplodia* is, in part, based upon characters which are not constant. The primary groups, viz., simple Diplodias and Diplodias united into a stroma, are not mutually exclusive. A *Botryodiplodia* may form isolated pycnidia and grouped subconfluent pycnidia as well as true stromata. However, this division might stand, if it is extended to mean that the first group includes those Diplodias which never form a stroma, while the second includes those which sometimes form a stroma and sometimes scattered pycnidia. But under these circumstances, the correct determination of a species would involve a more extensive examination of material than is at present customary.

More serious objections can be urged against the subgenera *Chætodiplodia* and *Lasiodiplodia*. A *Chætodiplodia* is a pilose simple *Diplodia*, while a *Lasiodiplodia* is a pilose *Botryodiplodia*. But if *Diplodia cacaoicola*, *i.e.*, *Botryodiplodia theobromæ* in its simple form, is grown on a cacao pod in a damp chamber, it becomes a *Chætodiplodia*, while if the *Botryodiplodia* form is grown under equivalent conditions it becomes *Lasiodiplodia*, as in Brick's specimens. From the example afforded by *Botryodiplodia theobromæ*, it is evident that *Chætodiplodia* and *Lasiodiplodia* are based on characters which are due to environmental factors, either growth in a more or less saturated atmosphere or on a substratum amply provided with moisture. They ought therefore to be discarded, *Chætodiplodia* being thrown into *Diplodia* and *Lasiodiplodia* into *Botryodiplodia*, the latter subgenus being amended as suggested. On the same grounds, *Rhynchodiplodia* should presumably be referred to *Pellionella*. Nothing would be lost by this sacrifice, since species of these supposed subgenera are only rarely recognizable as such. *Chætodiplodia* might be retained for those species, if any there be, which bear true setæ on the pycnidium wall.

Van Hall and Drost (18) have already arrived at similar conclusions. They state "as the hairlike processes of the pycnidia (*i.e.*, of *Botryodiplodia theobromæ*), the characteristic by which *Chætodiplodia* is distinguished from *Diplodia*, is not constant but results from definite conditions, the genus *Chætodiplodia* must be annulled and joined to the genus *Diplodia*." "Sometimes in diseased branches or pods the pycnidia appear in groups, sometimes they stand isolated. As this appearance in groups, the distinguishing character of the genus *Lasiodiplodia*, is not constant, the genus *Lasiodiplodia* must also be cancelled and joined to the genus *Diplodia*." The adoption of Van Hall and Drost's suggestion would involve the abandonment of the subgenus *Botryodiplodia* also. There is much in favour of such a course, since, without a large quantity of material, a *Botryodiplodia*, as at present understood, is not always recognizable. This is quite evident from the records of *Botryodiplodia theobromæ*. But it would seem preferable to refer *Lasiodiplodia* to *Botryodiplodia*, and admit that the species in the latter subgenus may form isolated pycnidia as well as stromata.

The present writer's opinion has been expressed (17) as follows: "*Botryodiplodia elasticæ* affords another instance of the multiplication of names which results from the transmission of specimens of tropical diseases to Europe. Species of *Diplodia* occur everywhere in the tropics, on all kinds of plants, and the majority of them are merely saprophytic, *i.e.*, they grow only on dead tissues. If a *Diplodia* occurs in masses, it is known as *Botryodiplodia*, and if the masses are surrounded by loose hyphæ, it is known as *Lasiodiplodia*. But, unfortunately, these apparent distinctions break down in practice, for the same species may exhibit all three forms. In that case, it usually gets three different names, according to the form which each describer happens to have. *Botryodiplodia* is a convenient name for those species which may sometimes grow in masses and sometimes singly, and distinguishes them from those species which always grow singly, but *Lasiodiplodia* is a purely herbarium distinction for which we have no use in practice."

The adoption of the views enunciated above would reduce the classification to the following:—

A.—Pycnidia isolated, stroma wanting.	
(*a*) Pycnidia rostrate.	
§ pycnidia superficial	*Rhynchodiplodia.*
§§ pycnidia sub-superficial	*Pellionella.*
(*b*) Pycnidia not rostrate.	
§ pycnidia innate or erumpent.	
† spores exceeding 15 μ	*Diplodia.*
†† spores not exceeding 15 μ	*Microdiplodia.*
††† spores large, surrounded by mucus	*Macrodiplodia.*
§§ pycnidia sub-superficial, lignicolous	*Diplodiella.*
B.—Pycnidia sometimes united into a stroma, sometimes isolated	*Botryodiplodia.*

It may be noted that there is only one species in each of the subgenera *Rhynchodiplodia* and *Pellionella*, and that practically only the pilose character of the former separates them; as this character has been proved inconstant in other

Diplodias, their separation is doubtful. *Diplodiopsis* P. Henn., if it has no more distinctive characters than "superficial, granulato-rugulose," cannot be separated from *Botryodiplodia*; both characters may be found in the specimens of *Botryodiplodia theobromæ* which develop from the points of origin of the lateral roots of young *Hevea*.

Diplodia Wurthii Koorders appears to furnish a further example in support of the above conclusions. This species was discovered on leaves and stems of *Ficus elastica* in Java. Its pycnidia are scattered or gregarious, sometimes confluent, 150–250 μ diameter; the spores measure 22–30 × 12–18 μ, and it has paraphyses 50–60 μ long. Koorders states (11) that the pycnidia which develop on nutrient media exhibit a development of hairs at the apex in some cases. He relates how, when a dead leaf of *Ficus elastica* which bore several pycnidia was left wrapped up in a damp cloth for several days, numerous pycnidia clothed with a thick growth of hairs developed on the under surface. These hairs developed from the apex and the upper part of the wall of the pycnidia, as well as from a black stroma, and formed a web of hyphæ; they originated beneath the epidermis, but subsequently broke through and became chiefly superficial. Koorders notes that if the non-pilose form were not known, these specimens might have been referred to *Lasiodiplodia* or *Chætodiplodia*. But since the black web of mycelium and the remarkable stroma-like structure of the pycnidia are only the result of the changed external conditions, he considers that the fungus should be referred to *Diplodia*. The behaviour of this species is identical with that of *Botryodiplodia theobromæ*. It must, however, be pointed out that in all probability this example does not really afford *additional* evidence in favour of the general conclusion that *Lasiodiplodia* and *Chætodiplodia* are founded on inconstant characters, for it is in the highest degree probable that *D. Wurthii* is identical with *Botryodiplodia theobromæ*. The latter grows abundantly on dead *Ficus elastica* in Ceylon.

As we have already seen, the presence of paraphyses in the hymenium has never been considered a character of sufficient importance to warrant the separation in distinct subgenera of those *Diplodias* which possess them. Ellis and Everhart's generic description of *Lasiodiplodia* is incorrect in laying special stress on this point, since species with and species without paraphyses are, according to the accepted practice, included indiscriminately in each subgenus. The distinguishing character of *Lasiodiplodia* is the pilose stroma. But the presence of paraphyses might be used as a character by which to split each of the present subgenera, if further investigation should prove that paraphyses are really absent from those species in which they have not been recorded. It is evident that our information on this point is at present insufficient. The paraphyses have been overlooked even in species in which they are specially well developed, as is illustrated by Hennings' description of "*Diplodia cacaoicola*." It may be noted that Koorders (*loc. cit.*) records that in *Diplodia Wurthii* the basidia and spores are formed before the appearance of the paraphyses.

Griffon and Maublanc accept the subgenus *Lasiodiplodia*, and have therefore named the species under discussion *Lasiodiplodia theobromæ* (Pat.) Griff. & Maubl. But in view of the fact that the genus *Lasiodiplodia* is based on a character which is entirely dependent upon external conditions, it would seem preferable to abandon it, and keep Patouillard's name, *Botryodiplodia theobromæ*, for this fungus.

Two other inconstant characters which often find a place in descriptions of Diplodias may be referred to here. Longitudinal striping of the spores, frequently a most striking feature, may be present or absent, not only in spores of the same species, but even on spores from the same specimen. Further, the colour of the spores of the same species varies according to the age of the spore, but apparently each shade of colour may persist for a long time under certain conditions. For example, spores of *Botryodiplodia theobromæ* extruded from fresh specimens may be hyaline, dark gray, blackish-gray, or violet-black, but in old specimens and material preserved in alcohol they are brown or blackish-brown.

Botryodiplodia theobromæ Pat. has been found in Ceylon on fruits and stems of *Theobroma cacao*, on fruits and stems of *Hevea brasiliensis*, on fruits and roots of *Cocos nucifera*, on the roots and stems of *Thea*, on surface roots of *Ficus elastica*, on stems of *Castilloa elastica*, *Albizzia moluccana*, *Erythrina lithosperma*, and *Carica papaya*. Brick records it on decaying fruits of *Latania borbonica* from Venezuela. V. K. Charles found what is probably the same species on fruits of *Mangifera indica* from Florida, and on fruits and stems of cacao from Brazil and San Domingo. Appel and Laubert recorded it on *Cacao* and *Carica papaya* from Samoa, Howard on cacao and sugar cane in the West Indies, Griffon and Maublanc on cacao from the Congo and *Albizzia moluccana* from Madagascar, Butler on sugar cane in India, while Hennings, Prillieux and Delacroix, Patouillard, and van Hall and Drost have found it on cacao in the Cameroons, Central America, and Surinam. It will be noted that these records are diametrically opposed to the belief which has apparently been held by describers of fungi, viz., that Diplodias on different host plants must be different species.

Griffon and Maublanc suggest that *Lasiodiplodia tubericola* Ell. & Ev., the original species of *Lasiodiplodia*, may be identical with *Botryodiplodia theobromæ* Pat.; its spores are given as 18–22 × 11–14 μ, *i.e.*, about one-third shorter than those of the latter species. *Lasiodiplodia Thomasiana* Sacc., with spores 28–30 × 11–12 μ and paraphyses 80–90 μ long, on leaves of *Heptapleurum Barteri* from S. Thome (13), would appear to be *Botryodiplodia theobromæ*. There does not seem much room for doubt that *Diplodia Wurthii* is *Botryodiplodia theobromæ*, and in all probability the same is true of *D. mangiferæ* Koorders and *D. cinchonæ* Koorders. The descriptions of these last three species do not reveal any striking points of difference, and it would seem that their author had been influenced chiefly by the fact that they grew on different hosts. A search through Saccardo shows that there are many species, anterior to *Botryodiplodia theobromæ*, which should be compared with it, to determine whether they are not the same. For example, on *Carica papaya* there is *Diplodia papayæ* Thüm., with spores 25 × 10 μ. Again, on *Cocos nucifera* we have *Diplodia cococarpa* Sacc., with spores 22 × 12 μ and long paraphyses, *Diplodia epicocos* Cooke, with spores 22 × 10–12 μ, *Diplodia palmicola* Thüm., with spores 20 × 10 μ, and *Chætodiplodia diversispora* March., with spores 25–33 × 13–15 μ.

Recently Ridley (20) has recorded a new fungus disease of *Hevea brasiliensis* in the Federated Malay States. The fungus attacked the shoots and worked down the stem until the tree was killed. In some places a black fungus was found emerging from the cracks in the bark, and on the older parts of the branch the bark was covered with larger elevated patches, black in colour and looking as if soot had been thrown on the tree. Ridley states that the perithecia are embedded in a black stroma and that the spores are oval and transversely divided, but he refers the fungus to *Cucurbitaria.* The disease is said to be a rapid one, killing two-year old trees almost down to the base in twelve days ; but this record is uncertain, since the tree was thought to be " wintering " when first observed. Subsequently, the same fungus was recorded (21) from Selangor : in this case it attacked stumps about 3 inches in girth, and killed 80 per cent. of them.

The symptoms described by Ridley are exactly those of the " dieback " and stump disease caused, in Ceylon, South India, and Burma, by *Botryodiplodia theobromæ.* The fungus has, however, been described by Massee (23) as *Diplodia rapax*—" Perithecia 3–7 aggregata, globosa atra, primo tecta, dein erumpentia, rugulosa, glabra, 160–180 μ diametro, ostiolo minuto vix stromatis superficiem attingente donata. Sporæ ærogenæ, ellipticæ, utrinque obtusæ, medio 1-septatæ, haud constrictæ, opace fuligineæ, 32–35 × 15–16 μ." Massee (22) suggests that it is a stage in the life cycle of some species of *Rosellinia !* The fungus was received at Kew, almost at the same date, from Singapore and the Gold Coast, and it is suggested (23) that it " has been conveyed along with the seed, as it is difficult to realize that the same species of fungus can have adapted itself to rubber trees in two distant countries, and within so short a period of time."

From the descriptions, it would appear that the fungus should have been described as a *Botryodiplodia.* Its spores are not larger than those of *Botryodiplodia theobromæ* as measured by Patouillard. There is no mention of any paraphyses, but this apparent difference may be, as usual, an oversight. It is in the highest degree probable that *Diplodia rapax* is the same as *Botryodiplodia theobromæ*. It would be strange indeed if a fungus which is known to grow on *Hevea* in Ceylon, South India, Burma, and Java, and which is known to be common throughout the tropics, did not occur in Malaya. On that supposition, its occurrence on *Hevea* on the Gold Coast, a cacao-growing country, is only to be expected. But in spite of its apparent abundance, I have not been able to obtain a specimen of *Diplodia rapax*, either from Kew or Malaya, and therefore this point remains undecided.

The opinions which have been expressed as to the parasitism of *Botryodiplodia theobromæ* have been for the most part based on an examination of preserved specimens in Europe, and under those circumstances they are of doubtful value. The fungus is a widespread saprophyte, and is seldom absent from dead *Cacao* or *Hevea* material : and as it is the most evident fungus on the specimens sent to Europe, all kinds of diseases are attributed to it. No sound pathological work can result from such conditions of investigation, and frequently such work occasions totally erroneous views of the situation. For example, every book which treats of the diseases of tea refers to the serious leaf disease caused by *Pestalozzia guepini :* yet, apart from the fact that the fungus is really *P. palmarum*, this disease occurs everywhere in tea in Ceylon and does so little damage that no steps have ever, to my knowledge, been taken to combat it. When the leaves of a tea bush wither, the planter (as a rule) gathers them and sends them as samples of the disease ; and it would be remarkable if none of the older leaves exhibited the gray patches caused by *Pestalozzia*. But the bushes may be really suffering from an attack of root disease, of which the withering of the leaves is only a secondary symptom.

Brick states that *Botryodiplodia theobromæ* is a dangerous parasite of *Hevea*, *Castilloa*, and *Cacao*. In the West Indies, most of the diseases of cacao have been attributed to *Botryodiplodia theobromæ*, though Howard's experiments only show that it is a wound parasite, and can attack picked pods if they are wounded. In Surinam, van Hall and Drost, working on the spot, have decided that " The dieback disease of cacao trees is caused by a fungus (*i.e.*, *Botryodiplodia theobromæ*) which also causes the ‘ brown rot ’ of the pods. The die-back disease only affects trees which by some cause (Thrips, witch broom disease, wind, sudden want of shade) are in a leafless or in a nearly leafless condition. The fungus does not affect healthy pods, but causes decay of picked pods, or pods which by some cause or other are wounded, or which have already been attacked by other fungi.” Experience in Ceylon agrees completely with the foregoing. “ Dieback ” of cacao occurs when the shade has been removed and the twigs killed by the sun, or when they have been severely attacked by *Helopeltis ;* the *Diplodia* then develops on the dead tissues, and may kill off the branch still further. Cacao pods develop *Botryodiplodia* if they have been attacked by other fungi, or if they are picked and stored. There is no doubt that *Botryodiplodia* is a secondary fungus in diseases of cacao. The name “ brown rot ” is an unfortunate one, for in the early stages of the disease caused by *Phytophthora faberi*, the diseased parts of the pod are clear brown.

On *Castilloa*, *Botryodiplodia* has been observed in Ceylon as a wound parasite only : it attacked young trees which had been damaged by fire. On *Carica papaya* it has been found, in Ceylon, only on felled stems. On *Erythrina lithosperma*, it is a wound parasite. On *Albizzia moluccana* it is also a wound parasite, entering the stems after they have been pruned. It is a most common saprophyte on *Hevea brasiliensis* and *Ficus elastica*, and if healthy stems of either are cut down and left lying on the laboratory verandah, they will develop this fungus within a fortnight. But it is a wound parasite in *Hevea* “ dieback,” as in the similar disease of cacao, and in this case it may kill the tree entirely. It occurs as a saprophyte in *Hevea* and cacao bark which has been killed by “ canker.” Its exact status in the case of young *Hevea* plants and of tea is somewhat uncertain. In the former, it may only attack the “ stumps ” through injuries inflicted during the planting out, while they are more or less dormant, but, as it is known to have killed “ basket plants,” it would appear probable that it can live as a soil fungus and attack the roots directly. Tea is undoubtedly attacked through the roots, but whether only after they have been injured has not yet been ascertained.

On the whole, though *Botryodiplodia theobromæ* is extremely widely spread, it has caused comparatively little damage, and it is impossible to resist the conclusion that in the majority of instances it is only saprophytic. Koorders concludes, as a result of his infection experiments, that *Diplodia Wurthii* is a saprophyte which in rare cases can function as a wound parasite.

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A Revised Catalogue of the Flowering Plants and Ferns of Ceylon.

BY

J. C. WILLIS.

THE catalogue published by the late Dr. Trimen in the Journal of the Ceylon Branch of the Royal Asiatic Society for 1885 has long been out of print, and the want of a new one is often felt. I have therefore prepared the following list of the native plants of the Island to replace it.

After each name are given the Sinhalese (S.) and Tamil (T.) equivalents, if any, and sometimes an English name. After these is quoted the page in Trimen's "Flora of Ceylon" upon which the description of the species is to be found. If the species is figured in the "Plates" of the Flora, the number of the plate is also given.

Certain Orders have been revised since the publication of Trimen, and, where I have considered it necessary, I have used the revision, indicating the source in a footnote.

One great interest of the Ceylon flora lies in the enormous number of endemics which it contains. These are always printed in small capitals, with the exception of varieties. When a genus is thus printed, it means that the whole genus is endemic.

Names with an asterisk prefixed are apparently exotic species so fully naturalized in Ceylon that their foreign origin cannot be certainly sworn to. The many naturalized species that are without doubt introduced are not included.

DICOTYLEDONS.

POLYPETALÆ.

1. Ranunculaceæ.

1. Clematis, L.	
1. smilacifolia, Wall. *Nara-wel*, S.	I.1
2. Gouriana, Roxb.	I.2
2. Naravelia, DC.	
3. zeylanica, DC. *Nara-wel*, S.	I.2

Annals of the Royal Botanic Gardens, Peradeniya, Vol. IV., Part VII., Sept , 1910.]

3. Anemone, L.	
4. rivularis, Ham.	I.3
4. Thalictrum, L.	
5. javanicum, Bl.	I.3
5. Ranunculus, L.	
6. SAGITTÆFOLIUS, Hook. *Buttercup.*	I.4
7. Wallichianus, W. & A.	I.4

2. Dilleniaceæ.

6. Delima, L.	
8. sarmentosa, L. *Korasa-wel*, S.	I.5
7. Tetracera, L.	
9. lævis, Vahl. *Et-korasa-wel*, S.	I.6
8. Acrotrema, Jack.	
10. UNIFLORUM, Hook. *Bin-beru*, S.	I.7
var. α petiolare, Thw.	
var. β rotundatum, Thw.	
var. γ bullatum, Hk. f. & Th.	
var. δ rugatum, Thw.	
var. ε sylvaticum, Hk. f. & Th.	
var. ζ Walkeri, Trim.	
var. η membranaceum, Thw.	
var. θ appendiculatum, Thw.	
var. ι dentatum, Thw.	
11. INTERMEDIUM, Thw.	I.8
12. LANCEOLATUM, Hook.	I.8
13. GARDNERI, Thw.	I.8
14. THWAITESII, Hk. f. & Th.	I.9
15. DISSECTUM, Thw.	I.9
16. LYRATUM, Thw.	I.9, Pl. I.
9. SCHUMACHERIA, Vahl.	
17. CASTANEÆFOLIA, Vahl. *Kekiri-wara*, S.	I.10
18. ALNIFOLIA, Hk. f. & Th.	I.10
var. β dentata, Wight.	
var. γ subglabra, Thw.	
19. ANGUSTIFOLIA, Hk. f. & Th.	I.11, Pl. II.
10. Wormia, Rottb.	
20. TRIQUETRA, Rottb. *Diyapara*, S.	I.11, Pl. III.
11. Dillenia, L.	
21. indica, L. *Hondapara*, *Wampara*, S.	I.12
22. RETUSA, Thunb. *Godapará*, S.	I.13

3. Magnoliaceæ.

12. Michelia, L	
23. nilagirica, Zenk. *Wal-sapu*, S.	I.14
var. β ovalifolia, Thw.	
var. γ Walkeri, Thw.	
13. Kadsura, Kæmpf.	
24. Wightiana, Arn.	I.16

4. Anonaceæ.

14. Uvaria, L.	
25. SPHENOCARPA, Hk. f. & Th.	I.18
26. macrophylla, Roxb.	I.18
27. semecarpifolia, Hk. f. & Th.	I.19
28. MACROPODA, Hk. f. & Th.	I.19
29. Narum, Wall.	I.19
30. zeylanica, L. *Palukan*, *Palanga*, S. *Karuveppal*, T.	I.20
15. Cyathocalyx, Champion.	
31. zeylanicus, Champ. *Kekala*, *Ipetta*, S.	I.20
16. Artabotrys, Br.	
32. odoratissimus, Br.	I.21
33. zeylanicus, Hk. f. & Th. *Petika-wel*, *Yakada-wel*, S.	I.22
17. Unona, L.	
34. ELEGANS, Thw.	I.23
35. ZEYLANICA, Hk. f. & Th.	I.23
18. Polyalthia, Bl.	
36. longifolia, B. & Hk. f. *Mara-iluppai*, T.	I.24
37. coffeoides, B. & Hk. f. *Omara*, S. *Nedunarai*, T.	I.24
38. ACUMINATA, Thw.	I.25
39. Korinti, B. & Hk. f. *Miwenna*, S. *Uluvintai*, T.	I.25
40. suberosa, B. & Hk. f. *Kalati*, S.	I.25
41. MOONII, Thw.	I.26
42. PERSICIFOLIA, B. & Hk. f.	I.26
19. Anaxagorea, St. Hil.	
43. luzonensis, Gray.	I.27
20. Xylopia, L.	
44. PARVIFOLIA, Hk. f. & Th. *Netawu*, *Atuketiya*, S. *Chidavintai*, T.	I.28
45. NIGRICANS, Hk. f. & Th.	I.28
46. CHAMPIONII, Hk. f. & Th. *Dat-ketiya*, S.	I.28

21. Goniothalamus, Bl.
    - 47. Thwaitesii, Hk. f. & Th. *Kalu-kera*, S. I.29
    - 48. GARDNERI, Hk. f. & Th. I.30
    - 49. HOOKERI, Thw. I.30
    - 50. WALKERI, Hk. f. & Th. *Kapuru*, S. I.30
    - 51. THOMSONI, Thw. I.31
    - 52. RETICULATUS, Thw. I.31
    - 53. SALICINUS, Hk. f. & Th. I.31

22. Mitrephora, Bl.
    - 54. Heyneana, Thw. I.32

23. Bocagea, St. Hil.[1]
    - 55. THWAITESII, Hk. f. & Th. I.33
    - 56. OBLIQUA, Hk. f. & Th. I.33
    - 57. CORIACEA, Hk. f. & Th. *Keku*, S. I.34

24. Miliusa, Leschen.
    - 58. indica, Leschen. I.34
        - var. β tomentosa, Thw.
    - 59. ZEYLANICA, Gardn. I.35

25. Orophea, Bl.
    - 60. zeylanica, Hk. f. & Th. I.35

26. Alphonsea, Hk. f. & Th.
    - 61. lutea, Hk. f. & Th. I.36
    - 62. zeylanica, Hk. f. & Th. I.36
    - 63. SCLEROCARPA, Thw. I.37

5. Menispermaceæ.

27. Tinospora, Miers.
    - 64. malabarica, Miers. *Bu-kinda*, *Wal-kinda*, S. I.38
        - var. β tomentosa, Miers.
    - *65. crispa, Miers. *Titta-kinda*, S. I.39
    - 66. cordifolia, Miers. *Rasa-kinda*, S. *Chintil*, T. I.39

28. Anamirta, Colebr.
    - 67. paniculata, Colebr. *Titta-wel*, S. I.40

29. Coscinium, Colebr.
    - 68. fenestratum, Colebr. *Weni-wel*, S. *False Calumba.* I.41

30. Tiliacora, Colebr.
    - 69. racemosa, Colebr. I.42

31. Limacia, Lour.
    - 70. cuspidata, Hk. f. & Th. *Niri-wel*, S. I.42, Pl. IV.

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[1] King (Anonaceæ of British India, Ann. R. B. G. Calcutta) places 55 in Sageræa, 56 and 57 in Orophea.

32. Cocculus, DC.	
71. macrocarpus, W. & A.	I.43
72. villosus, DC.	I.44
33. Pachygone, Miers.	
73. ovata, Miers. *Kaddukkodi*, T.	I.45
34. Stephania, Lour.	
74. hernandifolia, Walp. *Lunuketiya-wel*, S.	I.45
35. Cissampelos, L.	
75. Pareira, L. *Diyamitta*, S.	I.46
var. β subpeltata, Thw.	
36. Cyclea, Arn.	
76. Burmanni, Miers. *Kehi-pittan*, *Kesi-pissan*, S.	I.47

6. Berberideæ.

37. Berberis, L.	
77. aristata, DC. *Barberry.*	I.48

7. Nymphæaceæ.

38. Nymphæa, L.	
78. Lotus, L. *Olu*, *Et-olu*, S. *Waterlily*, *Egyptian Lotus.*	I.49
var. β pubescens, Willd.	
79. stellata, Willd. *Manel*, S. *Waterlily.*	I.50
39. Nelumbium, Juss.	
80. speciosum, Willd. *Nelun*, S. *Tamarai*, T. *Sacred Bean*, *Lotus.*	I.51

8. Cruciferæ.

40. Nasturtium, Br.	
*81. indicum, DC.	I.52
41. Cardamine, L.	
82. africana, L.	I.53
83. subumbellata, Hk. f.	I.53

9. Capparideæ.

42. Cleome, L.	
84. monophylla, L.	I.55
85. tenella, L. f.	I.55
86. aspera, Kœn.	I.56
87. Chelidonii, L. f.	I.56
88. viscosa, L. *Wal-aba*, *Ran-manissa*, S.	I.57
43. Gynandropsis, DC.	
89. pentaphylla, DC. *Wela*, S. *Tayirvalai*, T.	I.57

44. Mærua, Forsk.	
90. arenaria, Hk. f. & Th.	I.58
45. Cratæva, L.	
91. Roxburghii, Br. *Lunu-warana*, S. *Navala*, *Navilankai*, T.	I.59
46. Cadaba, Forsk.	
92. trifoliata, W. & A. *Mayaladikkuruntu*, T.	I.59
93. indica, Lam. *Vili*, T.	I.60
47. Capparis, L.	
94. zeylanica, L. *Kattoddi*, *Vennachchi*, T.	I.61
95. divaricata, Lam.	I.61
96. Moonii, Wight.	I.62
97. Roxburghii, DC. *Punaivirandi*, T.	I.62
98. grandis, L. f. *Mudkondai*, T.	I.63
99. pedunculosa, Wall. *Pichchuvilattai*, *Karunchurai*, T.	I.63
var. β longispina, Hk. f. & Th.	
100. sepiaria, L. *Karunchurai*, T.	I.64
var. β retusella, Thw.	
101. floribunda, Wight.	I.64
102. horrida, L. f. *Welangiriya*, S.	I.64
103. tenera, Dalz. var. zeylanica, Hk. f. & Th.	I.65

10. Violaceæ.

48. Viola, L.	
104. Patrinii, DC. *Violet.*	I.66
105. distans, Wall. *Violet.*	I.66
106. serpens, Wall. *Violet.*	I.67
49. Ionidium, Vent.	
107. suffruticosum, Ging. *Oritad-tamarai*, T.	I.67
108. RAMOSISSIMUM, Thw.	I.68
50. Alsodeia, Thouars.	
109. zeylanica, Thw.	I.68
110. DECORA, Trim.	I.69
111. VIRGATA, Hk. f. & Th.	I.69, Pl. V.

11. Bixaceæ.

51. Scolopia, Schreb.	
112. acuminata, Clos. *Katu-kenda*, S.	I.70
113. CRASSIPES, Clos.	I.71
114. GÆRTNERI, Thw. *Katu-kurundu*, S.	I.71
52. Erythrospermum, Lam.	
115. PHYTOLACCOIDES, Gardn.	I.72, Pl. VI.

53. Flacourtia, Comm.
  116. Ramontchi, L'Herit. var. sapida, Roxb. *Uguressa*, S. *Katukali*, *Karumurukki*, T. I.73
  117. sepiaria, Roxb. *Mulanninchil*, T. I.73

54. Aberia, Hochst.
  118. GARDNERI, Clos. *Ketambilla*, S. I.74, Pl. VII.

55. TRICHADENIA, Thw.
  119. ZEYLANICA, Thw. *Tolol*, *Titta*, S. I.75, Pl. VIII.

56. Hydnocarpus, Gærtn.
  120. VENENATA, Gærtn. *Makulu*, S. *Makal*, T. I.75
  121. alpina, Wight. *Gomma*, S. *Attuchankulai*, T. I.76
  122. OCTANDRA, Thw. I.76

12. Pittosporaceæ.

57. Pittosporum, Banks.
  123. tetraspermum, W. & A. I.77
  124. ZEYLANICUM, Wight. *Ketiya*, S. I.78

13. Polygalaceæ.

58. Polygala, L.
  125. arillata, Ham. I.79
  126. javana, DC. *Tilo-guru*, S. I.80
  127. leptalea, DC. I.80
  128. GLAUCOIDES, L. I.80
    var. β triflora, L.
    var. γ hirsutula (Arn.), Trim.
  129. chinensis, L. I.81
  130. rosmarinifolia, W. & A. I.82
  131. sibirica, L. var. MACROLOPHOS, Hassk. I.82
  132. telephioides, Willd. I.82

59. Salomonia, Lour.
  133. oblongifolia, DC. I.83
  134. CORDATA, Arn. I.83

60. Xanthophyllum, Roxb.
  135. flavescens, Roxb. *Palala*, S. I.84

14. Caryophyllaceæ.

61. Cerastium, L.
  136. indicum, W. & A. I.85
  *137. vulgatum, L. var. glomeratum, Thuill. I.85

62. Stellaria, L.
  138. DRYMARIOIDES, Thw. I.86

63. Drymaria, Willd.	
139. cordata, Willd. *Kukulu-pala*, S.	I.87
64. Polycarpon, L.	
140. Lœflingiæ, B. & Hk. f.	I.87
65. Polycarpæa, Lam.	
141. corymbosa, Lam.	I.88

15. Portulacaceæ.

66. Portulaca, L.	
142. oleracea, L. *Genda-kola*, S. *Pulikkirai*, *Pulichchankirai*, T.	I.89
143. Wightiana, Wall.	I.89
144. quadrifida, L. *Hin-genda-kola*, S.	I.90
145. tuberosa, Roxb. *Ura-genda*, S.	I.90
146. suffruticosa, Wight.	I.90

16. Tamariscineæ.

67. Tamarix, L.	
147. gallica, L. *Kirai*, *Tini*, T.	I.91

17. Elatineæ.

68. Bergia, L.	
148. ammannioides, Roxb.	I.92
149. verticillata, Willd.	I.92

18. Hypericaceæ.

69. Hypericum, L.	
150. mysorense, Heyne.	I.93
151. japonicum, Thunb.	I.93

19. Guttiferæ.

70. Garcinia, L.	
152. Cambogia, Desrouss. *Goraka*, S. *Korakkai-puli*, T.	I.95
var. β Papilla, Wight.	
153. Morella, Desrouss. *Kana-goraka*, *Gokatu*, *Kokatiya*, S. *Gamboge*.	I.96
154. ECHINOCARPA, Thw. *Madol*, S.	I.96
155. TERPNOPHYLLA, Thw. *Kokatiya*, S.	I.97
var. β acuminata, Thw.	
156. spicata, Hk. f. *Ela-gokatu*, *Gonapana*, S. *Kokottai*, T.	I.98
var. β acutifolia, T. And.	

71. Calophyllum, L.
157. spectabile, Willd. *Domba-kina*, *Mapat-kina*, S. I.99
158. BURMANNI, Wight. *Guru-kina*, *Hin-kina*, S. *Chirupunnai*, T. I.99
159. pulcherrimum, Wall. I.100
160. Inophyllum, L. *Domba*, *Tel-domba*, S. *Punnai*, *Dommakottai*, T. I.100
161. tomentosum, Wight. *Kina*, S. I.101
162. BRACTEATUM, Thw. *Walu-kina*, S. I.102
163. THWAITESII, Planch. & Tri. I.102
164. TRAPEZIFOLIUM, Thw. I.103
165. CUNEIFOLIUM, Thw. I.103
166. CORDATO-OBLONGUM, Thw. I.103
167. WALKERI, Wight. *Kina*, S. I.104

72. Kayea, Wall.
168. STYLOSA, Thw. *Suwanda*, S. I.104

73. Mesua, L.
169. ferrea, L. *Na*, S. *Naka*, T. *Iron-wood.* I.105
var. β sclerophylla, Thw.
var. γ pulchella, Planch. & Tri.
170. THWAITESII, Planch. & Tri. *Diya-na*, S. I.106

20. Ternstrœmiaceæ.

74. Ternstrœmia, L.
171. japonica, Thunb. I.107
172. EMARGINATA, Choisy. I.108

75. Adinandra, Jack.
173. LASIOPETALA, Choisy. I.108, Pl. IX.

76. Eurya, Thunb.
174. japonica, Thunb. *Neya-dasse*, S. I.109
var. α Thunbergii, Thw.
var. β zeylanica, Wight.
var. γ Chinensis, Br.
175. acuminata, DC. I.110

77. Gordonia, Ellis.
176. ZEYLANICA, Wight. I.110
var. β elliptica, Gardn.
177. SPECIOSA, Choisy. I.111

21. Dipterocarpaceæ.

78. Dipterocarpus, Gærtn. f.
178. HISPIDUS, Thw. *Bu-hora*, S. I.114
179. ZEYLANICUS, Thw. *Hora*, S. I.114, Pl. X.
180. SCABRIDUS, Thw. I.115
181. GLANDULOSUS, Thw. *Dorana*, S. I.115
182. INSIGNIS, Thw. I.116

79. Shorea, Roxb.	
183. OBLONGIFOLIA, Thw.	I.116
184. DYERII, Thw.	I.117
185. RETICULATA, Thw.	I.117
186. LISSOPHYLLA, Thw.	I.117
187. STIPULARIS, Thw.	I.118
var. β minor, Thw.	
80. DOONA, Thw.	
188. ZEYLANICA, Thw. *Dun*, S.	I.119
189. AFFINIS, Thw.	I.120
190. GARDNERI, Thw. *Red Doon.*	I.121
191. NERVOSA, Thw. *Kotikan-beraliya*, S. *Red Doon.*	I.121
192. TRAPEZIFOLIA, Thw. *Yakahalu*, S.	I.121
193. CONGESTIFLORA, Thw. *Tiniya*, S.	I.122, Pl. XI.
194. CORDIFOLIA, Thw. *Beraliya*, S.	I.122
195. OVALIFOLIA, Thw. *Pini-beraliya*, S.	I.123
196. OBLONGA, Thw.	I.123
197. VENULOSA, Thw.	I.123
198. MACROPHYLLA, Thw. *Honda-beraliya*, S.	I.124
81. Hopea, Roxb.	
199. DISCOLOR, Thw.	I.125
200. JUCUNDA, Thw. *Rat-beraliya*, S.	I.125
var. β modesta, A. DC.	
201. CORDIFOLIA, Trim.	I.126
82. Sunaptea, Griff.	
202. SCABRIUSCULA, Trim. *Na-mendora*, S.	I.126, Pl. XII.
203. ? DISTICHA, Trim.	I.127
83. Vatica, L.	
204. Roxburghiana, Bl. *Mendora*, S.	I.128
205. AFFINIS, Thw. *Hal-mendora*, S.	I.128
206. OBSCURA, Trim. *Tumpalai*, T.	I.129, Pl. XIII.
84. Balanocarpus, Bedd.	
207. ? ZEYLANICUS, Trim.	I.130, Pl. XIV.
85. Vateria, L.	
208. ACUMINATA, Hayne. *Hal*, S.	I.131
86. STEMONOPORUS, Thw.	
209. WIGHTII, Thw. *Hal-mendora*, S.	I.132
210. GARDNERI, Thw.	I.133
211. ACUMINATUS, Bedd.	I.133
212. LANCEOLATUS, Thw.	I.134
213. AFFINIS, Thw.	I.134, Pl. XV.
214. RIGIDUS, Thw.	I.134
215. CANALICULATUS, Thw.	I.135

216. PETIOLARIS, Thw.	I.135
217. OBLONGIFOLIUS, Thw.	I.135
218. RETICULATUS, Thw.	I.136
219. NITIDUS, Thw.	I.136
var. β lancifolius, Dyer.	
220. NERVOSUS, Thw.	I.136
221. (?) MOONII, Thw.	I.137
222. LEWISIANUS, Trim. Mss.	V.383
223. (?) REVOLUTUS, Trim. Mss.	V.384
87. Monoporandra, Thw.	
224. CORDIFOLIA, Thw.	I.137
225. ELEGANS, Thw.	I.138

21 bis. Ancistrocladaceæ.

88. Ancistrocladus, Wall.	
226. VAHLII, Arn. *Gona-wel*, S.	I.139, Pl. XVI.

22. Malvaceæ.

89. Sida, L.	
227. humilis, Cav. *Bevila*, S. *Palam-padu*, *Palam-pasi*, T.	I.141
228. mysorensis, W. & A. *Giriwadi-bevila*, S.	I.142
229. spinosa, L.	I.142
230. acuta, Burm. *Gas-bevila*, S.	I.142
231. rhombifolia, L. *Kotikan-bevila*, S. *Chitta-maddi*, T.	I.143
var. β retusa, L.	
232. cordifolia, L. *Wal-bevila*, *Hin-anoda*, S. *Chevakanpudu*, T.	I.143
90. Abutilon, Gærtn.	
233. asiaticum, G. Don. *Anoda*, S.	I.144
234. muticum, G. Don.	I.145
235. indicum, G. Don. *Anoda*, S. *Peruntutti*, *Vaddattutti*, T.	I.145
236. graveolens, W. & A. *Vaddattutti*, T.	I.145
237. crispum, G. Don.	I.146
91. Wissadula, Medik.	
238. zeylanica, Medik. *Kiri-kaju*, S.	I.146
92. Urena, L.	
239. lobata, L. *Patta-epala*, S.	I.147
240. sinuata, L. *Hin-epala*, S.	I.148
93. Pavonia, Cav.	
241. glechomifolia, A. Rich.	I.148
242. zeylanica, Cav.	I.149
243. odorata, Willd.	I.149

94. JULOSTYLIS, Thw.	
244. ANGUSTIFOLIA, Thw.	I.150
95. Dicellostyles, Benth.	
245. AXILLARIS, Benth.	I.150
96. Hibiscus, L.	
246. surattensis, L. *Hin-napiritta*, S.	I.152
247. furcatus, Roxb. *Napiritta*, S.	I.152
248. collinus, Roxb. *Parutti*, T.	I.152
249. lunariifolius, Willd.	I.153
250. micranthus, L. f. *Perumaddi*, T.	I.153
251. vitifolius, L. *Maha-epala*, S. *Vaddattutti*, T.	I.154
252. panduræformis, Burm.	I.154
253. Solandra, L'Herit.	I.155
254. ficulneus, L.	I.155
*255. Abelmoschus, L. *Kapu-kinissa*, S.	I.156
256. angulosus, Mast. *Kapu-kinissa*, S.	I.156, Pl.XVII.
var. α grandiflorus, Thw.	
var. β purpureus, Thw.	
257. tiliaceus, L. *Beli-patta*, S.	I.157
97. Thespesia, Corr.	
258. Lampas, Dalz. & Gibs.	I.158
259. populnea, Soland. ex Corr. *Suriya*, S. *Kavarachu*, *Puvarachu*, T. *Tulip Tree.*	I.158
98. Bombax, L.	
260. malabaricum, DC. *Katu-imbul*, S. *Parutti*, *Kaddu-parutti*, T. *Cotton Tree.*	I.160
99. Eriodendron, DC.	
*261. anfractuosum, DC. *Imbul*, *Pulun-imbul*, S. *Silk-cotton Tree.*	I.161
100. Cullenia, Wight.	
262. excelsa, Wight. *Katu-boda*, S.	I.162

23. Sterculiaceæ.

101. Sterculia, L.	
263. fœtida, L. *Telambu*, S.	I.164
264. urens, Roxb. *Kavali*, T.	I.164
265. guttata, Roxb.	I.165
266. Balanghas, L. *Nava*, S.	I.165
267. colorata, Roxb. *Malaiparutti*, T.	I.166
268. THWAITESII, Mast.	I.166
102. Heritiera, Ait.	
269. littoralis, Dryand. *Etuna*, S. *Chomuntiri*, T.	I.167

103. Helicteres, L.
    270. Isora, L. *Liniya*, S. *Vallampuri*, T. I.168

104. Pterospermum, Schreb.
    271. suberifolium, Lam. *Welanga*, S. *Vinanku*, T. I.169

105. Pentapetes, L.
    *272. phœnicea, L. I.169

106. Melochia, L.
    273. corchorifolia, L. *Gal-kura*, S. I.170

107. Waltheria, L.
    274. indica, L. *Punnikki*, T. I.171

24. Tiliaceæ.

108. PITYRANTHE, Thw.
    275. VERRUCOSA, Thw. *Dik-wenna*, S. *Vidpani*, T. I.172

109. Berrya, Roxb.
    276. Ammonilla, Roxb. *Hal-milla*, S. *Chavandalai*, T. *Trincomalee Wood.* I.173

110. Grewia, L.
    277. columnaris, Sm. *Kodi-taviddai*, T. I.174
    *278. asiatica, L. I.174.
    279. bracteata, Heyne. I.175
    280. DIPLOCARPA, Thw. I.175
    281. tiliæfolia, Vahl. *Daminiya*, S. *Chadachchi*, T. I.175
    282. hirsuta, Vahl. I.176
    283. orientalis, L. *Wel-keliya*, *Wel-mediya*, S. *Taviddai*, T. I.176
    284. polygama, Roxb. *Bora-daminiya*, S. *Taviddai*, T. I.177
    285. Microcos, L. *Keliya*, *Kohu-kirilla*, S. I.177
    286. populifolia, Vahl. *Katu-peratti*, *Achchu*, T. I.178, Pl. XVIII.

111. Triumfetta, L.
    287. tomentosa, Boj. I.179
    288. pilosa, Roth. I.179
    289. rhomboidea, Jacq. *Epala*, S. I.179
    290. GLABRA, Rottl. I.180, Pl. XIX.
    291. neglecta, W. & A. I.181

112. Corchorus, L.
    *292. capsularis, L. *Jute.* I.181
    293. olitorius, L. *Jute.* I.182
    294. urticæfolius, W. & A. I.182

*295. fascicularis, Lam. I.183
*296. tridens, L. I.183
297. acutangulus, Lam. I.183

113. Elæocarpus, L.
298. serratus, L. *Weralu*, S. *Wild Olive.* I.184, Pl. XX.
299. amœnus, Thw. *Titta-weralu*, S. I.185
300. OBOVATUS, Arn. I.186
301. MONTANUS, Thw. I.186
302. subvillosus, Arn. *Gal-weralu*, S. I.186
303. ZEYLANICUS, Mast. I.187
304. GLANDULIFER, Mast. I.187

25. Linaceæ.

114. Linum, L.
305. mysorense, Heyne. I.188

115. Hugonia, L.
306. Mystax, L. *Maha-getiya*, *Bugetiya*, S. *Motirakanni*, T. I.189
307. FERRUGINEA, W. & A. I.190

116. Erythroxylon, L.[1]
308. monogynum, Roxb. *Devadaram*, *Chemmanatti*, T. I.190
309. ACUMINATUM (Arn.) Walp. (LUCIDUM, Moon). *Bata-kirilla*, S. *Chiru-chemmanatti*, T. I.191
310. lanceolatum, Hk. f. I.191
311. OBTUSIFOLIUM, Hk. f. I.192

26. Malpighiaceæ.

117. Hiptage, Gærtn.
312. Madablota, Gærtn. *Puwak-gediya-wel*, S. I.193
313. parvifolia, W. & A. I.193

27. Zygophyllaceæ.

118. Tribulus, L.
314. terrestris, L. *Sembu-nerinchi*, S. *Chiru-nerinchi*, T. I.194

28. Geraniaceæ.

119. Geranium, L.
315. nepalense, Sweet. I.195

120. Oxalis, L.
316. corniculata, L. *Hin-embul-embiliya*, S. I.196

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[1] E. zeylanicum, n. sp., added by Schulz in Das Pflanzenreich.

121. Biophytum, DC.
317. sensitivum, DC. *Gas-nidikumba*, S. I.197
318. NERVIFOLIUM, Thw. I.198
319. NUDUM, Wight. I.198
320. intermedium, Wight. I.199. Pl. XXI.
321. PROLIFERUM, Wight. I.199

122. Impatiens, L. *Balsam.*
322. acaulis, Arn. I.201
323. oppositifolia, L. I.202
324. cuspidata, W. & A. I.202
var. β bipartita, Arn.
325. Balsamina, L. *Kudalu-kola*, S. I.203
var. β cornuta, Trim.
326. GLANDULIFERA, Arn. I.203
327. MACROPHYLLA, Gardn. I.204
328. REPENS, Moon. *Gal-demata*, S. I.205
329. LEPTOPODA, Arn. I.205
330. TRUNCATA, Thw. I.206
331. flaccida, Arn. *Kudalu-mal*, S. I.206
332. Henslowiana, Arn. I.207
333. JANTHINA, Thw. I.207
334. HOOKERIANA, Arn. I.208
335. SUBCORDATA, Arn. I.208
336. LEUCANTHA, Thw. I.209
337. LINEARIS, Arn. I.209
338. APPENDICULATA, Arn. I.209
339. ELONGATA, Arn. I.210
340. CORNIGERA, Arn. I.210
341. ARNOTTII, Thw. I.211
342. WALKERI, Hook. I.211

123. Hydrocera, Bl.
343. angustifolia, Bl. *Diya-kudalu*, *Wal-kudalu*, S. I.212

29. Rutaceæ.

124. Euodia, Forst.
344. Roxburghiana, Benth. *Lunu-ankenda*, S. I.214

125. Zanthoxylum, L.
345. tetraspermum, W. & A. I.215

126. Toddalia, Juss.
346. aculeata, Pers. *Kudu-miris*, S. *Kandai*, T. I.215

127. Acronychia, Forst.
347. laurifolia, Bl. *Ankenda*, S. I.216

128. Glycosmis, Correa.
    348. pentaphylla, Corr. *Dodan-pana*, S. *Kulapannai*, T. I.217
        var. β longifolia, Oliv.
    349. BILOCULARIS, Thw. I.218

129. Micromelum, Bl.
    350. pubescens, Bl. *Wal-karapincha*, S. *Kakaipalai*, T. I.218

130. Murraya, L.
    351. exotica, L. *Etteriya*, S. I.219
        *var. β buxifolia, Thw.
    352. GLENIEI, Thw. I.220, Pl. XXII.
    353. Kœnigii, Spreng. *Karapincha*, S. *Karivempu*, T. *Curry Leaf.* I.220

131. Clausena, Burm.
    354. indica, Oliv. *Migon-karapincha*, S. *Pannai*, *Purankainari*, T. I.221
    355. Willdenovii, W. & A. *Weda-pana*, S. I.222
        var. β pubescens, W. & A.

132. Limonia, L.
    356. alata, W. & A. *Tumpat-kurundu*, S. I.223
    357. crenulata, Roxb. I.223

133. Luvunga, Hamilt.
    358. eleutherandra, Dalz. I.224

134. Paramignya, Wight.
    359. monophylla, Wight. *Wellangiriya*, S. I.224
    360. armata, Oliv. I.225
    361. sp ? I.225

135. Atalantia, Correa.
    362. monophylla, Correa. *Perunkuruntu*, T. I.226
    363. racemosa, W. & A. I.226
    364. zeylanica, Oliv. *Yaki-naran*, S. *Pey-kuruntu*, T. I.227
        var. β rotundifolia, Oliv.
    365. Missionis, Oliv. *Pamburu*, S. *Kuruntu*, *Perum-kuruntu*, T. I.227

136. Feronia, Correa.
    366. elephantum, Correa. *Diwul*, S. *Vila*, *Vilatti*, *Mayaladikkuruntu*, T. *Elephant Apple*, *Wood-apple.* I.228

30. Simarubaceæ.

137. Ailantus, Desf.
    367. malabarica, DC. *Kumbalu*, *Wal-bilin*, S. I.230

138. Samadera, Gærtn.
  368. indica, Gærtn. *Samadara*, S. I.231

139. Suriana, L.
  369. maritima, L. I.232

31. Ochnaceæ.

140. Ochna, L.
  370. squarrosa, L. *Mal-kera*, S. *Chilanti*, T. I.233
    var. β cordata, Thw.
  371. Wightiana, Wall. *Bo-kera*, S. *Katkarai*, T. I.233
    var. β Moonii, Trim.
  372. RUFESCENS, Thw. I.234

141. Gomphia, Schreb.
  373. angustifolia, Vahl. *Bo-kera*, S. I.235

32. Burseraceæ.

142. Balsamodendrum, Kunth.
  374. caudatum, March. *Kilivai*, T. I.236
  375. Berryi, Arn. *Mulkilivai*, T. I.237

143. Canarium, L.
  376. BRUNNEUM, Bedd. *Maha-bulu-mora*, S. I.238 Pl. XXIII.
  377. ZEYLANICUM, Bl. *Kekuna*, S. *Pakkilipal*, T. I.239

144. Filicium, Thw.[1]
  378. decipiens, Thw. *Pehimbiya*, S. *Chittiraivempu*, T. I.240

33. Meliaceæ.

145. Munronia, Wight.
  379. PUMILA, Wight. *Bin-kohomba*, S. I.242

146. Melia, L.
  380. dubia, Cav. *Lunu-midella*, S. *Malaivempu*, T. I.243

147. Azadirachta, A. Juss.
  381. indica, A. Juss. *Kohomba*, S. *Vempu*, T. *Margosa*. I.244

148. Cipadessa, Bl.
  382. fruticosa, Bl. *Hal-bembiya*, S. I.245

149. Aglaia, Lour.
  383. APIOCARPA, Hiern. I.245
  384. Roxburghiana, Miq. *Kannakompu*, T. I.246

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[1] Usually placed in Sapindaceæ.

150. Dysoxylum, Bl.
385. binectariferum, Hk. f. I.247
var. β pyriforme, Trim.

151. PSEUDOCARAPA, Hemsl.
386. CHAMPIONI, Hemsl. *Gona-pana*, S. I.248 Pl. XXIV.

152. Amoora, Roxb.
387. Rohituka, W. & A. *Hingul*, S. I.249

153. Walsura, Roxb.
388. GARDNERI, Thw. I.250
389. Piscidia, Roxb. *Kiri-kon*, *Molpetta*, S. *Chadavakku*, T. I.250
var. β acuminata, Trim.

154. Carapa, Aubl.
390. moluccensis, Lam. I.251

155. Chickrassia, A. Juss.
391. tabularis, A. Juss. *Hulan-hik*, S. *Aglai*, *Kaloti*, T. *Chittagong Wood.* I.252

156. Chloroxylon, DC.
392. Swietenia, DC. *Buruta*, S. *Mutirai*, T. *Satinwood.* I.253

34. Chailletiaceæ.

157. Chailletia, DC.
393. sumatrana, Miq. *Balu-nakuta*, S. (?) I.254

35. Olacineæ.

158. Ximenia, L.
394. americana, Willd. *Chiru-illantai*, T. I.255

159. Olax, L.
395. scandens, Roxb. *Kadalranchi*, T. I.256
396. Wightiana, Wall. I.256
397. ZEYLANICA, L. *Mella*, S. I.257

160. Strombosia, Bl.
398. zeylanica, Gardn. I.257

161. Opilia, Roxb.
399. amentacea, Roxb. I.258

162. Cansjera, Juss.
400. Rheedii, Gmel. *Eta-mura*, S. I.259

163. Lasianthera, Beauv.
401. apicalis, Thw. *Urukanu*, *Uruhonda*, S. I.260

164. Gomphandra, Wall.	
402. axillaris, Wall.	I.261
403. coriacea, Wight.	I.261
165. Apodytes, E. Meyer.	
404. GARDNERIANA, Miers.	I.262
166. Mappia, Jacq.	
405. ovata, Miers. *Gandapana*, S.	I.262
var. β Championiana, Miers.	
167. Pyrenacantha, Hook.	
406. volubilis, Hook.	I.263

36. Ilicineæ.

168. Ilex, L.	
407. Walkeri, Wight & Gardn.	I.264
408. denticulata, Wall.	I.265
409. Wightiana, Wall. *Andun-wenna*, S.	I.265

37. Celastraceæ.

169. Euonymus, L.	
410. REVOLUTUS, Wight.	I.267
411. THWAITESII, Laws.	I.267
412. WALKERII, Wight.	I.267
170. Glyptopetalum, Thw.	
413. zeylanicum, Thw.	I.268
171. Microtropis, Wall.	
414. WALLICHIANA, Wight.	I.269
415. ramiflora, Wight.	I.269
172. Kokoona, Thw.	
416. zeylanica, Thw. *Kokun*, *Wana-potu*, S.	I.270
173. Pleurostylia, Wight.	
417. Wightii, W. & A. *Piyari*, *Panaka*, S. *Chiru-piyari*, T.	I.271
174. Elæodendron, Jacq. f.	
418. glaucum, Pers. *Neralu*, S. *Piyari*, *Perun-piyari*, T.	I.271
var. β montanum, Thw.	
175. Celastrus, L.	
419. paniculatus, Willd. *Duhudu*, S.	I.272
176. Gymnosporia, W. & A.	
420. FRUTICOSA, Hk. f.	I.273
421. emarginata, Hk. f.	I.273
177. Kurrimia, Wall.	
422. ZEYLANICA, Arn. *Palen*, *Et-heraliya*, *Uru-honda*, S. *Konnai*, T.	I.274

178. Hippocratea, L.
    423. obtusifolia, Roxb. *Diya-kirindi-wel*, S. I.275
    424. Arnottiana, Wight. I.275
    425. indica, Willd. I.276

179. Salacia, L.
    426. prinoides, DC. *Hin-himbutu-wel*, S. I.276
    427. reticulata, Wight. *Himbutu-wel*, *Kottala-himbutu*, S. I.277
        var. β diandra, Thw.
    428. oblonga, Wall. *Chundan*, T. I.277

38. Rhamnaceæ.

180. Ventilago, Gærtn.
    429. maderaspatana, Gærtn. *Yakkada-wel*, S. *Vempadam*, T. I.279

181. Zizyphus, Juss.
    430. Jujuba, Lam. *Maha-debara*, S. *Ilantai*, T. I.280
    431. Œnoplia, Mill. *Hin-eraminiya*, S. *Peri-lantai*, *Churai*, T. I.280
    432. NAPECA, Willd. *Yak-eraminiya*, S. I.281
        var. β lucida, Moon.
    433. xylopyra, Willd. *Kakuru*, S. *Nari-ilantai*, T. I.282
    434. rugosa, Lam. *Maha-eraminiya*, S. *Churai*, T. I.282

182. Rhamnus, L.
    435. ARNOTTIANUS, Gardn. I.283
    436. Wightii, W. & A. I.283

183. Scutia, Comm.
    437. indica, Brongn. *Tuvadi*, *Tudari*, T. I.284

184. Sageretia, Brongn.
    438. costata, Miq. I.284

185. Colubrina, Rich.
    439. asiatica, Brongn. *Tel-hiriya*, S. *Mayir-manikkam*, T. I.285

186. Gouania, L.
    440. microcarpa, DC. I.286

39. Ampelideæ.

187. Vitis, L.
    441. tomentosa, Heyne. I.288
    442. indica, L. *To-wel*, *Rata-bulat-wel*, S. I.288
    443. quadrangularis, Wall. *Hiressa*, S. *Pirandai*, T. I.289
    444. GLYPTOCARPA, Laws. I.289

445. LONCHIPHYLLA, Laws. I.290
446. adnata, Wall. I.290
447. Linnaei, Wall. *Wal-niviti*, S. *Kaddu-muntiri*, T. I.291
448. pallida, W. & A. I.291
449. repanda, W. & A. *Wal-diyalabu*, S. I.292
450. ACUMINATA, Trim. I.292
451. Heyneana, Wall. I.292
452. Rheedii, W. & A. I.293
453. GARDNERI, Laws. I.293
454. carnosa, Wall. *Wal-rat-diyalabu*, S. I.294
455. RETICULATA, Laws. I.294
456. pedata, Vahl. *Mediya-wel*, S. I.295
457. tenuifolia, W. & A. I.295
458. setosa, Wall. *Anaittadichchai*, T. I.296
459. lanceolaria, Wall. I.296
    var. β glycosmoides, Planch.

188. Leea, L.
    460. sambucina, Willd. *Burulla*, *Gurulla*, S. I.297

40. Sapindaceæ.

189. Cardiospermum, L.
    461. Halicacabum, L. *Penela-wel*, S. I.299
    462. Corindum, L. I.300

190. Hemigyrosa, Bl.
    463. canescens, Thw. I.301
        var. β trichocarpa, Thw.

191. Allophylus, L.
    464. zeylanicus, L. *Wal-kobbe*, S. I.302
        var. β acuminatus, Hiern.
        var. γ varians, Hiern.
    465. HISPIDUS, Trim. I.303
    466. Cobbe, Bl. *Kobbe*, *Bu-kobbe*, S. *Amarai*, T. I.303
        var. β villosus, Hiern.

192. Schleichera, Willd.
    467. trijuga, Willd. *Kon*, S. *Puvu*, *Kula*, T. *Ceylon Oak.* I.304

193. GLENIEA, Hk. f.
    468. ZEYLANICA, Hk. f. *Wal-mora*, S. *Kuma*, T. I.305, Pl. XXV.
        var. β unijuga, Trim.

194. Sapindus, L.
    469. laurifolius, Vahl. *Kaha-penela*, S. I.306
    470. emarginatus, Vahl. *Penela*, S. *Neykkoddan*, *Panalai*, T. I.307

471. bifoliatus, Hiern. I.307
472. ERECTUS, Hiern. I.307
473. THWAITESII, Hiern. I.308

195. Nephelium, L.
474. Longana, Camb. *Mora*, *Rasa-mora*, S. *Nurai*, T. *Longan.* I.309
var. β pallida, Trim.
475. GARDNERI, Thw. *Nurai*, T. I.309

196. Pometia, Forst.
476. eximia, Hk. f. *Gal-mora*, *Bulu-mora*, *Na-imbul*, S. I.310

197. Harpullia, Roxb.
477. imbricata, Thw. *Na-imbul*, *Pundalu*, S. I.311

198. Dodonæa, L.
478. viscosa, L. *Eta-werella*, S. *Virali*, T. I.312

199. Turpinia, Vent.
479. pomifera, DC. *Eta-hirilla*, *Kankumbala*, *Kukul-man*, S. I.313
var. β montana, Thw.

41. Sabiaceæ.

200. Meliosma, Bl.
480. Wightii, Planch. I.314
481. Simplicifolia, Walp. *Elbedda*, S. I.315
482. Arnottiana, Walp. I.315

42. Anacardiaceæ.

201. Buchanania, Roxb.
483. angustifolia, Roxb. I.316

202. Mangifera, L.
484. ZEYLANICA, Hk. f. *Et-amba*, *Wal-amba*, S. *Kaddu-ma*, T. I.317

203. Odina, Roxb.
485. Wodier, Roxb. *Hik*, S. *Odi*, T. I.318

204. Semecarpus, L. f.
486. MARGINATA, Thw. I.319
487. SUBPELTATA, Thw. *Maha-badulla*, S. I.320
488. PUBESCENS, Thw. I.320
var. β Thwaitesii, Engl.
489. OBOVATA, Moon. *Kalu-badulla*, S. I.321
490. MOONII, Thw. I.321
491. CORIACEA, Thw. *Badulla*, S. I.321
492. WALKERI, Hk. f. I.322
493. GARDNERI, Thw. *Badulla*, S. I.322

494. ACUMINATA, Thw.	I.323
var. β INTERMEDIA, Trim.	
495. NIGROVIRIDIS, Thw.	I.323
496. OBSCURA, Thw. *Badulla*, S.	I.324
497. PARVIFOLIA, Thw.	I.324
498. LÆVIGATA, Thw.	I.325
205. Nothopegia, Bl.	
499. Colebrookiana, Bl. *Bala*, S.	I.325
206. Campnosperma, Thw.	
500. ZEYLANICUM, Thw. *Aridda*, S.	I.326
207. Spondias, L.	
501. mangifera, Willd. *Embarella*, S. *Ampallai*, T. *Hog-plum.*	I.327

43. Connaraceæ.

208. Rourea, Aubl.	
502. santaloides, W. & A. *Kirindi-wel*, S.	II.1
209. Connarus, L.	
503. monocarpus, L. *Radaliya*, S. *Chettupulukodi*, T.	II.2
504. CHAMPIONII, Thw. *Wel-radaliya*, S.	II.3
210. Ellipanthus, Hk. f.	
505. THWAITESII, Hk. f.	II.3

44. Leguminosæ.

211. Rothia, Pers.	
506. trifoliata, Pers.	II.7
212. Heylandia, DC.	
507. latebrosa, DC.	II.8
213. Crotalaria, L.	
508. biflora, L.	II.9
509. prostrata, Roxb.	II.9
510. ferruginea, Grah.	II.10
511. evolvuloides, Wight.	II.10
512. MULTIFLORA, Benth.	II.11
513. rubiginosa, Willd.	II.11
514. mysorensis, Roth.	II.12
*515. triquetra Dalz.	II.12
516. albida, Heyne.	II.12
517. nana, Burm.	II.13
var. β umbellata (Wight), Trim.	
518. linifolia, L. f.	II.13
519. tecta, Heyne.	II.14
520. calycina, Schrank.	II.14

521. retusa, L. *Kaha-andana-hiriya*, S. *Kilu-kiluppai*, T. II.15
    var. β maritima, Trim.
522. verrucosa, L. *Nil-andana-hiriya*, S. *Kilu-kiluppai*, T. II.15
523. WALKERI, Arn. II.16, Pl. XXVI.
524. juncea, L. *Hana*, S. *Hemp*, *Sunn-hemp*. II.16
525. lunulata, Heyne. II.17
526. medicaginea, Lam. II.18
    var. β luxurians, Baker.
527. striata, DC. II.18
    var. β acutifolia, Trim.
528. clavata, W. & A. II.19
529. laburnifolia, L. *Yak-beriya*, S. II.19
530. quinquefolia, L. II.19

214. Parochetus, Ham.
    531. communis, Ham. II.20

215. Indigofera, L.
    532. echinata, Willd. II.21
    533. linifolia, Retz. II.22
    534. enneaphylla, L. *Cheppunerinchi*, T. II.22
    535. aspalathoides, Vahl. *Rat-kohomba*, S. *Chivanarvempu*, T. II.23
    536. glabra, L. II.23
    537. tenuifolia, Rottl. II.24
    538. viscosa, Lam. II.24
    539. trifoliata, L. II.24
    540. trita, L. f. *Wal-awari*, S. II.25
    541. subulata, Poir. II.25
    542. paucifolia, Del. *Nanti*, *Kuttukarasamatti*, T. II.25
    543. hirsuta, L. II.26
    *544. tinctoria, L. *Nil-awari*, S. *Indigo*. II.26
    545. constricta, Trim. II.27
    546. Wightii, Grah. II.27
    547. galegoides, DC. II.28

216. Psoralea, L.
    548. corylifolia, L. *Bodi*, S. II.28

217. Mundulea, DC.
    549. suberosa, Benth. II.29

218. Tephrosia, Pers.
    550. spinosa, Pers. II.30
    551. senticosa, Pers. II.30
    552. tinctoria, Pers. *Alu-pila*, S. II.31
        var. β pulcherrima, Baker.

553. purpurea, Pers. *Pila*, S. *Kolinchi*, *Kavilai*, T. II.31
var. β pumila, Baker.
554. maxima, Pers. II.32, Pl. XXVII.
555. Hookeriana, W. & A. II.32
556. villosa, Pers. *Bu-pila*, S. II.33

219. Sesbania, Pers.
*557. ægyptiaca, Pers. *Chittakatti*, T. II.34
558. aculeata, Pers. II.34
var. sericea, Benth.

220. Zornia, Gmel.
559. diphylla, Pers. II.35
var. β conjugata, Trim.
var. γ Walkeri, Baker.

221. Stylosanthes, Sw.
560. mucronata, Willd. *Wal-nanu*, S. II.36

222. Smithia, Aiton.
561. sensitiva, Ait. II.37
562. conferta, Sm. II.37
563. blanda, Wall. II.37

223. Æschynomene, L.
564. indica, L. *Diya-siyambala*, S. II.38
565. aspera, L. *Maha-diya-siyambala*, S. *Attuneddi*, T. *Shola-pith*. II.39

224. Ormocarpum, Beauv.
566. sennoides, DC. II.39

225. Eleiotis, DC.
567. sororia, DC. II.40

226. Pycnospora, R. Br.
568. hedysaroides, Br. II.41

227. Pseudarthria, W. & A.
569. viscida, W. & A. *Gas-gonika*, S. II.41

228. Uraria, Desv.
570. picta, Desv. II.42
571. hamosa, Wall. II.43

229. Alyssicarpus, Neck.
572. monilifer, DC. II.43
573. vaginalis, DC. *Aswenna*, S. II.44
574. bupleurifolius, DC. *Kutiraivali*, T. II.44
575. longifolius, W. & A. II.45
576. rugosus, DC. II.45
var. β Heyneanus, Baker.

230.	Desmodium, Desv.	
577.	umbellatum, DC.	II.47
578.	Cephalotes, Wall.	II.47
579.	pulchellum, Benth. *Hampilla*, S.	II.48
580.	biarticulatum, Benth.	II.48
581.	laburnifolium, DC.	II.48
582.	triquetrum, DC. *Baloliya*, S.	II.49
583.	ormocarpoides, DC.	II.49
584.	Gardneri, Benth.	II.50
585.	Scalpe, DC.	II.50
586.	gangeticum, DC.	II.51
587.	latifolium, DC.	II.51
588.	THWAITESII, Baker.	II.51
589.	Wightii, Grah.	II.52
590.	rufescens, DC.	II.52
591.	heterocarpum, DC. *Et-undupiyali*, S. var. β trichocaulon, Baker.	II.53
592.	JUCUNDUM, Thw.	II.54, Pl. XXVIII.
593.	triflorum, DC. *Hin-undupiyali*, S.	II.54
594.	heterophyllum, DC. *Maha-undupiyali*, S.	II.55
595.	parvifolium, DC.	II.55
596.	gyrans, DC. *Chanchala*, S. *Telegraph Plant.*	II.56
*597.	gyroides, DC.	II.56
231.	Abrus, L.	
598.	precatorius, L. *Olinda-wel*, S. *Kuntumani*, T. *Crab's Eyes, Indian Liquorice.*	II.57
599.	pulchellus, Wall.	II.57
232.	Shuteria, W. & A.	
600.	vestita, W. & A.	II.58
233.	Dumasia, DC.	
601.	villosa, DC. var. leiocarpa, Benth.	II.58
234.	Glycine, L.	
602.	javanica, L. *Goradiya*, S.	II.59
235.	Teramnus, Sw.	
603.	labialis, Spreng.	II.60
236.	Mucuna, Adans.	
604.	monosperma, DC.	II.61
605.	atropurpurea, DC. *Punnakalichi, Phandatullai*, T.	II.61
606.	gigantea, DC.	II.62
607.	pruriens, DC. *Achariya-pala*, S. *Cowitch.* var. β biflora, Trim.	II.62

237. Erythrina, L.	
608. indica, Lam. *Erabadu*, S. *Mullu-murukku*, T.	II.63
609. ovalifolia, Roxb. *Yak-erabadu*, S.	II.64
238. Strongylodon, Vog.	
610. ruber, Vogel.	II.65
239. Galactia, P. Br.	
611. tenuiflora, W. & A.	II.65
240. Butea, Roxb.	
612. frondosa, Kœn. *Gas-kela*, S. *Parasu*, T. *Bengal Kino.*	II.66
241. Canavalia, DC.	
613. ensiformis, DC. *Wal-awara*, S. *Koli-avarai*, T. *Sabre Bean.*	II.67
var. β virosa, Baker.	
614. obtusifolia, DC. *Mudu-awara*, S.	II.68
242. Dioclea, H. B. K.	
615. reflexa, Hk. f.	II.68
243. Phaseolus, L.	
616. adenanthus, Meyer. *Wal-me*, S.	II.70
617. Grahamianus, W. & A.	II.70
*618. semierectus, L.	II.70
619. trilobus, Ait. *Bin-me*, S. *Narippayaru*, T.	II.71
620. aconitifolius, Jacq.	II.71
621. Max, L. *Mun*, *Mun-eta*, *Bu-me*, S. *Chiruppayaru*, T. *Green Gram.*	II.72
var. β radiatus, Baker. *Ulundu*, S. *Uluntu*, T. *Black Gram.*	
622. trinervius, Heyne.	II.72
623. calcaratus, Roxb.	II.73
244. Vigna, Savi.	
624. luteola, Benth.	II.73
625. vexillata, Benth.	II.74
245. Clitoria, L.	
626. ternatea, L. *Nil-katarodu*, *Katarodu-wel*, S. *Karuttappu*, T.	II.75
246. Dolichos, L.	
627. Lablab, L. *Tatta-payaru*, *Minni*, T.	II.76
628. uniflorus, Lam. var. glaber, Thw.	II.76
629. ciliatus, Klein.	II.77
630. falcatus, Klein. *Wal-dambala*, S.	II.77

247. Atylosia, W. & A.	
631. Candollei, W. & A. *Et-tora*, S.	II.78
632. albicans, Benth.	II.78
633. rugosa, W. & A. *Wal-kollu*, S.	II.79
634. scarabæoides, Benth. *Wal-kollu*, S.	II.79
248. Dunbaria, W. & A.	
635. ferruginea, W. & A.	II.80
636. Heynei, W. & A.	II.80
249. Eriosema, DC.	
637. chinense, Vogel.	II.81
250. Rhynchosia, Lour.	
638. rufescens, DC.	II.82
639. nummularia, DC.	II.82
640. suaveolens, DC.	II.83
641. cana, DC.	II.83
642. cyanosperma, Benth.	II.84
643. minima, DC.	II.84
644. viscosa, DC.	II.85
645. acutissima, Thw.	II.85
646. densiflora, DC.	II.85
251. Flemingia, Roxb.	II.87
647. strobilifera, Br. *Hampinna*, S.	II.86
648. lineata, Roxb.	II.87
649. congesta, Roxb. var. β semialata, Baker.	II.87
252. Dalbergia, L. f.	
650. pseudo-Sissoo, Miq. (Championii, Thw.)[1] *Bambara-wel*, S.	II.88
651. lanceolaria, L. f. *Veluruvai*, T.	II.88
652. torta, Grah. (monosperma, Dalz.)	II.89
253. Pterocarpus, L.	
653. Marsupium, Roxb. *Gammalu*, S. *Venkai*, T.	II.90
254. Pongamia, Vent.	
654. glabra, Vent. *Magul-karanda*, S. *Punku*, T.	II.91
255. Derris, Lour.	
655. scandens, Benth. *Kala-wel*, S. *Tekil*, T.	II.91
656. PARVIFLORA, Benth.	II.92
657. uliginosa, Benth. *Kala-wel*, S.	II.92
658. PANICULATA, Benth.	II.93
659. oblonga, Benth.	II.93, Pl. XXIX.
660. sinuata, Benth.	II.94

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[1] Prain, Monograph of D. Ann. R.B.G. Calcutta, X., p. 60.

- 256. Sophora, L.
  - 661. tomentosa, L. *Mudu-murunga*, S. II.95
  - 662. VIOLACEA, Thw. II.95
  - 663. ZEYLANICA, Trim. II.96, Pl. XXX.
- 257. PERICOPSIS, Thw.
  - 664. MOONIANA, Thw. *Nedun*, S. II.97, Pl. XXXI.
- 258. Cæsalpinia, L.
  - 665. Bonduc, Roxb. *Kumburu-wel*, S. *Punaikkalaichchi*, T. II.98
  - 666. Nuga, Ait. *Diya-wawul-etiya*, S. II.99
  - 667. sepiaria, Roxb. II.100
    - var. β auricoma, Trim.
  - 668. digyna, Rottl. II.100
- 259. Peltophorum, Vogel.
  - 669. ferrugineum, Benth. *Iya-vakai*, T. II.101 Pl. XXXII.
- 260. Mezoneurum, Desf.
  - 670. enneaphyllum, W. & A. *Goda-wawul-etiya*, S. II.102
- 261. Cassia, L.
  - 671. Fistula, L. *Ehela*, S. *Tirukkontai*, *Kavani*, T. II.103
  - 672. marginata, Roxb. *Ratu-wa*, S. *Vakkai*, T. II.104
  - 673. occidentalis, L. *Peni-tora*, S. *Ponnantakarai*, T. II.105
  - 674. Sophera, L. *Uru-tora*, S. *Takarai*, T. II.105
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  - 682. mimosoides, L. *Bin-siyambala*, S. II.110
    - var. β auricoma, Grah.
    - var. γ Wallichiana, Baker.
- 262. Cynometra, L.
  - 683. ramiflora, L. *Gal-mendora*, S. *Attukaddupuli*, T. II.111
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- 263. Dialium, L.
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686. indica, L. *Diya-ratmal*, *Diya-ratambala*, S. II.114

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687. laurifolia, Vahl. *Gal-karanda*, S. II.115

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688. tomentosa, L. *Petan*, *Kaha-petan*, S. *Tiruvatti*, T. II.116
689. racemosa, Lam. *Mayila*, S. *Atti*, T. II.116
*690. anguina, Roxb. II.117

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691. oleracea, Lour. *Diya-nidi-kumba*, S. II.118

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692. scandens, Benth. *Pus-wel*, S. II.119

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693. pavonina, L. *Madatiya*, S. *Anaikuntumani*, T. II.120
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*696. arabica, Willd. *Karuvel*, T. II.122
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705. Lebbek, Benth. *Mara*, S. *Kona*, *Vakai*, T. II.128
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713. Wightianum, Bl.	II.134
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714. ZEYLANICUM, Gærtn. *Golu-mora*, *Kankumbalketiya*, S.	II.135
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715. glomeratus, Bl.	II.136
716. moluccanus, L. *Wel-bute*, S.	II.136
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718. lasiocarpus, Sm.	II.138
var. β subglaber, Thw.	
277. Potentilla, L.	
719. Mooniana, Wight.	II.139
720. Kleiniana, W. & A.	II.139
278. Alchemilla, L.	
721. indica, Gardn.	II.140
var. β sibthorpioides, Hk. f.	
279. Poterium, L.	
722. INDICUM, Gardn.	II.141
280. Agrimonia, L.	
723. ZEYLANICA, Moon.	II.141
281. Photinia, Lindl.	
724. Notoniana, W. & A.	II.142

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282. Vahlia, Thunb.	
725. oldenlandioides, Roxb.	II.143

47. Crassulaceæ.

283. Kalanchoe, Adans.	
726. floribunda, W. & A. var. glabra, Clarke.	II.144
727. laciniata, DC.	II.144

48. Droseraceæ.

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    728. Burmanni, Vahl. *Wata-essa*, S. *Sun-dew.* II.145
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287. Callitriche, L.
    734. stagnalis, Scop. II.149

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288. Rhizophora, L.
    735. mucronata, Lam. *Kadol*, S. *Kandal*, T. *Mangrove.* II.151
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289. Ceriops, Arn.
    737. Candolleana, Arn. *Chirukandal*, T. II.152
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290. Bruguiera, Lam.
    739. gymnorhiza, Lam. *Mangrove.* II.153
    740. caryophylloides, Bl. II.154

291. Carallia, Roxb.
    741. integerrima, DC. *Dawata*, S. II.155
    742. CALYCINA, Benth. *Ubberiya*, S. II.155, Pl. XXXVI.

292. Weihea, Spreng.
    743. zeylanica, Baill. *Pana*, S. *Kannu*, T. II.156

293. Anisophyllea, Br.
    744. ZEYLANICA, Benth. *Weli-penna*, *Weli-piyana*, S. II.157

51. Combretaceæ.

294. Terminalia, L.
    745. belerica, Roxb. *Bulu*, S. *Tanti*, T. *Myrobalans.* II.159

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[1] Cf. Schindler in Das Pflanzenreich.

746. chebula, Retz. *Aralu*, S. *Kadukkai*, T. *Myrobalans*, *Gall-nut*, *Ink-nut.* II.159
747. PARVIFLORA, Thw. *Hanpalanda*, S. II.160
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749. latifolia, Wall. *Dawu*, S. *Vekkali*, T. II.162

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752. acuminatum, Roxb. II.163
753. ovalifolium, Roxb. *Kaduru-ketiya-wel*, S. II.163
754. extensum, Roxb. II.164

298. Gyrocarpus, Jacq.
755. Jacquini, Roxb. *Hima*, S. *Thinakku*, T. II.165

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299. Rhodomyrtus, DC.
756. tomentosa, Wight. *Wild Guava.* II.166

300. Eugenia, L.
757. aquea, Burm. *Wal-jambu*, S. II.169
758. grandis, Wight. II.170
759. hemispherica, Wight. II.170
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762. lanceolata, Lam. II.172
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765. SUBAVENIS, Duth. II.173
766. Gardneri, Duth. *Dambu*, S. *Nir-naval*, T. II.174
767. corymbosa, Lam. *Dan*, *Hiṅ-dan*, S. II.174
768. MICRANTHA, Duth. II.175
769. revoluta, Wight. II.175
770. SYLVESTRIS, Wight. *Alu-bo*, S. II.175
771. ASSIMILIS, Duth. II.176
772. CORDIFOLIA, Wight. II.176
773. NEESIANA, Wight. *Panu-kera*, S. II.177
774. CYCLOPHYLLA, Thw. II.177
775. ROTUNDIFOLIA, Wight. II.177
776. SCLEROPHYLLA, Duth. II.178
777. OLIGANTHA, Duth. II.178
778. OLIVIFOLIA, Duth. II.178

779. operculata, Roxb. *Bata-damba, Kobomal*, S. II.179
780. Jambolana, Lam. *Maha-dan, Madan*, S. *Naval, Peru-naval*, T. II.179
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781. lucida, Lam. II.180, Pl. XXXVII.
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783. TERPNOPHYLLA, Thw. II.181
784. XANTHOCARPA, Thw. II.182
785. bracteata, Roxb. *Tembiliya*, S. *Kaya, Venkalikaya*, T. II.182
786. RUFO-FULVA, Thw. II.183
787. PHILLYRÆOIDES, Trim. II.183
788. FLOCCIFERA, Thw. II.183
789. RIVULORUM, Thw. II.184
790. FULVA, Thw. II.184
791. INSIGNIS, Thw. II.185
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795. APRICA, Trim. II.186
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797. PEDUNCULATA, Trim. II.187
798. Mooniana, Wight. *Pinibaru*, S. II.187
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800. speciosa, Forst. *Mudilla*, S. II.189
801. racemosa, Bl. *Diya-midella*, S. II.189
802. ZEYLANICA, Gardn. *Goda-midella*, S. II.190
803. acutangula, Gærtn. *Ela-midella*, S. *Adampu*, T. II.191

302. Careya, Roxb.
804. arborea, Roxb. *Kahata*, S. *Kachaddai*, T. *Patana Oak.* II.191

53. Melastomaceæ.

303. Osbeckia, L.
805. erythrocephala, Naud. *Bowitiya*, S. II.194
806. RHEEDII, Gardn. II.194
807. zeylanica, L. f. II.195
808. aspera, Bl. *Bowitiya*, S. II.195
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var. γ Kleinii, Arn.
var. δ Wightiana, Benth.
809. WALKERI, Arn. II.196
var. β Beckettii, Thw.

810. BUXIFOLIA, Arn. II.197
    var. β minor, Thw.
811. RUBICUNDA, Arn.
812. MOONII, Thw. II.198
813. octandra. DC. II.198

304. Melastoma, L.
814. malabathricum, L. *Maha-bowitiya*, S. II.199

305. Kendrickia, Hk. f.
815. Walkeri, Hk. f. II.200

306. Sonerila, Roxb.
816. ZEYLANICA, W. & A. II.202
    var. β pumila, Clarke.
    var. γ cordifolia, Thw.
    var. δ affinis, Trim.
    var. ε rostrata, Clarke.
817. RHOMBIFOLIA, Thw. II.203
    var. β angustata, Thw.
818. Brunonis, W. & A. II.203
819. Arnottiana, Thw. II.204
    var. β tomentella, Trim.
820. WIGHTIANA, Arn. II.204
    var. β Hookeriana, Trim.
821. HIRSUTULA, Arn. II.205, Pl. XXXIX.
822. GARDNERI, Thw. II.205
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823. ROBUSTA, Arn. II.206
    var. β glabricaulis, Thw.
    var. γ Harveyi, Trim.
824. LANCEOLATA, Thw. II.206
825. PILOSULA, Thw. II.207
826. linearis, Hk. f. II.20
827. pedunculosa, Thw. II.208

307. Medinilla, Gaud.
828. FUCHSIOIDES, Gardn. II.208
829. MACULATA, Gardn. II.209, Pl. XL.
    var. β cuneata, Thw.

308. Memecylon, L.
830. ARNOTTIANUM, Wight. II.211
831. GARDNERI, Thw. II.211
832. HOOKERI, Thw. II.212
    var. β exalatum, Trim. *Kevitiya-kera*, S.
833. Wightii, Thw. II.212
    var. β cylindricum, Trim.
834. PARVIFOLIUM, Thw. II.213
835. VARIANS, Thw. II.213
    var. β rotundatum, Thw.

836. ELEGANTULUM, Thw. II.214
837. ELLIPTICUM, Thw. II.214
838. MACROPHYLLUM, Thw. II.214
839. OVOIDEUM, Thw. II.215
840. REVOLUTUM, Thw. II.215
841. ORBICULARE, Thw. II.215
842. PROCERUM, Thw. II.216
843. CUNEATUM, Thw. II.216
844. umbellatum, Burm. f. *Kora-kaha*, S. *Kaya*, *Kurrekaya*, *Pandikaya*, T. II.216
    var. β Thwaitesii, Clarke.
    var. γ rubro-cœruleum, Clarke.
845. CLARKEANUM, Cogn. II.217
846. discolor, Cogn. II.218
847. FUSCESCENS, Thw. II.218
848. ROSTRATUM, Thw. *Kuretiya*, *Hin-kuretiya*, S. II.218
849. angustifolium, Wight. II.219
850. PHYLLANTHIFOLIUM, Thw. II.219
851. RHINOPHYLLUM, Thw. II.219
852. LEUCANTHUM, Thw. II.220
853. MACROCARPUM, Thw. II.220
854. lævigatum, Bl. II.220
855. grande, Retz. *Dodan-wenna*, *Dedikaha*, S. II.221
    var. β ovatum, Clarke.
856. CAPITELLATUM, L. *Weli-kaha*, *Dodan-kaha*, S. *Kattikaya*, *Venkalikaya*, *Pavaddai-kaya*, T. II.222, Pl. XLI.

54. Lythraceæ.

309. Ammannia, L.
    857. peploides, Spreng. II.223
    858. Rotala, F. Muell. II.224
    859. pentandra, Roxb. II.224
    860. baccifera, L. II.224
    861. cordata, W. & A. II.225
    862. lanceolata, Heyne. II.225
    863. octandra, L. f. II.225

310. Woodfordia, Salisb.
    864. floribunda, Salisb. *Malitta*, S. II.226

311. Pemphis, Forst.
    865. acidula, Forst. II.227

312. Lawsonia, L.
    866. alba, Lam. *Marutonti*, T. *Henna*, *Tree Mignonette*. II.228

313. Lagerstrœmia, L.
867. Flos-reginæ, Retz. *Muruta*, S. II.228

314. Sonneratia, L. f.
868. apetala, Ham. II.229
869. alba, Smith. II.230
870. acida, L. f. *Kirilla*, S. *Kinnai*, T. II.230

315. Axinandra, Thw.
871. ZEYLANICA, Thw. *Kekiri-wara*, S. II.231

55. Onagraceæ.

316. Jussiæa, L.
872. repens, L. *Beru-diyanilla*, S. II.233
873. suffruticosa, L. II.233
var. β subglabra, Thw.

317. Ludwigia, L.
874. parviflora, Roxb. II.234
875. prostrata, Roxb. II.234

318. Trapa, L.
876. bispinosa, Roxb. *Ikiliya*, S. II.235

56. Samydaceæ.

319. Casearia, Jacq.
877. esculenta, Roxb. *Wal-waraka*, S. *Kakkai-palai*, T. II.237
878. CORIACEA, Thw. II.237
879. tomentosa, Roxb. II.238

320. Osmelia, Thw.
880. GARDNERI, Thw. II.238

321. Homalium, Jacq.
881. zeylanicum, Benth. *Liyan*, *Liyangu*, S. II.239

57. Passifloraceæ.

322. Modecca, Lam.
882. Wightiana, Wall. II.240
883. palmata, Lam. *Hondala*, *Potu-honda*, S. II.241

58. Cucurbitaceæ.

323. Trichosanthes, L.
884. palmata, Roxb. *Titta-hondala*, S. II.244
var. β tomentosa, Heyne.
885. nervifolia, L. II.244
886. cucumerina, L. *Dummella*, S. *Pudal*, T. II.245
var. β laciniosa, Thw.
887. INTEGRIFOLIA, Thw. II.245, Pl. XLII.

324. Gymnopetalum, Arn.
888. Wightii, Arn. II.246, Pl. XLIII.
var. β zeylanicum, Arn.

325. Cephalandra, Schrad.
889. indica, Naud. *Kowakka*, S. *Kovvai*, T. II.247

326. Momordica, L.
*890. Charantia, L. *Karivila*, *Batu-karivila*, S. *Pakal*, *Nuti-pakal*, T. II.248
891. dioica, Roxb. *Tumba-karivila*, S. *Tumpai*, *Palu-pakal*, T. II.249
892. DENUDATA, Clarke. II.249

327. Cucumis, L.
893. trigonus, Roxb. *Metukku*, T. II.250
894. pubescens, Willd. *Gon-kekiri*, *Kekiri*, S. II.250

328. Luffa, Cav.
*895. ægyptiaca, Mill. *Niyan-weta-kolu*, S. *Pikku*, *Pichukku*, T. II.251
896. acutangula, Roxb. *Weta-kolu*, *Dara-wetakolu*, S. *Peypichukku*, T. II.252
var. β amara, Roxb.

329. Citrullus, Schrad.
897. Colocynthis, Schrad. *Yakkomadu*, S. *Peykkomaddi*, T. *Colocynth.* II.253

330. Bryonia, L.
898. laciniosa, L. II.254

331. Mukia, Arn.
899. scabrella, Arn. *Hin-kekiri*, S. *Mochu-mochukkai*, T. II.254
900. leiosperma, Wight. II.255

332. Zehneria, Endl.
901. Hookeriana, Arn. II.256
902. hastata, Miq. *Kawudu-kekiri*, S. *Peyp-pudal*, T. II.256

333. Melothria, L.
903. ZEYLANICA, Clarke. II.257

334. Rhynchocarpa, Schrad.
904. rostrata, Naud. II.258

335. Corallocarpus, Welw.
905. epigæus, Clarke. *Gopalanga*, S. II.258

336. Cerasiocarpum, Hk. f.
906. zeylanicum, Clarke. II.259, Pl. XLIV.

337. Ctenolepis, Hk. f.
907. Garcini, Clarke. *Mochu-mochukkai*, T. II.260

338. Gynostemma, Bl.	
908. laxa, Cogn.	II.260, Pl. XLV.
339. Zanonia, L.	
909. indica, L. *Wal-rasakinda*, S.	II.261

59. Begoniaceæ.

340. Begonia, L.	
910. cordifolia, Thw. *Gal-ambala*, S.	II.262
911. TENERA, Dryand.	II.263
912. THWAITESII, Hook.	II.264
913. subpeltata, Wight.	II.264
914. malabarica, Lam. *Hak-ambala*, S.	II.264

60. Datiscaceæ.

341. Tetrameles, Br.	
915. nudiflora, R. Br. *Nigunu*, *Mugunu*, S.	II.265

61. Cactaceæ.

342. Rhipsalis, Gærtn.	
916. Cassytha, Gærtn. *Wal-nawahandi*, S.	II.266

62. Ficoideæ.

343. Sesuvium, L.	
917. Portulacastrum, L. *Vankiruvalai*, T.	II.268
344. Trianthema, L.	
918. monogyna, L. *Hin-sarana*, S.	II.269
919. triquetra, Rottl. & Willd. *Chirup-padikkirai*, T.	II.269
var. β Rottleri, Trim.	
920. decandra, L. *Maha-sarana*, S. *Charanai*, T.	II.270
345. Mollugo, L.	
921. hirta, Thunb.	II.270
922. oppositifolia, L. *Hin-pala*, S. *Kachchantirai*, T.	II.271
923. pentaphylla, L.	II.271
924. Cerviana, Ser. *Pat-padakam*, T.	II.272
925. disticha, Ser.	II.272
926. nudicaulis, Lam.	II.272
346. Gisekia, L.	
927. pharnaceoides, L. *Manali*, T.	II.273

63. Umbelliferæ.

347. Hydrocotyle, L.
  928. javanica, Thunb. *Maha-gotukola*, S. II.275
  929. rotundifolia, Roxb. II.275
  930. asiatica, L. *Hin-gotukola*, S. *Vallarai*, T. II.276

348. Sanicula, L.
  931. europæa, L. II.276

349. Bupleurum, L.
  932. virgatum, W. & A. *Wal-enduru*, S. II.277

350. Carum, L.
  933. stictocarpum, Clarke. II.278

351. Pimpinella, L.
  934. Heyneana, Wall. *Wal-asamodagan*, S. II.279
  935. Leschenaultii, DC. II.279

352. Peucedanum, L.
  936. ZEYLANICUM, Gardn. II.280

353. Heracleum, L.
  937. ZEYLANICUM, Gardn. II.280

64. Araliaceæ.

354. Polyscias, Forst.
  938. acuminata, Seem. II.282

355. Heptapleurum, Gærtn.
  939. racemosum, Bedd. II.283
  940. stellatum, Gærtn. *Itta*, *Itta-wel*, S. II.283
  941. exaltatum, Seem. II.284
  942. EMARGINATUM, Seem. II.284, Pl. XLVI.

65. Cornaceæ.

356. Alangium, Lam.
  943. Lamarckii, Thw. *Mul-anninchil*, T. II.285
  944. GLANDULOSUM, Thw. II.286

357. Mastixia, Bl.
  945. TETRANDRA, Clarke. *Maha-tawara*, S.
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    var. β Thwaitesii, Clarke. *Diya-taleya*, S.
  946. arborea, Clarke. II.287

66. Caprifoliaceæ.

358. Viburnum, L.
  947. coriaceum, Bl. II.288
    var. β capitellata, Clarke.
  948. erubescens, Wall. II.289

67. Rubiaceæ.

359. Sarcocephalus, Afzel.
    949. cordatus, Miq. *Bakmi*, S. *Vammi*, T. II.292

360. Anthocephalus, A. Rich.
    950. Cadamba, Miq. *Embul-bakmi*, S. *Vellai-kadampa*, T. II.293

361. Adina, Salisb.
    951. cordifolia, Hk. f. *Kolon*, S. *Manchal-kadampa*, *Raja-murunkai*, T. II.293

362. Stephegyne, Korth.
    952. parvifolia, Korth. *Chelampai*, *Nir-kadampa*, T. II.294
    953. tubulosa, Hk. f. *Helamba*, S. II.295
        var. β minor, Thw.

363. Nauclea, L.
    954. ZEYLANICA, Hk. f. II.296

364. Uncaria, Schreb.
    955. dasyoneura, Korth. var. Thwaitesii, Hk. f. II.296

365. Wendlandia, Bartl.
    956. Notoniana, Wall. *Rawanidala*, S. II.297
        var. β zeylanica, Hk. f.

366. Dentella, Forst.
    957. repens, Forst. II.298

367. Neurocalyx, Hook.
    958. ZEYLANICUS, Hook. II.299
    959. Wightii, Arn. II.299
    960. GARDNERI, Thw. II.300
    961. CHAMPIONII, Benth. II.300

368. Allœophania, Thw.
    962. DECIPIENS, Thw. II.301, Pl. XLVIII.
        var. β flavescens, Thw.
        var. γ Arnottii, Hk. f.

369. Fergusonia, Hk. f.
    963. zeylanica, Hk. f. II.302

370. Hedyotis, L.
    964. fruticosa, L. *Weraniya*, S. II.304
    965. EVENIA, Thw. II.304
    966. CYMOSA, Thw. II.305
    967. MACRÆI, Hk. f. II.305
    968. OBSCURA, Thw. II.305
        var. β minor, Thw.
    969. COPROSMOIDES, Trim. II.306

970. MEMBRANACEA, Thw. II.306
971. THWAITESII, Hk. f. II.307
972. NODULOSA, Arn. II.307
    var. β Walkeri, Hk. f.
973. CINEREO-VIRIDIS, Thw. II.308
    var. β subverticillata, Trim.
    var. γ fumata, Thw.
974. RHINOPHYLLA, Thw. II.308
975. LESSERTIANA, Arn. II.309, Pl. XLIX.
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    var. γ confertiflora, Thw.
    var. δ marginata, Thw.
    var. ε flavescens, Thw.
976. QUINQUENERVIA, Thw. II.310
977. GARDNERI, Thw. II.310
978. LAWSONIÆ, W. & A. II.310
979. verticillaris, W. & A. II.311
980. cærulea, W. & A. II.312
981. nitida, W. & A. *Pita-sudu-pala*, S. II.312
982. Auricularia, L. *Geta-kola*, S. II.313
983. INAMŒNA, Thw. II.313
984. CYANESCENS, Thw. II.313

371. Oldenlandia, L.
985. corymbosa, L. *Wal-patpadagam*, S. II.314
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986. diffusa, Roxb. II.315
987. herbacea, Roxb. II.315
988. umbellata, L. *Saya*, S. *Chaya*, T. *Chay-root*. II.316
989. trinervia, Retz. II.316
990. stricta, L. II.316
991. biflora, L. II.317

372. Anotis, DC.
992. quadrilocularis, Hk. f. II.318
993. NUMMULARIA, Hk. f. II.318
994. NUMMULARIFORMIS, Trim. II.319
995. RICHARDIANA, Hk. f. II.319

373. Ophiorrhiza, L.
996. Mungos, L. *Dat-ketiya*, *Wal-ekaweriya*, S. II.320
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997. Harrisiana, Heyne. II.321
998. RADICANS, Gardn. II.321
999. pectinata, Arn. II.322
1000. PALLIDA, Thw. II.322
1001. GLECHOMIFOLIA, Thw. II.323

374. Mussænda, L.
  1002. frondosa, L. *Mussenda*, *Wel-but-sarana*, S. II.323
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375. Acranthera, Arn.
  1003. ZEYLANICA, Arn. II.324

376. LEUCOCODON, Gardn.
  1004. RETICULATUM, Gardn. II.325

377. Urophyllum, Wall.
  1005. ELLIPTICUM, Thw. II.326
  1006. ZEYLANICUM, Thw. II.326

378. SCHIZOSTIGMA, Arn.
  1007. HIRSUTUM, Arn. II.327

379. Webera, Schreb.
  1008. corymbosa, Willd. *Tarana*, S. *Karanai*, T. II.328
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380. Byrsophyllum, Hk. f.
  1009. ELLIPTICUM, Bedd. II.329

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  1011. dumetorum, Lam. *Kukuruman*, S. *Karai*, T. II.330
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383. NARGEDIA, Bedd.
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384. SCYPHOSTACHYS, Thw.
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1044. hispidula, W. & A. II.350
1045. ANGUSTIFOLIA, Thw. II.350
1046. GLENIEI, Thw. *Vetpavaddai*, T. II.351
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394. Coffea, L.
1048. Wightiana, Wall. *Kaddumallikai*, T. II.352
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Thielaviopsis paradoxa (de Seynes) v. Höhnel.

BY

T. PETCH, B.A., B.Sc.

Thielaviopsis paradoxa was first found by de Seynes, on pineapples in France, and was described by him under the name *Sporochisma paradoxum* in 1886. Subsequently it was discovered, parasitic on sugar cane in Java, by F. A. F. C. Went, who re-described it as *Thielaviopsis ethaceticus.* As the cause of disease in sugar cane, it has since been studied by Howard, Massee, Prillieux and Delacroix, Cobb, Lewton Brain, and Butler, all of whom refer to it under Went's name. v. Höhnel found it growing on coconut in Vienna, and showed that Went's fungus was identical with that described by de Seynes. Recently it has been found to be the cause of a stem disease of the coconut palm in Ceylon ; and as it has been under investigation for some considerable time, it has been thought advisable to summarize the observations of previous authors, and to indicate how far they agree with observations made in this country.

de Seynes.

As stated above, de Seynes (3) found his fungus in pineapples, and, contrary to the experience of subsequent investigators, he was not able to grow it on other fruits. The affected pineapples showed, in longitudinal section, a black patch, which evidently originated towards the exterior of the fruit. In advanced cases this patch sometimes extended to, and involved, the bases of the leaves which crown the fruit. (This last observation is in opposition to that of Cobb, but it may be explained on the supposition that de Seynes examined cut fruits only.) From the black patch, especially from its margin, there emerged a white mould, continuous with the mycelium which caused the stain.

The mycelium of the fungus is described as slender, slightly branched, hyaline, and thin-walled, with septa 25–40 μ apart.

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Its diameter was only 2–3 μ, though de Seynes found some branches up to 6 μ diameter, which he regards as arrested sporophores. (This diameter is very much smaller than that observed in Ceylon.)

The sporophores were erect and fusiform, and stouter than the mycelium. They appeared first as small spherical prominences which were cut off by a septum a little above the point of origin. Thence they increased suddenly in diameter to 8 or 10 μ, after which they diminished gradually to a diameter of about 5 μ. Their total length was 100–150 μ, and their colour, especially towards the base, was reddish-brown or fuliginous. They possessed two to four septa near the base. Branched sporophores were not rare.

The conidia were one-celled, hyaline, cylindric, truncate or rounded at the extremities, 4–5 μ in diameter, and 5–8 μ in length. Sometimes they separated from one another, sometimes several remained united in a chain, but those formed last issued freely from the interior of the sporophore. de Seynes understood that the spores were formed in succession within the sporophore, but he appears to have believed that those first formed were united to the wall of the spore cell, and broke away with part of the latter, while those formed later were formed free in the cell, and therefore after their expulsion part of the wall of the latter remained as an empty tube. This, and other examples, serve as a basis for his paper on acrogenous conidia (2).

In addition to the conidia described above, the same mycelium bore other conidia, which de Seynes named *Macroconidia*. They occurred singly, or in chains of two or three, on branches less specialized than the sporophores previously described. These conidia were oval, rarely spherical, 10–22 × 7–10 μ, olivaceous brown, black in mass. They are said to be segmented off from the parent cell, but endogenous, and to be set free by the destruction of the upper part of the cell wall of the parent cell. It is extremely doubtful from this description whether de Seynes really observed the perfect formation of what are now known as Macroconidia.

He notes that among the conidia developed from the special sporophores (*i.e.*, those now known as microconidia) one often finds examples which have assumed the colour, and sometimes the form, of the macroconidia. Further, when his cultivation was old, he found that groups of erect sporophores were produced, resembling the stalks of an *Isaria* or *Stysanus*, in which each microconidiophore retained its individuality. (This formation has not been recorded by any subsequent investigators, though it is quite easily obtained.)

F. A. F. C. Went.

Went's first accounts of *Thielaviopsis ethaceticus*, and its effect upon sugar cane, were published in agricultural journals which I have not been able to consult. The following description is taken from his article in the Annals of Botany (8).

Went states that the conidia soon germinate in any nutrient solution, and the cultures remain snowy white as long as only vegetative mycelium is developed, but that in from twelve to twenty-four hours they become olive-green or dark green, owing to the formation of conidia. He was able to grow the fungus on mangoes, pineapples, bananas, &c., and states that it will grow on all sorts of materials containing sugar. (In my experience, the change of colour takes place *after* the formation of microconidia, when the macroconidia begin to appear.)

The conidiophore which produces microconidia (de Seynes' specialized conidiophore) is at first a thick, somewhat curved branch of the mycelium, which lengthens into a regularly tapering cell, 100-200 μ in length, in which the conidia are developed, and from which they are ejected in a continuous chain. These microconidia are rectangular, and measure 10–15 × 3·5–5 μ: as a rule they are colourless; but sometimes they are slightly coloured and more oval, thus resembling to some extent the macroconidia.

The macroconidia are situated in chains at the ends of short branches of the mycelium: they are dark olive-green, and measure 16–19 × 10–12 μ. The conidium at the top of the chain is often almost spherical, but the remaining conidia are more elongated. According to Went, the first macroconidium is formed by the growth of a septum across the hypha, a short distance below the apex: soon afterwards a second is produced by the growth of another septum below the first ; and the process continues until a chain of conidia is produced. The macroconidia are therefore produced in a basipetal manner and are not endogenous. (It is now generally admitted that this observation is incorrect.)

Went states that the size of the macroconidia, and that of the microconidia too (but in a less degree), is extremely variable, so that the measurements given are only approximately true. Macroconidia and microconidia may be produced on branches of the same mycelial filament ; and in cultures started with either form, both kinds of conidia are produced. He also considers that both macro- and micro-conidia may occur in the same chain, and he figures a case in which the first three conidia are macroconidia, formed basipetally, while the fourth is a microconidium formed within the hypha. (But there is no doubt that this observation is incorrect, and that he was mistaken in his idea of the mode of formation of the macroconidia.)

As the result of various cultures, Went concludes that the fungus can invert dextrine and saccharose into glucose, can make ethylic alcohol out of glucose, and finally can oxidize this alcohol to acetic acid. The odour of pineapples, which it causes in diseased sugar cane, is due to the formation of ethyl acetate. Went observes that the odour disappears from old cultures of the fungus, so that it is probable that ethyl acetate may be assimilated by *Thielaviopsis.*

Went's figures in the Annals of Botany are still the most accurate that have been published of this species.

Massee.

Massee obtained his material from the West Indies, and cultivated the fungus at Kew. The nutrient solution employed was a decoction of sugar cane. His account is complicated by the introduction of two other species, *Trichosphæria sacchari* and *Melanconium* sp. He considered that the *Thielaviopsis* and the *Melanconium* were stages in the life history of the *Trichosphæria*, but it is now generally admitted that this view is doubtful. The *Melanconium* is common on sugar cane in the West Indies, but the *Trichosphæria* is apparently rare.

Massee states (6) that the microconidiophore when mature is pale gray, sparingly septate, and from 150 to 220 μ in length; it is swollen to a breadth of 12 to 16 μ at a short distance from the base, and gradually tapers to the apex, where it is about 6 μ in diameter. The conidia were developed in a chain at the ruptured apex of the conidiophore "in a manner precisely similar to the macroconidia": they were elliptic-oblong with truncate ends, of a clear pale reddish-brown in colour at maturity, and measured on an average 10–11 × 6 μ. The number of conidia in a chain rarely exceeded ten, and the terminal conidium was of the same shape as the rest, not spherical as in the case of the macroconidia.

The macroconidia were produced on short lateral branches. The top of the branch swelled out until it was about twice the diameter of the hypha, its apex was dissolved, and some of the protoplasm extruded. This mass of protoplasm then acquired a cell wall. Succeeding conidia were formed in the same way until a chain of fifty or more was produced. The wall of a conidium was at first colourless; in about twelve hours it had become tinged with clear olive-green; in twenty-four hours it was sooty-brown; and finally opaque blackish-brown. The terminal conidium was always spherical, and measured 24–26 μ in diameter, but the remainder were barrel-shaped, with truncate ends, and measured 18–20 × 12 μ.

It is difficult to harmonize these observations with those of other observers. The microconidia are produced in long tapering tubes, and the macroconidia on short lateral branches; but eighty or more microconidia may be produced from one conidiophore, while the chain of macroconidia usually does not contain more than ten. The microconidia are at first almost exactly rectangular in outline, and they are formed *within* the tube; they usually remain colourless for so long a period that many investigators have described them as permanently colourless. The macroconidia, on the other hand, are formed by the extrusion of protoplasm, and therefore assume a spherical or elliptical shape; and they rapidly become almost black. The apparently swollen apex of the macroconidiophore is the first extruded mass of protoplasm.

From Massee's figures of spores (6) one would judge that he had seen *macroconidia* only; but from the figures of conidiophores, it would be supposed that he had seen only *microconidiophores.* The figures of the latter, however, bear very little resemblance to the elegantly tapering tube of the reality; and I have never been able to observe a flaring mouth as there depicted. Went, who also obtained material from the West Indies, states that the *Thielaviopsis* on sugar cane there is identical with that found in Java; so the supposition that Massee worked with a different species is improbable.

Throughout his article Massee regards the microconidia as aerial, and the macroconidia as formed only within the tissues of the host, or, in the case of liquid media, beneath the surface of the liquid. Hence he writes with regard to the microconidia: "This form of reproduction is a modification of the one last described (*i.e.*, the macroconidium), developing from the same hyphæ, and owing its structural peculiarities to exposure to light and air during growth; thus illustrating from an unexpected quarter a general rule amongst groups of fungi showing a transition from a subterranean to an aerial condition ...... In the present instance, the advance made in the general structure of the microconidia over the macroconidia tends in the direction of favouring the dispersion of the conidia by wind; the entire fructification is developed in the air, the conidiophores are elongated, and the conidia are comparatively minute." It will be shown later that this explanation is based upon incomplete observations.

The supposed genetic connection between the *Melanconium*, *Thielaviopsis paradoxa*, and *Trichosphæria sacchari* was considered to be established by the following experiments:— In one flask, out of three in which *Melanconium* conidia were sown, microconidia of *Thielaviopsis* developed after twelve days. Nothing of the kind developed in hanging drops, in which the whole course of development could be watched, and the *Melanconium* conidia were evidently obtained from an impure source, *i.e.*, from ordinary diseased sugar cane; under such circumstances, the evidence of a single culture from uncontrolled spores is scarcely sufficient. A second flask culture, which had been started with a single (?) macroconidium of *Thielaviopsis*, and contained an abundance of macro- and micro-conidia, was put aside for an unstated period. The flask was subsequently broken by accident, and on examination there were found "two young perithecia, almost colourless and without fruit, but bearing the long characteristic bristle-like septate hyphæ, present on the mature perithecia (of *Trichosphæria sacchari*) found on the decayed cane; two examples of the initial stage of a perithecium were also found." The initial stage of a perithecium, as figured, bears much resemblance to the macroconidiophore bearing suppressed macroconidia, such as often occurs in old cultures: and in the absence of any spores, the identification of the perithecia must be doubtful. In any case the evidence scarcely supports the conclusions formed by Massee.

Prillieux and Delacroix.

Prillieux and Delacroix (7) investigated (in France) specimens of sugar cane from Mauritius attacked by a disease which they attributed to *Coniothyrium melasporum* (Berk.) Sacc. They considered that the fungus was identical with Massee's *Melanconium*, and with a species said to occur on sugar cane in Australia, which Berkeley named *Darluca melaspora;* Thiselton-Dyer has, however, stated that Berkeley's fungus came from Porto Rico, and is a *Diplodia;* so that the latter part of their identification is incorrect.

In addition to *Coniothyrium*, they obtained from the decayed canes an "endocellular" form of conidium, supposed to be identical with the macroconidia of Massee's paper. The conidia were produced in chains of five to ten at the ends of the hyphæ within the decaying tissues; they were black, oval, somewhat truncate, sometimes pyriform, or barrel-shaped, 18 × 9 μ. Intercalary or terminal chlamydospores, about 15 μ diameter, were also observed. On placing diseased canes in damp chambers, the cut surfaces were covered with a black velvety coating formed by chains of the same conidia. When sown in nutrient media, these spores, which the authors here style brown, produced a white mycelium which practically remained sterile; only occasionally were found chains of hyaline conidia, 10 × 6–7 μ., which the authors believe were identical with Massee's microconidia.

It is to be noted that the conidia observed by Prillieux and Delacroix are styled "endocellular," because they were formed within the decaying cane; the term must not be confused with "endoconidia," which has been applied to the spores of *Thielaviopsis*, because they are formed within the hypha. Neither in the figures nor the text is there any indication that Prillieux and Delacroix saw conidia produced within the hyphæ; and the absence of any reference to this, the most striking feature of *Thielaviopsis*, casts some doubt upon their determination of their species. They did not observe the characteristic odour in their cultures.

Thiselton-Dyer.

Howard's account of his investigations is prefaced by a short summary by Sir W. T. Thiselton-Dyer (9), in which the latter upholds Massee's view that *Thielaviopsis paradoxa* is genetically connected with *Trichosphæria sacchari.* He cites Massee's experiment in which macro- and micro-conidia of *Thielaviopsis* were produced in a flask culture started with *Melanconium* spores, and dismisses Went's suggestion, that the culture was impure, on the ground that the *Melanconium* spores are produced on the exterior of the cane, while the macroconidia of *Thielaviopsis* are produced only in the interior, so that a mixture of the two is improbable. In this respect, however, his information was incorrect, for the macroconidia are produced in abundance on the exterior. He also states that Howard obtained the macro- and micro-conidia without difficulty by inoculating the interior of healthy canes with *Melanconium* spores, and that Prillieux and Delacroix appear to have been equally successful. Howard, however, has since withdrawn his claim; and the reference to Prillieux and Delacroix is apparently based upon a misinterpretation of their account. The latter authors state (7) "En dehors de la forme *Coniothyrium*, le mycelium nous a montre une forme conidienne endocellulaire déjà observée par M. Massee. Les conidies se produisent a l'extremité des filaments mycéliens dans les tissus de la canne à sucre, mais lorsque celle-ci est tuée depuis longtemps et que les contenus cellulaires ont entièrement disparu." It is evident from the context that "le mycelium" refers to the mixed mycelium in the naturally diseased sugar cane, and not to the mycelium produced by artificial infection; they did not succeed in reproducing the *Coniothyrium*, or any other form, in artificially infected cane, nor did the latter decay to any marked extent.

Howard.

Howard's investigations were carried out in Barbados, with the object of deciding the disputed life history of *Trichosphæria sacchari*. As the result of an extensive series of cultures, he stated (10) that all attempts to produce *Thielaviopsis* from *Melanconium* spores in sterilized media failed, but that he was able to secure the desired result by inoculating unsterilized pieces of sugar cane. In a later communication (11), however, he states that he was unable to repeat this success, and admits that the sugar cane used was probably previously infected. He was not able to find the perithecia of *Trichosphæria sacchari* on dead canes, nor to obtain it in his cultures. He concludes that the whole of the evidence obtained points to the *Melanconium* being quite distinct from *Thielaviopsis*.

Cultures of mixed macro- and micro-conidia of *Thielaviopsis* on sterilized cane slabs produced a white mycelium in twenty-four hours; they turned black in three days owing to the formation of large numbers of microconidia and a few macroconidia. The same result was obtained in plate and flask cultures.

The development of the spores was studied separately in hanging drops. The macroconidia "germinated in five hours after sowing, and in eleven hours the hypha commenced to branch. In eighteen hours the drop was filled with a branched septate colourless mycelium, which exhibited very rapid growth. In twenty-four hours some of the hyphæ commenced to grow down into the air, especially round the margin of the drop. This behaviour soon became general all over the drop. The aerial mycelium appeared olive in colour, and grew with great rapidity. One of these aerial hyphæ was fixed, and stages of its development were obtained under a higher power. Three hours after leaving the drop the hypha commenced to bend, and the contents showed segmentation. Soon after this appearance the hypha became top-heavy and fell back on to the surface of the drop. This was the signal for the rapid liberation of a chain of grayish rectangular conidia, averaging 7 × 10 μ, from the distal end of the aerial hypha. This behaviour of the aerial hyphæ was found to be general, and, except round the edges, the surface of the drop was speedily covered with ejected spores. The aerial hyphæ proved to be microconidiophores and the spores microconidia. When first extruded from the hyphæ the conidia are grayish in colour, rectangular in shape, and filled with granular protoplasm. In an hour after extrusion from the conidiophore the protoplasm of the conidium became vacuolated, and the conidia became rounder and larger. After this they gradually turned brown, and in twenty-four hours became reddish-brown, with a darker coloured central portion, and measured 15 to 10 μ × 9 to 7 μ. The conidiophores measured 300 μ or more in length.

" During the above developments the submerged hyphæ were observed to form short branches, from which chains of conidia, larger and darker in colour than the microconidia, were produced. Several likely portions of mycelium were fixed, and stages in the formation of these, which proved to be macroconidia, were observed. The short clavate hyphæ soon showed the formation of a clear band near the apex, which divided off the protoplasm of the globose end from the remainder. Five minutes later the cell wall at the apex of the hypha disappeared, and a spherical mass of granular protoplasm was extruded. A distinct cell wall was evident forty minutes after, and the protoplasm was now more coarsely granular and showed vacuolation. After this more conidia were formed in basipetal succession in a chain. Their protoplasm became vacuolated, and the walls gradually darkened. When first extruded the protoplasm is finely granular, about thirty minutes afterwards several small vacuoles appear, which gradually approach the centre and coalesce. After the formation of the central vacuole the wall begins to darken, and in twelve hours becomes sooty black in colour, when the central vacuole can no longer be observed. They measure on the average 22 × 15 μ.

"In many cases in this drop submerged macroconidiophores and collapsed aerial microconidiophores were seen to be developed from the same hypha, thus bearing out Massee's statement that micro- and macro-conidia are developed from the same mycelium. The drop in question was freely exposed to the diffused light of the laboratory, but not to direct sunlight, consequently darkness is not necessary for the formation of macroconidia. A similar development was observed in several other hanging drops containing macroconidia only.

"A hanging-drop culture was obtained containing a single microconidium. The spore germinated six hours after sowing and sent out a colourless septate hypha which soon branched. The mycelium quickly extended right through the drop, and its subsequent development was similar in all respects to that described above in the case of the macroconidia. Aerial microconidiophores were formed as before, which ejected chains of microconidia, while the submerged hyphæ formed chains of macroconidia inside the drop.

"The number of microconidia formed by one conidiophore is frequently very large, as many as ninety being observed.

"The development of the micro- and macro-conidia is therefore practically identical; had the drops not been labelled it would have been impossible to have distinguished between them."

Howard states that he separated the macro- and microconidia by beating up the mycelium in water and pouring off the upper portion. "The macroconidia being larger and heavier, subsided more quickly than the lighter microconidia, and therefore the lower layers of water were richer in the former bodies."

F. von Höhnel.

Sporochisma paradoxum was rediscovered, on the endosperm of a coconut in Vienna, by Dr. F. v. Höhnel (12). He considered that it was identical with *Thielaviopsis ethaceticus* Went, and submitted specimens to Went, who confirmed his opinion. The mycelium was hyaline or slightly brownish, 3–5 μ thick, and not much branched, the branches being almost at right angles to the main hyphæ. The conidiferous hyphæ were perpendicular to the substratum, pale brown, usually simple and scattered, up to more than 200 μ long; they were 8–12 μ in diameter below and 4–5 μ above, and furnished with one to three cross walls towards the base. The apices of the conidiferous hyphæ were without exception open, and the spores were formed within the hyphæ. In some cases these erect hyphæ were massed together into cushions on a foundation of interwoven hyphæ. (This is the only record of any form resembling de Seynes "*Stysanus*" form. It is curious that it should only have been observed in "wild" growths in temperate climates, prior to recent observations in Ceylon.)

The spores were either thin-walled, hyaline, shortly cylindric, 10 × 5 μ (*i.e.*, microconidia), or elliptical, black-brown, almost opaque, thick-walled, 10–18 × 7–10½ μ, generally 12 × 8–9 μ (*i.e.*, macroconidia). All intermediate stages between these two extremes occurred. According to von Höhnel, the dark spore can develop from the hyaline. In some cases the whole chain of spores was hyaline; in others it was partly hyaline and partly dark, while black spores were sometimes found within the hypha. He states that the hyaline spores are not a separate form, but only a stage in the development of the dark spores; and refers to the general occurrence of hyaline spores in other dark-spored conidial species. The fully developed spores are, according to his view, brown. He declares that Went's statement that the macroconidia are formed in a different way from the microconidia is an error, but it is clear that he did not see the macroconidiophores, and hence could not distinguish between the two kinds of conidia.

Cobb.

Cobb examined *Thielaviopsis paradoxa* in connection with sugar cane (14) and pineapple (15) diseases in Hawaii. He states that the mycelium, at first colourless, becomes at last light or dark brown, though never the latter colour except in the fully decomposed tissues of the heart of the cane; it varied in thickness from 3 to 8 μ.

The microconidiophores were about 100 μ long and of varying diameter according to the part measured, being widest (8–10 μ) considerably behind the middle, and thence tapering to the open end. His figures represent them as terminal, not lateral. The microconidia were produced within the hypha, and were cylindrical, nearly colourless, 10–14 × 5 μ, in numbers up to twenty, but generally less than ten. Sometimes they were smaller, ellipsoidal, with a thicker and darker wall.

The macroconidia are said to be borne in an entirely different manner, in chains at the ends of special branches. They were more or less ellipsoidal, brown or blackish, and measured 16–19 × 10–12 μ.

Cobb states that the microconidia germinate readily, merely in the presence of moisture, but that the macroconidia require a period of rest before germination. The latter observation is incorrect. Contrary to the case of coconut, and the experience of the workers with sugar cane, Cobb states that both micro- and macro-conidia are formed within the tissues of the pineapple.

He describes (15) another form of microconidium which occurred on the cut surface of diseased pineapple shortly after cutting. These were formed in the usual way, within the tube, but were united in moniliform chains as "in the case of the aerial conidia of *Sphærotheca pannosa* and other *Erisyphaceæ*." His figure resembles a chain of conidia of *Cystopus*. (Nothing of this kind has been observed by other investigators; the conidia first formed on the cut surface of diseased tissues are normal microconidia, which may adhere in chains but are united.)

In the germination of the microconidia, the spore is said to become nearly spherical.

Lewton Brain.

Lewton Brain (16) working in Hawaii claims to have obtained *Thielaviopsis* spores by sowing *Melanconium* spores in culture media. He writes: "The evidence for the view that *Thielaviopsis* and *Melanconium* are different stages of one and the same figure is, briefly, that when we sow *Melanconium* spores under certain conditions in culture media, the mycelium which arises produces spores which are identical in form and size and method of formation with the spores of *Thielaviopsis*; other observers have found this, and I have also secured the same results. On making a few hurried trials for the purposes of this lecture, I was unable to repeat my previous results." This was written in 1907, but no further particulars have been published.

Butler.

Butler (13) cultivated *Thielaviopsis paradoxa* during the course of investigations into the diseases of sugar cane in India. He writes: "Two different kinds of spores are produced, and the blackening which eventually is seen in the pith is due to one of these.

"The first spore form—the macroconidia—is formed within the tissues. The spores are produced in chains extruded from the tips of short lateral filaments, and are olive-green and thick-walled. I have never seen macroconidia budded off basipetally as described by Went.

"The second spore form—the microconidia—is formed on special lateral branches in chains like the first, developed within the filament (which is often like a miniature cannon), and expelled through an opening at its tip. The spores are formed usually at the surface ....

"It has been stated that this fungus, like *Colletotrichum falcatum*, is only a form of *Trichosphæria sacchari*. I have kept pure cultures on cane slabs, starting from a single microconidium, under observation for more than a year, without obtaining anything but the macro- and micro-conidia. In the opposite direction, out of many dozens of cultures of *Colletotrichum falcatum* in the last two years I have never obtained macro- or micro-conidia. This is in accordance with the view now held in Java that both are independent species."

South.

The question of the connection between *Trichosphæria sacchari* and *Thielaviopsis paradoxa* has recently been discussed by F. W. South (17), who favours the view that the former has an endoconidial stage, though it is doubtful whether that stage is identical with *Thielaviopsis.* His account contains several misquotations. He writes : " Massee states that an endospore condition consisting of macro- and micro-conidia very frequently developed in pure cultures of the *Melanconium* fungus in the Laboratory at Kew. Prillieux and Delacroix confirm this, and more recently Lewton Brain has also obtained them in Hawaii." Massee, however, only records one instance of this in flask cultures, and none in hanging drops ; on the same evidence it would be possible, from Ceylon experience, to claim that *Pestalozzia palmarum* was a stage of *Thielaviopsis.* Further, Prillieux and Delacroix did not confirm Massee's culture results ; they merely found the *Melanconium* and endoconidia together in diseased cane ; and no account of Lewton Brain's experiments has yet been published.

He further states that subsequent cultures from single spores have disproved Went's suggestion that Massee's culture was impure ; but here again this apparently rests upon unpublished work, and cannot be accepted without some particulars. Another statement is to the effect that Butler suggests that the endoconidia of *Sphæronema adiposum* may be identical with *Thielaviopsis*, but no such suggestion appears in Butler's paper.

Four arguments are put forward in favour of the view that the two fungi are genetically connected. The last three of these prove nothing ; and the first is misleading, since it states that *Trichosphæria sacchari* forms endoconidia in cultures. As a matter of fact, nothing was obtained from the spores of *Trichosphæria sacchari ; Thielaviopsis* is claimed to have been produced from *Melanconium* spores, but there is no proof that the *Melanconium* is a stage of the *Trichosphæria.* There is another error in the third argument : Stockdale (West Indian Bulletin, VIII., p. 163) did not find *Trichosphæria* on pineapples ; Howard found *Thielaviopsis*, but Stockdale records it under Massee's name, as he apparently accepts Massee's proof that the two are forms of the same fungus.

The arguments quoted in opposition to Massee's view are equally weak, and there is an error in the statement that

Trichosphæria sacchari is found in Java. It may be as well to restate the fact that the *Trichosphæria* has only been found once ; two perithecia were found at Kew on diseased sugar cane from the West Indies. Howard failed to find it in Barbados, and Went does not record it from Java. Butler states that he found the *Melanconium* stage of *Trichosphæria sacchari* twice in India, but he is assuming the unproved connection between the two forms.

The real argument in opposition is that no one has succeeded in proving any connection between *Trichosphæria sacchari*, the *Melanconium*, and *Thielaviopsis paradoxa* by experiments which are not open to obvious and fatal objections.

Most of the errors noted above are due to the fact that all the supposed stages of *Trichosphæria sacchari* are referred to indiscriminately under that name. In leading evidence in support of their connection, it is surely necessary to distinguish the forms which the different recorders were referring to.

II.—OBSERVATIONS IN CEYLON.

The Mycelium.

Though *Thielaviopsis paradoxa* was originally described as having two kinds of spores, the one hyaline and the other coloured, all its spores are, ultimately, coloured ; and with few exceptions they are oval when mature. When sown in water, the mature spores do not germinate, but in nutrient media they begin to germinate in about five hours. Various nutrient solutions have been tried, but the best in this case is made by boiling sugar cane in tap water ; the solution was usually concentrated until it contained about 6 per cent. cane sugar, but this is not necessarily an optimum for *Thielaviopsis*. The spores were sown in hanging drops, flasks, and cane-extract-agar plates, as well as on blocks of sugar cane and the stem tissues of the coconut.

When the spore begins to germinate, the dark, thick outer wall splits longitudinally—sometimes, in oval spores, from pole to pole—and the " germ tube " gradually pushes out through the crack, usually about the middle of the spore.

The spores do not become spherical, as stated by Cobb (14). The "germ tube" generally takes a tongue-shaped form, its base occupying about one-half the length of the spore, but in some cases it is semicircular with a base occupying the whole length of the spore. After this has protruded for about 20–40 μ, the apex proceeds to grow on as a normal hypha, which is soon cut off by a septum from the tongue. Sometimes two hyphæ are produced from the thickened germ tube.

The mycelium is strikingly regular, and usually stout, 6-8 μ in diameter. I have measured mycelium 12 μ in diameter on sugar agar. In poor growths it may be only 3–4 μ in diameter; I have noticed this from spores which had been kept dry for several weeks, but the slender mycelium produced thicker hyphæ shortly afterwards. It branches at an acute angle, the branches following the same general direction as the main hypha. At first it is filled with fine-grained protoplasm, but it becomes strongly vacuolate later, and contains scattered, refringent granules when old. The distance between the septa varies from 40 to 200 μ in the main hyphæ, but about 80 μ is a common distance. The mycelium is at first hyaline, and becomes fuliginous when old. In hanging drops and flask cultures, this change is not well marked; the germ tube is usually strongly coloured, but the remainder of the mycelium is almost hyaline. On solid media, *e.g.*, coconut and sugar cane, the mycelium generally becomes fairly dark; but on agar plates made with a decoction of coconut stem, and therefore poor in sugar, the mycelium remained white in mass during the fourteen days for which it was kept.

After about twelve hours from the time of sowing the spores the formation of microconidia begins. In flask cultures the surface is usually covered with white mycelium and microconidiophores at the end of twenty-four hours. The second form of spore—the macroconidium—then appears, and the culture gradually becomes greenish-black and finally quite black. The final change generally occurs in two days, sometimes in three, from sowing; it is due in part to a slight darkening of the mycelium, but chiefly to the enormous numbers of dark spores produced.

The Microconidia.

The microconidiophores arise as stout, lateral branches practically perpendicular to the vegetative hyphæ. The branch usually springs from a narrow base, and almost immediately swells out to a diameter greater than that of the parent hypha. It grows on for from 30 to 100 μ, increasing slightly in diameter upwards until it attains 7 or 12 μ; for the remainder of its growth it tapers uniformly, until it reaches a length of from 90 to over 300 μ and an apical diameter of 4–6 μ. The conidiophore is cut off from the main hypha by a septum shortly above the point of origin. If it is a short conidiophore (about 90 μ long), this is the only septum in it. But the longer conidiophores have usually two or three additional cross septa, the highest being about 80 μ from the base, a little below the point at which the conidiophore begins to taper. The normal conidiophore, therefore, consists of a sterile basal portion, which is one to three septate, surmounted by a long tapering tube. All the septa are formed before the spores are produced. The sterile base is often curved, but the long tapering upper cell is always straight. The growth of the conidiophores is fairly rapid. In one case an extension of 20 μ occurred in 23 minutes; in another instance 70 μ in 105 minutes.

It is not easy to observe the development of the microconidia in hanging drops owing to the length of the microconidiophore, though occasionally one may lie parallel to the cover glass. The majority, however, project from the drop into the cell below. I have obtained better results by sowing the spores in drops of a sugar solution placed on sterilized slides and covered by a large (1 inch square) cover glass supported on four wax feet. By pressing down the cover glass, a film of liquid of any desired thickness can be obtained, and the conidiophores must develop horizontally, or nearly so. Development, probably through lack of oxygen, is retarded by this method; but this is an advantage since it delays the appearance of the conidiophores until the next day. When the cultures are examined, the liquid may be prevented from evaporating by placing strips of moist blotting paper round the cover glass. Cultures made in this way remain pure for four or five days, being kept, of course, between the examinations, in a damp chamber. I have been able to keep them under the microscope for three hours continuously by occasionally moistening the blotting paper.

When mature, the conidiophore is hyaline or grayish, and is filled with finely granular protoplasm. It remains quiescent for some time after it has reached its full extension, and then begins to extrude spores from the apex. A cell wall is developed round the protoplasm in the apex of the tube ; at a distance of about 10 μ behind the tip, the protoplasm becomes slightly constricted, as is evident from the minute V-shaped depression which is visible on each side within the tube in optical section ; a cross septum next appears as a dark line at this level, and the terminal mass of protoplasm thus completes its cell wall ; the apex of the tube is then dissolved, and the spore is slowly extruded by the expansion of the protoplasm behind it. The apex of the conidiophore as a rule is not inflated ; sometimes it is slightly swollen, and then the spore first extruded is somewhat capitate, but the swelling in the most pronounced cases is only slight. In general, the microconidia, when first extruded, are almost exactly rectangular in outline.

By the time the proximal end of the first conidium has reached the apex of the tube, another septum appears in the tube at the same distance from the apex as before, thus completing a second spore, which follows the first out of the tube without any resting period ; and this process is continued until as many as eighty spores have been extruded. The spores issue in a steady continuous stream, each pressing close on the previous one. It is evident that when the cross septum appears in the tube, two terminal spore walls are formed, one of which completes the spore wall of the upper spore while the other begins the wall of the lower. At first, during the extrusion of the first twenty or thirty spores, the cross septum appears always at the same distance from the apex : there is therefore never more than one spore within the tube, and that is just about to be extruded. In the later stages, however, the formation of spores is more rapid than the process of extrusion, and it is possible to find two or three completed spores within the tube in addition to the one which is being pushed out. In the final stages, the process appears to vary ; normally, the remaining protoplasm becomes highly vacuolated and may therefore push out the last spore. I have however seen a spore separate from the protoplasm (which was still dense and granular) and advance towards the open end, leaving a gap of about 10 μ ; the protoplasm then advanced and diminished the gap to about 5 μ, after which the spore moved forward again ; in this case the residual protoplasm did not possess a terminal wall. It seems probable that the extrusion of the last-formed spores may be in part a capillarity effect. It is not, however, uncommon to find one or more spores left permanently in the tube.

The time of extrusion of the earlier conidia occupies from three to six minutes. In one instance, the fifth was extruded in four minutes, and the sixth in six minutes. In another case, the nineteenth was extruded in five minutes thirty-five seconds, the twentieth in five minutes five seconds, and the twenty-first in six minutes twenty seconds.

When the conidia are extruded, they adhere by their ends in a chain. If the conidiophore projects from the surface of a liquid or solid medium, the chain soon falls over and the conidia come to lie in a mass beneath the apex of the conidiophore. When the conidiophore lies in a film of water on a cover glass, the first three or four conidia are pushed out in a straight line along the glass : the force required to push them further is evidently greater than the cohesion of the spores can withstand, for the chain is then bent and the succeeding conidia are pushed up by the side of the former, so that they come to be arranged at first in more or less parallel lines and later in an irregular group ; in these cases, when a conidium has to overcome the pressure of the mass of spores in front of it, the final stage of its extrusion occurs with a distinct jerk. When the conidiophore lies within a hanging drop, the spores remain in contact and form a long chain containing up to eighty or more. Frequently the chain assumes a zigzag pattern as it is pushed forward. The shapes assumed are exactly those obtained by placing dominoes end to end in one line and pushing them across a table.

The extrusion of the microconidia, as seen in Ceylon, is a steady continuous process. It is probable that the times given above are greater than would be the case under natural conditions, but it is scarcely likely that the process would be materially different. It is, however, very different from Howard's account (10). Howard states: "Three hours after leaving the drop, the hypha (*i.e.*, conidiophore) commenced to bend, and the contents showed segmentation. Soon after this appearance the hypha became top heavy and fell back on to the surface of the drop. This was the signal for the rapid liberation of a chain of grayish rectangular conidia." It may be pointed out that if the conidiophore were bent abruptly, liberation of previously-formed conidia would be impossible, except for those on the distal side of the bend. Further, if all the contents were segmented into spore equivalents, there would not be room, even in the longest conidiophore, for more than twenty spores; yet we know that it may produce eighty or more, and that even after it has produced forty, the tube is still nearly filled with protoplasm which does not show segmentation. It is not possible, therefore, that the conidiophore should contain a number of preformed conidia, awaiting a favourable moment for rapid liberation. The only other observation on the extrusion of the microconidia is that of Massee, who states that they are produced in the same way as the macroconidia; the modes of production of the two kinds of spores differ, however, in several particulars.

I have stated above that the apex of the conidiophore is dissolved. This, however, is a matter of conjecture. It certainly does not split off a cap or lid, and there are no indications of any rupture. The end of the tube is quite even, and it generally fits quite closely round the escaping conidia; it terminates as evenly and regularly as a gun-barrel. Sometimes, however, especially in old specimens, the edge is recurved; but even in these cases the bore of the tube is not widened, and the recurved portion is not more than 1 μ broad. I have never seen a trumpet-shaped mouth, as figured by Massee (6). As a rule, the end of the tube can only be detected when the conidia are escaping, by noting the apparent change in thickness of the wall of the escaping spore.

If undisturbed, the microconidia remain in chains in the liquid. But they are merely in contact, end to end, and are not organically connected. I have on several occasions noted the appearance figured by Cobb (see p. 523), but have always been able to determine that the spores were not united.

When first extruded, the microconidia are hyaline, and almost exactly rectangular in outline. Their length is usually 8–12 μ, but I have measured one 32 μ long in a chain in which none of the remainder exceeded 12 μ. Their breadth depends upon the apical diameter of the conidiophore ; usually it is 5 μ, but sometimes only 4 μ, and rarely 6 μ. Subsequently they become oval, and gradually darken until they are fuliginous, or greenish black, but this change in colour is much slower than in the case of the macroconidia. In hanging drops, the macroconidia have usually been produced and have changed colour before the change of the microconidia has occurred. The spores which remain permanently within the conidiophore darken much more rapidly than those which have been extruded. Also, if the hyaline microconidia are transferred to a hanging drop of water, the colour change is still further delayed : in one such instance, only fifty per cent. of the spores changed colour in fourteen days. It would appear from this that the colour change is dependent upon some product of the mycelium. No hyaline conidia are to be found in a flask culture six days old.

When the hyaline conidia are sown in a hanging drop of water, some of them put out a germ tube, usually from one corner, but this seldom grows longer than 5 to 10 μ. If sown in sugar cane extract, the subsequent development is exactly the same as in the case of the mature conidia.

When fully mature the microconidia are greenish-black or brownish-black, oval, usually 11–14 × 7–9 μ ; some are larger than this ; and sometimes the smallest become spherical, 5–7 μ diameter.

The Macroconidia.

About twenty-four hours from the time of sowing the spores, the macroconidia begin to appear. At first the macroconidiophores are produced with the last of the microconidiophores, and on the same hyphæ, but later all the conidiophores produced are macroconidiophores. They are short, lateral branches, perpendicular to the main hypha, 20–80 μ long and 4 μ in diameter. Like the microconidiophores, they are cut off by a septum just above the point of origin, and the longer of them may have one or two additional septa, rather close together, above this. At first they are slightly clavate and filled with finely granular protoplasm.

When the conidiophore is mature, the apex dissolves, and some of the protoplasm is extruded. In general the extruded mass assumes an oval shape, but sometimes it becomes spherical. A wall is then formed round it, with a flat septum, cutting it off from the remaining protoplasm, at the apex of the conidiophore. At first the contents of the spore are finely granular, but they soon become vacuolated, and the spore increases in size. Meanwhile another portion of the protoplasm within the conidiophore is seen to divide off, and is gradually pushed out : as it emerges it is more or less pyriform, but when completely extruded it becomes oval and proceeds to form a cell wall, &c., exactly in the manner of the first. I have never been able to detect any division of the protoplasm before the extrusion of the first spore mass, but all succeeding spore masses are clearly cut off, one at a time, within the tube. This process is continued until a chain of spores, usually about a dozen, is produced. The conidiophore is then highly vacuolated, and subsequently appears empty. The spores are generally united, end to end, but sometimes a chain is divided into two or three separate portions. The spores increase in size after their formation, but the terminal one is always the largest. Short conidiophores, which form only one conidium, are not uncommon, and any number from this to twenty may be produced.

The production of macroconidia is a much slower process than that of the microconidia. On the average, one microconidium is extruded in from forty-five to sixty minutes. They begin to darken about three hours after extrusion ; the chain of macroconidia therefore exhibits dark spores at the apex and hyaline spores at the base during the period of formation. At first the spores decrease in size from the apex to the base of the chain, but subsequently all but the apical spore attain practically the same dimensions.

The dimensions of the macroconidia vary enormously. 17 × 10 μ is a common size, and so is 12 × 8 μ. But many are only 8 × 5 μ, or 9 × 7 μ; while, on the other hand, some attain 19–30 × 11–18 μ. When mature, they are greenish-black or brownish-black. In general, they are oval, truncate when they remain united; but sometimes they are pyriform, and the apical spore may be spherical. Howard states (10) that the colour is contained in the cell contents, not in the wall; but it is evident when they germinate that the wall is coloured and the contents hyaline.

There is no doubt that the macroconidia are formed by the extrusion of masses of protoplasm. When the chain of conidia is fully formed, it frequently remains in contact with the apex of the conidiophore, and as the latter is then practically not inflated at the top, the conidia appear to be ordinary acrogenous conidia. But if the process of formation is watched, their production from within the conidiophore is unmistakable. Sometimes the last-formed conidium of a chain fails to be pushed completely out of the tube; in that case, the extruded portion becomes oval, while the part still in the tube remains cylindric, and the conidium acquires its spore wall and blackens while retaining this shape. The occurrence of such spores, socketed in the tube, confirms the previous observations as to the mode of production.

Massee has stated (6) that by staining with chlor-zinc-iodide he was able to determine that the wall of the developing spore first began to be formed at the distal end, and thinned away along the sides. I have not been able to stain the wall with this re-agent.

The macroconidia do not germinate in water. When sown in a nutrient solution they germinate in about five hours. Cobb's statement that they require a period of rest before germination is not correct.

In flask cultures, the conidia ultimately form a black powdery mass on the surface of the liquid.

As Howard (10) has previously shown, it is not necessary for the formation of macroconidia that the cultures should be kept in the dark.

The Colour of the Spores.

The differences in the recorded colours of the spores, as described by different observers, are at first somewhat bewildering. de Seynes states that the microconidia are hyaline, and the macroconidia olivaceous brown, black in mass ; but he notes that some of the microconidia assume the colour of the macroconidia. Went (8) gives the microconidia as colourless, sometimes slightly coloured, and the macroconidia as dark olive-green. According to Massee (6) the microconidia are pale reddish-brown, while the macroconidia are clear olive-green, then sooty-brown, and finally opaque blackish brown. Prillieux and Delacroix (7) state that the microconidia are hyaline and the macroconidia black. Howard (10) states that the microconidia are hyaline, then reddish-brown, and the macroconidia sooty black. V. Höhnel (12) regards the supposed two forms as identical, the final colour being brown. Cobb (14) states that the microconidia are nearly colourless, sometimes darker, and the macroconidia brown or blackish.

With one possible exception, all these colours are correct at some stage or other. The microconidia are at first hyaline, then fuliginous, then almost black, while the macroconidia are hyaline, then clear green or olive-green, then greenish-black. They are black in mass. If they are left lying in the culture medium, or if they are dried, or preserved in alcohol, or mounted in glycerine, they become blackish-brown. I have never been able to detect any pronounced reddish tint.

Similar cases are not uncommon among the *Phæosporæ.* The extruded spores of *Botryodiplodia theobromæ*, for example, are hyaline when the substratum is dry, and they remain hyaline for a long period ; sent to Europe from America in this condition, the fungus was re-named *Macrophoma vestita.* In fresh pycnidia of the same species, the spores may be grayish, or greenish-black, or violet-black. But old spores, whether preserved dry or in alcohol, are blackish-brown, black in mass.

The Order of Occurrence.

The spores which are formed within the decaying tissues of sugar cane or coconut are apparently always macroconidia. If the diseased tissue is cut and kept damp, microconidiophores appear on hyaline mycelium on the cut surface. Hence the macroconidia have been styled the first kind of spore and the microconidia a higher type more adapted to aerial conditions.

But if the spores are sown in nutrient solutions, or on agar plates, or on blocks of sugar cane, &c., the microconidia invariably appear first. If the substratum is somewhat dry, the microconidial stage may be of short duration, but it is never absent. Hence the microconidium must be regarded as the first type of spore.

Several observers have considered that the macroconidia were produced only within the tissue of the host plant, or beneath the surface of solid or liquid media, in contrast to the microconidia, which are supposed to be always aerial. This view, however, is not correct. It is true that in hanging drops the majority of the microconidiophores project into the air, while the chains of macroconidia do not; but this is merely owing to the greater length of the microconidiophore. On decayed tissue, the crop of aerial microconidiophores is always followed by the production of aerial macroconidiophores, and the same occurs also in flask cultures and on agar plates. When the fungus is grown in films of nutrient solution as described on p. 528, most of the conidiophores, both micro and macro, are produced at the edge of the film, but *both kinds* are also produced within the film. There is therefore no such delimitation as has been supposed.

One variation from the normal course occurred on agar plates made with a decoction of coconut stem tissue. Two sets of plates were inoculated, the one with hyaline microconidia and the other with black spores. Both series grew well, and in three days the plates were covered with a white mass of mycelium bearing microconidiophores. On the fourth day, de Seynes' *Stysanus*-like fructification, which consists entirely of microconidiophores, appeared, and this continued to be produced for the next four days. After the expiration of fourteen days the plates were still white, and there were no macroconidia. In this instance the macroconidial stage was eliminated. As there was no difference between the two series, this effect cannot be attributed to the type of spore employed in inoculation.

de Seynes' Stysanus-*like Fructification.*

The groups of conidiophores seen by de Seynes (3) and likened by him to the conidiophores of a *Stysanus* have not been recorded by any subsequent writer, though they are of quite common occurrence. On natural substrata, *e.g.*, diseased coconut and sugar cane, they occur when the cultivation is old, that is, after the micro- and macro-conidia have been produced, and the substratum is becoming rather dry. Similarly, they frequently occur on sugar-agar plates, when the culture is old and drying. An almost certain way of obtaining them is as follows: a drop of sugar cane extract placed on a sterilized glass slip is inoculated with *Thielaviopsis* spores and kept in a damp chamber; after a few days (two or three) the mycelium, which is now producing micro- and macro-conidia in abundance, runs from the drop over the slide in more or less radiating strands; the *Stysanus*-like fructification is then produced along these strands.

The foundation of these fructification is formed by a small plate of interwoven hyphæ, or by a number of hyphæ running parallel and close together, so as to form a strand. From a point on such a strand, or from the plate of hyphæ, a number of microconidiophores arise side by side and adhere to one another, thus forming an erect stalk from 1 to 3 mm. high and from 0·08 to 0·25 mm. in diameter. These extrude conidia in the usual way, but the conidia remain in a globule at the top of the "stalk." The stalk rapidly turns black, but the mass of conidia remains white much longer than the microconidia do in hanging drops; eventually, however, the mass darkens. The whole structure, pseudo-stalk and globose head of spores, superficially resembles a *Stilbum*, or a ripe *Sphæronema;* I have referred to it elsewhere as the "Sphæronemoid" stage, before I was aware that it had been noted by de Seynes. On sowing the spores in sugar cane extract, their identity with the normally-produced microconidia is fully established.

This form is produced if the spores are placed on pieces of filter paper, which are floated on the surface of a nutrient solution. From this and the other instances given above it would appear that it is some way dependent upon the water supply, being produced when this is diminishing or not readily available. It is interesting to note that when the spores of *Thielaviopsis* are sown in nutrient solutions which contain poisons in a concentration approaching that which inhibits their germination, the *Stysanus*-like form is frequently produced; small floating islands of mycelium appear, and these, after bearing a few micro- and macro-conidia in the usual way, produce the upright fructifications.

The most puzzling feature about these compound fructifications is the fact that they are composed of microconidiophores. Under normal conditions the microconidiophores are the *first* form produced by *Thielaviopsis*, and they are soon succeeded by the macroconidiophores. But, in the *Stysanus*-like fructification, there is a return to microconidiophores when the conditions of growth are unfavourable. This would appear to negative any supposition that the production of the two kinds of conidiophore is dependent upon the available supply of food.

Nothing has been observed which would throw any light on the cause of the change from the production of microconidiophores to the production of macroconidiophores. The macroconidiophore appears to be a depauperate form of the microconidiophore, but the return to microconidiophores, when the culture is old or when the conditions are unfavourable, would seem to render inadequate any explanation based on food supply or substances excreted by the fungus during its growth.

Variation in the Macroconidiophore.

In old hanging-drop cultures, the macroconidiophore frequently fails to open. The upper part of the conidiophore usually becomes curved, either in simple hook fashion or in a complete coil, and its contents round off into one large oval spore mass or segment into a chain of two or three. These spore masses then acquire a spore wall and turn black, while still retained within the conidiophore. They are arrested macroconidia, and can only be liberated by the decay of the conidiophore. It seems probable that de Seynes' macroconidia—which occurred singly or in chains of two or three, were segmented off from the parent cell within the hypha, and were set free by the destruction of the upper part of the wall of the parent cell—may have been only arrested macroconidia as described above.

A similar development occurred in flask cultures, to which 0·2 and 0·3 per cent. of hydrochloric acid and 0·09 and 0·1 per cent. of sulphuric acid, respectively, had been added. The mycelium developed in the form of rather compact submerged spheres, which turned pale brown at their surfaces. These spheres bore large numbers of suppressed macroconidia, but no other spores. In general, the conidiophores were not curved, and each bore one conidium only, but instances of two or three in a chain within the conidiophore were found.

Micro- v. Macro-conidia.

The separation of the two forms of conidia on the basis of size is to some extent misleading. I have measured microconidia, 17 and 32 μ in length, though they rarely approach the latter size. On the other hand, macroconidia, 8 × 5 μ or 9 × 7 μ, are not uncommon; and these are smaller than the average microconidium (11–14 × 7–9 μ). Howard's method of separating the two kinds of spores—by beating up the mycelium in water and allowing it to subside, whereby he supposed the upper layers contained chiefly microconidia—must therefore be regarded as fallacious. When the spores are recently formed but have changed colour, it is possible to identify the macroconidia by their more oval shape, their more vacuolate contents, and by the fact that they are sometimes *united* in chains; but many doubtful cases occur, and all these criteria fail when the spores are old and blackish-brown.

Practically, the only constant difference lies in the mode of formation of the spores and the structure of the conidiophores. The microconidiophore is the longer, and terminates in a long tapering tube, while the macroconidiophore is a short branch, of almost uniform diameter when empty; the former produces a large number of spores, up to eighty or more, while the latter produces twenty at most, and sometimes only one. The microconidium acquires its wall within the tube, and hence is cylindrical when extruded, but the wall of the macroconidium is formed after the extrusion of its protoplasm, and hence it is oval from the beginning.

There is no difference between cultures established from macro- and micro-conidia respectively.

Other Stages of Thielaviopsis.

Though *Thielaviopsis* has been grown in flask cultures on sugar cane extract and artificial nutrient solutions, and the cultures have been kept in some cases for more than six months, no ascigerous or pycnidial stage has been observed. Similarly, nothing of the kind has been found in cultures on agar plates or on blocks of coconut or sugar cane tissue, nor has any other fungus been found in the field which could be united with *Thielaviopsis.*

Trichosphœria sacchari Mass., and the *Melanconium* so common in the West Indies, do not occur on coconut, and they have not yet been found on sugar cane in Ceylon. An ascigerous species, which has been named *Metasphœria cocoes*, occurred on coconut leaf stalks, but this is a common saprophyte on coconut, and its spores do not produce *Thielaviopsis* when sown in sugar cane extract. Two fungi are commonly found on coconut tissue attacked by *Thielaviopsis*, and they are frequently found in flask cultures if the latter have been inoculated with spores direct from the tissue: one of these is a *Chromosporium*, and the other *Pestalozzia palmarum* Cooke. Both these have been grown in pure culture, but they do not produce *Thielaviopsis. Sphœronema adiposum* Butler sometimes occurs on diseased coconut wood ; when the spores are sown in sugar cane extract, a mycelium which bears endoconidia is produced, but these endoconidia are clearly different from the endoconidia of *Thielaviopsis.*

The " Pineapple " Odour.

Sugar cane attacked by *Thielaviopsis* has, according to Went, a distinct odour of pineapples when cut open ; hence the disease of sugar cane caused by the fungus is known as the "Pineapple disease of sugar cane." According to Cobb, the odour is not always noticeable, and the strength varies with the variety of cane.

This odour is seldom noticeable when the stems of diseased coconut trees are cut open, though I have observed it on two or three occasions. If, however, the spores are sown on coconut stem tissue in a damp chamber, the odour is well marked on the second day ; on the third day the culture smells rather of apples ; and on the fourth and subsequent days no distinctive odour is perceptible. When *Thielaviopsis* is grown on sugar-agar, the smell similarly disappears in a few days, but it persists in flask cultures for a week or more.

According to Went (8), this odour is due to the production of ethyl acetate (ethyl acetic ester), and its disappearance is regarded as evidence that this substance is consumed by the fungus. The ethyl ester which has a pineapple odour is, however, according to Richter, ethyl butyric ester (Richter Ed. 6).

Growth on Coconut Tissue.

Experiments were made to determine to what extent *Thielaviopsis* would grow on the different tissues of the coconut. The pieces were not sterilized, but were cut from healthy tissues, trimmed with a sterilized knife, enclosed in sterilized dishes, and moistened with sterilized water.

(*a*) Pieces cut from a fresh green husk ; spores sown on the inner white tissue. No growth in two days. Poor growth, with macroconidia and the "*Stysanus*" form in five days.

(*b*) Brown husk from a stored nut, brown internally ; spores sown on inner brown tissue. No growth in fourteen days.

(*c*) Fresh green leaf stalk cut from the tree ; section cut near the base ; spores sown on the internal white tissue. No growth in two days. Very slight growth, with macroconidia, in five days.

(*d*) Leaf stalk taken immediately the leaf had fallen ; tissue brown internally, but not decayed and fibrous ; spores sown on internal brown tissue. No growth in fourteen days.

(*e*) Section of the bud through the developing leaves ; spores sown on the cut surface. No growth in seven days.

(*f*) Undifferentiated tissue from the bud ; spores sown on the cut surface. No growth in seven days. This piece developed two colonies of *Sterigmatocystis*, one colony of *Mucor stolonifer*, and seven colonies of *Pestalozzia palmarum*.

(*g*) White tissue from the centre of the stem. Good growth in two days, chiefly macroconidia, with a few microconidia.

This series of experiments shows that *Thielaviopsis* grows luxuriantly only on the stem tissues of the coconut. Its failure to develop on the immature bud tissues agrees with the observed fact that the disease, even on trees which have been hollowed out by it for several years, does not extend into the bud. Analyses by Mr. A. Bruce show that none of the tissues employed contain free sugars except the stem, and even there the amount is small. It would appear, therefore, that the growth of *Thielaviopsis* is governed by the amount of sugar available. If the tissue of the leaf stalk is boiled, sugar is obtained in abundance, probably from glucosides ; apparently, therefore, *Thielaviopsis* is not able to make use of this combined sugar.

The Need of Oxygen.

As the fungus grows and forms conidia within the tissues of the coconut and sugar cane, the effect of depriving it of oxygen was tried.

Two sterilized watch glasses were filled with sugar cane extract, and placed on glass supports under bell glasses standing in glass dishes. Spores from the same cultures were sown in each. A was isolated from the room atmosphere by a water seal, and the oxygen in B was absorbed with pyrogallic acid and caustic potash. There was a copious growth of *Thielaviopsis* in A after three days, but no growth in B at the end of a week. The spores and sugar solution from B were then transferred to a sterilized flask, where *Thielaviopsis* appeared and attained the macroconidial stage after one to two days.

Growth in Light and in Darkness.

In each of two 150 c. c. conical flasks, 50 c. c. of the same sugar cane extract was placed, and the flasks were inoculated as far as possible with the same number of spores by suspending the latter in water and adding equal amounts to each. One of these was left on the laboratory table exposed to diffuse daylight, while the other was kept in complete darkness. After seven days the contents of both were filtered through tared filter papers, washed well with distilled water, and dried until the weight was constant. The dry weight of the culture grown in the dark was 0·270 grams; that of the culture grown in diffuse light was 0·143 grams.

The experiment was repeated, and the product dried and weighed after four days; the dry weight of the culture in the dark was 0·080 grams, while that of the culture in the light was 0·056 grams. There was no difference in the appearance of the two cultures; both in the light and in the dark they were black with macroconidia. It would appear, therefore, that *Thielaviopsis* grows more luxuriantly in darkness than in the light, and that the absence of light does not prevent the production of conidia.

The Longevity of the Spores.

The following experiment was instituted to determine how long the spores retained their germinative capacity under different conditions. The nutrient solution was poured away from a large flask culture, about ten days old, which contained an abundance of macroconidia. The mass of mycelium and spores was then shaken well with sterilized water, and the liquid with the suspended spores was poured through a filter. The process was repeated until a dozen filter papers uniformly covered with black spores had been obtained. These were then allowed to dry at the room temperature. Each filter paper was cut into four numbered pieces to secure uniformity as far as possible, and these were arranged in four lots as follows:—

A.—In a desiccator over calcium chloride in semi-darkness.

B.—In a closed and sealed glass vessel in semi-darkness.

C.—In a desiccator over calcium chloride exposed to full sunlight for four to six hours per day.

D.—In a closed and sealed glass vessel exposed with C.

In A the spores are quite dry and in semi-darkness ; in B they are merely air-dry, but under the same conditions of light. Similarly, C is quite dry, while D is only air-dry. C and D were placed in a window and were exposed to full sunlight every morning in December–January, from 7 A.M. to 1 P.M. In February–March the sun goes off the window earlier, and the vessels were therefore put outside each morning until 12 noon. The mornings were sunny throughout the sixteen weeks for which C and D were exposed, except on eleven occasions. The black bulb thermometer (*in vacuo*) exposed in the window by the side of C and D reached 50·5 at midday in January.

Samples were taken from each lot every seven days and placed in sterilized flasks of sugar cane extract. The results are given in the following table. The experiment was begun on November 14, and the first samples taken on November 21. The times given under A, B, C, D are those which elapsed before the formation of a good covering of macroconidia, not the time of germination, which is at least two days earlier :—

Sample taken.	A.	B.	C.	D.	Notes.
1908.	Days.	Days.	Days.	Days.	
Nov. 21 ..	3	3	3	4	—
Nov. 28 ..	3	3	4	—	D kept for fourteen days ; no growth.
Dec. 5 ..	3	3	—	—	C and D kept for fourteen days ; no growth.
Dec. 12 ..	3	3	—	—	do.
Dec. 19 ..	3	3	4	—	D kept for fourteen days ; no growth.
Dec. 26 ..	3	3	—	—	C and D kept for fourteen days ; no growth.
1909.					
Jan. 2 ..	3	3	—	—	C and D kept for fourteen days ; no growth.
Jan. 9 ..	3	3	6	—	D kept for fourteen days ; no growth.
Jan. 16 ..	3	4	6	—	do.
Jan. 23 ..	3	3	4	—	do.

Sample taken.	A.	B.	C.	D.	Notes.
1909.	Days	Days.	Days.	Days.	
Jan. 30 ..	3	4	—	—	C and D kept for fourteen days; no growth.
Feb. 6 ..	3	4	—	—	do.
Feb. 13 ..	3	3	—	—	D discarded. C kept for fourteen days; no growth.
Feb. 20 ..	3	3	—	—	C kept for fourteen days; no growth.
Feb. 27 ..	4	4	—	—	do.
Mar. 6 ..	3	3	—	—	C discarded. March 13, 1909.
April 3 ..	3	3	—	—	—
Aug. 7 ..	4	5	—	—	—
Oct. 25 ..	4	—	—	—	B kept for twenty-two days.
Oct. 30 ..	4	—	—	—	Three samples from B.
Nov. 17 ..	3	—	—	—	B kept for twenty-five days.
Dec. 30 ..	4	—	—	—	B discarded.
1910.					
Jan. 8 ..	—	—	—	—	—
Jan. 17 ..	3	—	—	—	Growth fair.
Jan. 29 ..	—	—	—	—	No further growth.
Feb. 10 ..	—	—	—	—	do.
Feb. 19 ..	—	—	—	—	do.

Air-dry spores exposed to sunlight survived exposure for seven days, but were killed before the expiration of fourteen days; spores dried over calcium chloride and similarly exposed were in some cases killed within twenty-one days, but some survived for seventy days.

Air-dry spores in semi-darkness survived for two hundred and sixty-six days, but were dead at the end of three hundred and forty-five days. The experiment had unfortunately been neglected for nearly three months, under pressure of other work and through absence in field investigations. Spores dried over calcium chloride survived in some cases for four hundred and twenty-nine days, but none germinated after four hundred and forty-one days.

Lack of time has prevented further experiments to determine a closer limit for D, and to ascertain whether any spores survive if they are dried in full sunlight.

III.—EFFECT OF FUNGICIDES, &c., ON THE SPORES.

The following experiments sprang from an attempt to discover in how far the usual fungicides were effective in preventing the germination of the spores of *Thielaviopsis*. The first three or four of the substances experimented with were recommended for use in combating the coconut stem disease, and the experiments were conducted in order to demonstrate that they had no fungicidal action.

The spores were sown in flasks containing sugar cane extract, to which various percentages of the fungicide or other substance under experiment had been added. Flasks of about 40 c. c. capacity were used, and 20 c. c. of sugar cane extract containing 6 per cent. of sugar was placed in each. This was made up to 25 c. c. by the addition of the solution of the fungicide, together with the required quantity of water. The percentage of sugar, except where otherwise stated, was, therefore, 4·8. The experiments were usually conducted in duplicate, sometimes in quadruplicate.

A rather small supply of flasks prolonged the experiments, and made it impossible to use spores from the same culture throughout ; but in all cases they were taken from cultures six days old. Black, fully mature spores were therefore only used. Incubators were not available; and, therefore, the experiments were subject to a range of temperature of about 10° F., from 71° F. to 81° F. The range of temperature during a single experiment was less than this, at most 71–79° F., or 73–81° F.

Owing to repeated absences, it was impossible to make continuous observations on the progress of all the cultures. In many instances only final results can be given. But in all cases the cultures were left until there was no probability that any more in the series would develop. The results, therefore, give the concentration required to prevent the germination of the most resistant spores, which after all is what is required in estimating the value of a fungicide. It has been determined by other investigators that fungus spores from the same source vary greatly in their power of resistance ; and Stevens (18) states that an occasional spore may germinate and grow perfectly normally in a solution which prevents hundreds of normal spores round it from germinating. From the appearance of the developing cultures, it would seem that a large proportion of *Thielaviopsis* spores germinated even in the strongest solution in which they germinated at all, but this point was not tested by observations in hanging drops, as the behaviour of the spores is not the same under the latter conditions.

In the following tables the first column gives the date of instituting the cultures and the percentage of the chemical in them; the others record the observed growth. The control culture was made with cane extract only. Where the growth is said to be good, the culture had reached the macroconidial stage and covered the surface of the liquid.

Potassium Nitrate.

Dec. 27. Percentage.	Dec. 29.	Dec. 30.	Dec. 31. Percentage.	Jan. 2.	Jan. 4.
·5	All growing well. Macroconidia forming.	Good growth in all.	6·0	Growth beginning in all.	Good
1·0			6·5		do.
1·5			7·0		do.
2·0			7·5		do.
2·5			8·0		do.
3·0			8·5		do.
Control	Good.		9·0		do.
			9·5		do.
			10·0		do.
			Control	Good.	do.

Jan. 5. Percentage.	Jan. 8.	Jan. 9.	Jan. 11.
10	Growth beginning.	Fair growth; macrospores.	Good growth.
12	Do.	Poor growth; macrospores.	Poor growth; macrospores.
14	Do.	do.	do.
16	Nothing.	Mycelium only.	Poor growth; only one small patch of spores.
18	Do.	Nothing.	Nothing up to January 14.
20	Do.	do.	do.
Control	Good.		

Penicillium subsequently developed in the 12 and 14 per cent. cultures.

Kainit.

A commercial sample of Kainit was employed. It was dried at 100° in a water oven. When dry it contained 4·8 per cent. of insoluble matter. This should therefore be deducted from the percentages given below. The percentage which inhibits germination is therefore 14–0·67 = 13·33, for this particular sample. The 17 per cent. solution was not alkaline.

Jan. 23. Percentage.	Jan. 26.	Jan. 27.	Jan. 28.
5	Nothing.	Slight growth ; Stysanus form.	Fair growth.
6	Do.	do.	do.
7	Do.	Very slight development.	do.
8	Do.	do.	do.
9	Do.	do.	do.
10	Do.	do.	do.
Control	Good.		

Feb. 3.	Feb. 6.	Feb. 8.	Feb. 13.	Feb. 15–28.
11	Nothing.	Fair growth.	Fair.	Good.
12	Do.	Three small patches of mycelium.	Poor.	Fair.
13	Do.	Nothing.	Growth beginning.	Poor.
14	Do.	do.	Nothing.	Nothing.
15	Do.	do.	do.	do.
16	Do.	do.	do.	do.
17	Do.	do.	do.	do.
Control	Good.			

Temperature, 73–81° F.

Common Salt.

Ordinary Table Salt, dried at 100° C., was used.

Nov. 28. Percentage.	Dec. 1.	Dec. 8. Percentage.	Dec. 11	Dec. 14	Dec. 17. Percentage.	Dec. 21.	Dec. 23.
0·5	Good.	2	Good.	Good.	5	Fair.	Fair.
1·0	Do.	3	do.	do.	6	Poor growth.	Poor.
1·5	Do.	4	Fair	do.	7	Nothing.	Nothing.
2·0	Do.	5	do.	do.	8	do.	do.
Control	Do.	Control	Good.		9	do.	do.
					Control	Good.	

Temperature, 73–81° F.

Penicillium grew subsequently in the 7, 8, and 9 per cent. solutions on keeping.

Sodium Chloride.

Feb. 3. Percentage.	Feb. 5.	Feb. 6.	Feb. 8.	Feb. 9. Percentage.	Feb. 13.	Feb. 18.
1	Fair.	Good.	Good.	5	Nothing.	Poor growth.
2	Do.	do.	do.	6	do.	Nothing.
3	Moderate.	do.	do.	7	do.	do.
4	Nothing.	Nothing.	Moderate.	8	do.	do.
5	Do.	do.	do.	9	do.	do.
Control	Good.			Control	Good	

Temperature, 73–78° F.

Magnesium Sulphate.

Feb. 4. Percentage.	Feb. 6.	Feb. 8.	Feb. 9. Percentage.	Feb. 12.
1	All growing.	Good.	6	Good.
2		do.	7	do.
3		do.	8	do.
4		do.	9	do.
5		do.	10	do.
Control	—	do.	11	do.
			Control	do.

Feb. 19. Percentage.	Feb. 22.	Feb. 23.	Mar. 3. Percentage.	Mar. 5.	Mar. 6.	Mar. 8.
12	All growing.	Fair; macroconidia in all.		Slight growth in all, chiefly small patches with Stysanus form.		
13			19		Fair	Good.
14			20		do.	do.
15			21		do.	do.
16			22		do.	do.
17			23		do.	do.
18			24		do.	do.
Control	Good.		25		do.	do.
			Control	Good.		

This experiment was not continued further. Penicillium developed in the 23, 24, and 25 per cent. solutions.

Ferrous Sulphate.

Jan. 7. Percentage.	Jan. 11.	Jan. 13.
0·1	Mycelium only	Fair growth with Stysanus form
0·2	Nothing	Nothing
0·3	Do.	do.
0·4	Do.	do.
0·5	Do.	do.
Control	Good	

Zinc Sulphate.

Feb. 4. Percentage.	Feb. 6.	Feb. 8.	Feb. 13.
1	Nothing	Mycelium only	Poor growth with Stysanus form
2	Do.	Nothing	Nothing
3	Do.	do.	do.
4	Do.	do.	do.
5	Do.	do.	do.
Control	Good		

Temperature, 73–78° F.

Copper Sulphate.

Jan. 14. Percentage.	Jan. 16.	Jan. 18.	Jan. 19.	Jan. 22–26.
0·01	Growing	Good	Good	Good
0·02	Do.	do.	do.	do.
0·03	Nothing	Growing	Fair	Fair
0·04	Do.	Nothing	Nothing	Mycelium only
0·05	Do.	do.	do.	do.
0·06	Do.	do.	do.	do.
0·07	Do.	do.	do.	Nothing
0·08	Do.	do.	do.	do.
0·09	Do.	do.	do.	do.
0· 1	Do.	do.	do.	do.
Control	Good			

Temperature, 72–82° F.

The spores from the last four cultures (0·07–0·1) were transferred after twelve days' immersion to pure sugar cane extract, where they developed an excellent growth in all cases in three days.

Mercuric Chloride.

Mar. 12. Percentage.	Mar. 22.
·01	No growth
·02	
·03	
·04	
·05	
·06	
·07	
·08	
·09	
· 1	
Control	Good

Mar. 27. Percentage.	Mar. 29.	Mar. 30.	April 1.
·001	Fair	Good	Good
·002	Nothing	Slight	do.
·003	do.	Nothing	Nothing
·004	do.	do.	do.
·005	do.	do.	Kept until April 12.
·006	do.	do.	do.
·007	do.	do.	do.
·008	do.	do.	do.
·009	do.	do.	do.
· 01	do.	do.	do.
Control	Good		

The spores from the first ten cultures were transferred to pure sugar cane extract, March 23, but no growth resulted.

Potassium Hydrate.

Dec. 23. Percentage.	Dec. 27.	Litmus re-action.
0·1	Good	Feebly acid
0·2	Do.	do.
0·3	Poor	Feebly alkaline
0·4	None	Distinctly alkaline
0·5	Do.	do.
0·6	Do.	do.
0·7	Do.	do.
0·8	Do.	do.
0·9	Do.	do.
1·0	Do.	do.
Control	Good	Acid

Kept to January 4; no further development.

Sodium Hydrate.

Jan. 27. Percentage.	Observation. Jan. 29.	Observation. Feb. 1.	Litmus re-action.
0·1	Growing	Good	Feebly acid
0·2	Nothing	Nothing	Alkaline
0·3	Do.	do.	do.
0·4	Do.	do.	do.
0·5	Do.	do.	do.
Control	Good	—	Acid

Kept to February 8; no further development.

The last two experiments agree in showing that the growth of *Thielaviopsis* is inhibited directly the solution becomes distinctly alkaline.

Hydrochloric Acid.

June 17. Percentage.	June 19.	June 23.
0·01	Good growth of mycelium, with a few microconidia	Good
0·02		
0·03		
0·04	Good growth of mycelium, with Stysanus form	do.
0·05		
0·06	Fair growth, with few microconidia	do.
0·07	Slight growth, with microconidia	Fair
0·08	Do. do.	do.
0·09	Small suspended tufts of mycelium	do.
0· 1	Do. do.	do.
0· 2	Minute spheres of mycelium	Spheres of mycelium
0· 3	Nothing	One sphere of mycelium
0· 4	Do.	Nothing up to June 30
0· 5	Do.	do.
Control	Good	

Temperature, 75–79° F.

In this and the next series the last two cultures which germinated produced submerged compact spheres of mycelium which bore large numbers of suppressed macroconidia only, usually one on each conidiophore.

Sulphuric Acid.

June 17. Percentage.	June 19.	June 23.	June 30.
0·01	Good growth of mycelium with some macro- and micro-conidia	Good	
0·02			
0·03			
0·04	Fair growth; micro-conidia only	do.	
0·05	Tufts of mycelium only	Fair	
0·06	Minute tufts of mycelium	do.	
0·07	Do.	Poor growth with macroconidia	
0·08	Do.		
0·09	Nothing	Submerged tufts of mycelium	Tufts bearing macroconidia
0· 1	Do.		
0· 2	Do.	Nothing	Nothing up to June
0. 3	Do.	do.	
0. 4	Do.	do.	
0. 5	Do.	do.	
Control	Good		

Temperature, 75–79° F.

Acetic Acid.

June 17. Percentage.	June 19.	June 23.
0·01	Good growth of mycelium	Good
0·02	Fair growth, with microconidia	do.
0·03	Do.	do.
0·04	Fair; few microconidia	do.
0·05	Do.	do.
0·06	Do.	do.
0·07	Do.	do.
0·08	Fair; very few microconidia	do.
0·09	Small suspended tuft of mycelium	do.
0·1	Minute growth of mycelium	Fair
0·2	Nothing	Nothing up to June 30
0·3	Do.	
0·4	Do.	
0·5	Do.	
Control	Good	

Temperature, 75–79° F.

Lactic Acid.

Sept. 27. Percentage.	Sept. 30.	Oct. 1.	Oct. 2.
0·5	Poor; Stysanus form	Fair	Fair
1·0	Nothing	Beginning	Stysanus form
1·5	Do.	Nothing	Nothing to Oct. 13
2·0	Do.	Nothing	do.

Tannic Acid.

As a preliminary experiment, spores were sown in sugar cane solution to which 1 per cent. tannic acid had been added. There was no trace of tannic acid in the original solution. The control culture showed good growth in two days, but there was no growth after ten days in the tannic acid culture. The spores from this culture were transferred to sugar cane extract, and produced a good growth of macroconidia within five days. Temperature, 71–78° F. Further cultures were then made, as follows :—

Nov. 23. Percentage.	Observation. Nov. 27.	Observation. Nov. 28.	Observation. Dec. 4.
0·05	Good	Good	Good
0·1	Do.	do.	do.
0·2	Do.	do.	do.
0·3	Growing	Moderate	Fair
0·4	Nothing	Nothing	Nothing
0·5	Do.	do.	do.
Control	Good		

This experiment was repeated with the same sugar cane extract, diluted to contain half the previous percentage of sugar, with the following results :—

November 24. Percentage.	Observation. November 27.	Observation. November 28.	Observation. December 4.
0·05	Good	Good	Good
0·1	Do.	do.	do.
0·2	Fair	Fair	Fair
0·3	Growing	do.	do.
0·4	Nothing	Nothing	Nothing
0·5	Do.	do.	do.
Control	Good		

Temperature, 75·5–79·5° F.

The dry weight of *Thielaviopsis* in the control culture on December 4 was 0·044 grams ; that in the 0·1 per cent. tannic acid culture was 0·025 grams. 0·3 per cent. of tannic acid is the limiting percentage in both cases, *i.e.*, the difference in the percentage of food in the solution does not alter the percentage of tannic acid required to inhibit growth. This is in accordance with the known behaviour of other chemicals on different fungi. It will be noted from the preliminary experiment that the spores are not killed by tannic acid, even if the percentage employed is more than three times that required to prevent the growth of the fungus.

It was thought that the marked influence of a small percentage of tannic acid upon the growth of the fungus might serve to explain why the disease does not attack the bud of the coconut, but subsequent analyses have shown that there is no tannic acid in coconut tissues.

Gallic Acid.

(This contained traces of Tannic Acid.)

December 10. Percentage.	Observation. December 12.	Observation. December 14.
0·1	Growth beginning in all	Excellent growth in all
0·2		
0·3		
0·4		
0·5		
Control		

December 17. Percentage.	Observation. December 21.	Observation. December 22.
0·6	Good	Good
0·7	Fair	do.
0·8	Do.	do.
0·9	Do.	Fair
1·0	Poor	do.
Control	Good	

Temperature, 73–81° F.

December 23. Percentage.	December 27.	December 31.
1·1	Poor	Good
1·2	Do.	do.
1·3	Do.	do.
1·4	Do.	do.
1·5	Slight development of mycelium	Fair ; Stysanus form
1·6	Do.	do.
1·7	Nothing	Poor ; Stysanus form
1·8	Do.	do.
1·9	Do.	do.
2·0	Do.	do.
Control	Good	

Temperature, 73–79° F.

January 4. Percentage.	January 11.	January 15.
2·0	Fair	Fair
2·1	Slight development of mycelium	Poor ; Stysanus form
2·2	Do.	do.
2·3	Do.	do.
2·4	Nothing	Nothing
2·5	Do.	do.
Control	Good	do.

Temperature, 73–79° F.

Carbolic Acid.

January 5. Percentage.	January 18.	January 20.	January 22–26.
0·01	Good	Good	Good
0·02	Do.	do.	do.
0·03	Fair	do.	do.
0·04	Do.	do.	do.
0·05	Do.	do.	do.
0·06	Beginning	do.	do.
0·07	Do.	Fair	do.
0·08	Nothing	Moderate	Fair
0·09	Do.	do.	do.
0·1	Do.	Nothing	Small patch of submerged mycelium about 5 mm. diameter
Control	Good		

January 23. Percentage.	January 26.	January 28–February 1.
0·1	Nothing	Submerged mycelium about 2 mm. diameter
0·11	Do.	Nothing
0·12	Do.	do.
0·13	Do.	do.
0·14	Do.	do.
0·15	Do.	do.
Control	Good	

The spores and mycelium from the last six cultures were transferred to pure cane extract on February 4, after twelve days' immersion. The first three produced a good growth, with macroconidia, in two days, and the remaining three were then beginning to grow. All showed a good growth, with macroconidia, in four days.

Formaldehyde.

September 4. Percentage.	September 13.
0·01	No growth
0·02	
0·03	
0·04	
0·05	
0·06	
0·07	
0·08	
0·09	
0·1	
Control	Good

October 2. Percentage.	Oct. 8.	Oct. 15.
0·001	Good	Good
0·002	do.	do.
0·003	do.	do.
0·004	do.	do.
0·005	Growing	do.
0·006	Good	do.
0·007	Nothing	Nothing
0·008	do.	do.
0·009	do.	do.
0·01	do.	do.
Control	Good	

Spores from the first ten cultures were transferred to pure cane extract on September 16, after twelve days' immersion ; no growth resulted.

The following table summarizes the results of the foregoing experiments. The first column gives the highest percentage in which the fungus grew, while the second gives the lowest observed percentage in which no growth occurred. The third and fourth columns give the same quantities converted into fractions of a "normal solution," *i.e.*, a solution which contains the molecular weight in grams in a litre :—

	Growth in.	No Growth in.	Growth in.	No Growth in.
	Per cent.	Per cent.		
Potassium nitrate ..	16	18	1·57 N	1·77 N
Sodium chloride ..	5	6	0·85 N	1·02 N
Magnesium sulphate ..	25+	—	1 N	—
Ferrous sulphate ..	0·1	0·2	0·0036 N	0·0072 N
Zinc sulphate ..	1·0	2·0	0·035 N	0·07 N
Copper sulphate ..	0·06	0·07	0·0024 N	0·0028 N
Mercuric chloride ..	0·002	0·003	0·000074 N	0·00011 N
Potassium hydrate ..	0·3	0·4	0·053 N	0·071 N
Sodium hydrate ..	0·1	0·2	0·024 N	0·048 N
Hydrochloric acid ..	0·3	0·4	0·082 N	0·1 N
Sulphuric acid ..	0·1	0·2	0·01 N	0·02 N
Acetic acid ..	0·2	0·3	0·033 N	0·05 N
Lactic acid ..	1·0	1·5	0·11 N	0·16 N
Carbolic acid ..	0·1	0·11	0·011 N	0·012 N
Tannic acid ..	0·3	0·4	0·008 N	0·011 N
Gallic acid ..	2·3	2·4	0·12 N	0·13 N
Formaldehyde ..	0·006	0·007	0·002 N	0·0023 N

In most of the recorded investigations into the action of toxic substances on fungus spores, the concentration required to prevent germination is all that has been determined. But it is clear from the foregoing records, *e.g.*, with tannic acid, carbolic acid, and copper sulphate, that the spores are not killed by much higher percentages of the toxic substance than are required merely to inhibit germination. Further, it is evident that the spores, when placed in a nutrient solution which contains a toxic substance in excess of the inhibiting percentage, do not germinate and die, as is frequently supposed: they merely remain dormant. Whether they ultimately die depends on the percentage of the fungicide and the duration of immersion.

These points are of considerable importance in regard to the action of fungicides on fungus spores. Determinations based only on the non-germination of the spores give scarcely any information as to the actual fungicidal value of the fungicide. Copper sulphate, for example, in a concentration of 0·07 per cent., prevents the germination of *Thielaviopsis*, but, as will be shown later, its actual fungicidal value, tested by its power of killing the spores, is not great in this case.

It is usually supposed that when plants are sprayed with a fungicide, they are protected from the attacks of fungi, because the fungicide kills any spores which may alight upon the sprayed leaves. How this action occurs is a matter of doubt. One view holds that the spores are actually killed by contact with the fungicide ; this may be true of thin-walled spores, but it is improbable with thick-walled spores, such as *Thielaviopsis*, unless the period of contact extended over several months. Another view is that the spores germinate, and that the developing mycelium is killed by the fungicide. This latter view would appear to be disproved by the experiments with copper sulphate already quoted. It would seem that the spores of *Thielaviopsis* would remain dormant in contact with such a fungicide ; and would germinate when the fungicide were washed away, provided that the exposure to its action had not been too prolonged.

In the experiments described below, the spores were immersed in a solution of known strength, and were transferred at regular intervals to a nutrient solution, viz., sugar cane extract. Obviously, by varying the concentration of the fungicide, such experiments can be carried on indefinitely ; but as little time was available it was necessary to restrict them to those percentages which are commonly employed.

The spores, except where otherwise stated, were taken from cultures six days old. The mass of spores and mycelium was transferred to a glass cylinder, 8 cm. high and 4 cm. diameter, where it was torn into small pieces with needles, and pounded with a glass rod to moisten the spores. The cylinder was then placed in a basin, and the fungicide was poured into it and allowed to overflow. Any floating spores were then rapidly wiped off with a piece of filter paper. When the spores alone were being tested, the liquid was poured into another similar cylinder after the fragments of mycelium had settled ; by this procedure, the liquid could be periodically stirred without any danger of obtaining spores which had been protected by the mycelium. When it was wished to take samples at short intervals, the culture was divided into three parts, and the three series of tests, as described below, were carried out separately. With copper sulphate, and in some instances with carbolic acid, where the experiment was prolonged for several weeks, the fungicide and spores, or mycelium, was kept in wide-mouthed stoppered bottles.

Spores were transferred by means of a straight platinum wire to hanging drops of sugar cane extract. They were also transferred by means of a platinum loop to flasks of the same medium. The former was adopted in order to transfer as small an amount of the fungicide as possible with the spores; the wire was merely dipped in the mixture. In addition, small fragments of mycelium containing spores were transferred to sugar cane extract; this was done with a hooked platinum wire and as small a quantity as possible was transferred; in general, it did not exceed 0·5 mm. in diameter when collapsed on the wire; but no exact results can be expected by this last method, since it is usually possible to obtain a germination by transferring a larger quantity of mycelium. *Thielaviopsis* is peculiar in that some spores remain within the conidiophores, and apparently these are protected from the action of the fungicide for an indefinite period.

In making transfers per minute, the mixture was stirred immediately after a sample had been taken and then allowed to settle. In other cases it was stirred shortly before the transfer was made. From observed weights of previous cultures, it was estimated that in no case would the dry weight of a culture exceed 0·5 grams; as a rule the cultures were divided into three, and the mass of spores or mycelium was therefore small in comparison with the volume of the fungicide. In the case of copper sulphate, when the experiment was of several weeks' duration, 200 c. c. of the fungicide was used with not more than 0·2 grams (dry weight) of mycelium and spores.

Mercuric Chloride, 0·1 per Cent.

(1) As a preliminary experiment, the spores were immersed in this solution and transferred by a platinum loop every minute to flasks of sugar cane extract. The spores transferred

in the first four minutes produced a fair growth in three days, but nothing resulted from the transfers at the end of the fifth and the succeeding twenty minutes. In this case, therefore, the spores were killed by an immersion of five minutes.

The growth of the first four cultures was somewhat slower than is usual with normal spores, but not markedly so ; and there was no difference between the four cultures.

(2) Culture divided into three parts treated separately :—

(*a*) Spores transferred to hanging drops by a straight platinum wire after two minutes' immersion, and every subsequent minute for ten minutes ; then every two minutes for twenty minutes. No germination in five days.

(*b*) Spores transferred to flasks by a platinum loop after two minutes' immersion, and every minute for ten minutes; then every two minutes for twenty minutes, every five minutes for the next half hour, and every fifteen minutes for one hour. After two days, growth in Nos. 1, 2, and 8; good growth in these three at the end of five days. These spores therefore survived immersion for two, three, and ten minutes respectively. Total period of transfers, two hours. Growth was considerably retarded.

(*c*) Mycelium and spores transferred to flasks of sugar cane extract. First transfer after eight minutes' immersion ; subsequently every two minutes up to one hour, and then at intervals of ten to fifteen minutes for two hours. No growth in any in six days. Total period of transfers three hours.

(3) Culture, nine days old, instituted at the same time as (2), and from the same spores, separated into three parts, treated separately :—

(*a*) Spores transferred to hanging drops by a straight platinum wire every fifteen seconds for two minutes. No germination in five days.

(*b*) Spores transferred to flasks by platinum loop ; every thirty seconds for six minutes. No growth in two days ; microconidia in Nos. 2 and 7 after three days.

Good growth is Nos. 2 and 7 after four days. These spores therefore survived immersion for one and three and a half minutes respectively.

(*c*) Mycelium and spores transferred to flasks, every thirty seconds for ten minutes. Poor growth in Nos. 1, 2, and 3 after two days. Fair in 1, 2, 3; poor but black in 4 and 5; still white in 6; nothing in 7; poor but black in 8—after three days. Good growth in 1–6 and 8, after five days. No further development. These spores therefore germinated regularly up to the end of three minutes' immersion; the sample taken after three and half minutes was dead, but those taken after four minutes germinated.

At the end of six days, fresh spores of *Thielaviopsis* were sown in several of the hanging drops and flasks in which no growth had occurred, to determine whether this was due to the amount of mercuric chloride transferred with the spores. In all cases these spores germinated and the fungus developed normally.

The growth of the fungus is usually considerably retarded by the previous immersion of the spores. In 3 (*b*) the growth in four days was about equal to a normal two days' growth; while in 3 (*c*) the same stage was reached in three days by the earlier and four days by the later transfers.

Summarizing the experiments with 0·1 per cent. mercuric chloride, we have the following results:—

(*a*) Spores transferred to hanging drops do not germinate after an immersion of fifteen seconds.

(*b*) Spores transferred to flasks germinated in no case after eleven minutes' immersion. In one case no growth occurred after five minutes; in another, the majority were killed by four minutes' immersion, but some survived ten minutes; in the third case, some were killed by an immersion of thirty seconds, others survived one minute's immersion, most were killed by one and half minutes, but some survived three and half minutes.

(*c*) Transfers of mycelium and spores show the same irregularity as transfers of spores only. In one case no growth was obtained after an immersion of eight

> minutes, though the spores alone germinated after an immersion of ten minutes. In the other, transfers of mycelium and spores failed to grow after four and half minutes' immersion, while the spores alone did not survive four minutes. Experiments with other fungicides usually show that the spores in the mycelium, as would be expected, survived a longer immersion than the spores alone ; but even that does not hold good in the present case.

It has been shown previously by Brooks (19) that the concentration of the toxic agent required to produce injury in flasks is greater than that required in hanging drops. Apparently a similar rule is true in the present case, viz., that spores subjected to immersion in a toxic solution will grow in flasks when they will not grow in hanging drops. To whatever cause this may be due, it is evident that in order to determine whether spores are dead they should be tested in flask cultures, not in hanging drops.

The impossibility of obtaining a sample of spores, all of the same power of resistance, introduces a large element of chance into such experiments as those described above. For example, we may imagine that a given sample consists chiefly of spores which would be killed by an immersion of two minutes, in a certain fungicide, but contains a few which would survive ten minutes but be killed by eleven minutes. If the latter spores happened to be all taken in the first minute, the death point of the whole sample would be two minutes. Similarly, if none of them were taken in the first eleven minutes, the death point of the whole would again be two minutes. And, of course, all other numbers from two to ten would be possible. The heterogeneity of the material renders any uniform result impossible.

Formaldehyde, 1·0 per Cent.

(1) As a preliminary experiment, spores from a six days old culture were immersed in 1·0 per cent. formaldehyde, and transferred at intervals to flasks of pure cane extract by means of a platinum loop. Transfers 1–20 were made at intervals of one minute, 21–28 at intervals of five minutes, and 29–37 at intervals of fifteen minutes. Further transfers

were made, extending over the next two days. Nos. 1 and 2 began to grow two days after the transfer, and produced a good growth of macroconidia, &c., on the following day. There was no growth in any of the remaining flasks, though they were kept for ten days. These spores therefore survived an immersion of two minutes, but were killed by an immersion of three minutes.

(2) Culture six days old, divided into three parts which were treated separately :—

(*a*) Spores transferred to hanging drops by a straight platinum wire every fifteen seconds for two minutes, and every thirty seconds for the succeeding four minutes. Examined two days later, transfers 1–4 showed good growth, 5 was fair, and there was a slight growth in 6 ; in the remaining ten no spores had germinated. On the third day, the spores in transfers 7 and 8 had germinated, but there was no growth in 9–16. Nothing further occurred. These spores therefore survived an immersion of two minutes, but were killed by an immersion of two and a half minutes. Isolated spores in transfers 7 and 8 germinated.

(*b*) Spores transferred to flasks of sugar cane extract by means of a platinum loop. Transfers made every thirty seconds for five minutes, and every minute for the succeeding twenty-five minutes. Growth occurred in all flasks up to and including No. 13. These spores therefore survived an immersion of eight minutes, but were killed by an immersion of nine minutes (see below).

(*c*) Mycelium transferred to flasks of sugar cane extract, every minute for twenty minutes, then at intervals of five minutes for the next forty minutes, and subsequently at intervals of fifteen minutes for the next six hours. All transfers up to and including No. 12 grew, 13 failed, 14 and 15 grew, 16 failed, 17 grew ; the remainder all failed. The spores of No. 17 thus survived an immersion of seventeen minutes.

In 2 (*a*) it will be noted that the germination of the surviving spores in transfers 7 and 8 was retarded by one day in comparison with transfer 6 of the same series and nearly three days in comparison with normal *Thielaviopsis* spores. This point is particularly well illustrated by an examination of the detailed results of (*b*) and (*c*). These are given below, the days being the number of days since the transfer of the spores.

(*b*)—

2 days. No. 1, fair growth, but white ; No. 2, growing.

3 days. No. 1, good ; No. 2, fair ; Nos. 3 and 4, growing.

4 days. Nos. 1 and 2, good ; Nos. 3 and 4, fairly good.

5 days. Nos. 1–4, good ; Nos. 5 and 6, growing.

6 days. Nos. 1–6, good ; No. 7, growing ; No. 11, growing.

7 days. No. 7, fair ; Nos. 8 and 9, growing ; No. 11, fair.

8 days. No. 7, good ; No. 8, fair ; No. 9, mycelium only ; No. 10, growing ; No. 11, good.

9 days. No. 9, good ; No. 10, fair but white ; No. 11, good.

This was not examined again until forty days from the time of transfer ; Nos. 12 and 13 had then developed a good growth.

(*c*)—

2 days. No. 1, fair.

3 days. No. 1, good ; No. 2, growing.

4 days. Nos. 1 and 2, good ; No. 3, growing.

5 days. Nos. 1 and 2, good ; No. 3, fair ; No. 4, growing.

6 days. Nos. 1–4, good.

7 days. No. 5, growing.

8 days. No. 5, fair ; No. 6, growing.

9 days. No. 5, fairly good ; No. 6, fair but white ; No. 7, growing, but not above surface of liquid.

As with (*b*), this was not examined further until forty days had elapsed from the time of transfer. Every transfer had then developed up to and including No. 17, except Nos. 13 and 16.

It is clear from these records that this retardation is not due to a diminished rate of growth after the germination of the spores. In each case the culture has produced a good growth of mycelium, covering the whole surface, and has arrived at the macroconidial stage, within two days of germination, as is usual with untreated spores. The retardation is therefore due to a delayed germination ; this conclusion is confirmed by the results of 2 (*a*).

This result is extremely important, in that it indicates the necessity of a more prolonged examination than is usually given when estimating the effect of a fungicide upon fungus spores. Brooks (19) states that his charts of results are based entirely upon the data secured on the first and second days after transferring, and that in very few instances did spores germinate on the second day. In the present instance any arbitrary limitation of the period of observation to two or three days would certainly have resulted in an entirely erroneous estimate of the fungicidal value of formalin. To arrive at the true value the cultures must be left until no further germination occurs. This retardation of germination is more marked with formalin than with any of the other substances tested in this series of experiments. A 0·1 per cent. solution of formaldehyde is now being largely recommended as a disinfectant for seeds, but in view of the foregoing results it would seem that its retarding effect has been mistaken for actual killing. In a recent study of the fungi occurring on wheat stems, it is stated that the stems "were sterilized by treating one minute with 1 per cent. formaldehyde, and afterwards washing with sterile distilled water. Thus it is presumed that all saprophytes and surface fungi were eradicated." As the fungi in question included species of *Macrosporium* and *Helminthosporium*, it is highly probable that this method is fallacious.

Carbolic Acid, 1·0 per Cent.

(1) As a preliminary experiment, the spores were immersed in the solution in the manner already described, and transferred by a platinum loop every five minutes for one hour, and at the end of every hour for the succeeding twelve hours. The spores transferred after five minutes' immersion developed a good growth in two days, while those transferred after ten minutes' immersion developed a good growth in three days. No growth occurred in any of the remaining flasks. The spores were therefore killed by an immersion of between ten and fifteen minutes.

(2) An attempt was next made to determine whether the age of the culture affected the time required to kill the spores. Three cultures were employed: the first eight days old, the second twenty days, and the third thirty-three days. The spores were transferred as above by a platinum loop. In the

first, transfers were made every minute for twenty-six minutes; in the second, every minute for thirty-two minutes; in the third, every minute for forty minutes. As the spores were killed by an immersion of fifteen minutes in the previous experiment, it was expected that these times would be amply sufficient, but contrary to this expectation all the transfers grew well, and therefore no result was arrived at.

(3) Culture, six days old, divided into three parts which were treated separately :—

(*a*) Spores transferred to hanging drops by means of a straight platinum wire. Transfers made every five minutes for the first hour, every ten minutes for the second hour, and every fifteen minutes for the fifth, sixth, and seventh hours. No spores germinated after the eighth transfer. They, therefore, survived an immersion of forty minutes, but were killed by an immersion of forty-five minutes. Germination of isolated spores occurred in all transfers up to the eighth; in the latter, 50 per cent. of the isolated spores and 53 per cent. of the spores in groups germinated within twenty-four hours.

(*b*) Spores transferred by platinum loop to flasks of cane extract. Transfers as above. All transfers grew up to No. 20, *i.e.*, after an immersion of two hours twenty minutes; all subsequent transfers failed. Unfortunately, No. 21 was transferred only after an immersion of four hours and forty-four minutes.

(*c*) Mycelium and spores transferred by platinum wire to flasks. First transfer after an immersion of one hour, then every ten minutes for the second hour, every fifteen minutes for the fifth, sixth, and seventh hours, then every hour to the end of the twelfth hour, and again every hour from the twentieth to the twenty-fifth hour. As in the case of (*b*) all the transfers grew up to No. 20. The death point lies therefore between two hours twenty minutes and four hours and forty-four minutes.

(4) The last experiment was repeated with another culture, six days old, in the expectation of obtaining a closer

approximation to the actual times required to kill the spores :—

(*a*) Spores were transferred by a straight platinum wire to hanging drops. Transfers made every minute for the first twenty minutes, and then every two minutes for the next forty minutes. Examined twenty-four hours afterwards, germinated spores were found in all the transfers. These spores, therefore, survived an immersion of one hour, and the death point was not reached.

(*b*) Spores transferred by platinum loop to flasks of sugar cane extract. Transfers 1–40 as above, then every ten minutes for two hours, and every fifteen minutes for four hours. All transfers grew, up to and including that at six hours thirty minutes; the two succeeding transfers failed, as did also those transferred on the following day.

(*c*) Mycelium and spores transferred by platinum wire to flasks of sugar cane extract. Transfers were made at intervals of ten to fifteen minutes until seven hours had elapsed, and others were made on the following morning after twenty-four hours' immersion. All the former transfers grew well, but none of the latter. These spores, therefore, survived immersion for seven hours, but were killed by an immersion of twenty-four hours.

These experiments with carbolic acid were not carried further. The results given above show that no uniformity in the period required to kill the spores can be obtained by any of these methods, and that it is impossible from experiments with one sample of spores to forecast even approximately the behaviour of the next. Spores transferred to hanging drops were in one case killed by an immersion of forty-five minutes, but those from another culture of the same age survived an immersion of sixty minutes, and probably longer. Spores transferred to flask cultures were killed in one case in fifteen minutes ; in three other cases they survived an immersion of twenty-five, thirty-two, and forty minutes, respectively, no death point being reached ; in a fifth case they survived an immersion of two hours twenty minutes, but were killed by four hours forty-four minutes, no intermediate transfers being made;

while in a sixth case, they were killed by an immersion of six hours forty-five minutes, but as the experiment was only carried on for another transfer (at seven hours) this result is doubtful. Transfers of mycelium plus spores were killed in one case between two hours twenty minutes and four hours forty-four minutes, but in the subsequent experiment to determine a more approximate death point they survived an immersion of seven hours.

No agreement was expected between the results obtained by the three methods, and it is clear that the results of the third method depend upon the size of the masses of mycelium transferred. For example, after twenty-four hours' immersion in 1 per cent. carbolic acid all transfers of small fragments of mycelium failed to grow, but growth was obtained from a larger mass in the same solution. But there does not seem to be any explanation of the variation in the results obtained by transferring the spores alone, except on the supposition that the spores vary in their power of resistance to the fungicide. The spores are comparatively large, and are easily wetted by the liquid. Examination of the hanging drops showed that in no case did groups of spores enclose air bubbles, and tests of the loop transfers gave the same result ; it is improbable, therefore, that the variation is due to this cause.

Copper Sulphate.

(1) A flask culture, six days old, was divided into two parts, one of which was torn up in 1 per cent. carbolic acid, and the other in 1 per cent. copper sulphate. The two bottles containing the mixtures were then placed under an air pump, and any air in the mycelium extracted. Transfers were made to flasks of sugar cane extract every twenty-four hours for thirty-five days. No growth was obtained in any of the transfers from carbolic acid. In the case of the copper sulphate, good growth resulted in all transfers up to the nineteenth ; the twentieth, twenty-first, and twenty-fourth failed, but the subsequent transfers grew up to the twenty-seventh ; no growth was obtained from the twenty-eighth and seven following transfers. Germination was delayed about two days in the last living transfers. Judged by this experiment the killing power of copper sulphate is small compared

with that of carbolic acid, though the former is the more efficacious in inhibiting germination.

(2) A flask culture, six days old, was divided into three parts, which were shredded in 5, 4, and 3 per cent. copper sulphate, respectively. Transfers of fragments of mycelium containing spores were made every twenty-four hours to flasks of sugar cane extract. The experiment was prolonged for one hundred and thirteen days. From the 5 per cent. solution all the transfers grew until the forty-fifth day; subsequently growth occurred in the transfers on the forty-ninth, fiftieth, fifty-first, fifty-fourth to fifty-seventh, sixty-second, sixty-sixth, sixty-seventh, seventy-third, seventy-fifth, and eighty-second days. In the eighty-second transfer, the spores germinated in five days and produced a fair growth in eight days, as compared with two days from untreated spores. From the 4 per cent. solution, all the transfers grew until the sixty-fifth day; failures occurred on the sixty-fifth, seventy-sixth, eighty-first, eighty-second, eighty-fourth, eighty-sixth, eighty-seventh, ninety-second, ninety-third, ninety-fifth to ninety-eighth, and one hundredth days; the one-hundred and first transfer was the last that grew. From the 3 per cent. solution, the first failure occurred on the forty-fifth day, as in the case of the 5 per cent. solution; further failures occurred on the forty-ninth, fifty-second, fifty-seventh, sixty-first, sixty-third, sixty-sixth, sixty-eighth, seventy-first to seventy-fourth, seventy-sixth to eighty-fourth days; the eighty-fifth was the last transfer which grew.

(3) A culture, eight days old, was divided into five parts, which were shredded in 1, 2, 3, 4, and 5 per cent. copper sulphate respectively. The mixtures were shaken up and allowed to stand until the mycelium had sunk to the bottom. The liquids with the suspended spores were then decanted into other bottles, and fresh copper sulphate solutions of the same strength were added to the mycelium. The bottles containing the latter were put aside, and spores were transferred every twenty-four hours by means of a platinum loop from the bottles which contained spores only. The experiment was continued for twenty-eight days. From the 5 per cent. solution, the first and second transfers failed, but the third

grew ; this was the only transfer which grew. From the 4 per cent. solution, the first, second, fifth, and sixth grew. From the 3 per cent. solution all grew, up to and including the tenth ; the eleventh to the sixteenth failed, but the seventeenth grew. From the 2 per cent. solution all grew up to and including the eleventh; the twelfth and thirteenth failed, but the fourteenth grew. From the 1 per cent. solution all grew up to and including the ninth ; the tenth failed, but the eleventh grew; the twelfth and thirteenth failed, but the fourteenth grew ; the fifteenth to the nineteenth failed, but the twentieth grew.

The samples of mycelium and spores, which had been put aside in copper sulphate solutions, were tested by transference on the thirtieth and following days. No growth was obtained from the 4 and 5 per cent. solutions. Growth from the other three solutions occurred up to and including the seventieth day, after which the experiment was discontinued.

(4) This experiment was repeated with a culture six days old, and 4 and 5 per cent. solutions of copper sulphate. As some of the spores were dead in the 5 per cent. solution after twenty-four hours in experiment 3, transfers were made at intervals during the first day. The first failure of the spores transferred from the 4 per cent. solution occurred on the fourth day ; the transfers grew on the fifth to the eighth day, but failed on the ninth ; they grew on the tenth but failed on the eleventh and twelfth ; the transfer on the thirteenth day was the last that grew. From the 5 per cent. solution all the transfers grew, up to and including that on the fifth day. The experiment was continued for twenty days.

As in experiment 3, the mycelium and spores which had been kept in separate bottles of copper sulphate solution were also transferred. From the 5 per cent. solution, growth occurred in transfers on the twenty-fourth, twenty-ninth, fortieth, and fiftieth days, no intermediate transfers being made ; no further test was made until the sixty-sixth day, when, and on subsequent days, all the spores were found to be dead. From the 4 per cent. solution growth occurred on the sixty-sixth day, and in various transfers up to and including the ninetieth day ; a transfer on the one-hundredth day failed. The experiment was not continued further.

The following table gives the results of these experiments. The times quoted are *maximum* times required to kill the spores :—

		Transfers of		
		Spores to Hanging Drops.	Spores to Flasks.	Mycelium and Spores to Flasks.
Mercuric chloride 0·1 per cent.	(1)	—	5 minutes	—
	(2)	< 2 minutes	11 minutes	< 8 minutes
	(3)	< 15 seconds	4 minutes	4½ minutes
Formalin 1 per cent.	(1)	—	3 minutes	—
	(2)	2½ minutes	9 minutes	18 minutes
Carbolic acid 1 per cent.	(1)	—	15 minutes	—
	(2*a*)	—	> 26 minutes	—
	(2*b*)	—	> 32 minutes	—
	(2*c*)	—	> 40 minutes	—
	(3)	45 minutes	> 2 hours 20 minutes < 4 hours 44 minutes	> 2 hours 20 minutes < 4 hours 44 minutes
	(4)	> 1 hour	6 hours 45 minutes	> 7 hours < 24 hours
Copper sulphate 1 per cent.	(1)	—	—	28 days
	(3)	—	21 days	> 70 days
2 per cent.	(3)	—	15 days	> 70 days
3 per cent.	(2)	—	—	86 days
	(3)	—	18 days	> 70 days
4 per cent.	(2)	—	—	102 days
	(3)	—	7 days	< 30 days
	(4)	—	14 days	> 90 < 100 days
5 per cent.	(2)	—	—	83 days
	(3)	—	4 days	< 30 days
	(4)	—	6 days	> 50 < 66 days

Transfers of spores from copper sulphate to hanging drops of cane extract were not made.

The lack of any uniformity in the foregoing figures is in striking contrast to the regularity observed in the experiments on the inhibition of germination by toxic agents, &c. In the latter, it was possible to carry an experiment on up to a certain percentage, and then to begin another series at that percentage with a different sample of spores, with the certainty that the first result would be repeated. For instance, spores sown in a nutrient medium with 0·1 carbolic acid produced submerged mycelium only ; in another series, beginning with 0·1 per cent. carbolic acid, the same result was obtained. Gallic acid and sodium chloride provide two other examples. Moreover, in the preliminary tests, it was determined whether the fungus would grow in solutions which contained 0·5, 1·0, and 1·5 per cent. of the toxic agent ; and in no case did the limit in the succeeding experiment exceed that found in the preliminary test, though the former was made with another sample of spores. Apparently, therefore, the percentage of a toxic agent which will inhibit germination is about the same for all samples of spores, but the time required to *kill* the spores by a given percentage differs with different samples.

From the table on page 571, the order of the four substances arranged according to their fungicidal value is mercuric chloride, formalin, carbolic acid, copper sulphate. Arranged according to their power of inhibiting germination, the order is mercuric chloride, formalin, copper sulphate, carbolic acid. With *Thielaviopsis* at least the real fungicidal value of copper sulphate is remarkably low.

Though no definite result was obtained in this second series, the following conclusions appear to be warranted by the foregoing experiments :—

(1) Tests of fungicides, which determine only the percentage required to prevent germination, do not give a true idea of their actual or relative fungicidal value.

(2) Spores which are subjected to the action of a fungicide of such concentration as to inhibit germination remain dormant, and may germinate when the fungicide is removed.

(3) In estimating the value of a fungicide, by testing the germination of spores after they have been submitted to its action, it is necessary to keep the transfers under observation for several days, even in the case of spores which normally germinate within a few hours.

(4) In the case of thick-walled spores, the fungicidal value of copper sulphate is small.

(5) Spores of the same fungus vary enormously in their power of resisting the action of toxic agents, so much so that it is not possible to find an approximately constant time in which the spores would be killed by immersion in a solution of given percentage. It is only possible to give a maximum limit, and this could only be obtained by an extended series of tests. Single experiments may be quite misleading.

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A detailed discussion of the morphology of many forms, including some local ones.

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J. C. W.

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Secondary thickening in Kendrickia.

[Secondary thickening in Kendrickia Walkeri Hook. f. A. M. Clark. Ann. of Bot., XXI., 1907, p. 361.]

A description of the process, which is in some respects unique.

J. C. W.

Note on the Roots of Terminalia Arjuna, Bedd.

[R. S. Adamson, in New Phytol., IX., p. 150, 1910.]

This is *T. Glabra* W. & A., the Kumbuk, so common in Ceylon. From the trees growing on the banks of a river (in India) certain roots grow out horizontally into the river bed, among the stones, or just below the surface of the water. From these roots lateral branches are given off that rise vertically to the surface of the water or mud. These were examined, and it was found they were for aeration purposes. An account is given of their anatomy.

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Abnormal Vessels in Canarium, &c.

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J. C. W.

The Assimilatory Tissue of Mangrove Seedlings.

[Carson, in New Phyt., II., 1907, p. 178.]

The seeds of the Mangroves, Rhizophora, and Bruguiera germinate on the tree. They are found to have rows of lenticels with assimilating tissue beneath them.

J. C. W.

The Stem and Leaf of the Dipterocarps.

[Contribution à l'étude anatomique de la tige et de la feuille des Dipterocarpées ; Son application à la systématique. P. Guérin. Mem. Soc. Bot., France, Dec., 1907.]

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Germination of Borassus.

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An illustrated account of the growth in thickness in this palm.

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A careful account of the flower, hitherto inaccurately described.

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Plankton in Colombo Lake.

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Herr Apstein received collections made by Borgert and by Dr. Willey. They show that there is a marked periodicity of the plankton, which is attributed to changes of monsoon, with the consequent changes of level and of amount of food in the water.

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Algæ in Ceylon.

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[Uber einen Fall von Symbiose zwischen zoochlorellen und einer marinen Hydroide. Svedelius. Svensk Bot. Tidsk I., 1907, p. 32.]

A series of papers by former visitors. The first two are of special interest to the student of the general distribution of algæ.

J. C. W.

The Alga Martensia.

[Ueber den Bau und die Entwicklung der Florideen-gattung Martensia. By N. Svedelius. Kgl. Sv. Vetenskapsakad. Handl, 43.]

Dr. Svedelius collected this alga at Galle, and gives here a detailed account of its structure and development.

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