CEYLON JOURNAL OF SCIENCE

Biological Sciences

[Former Sections A, B & C]

Vol. 12, No. 2

NOVEMBER, 1977

THE LIBRARIAN
UNIVERSITY OF SRI LANKA
PERADENIYA CAMPUS

Ceylon Journal of Science

The *Ceylon Journal of Science* was founded in 1924 by the Government of Ceylon to provide for the publication of papers dealing with scientific researches carried out in Ceylon by officers in the Public Service and others. Different branches of the sciences were covered by separately published Sections A, B, C, D, E, F and G. With the establishment of the University of Ceylon in 1942, the administration of the Journal was handed over to the University, and it has been developed as the chief means of contact with scientists elsewhere. The *Ceylon Journal of Medical Science* (successor to the former Section D of the *Ceylon Journal of Science*) was from 1967 taken over by the former Colombo branch of the University of Ceylon which was a separate university known as the University of Ceylon, Colombo. Sections E and F (Meteorology, Chemistry, Physics and Mathematics) have not been published since Vol. 1, No. 1 (June 1958). Section G (Anthropology, Archaeology and Ethnology) has not been published since Vol. 5, Pt. 2 (June 1954), while Sections H (Engineering) and K (Geography, Geology and Mineralogy) were never published. The *Ceylon Journal of Science : Biological Sciences* (former Sections A, B and C, comprising Botany, Zoology and Fisheries) continues to be published by the University of Ceylon, Peradeniya, which is now the Peradeniya Campus of the University of Sri Lanka.

CEYLON JOURNAL OF SCIENCE

Biological Sciences

(Former Sections A, B & C)

MANUSCRIPTS and all communications concerning them should be addressed to the General Editor or one of the Sectional Editors.

There will normally be two parts to a volume, and it is hoped to produce a volume each year. The subscription to a volume will be Rs. 30/- (local) and £ 3 or U.S. $ 8.00 (foreign). The price of a single part is Rs. 15/-(local), and £ 1.5 or U.S. $ 4.00(foreign).

Since 1966, Lake House Bookshop, P.O. Box 244, Colombo, Sri Lanka, have been the sole agents for all SALES AND SUBSCRIPTIONS, both local and foreign, and all communications regarding these should be addressed to them. EXCHANGES have continued as usual to be handled by the Librarian, University of Sri Lanka, Peradeniya Campus.

CEYLON J. SCI. (BIO. SCI.) VOL. 12, NO. 2, NOVEMBER, 1977

Studies on Plant Galls from India. 2. Leaf Galls of *Cordia obliqua* Willd. (*Cordia myxa* Linn.) (Boraginaceae)

by

K. V. KRISHNAMURTHY

Presidency College, Madras 5, India

A. RAMAN AND T. N. ANANTHAKRISHNAN

Loyola College, Madras 34, India

(With sixteen text figures and one plate)

ABSTRACT

Histological studies have been made on the three distinct types of galls on the leaves of *Cordia obliqua* Willd., (Boraginaceae) caused by weevils, mites and thrips. The occurrence of all the three gall types on the same leaf appears to be of interest and the tissue responses of the leaf to varied insects and mites have been analysed.

INTRODUCTION

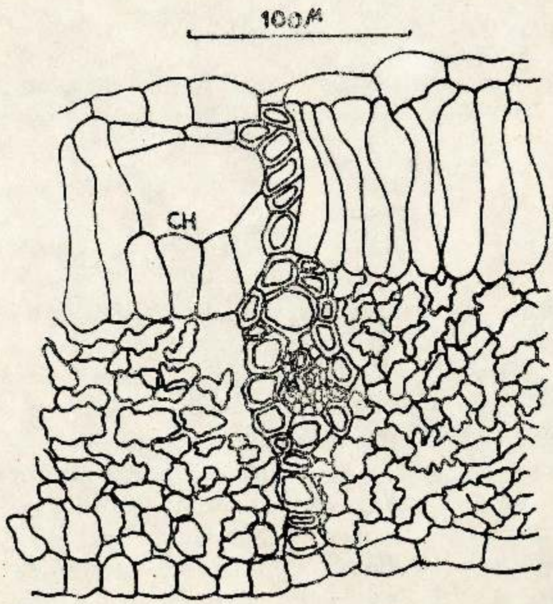
Three morphologically distinct types of galls are encountered on the leaves of *Cordia obliqua* Willd. (= *Cordia myxa* Linn.) caused (i) by a weevil—*Baris cordiae* Marshall—on the petiole, midrib and larger lateral veins (Agrawal, 1970 ; Mani, 1948, 1959, 1973), (ii) by a mite—*Eriophyes cordiae* Nalepa—on the lamina (Mani, 1959, 1973) and (iii) by a species of *Aneurothrips* on the leaf margins (Ananthakrishnan & Jagadish, 1969). These have been reported from various parts of India, while Karny & Docters van Leeuwen Reijnvaan (1913) reported similar thrips galls on *Cordia suaveolens* Blume from Java. These reports concern individual galls on geographically isolated host plant species, and the existence of all the three types of galls on the same leaf (Fig. 1) appears to be of interest. Hence, an attempt is made to study the differential tissue responses in the galls on the same plant organ caused by different insects and mites.

MATERIALS AND METHODS

Locally collected galled and normal leaves were fixed in FAA and were processed through customary methods of dehydration and embedding. Sections were cut at 12—15 μ and were stained with tannic acid — ferric chloride — safranin and tannic acid — ferric chloride-haematoxylin combinations. Supplementary epidermal peels were prepared, treated with Jeffrey's fluid.

OBSERVATIONS

The fusiform galls by *Baris cordiae* on the petiole and midrib are oval to circular in transectional outline, diffuse or localised, often unilateral, solid, woody with pale brownish tumescence, measuring 15—40 mm in length and 3—7 mm in thickness. Green to dark-green epiphyllous filzgalls caused by *Eriophyes* mites on the lamina number 9—12 per leaf, each with a 3—7 mm broad and 1—3 mm deep depression, covered with a dense mat of long multicellular hairs. Some of the marginal galls caused by *Aneurothrips* sp., largely resemble morphologically the marginal roll galls on *Cordia suaveolens* described by Karny & Docters van Leeuwen Reijnvaan (1913), while the remaining ones have been observed to be fold galls. Both types are epiphyllous, localised to one or both leaf margins. The roll galls possess a distinct ostiole at either end and are 30—40 mm long and 1—2 mm broad, while the fold galls have a slit-like opening.



2

Fig. 2 : Transverse section of normal leaf. (CH) = crystal chamber.

The normal laminal part shows in transverse sections (Fig. 2) a dorsiventrally differentiated mesophyll and the two epidermises. The closely arranged, uniformly cutinised, barrel-shaped epidermal cells are interrupted at regular intervals by crystal idioblasts whose tips project beyond the epidermal surface, while their urn-shaped body is deeply sunken in the palisade mesophyll. Epidermal cells possess straight walls, interspersed with anomocytic stomata along both the epidermises, the stomatal index of the dorsal and ventral sides being 4 and 26 respectively. The palisade mesophyll is one-layered with long ($76 \times 6\mu$) and closely arranged cells, possessing shorter linear values ($42 \times 6\mu$), at the sites of crystal chambers. The spongy mesophyll is made up of 8—10 layers of armed parenchyma cells with a well-aerated intercellular system. Each vascular bundle is embedded in a bundle-sheath of fibrous elements extending to both epidermises.

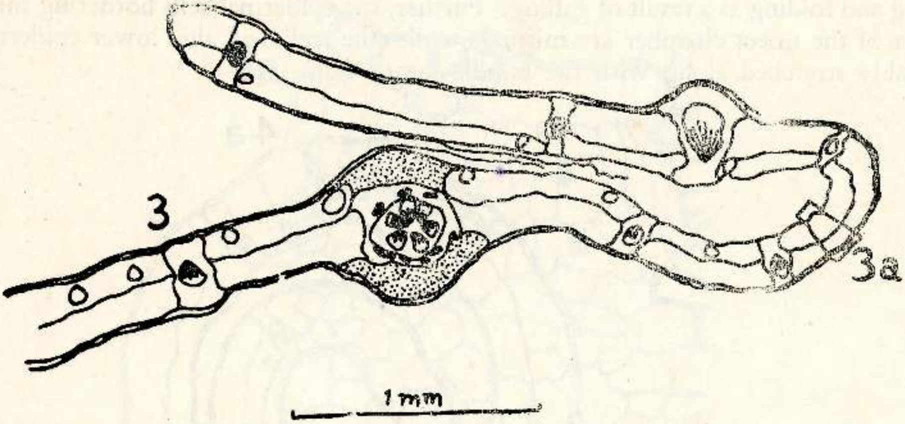


Fig. 3 : Transverse section of fold gall caused by thrips.

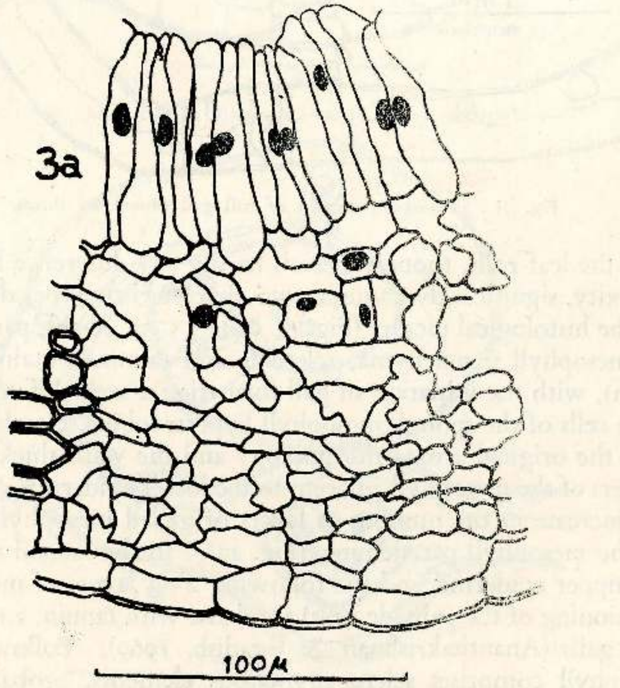


Fig. 3a : Portion shown as inset in Fig. 3, enlarged.

As mentioned earlier, basically there are two types of thrips galls evident on *Cordia* leaves. In the fold galls (Fig. 3 & 3a) the basic structure of the lamina is retained except for a moderate hypertrophy in the cells of the spongy mesophyll, resulting in cells of isodiametric contour, conspicuously losing their armed nature. Also at certain places, large air-cavities are evident which seem to have developed by the displacement of cells due to stretching and folding as a result of galling. Further, the epidermal cells bordering the inner perimeter of the insect chamber are missing, while the cells of the lower epidermis are considerably stretched along with the bundle-sheath cells.

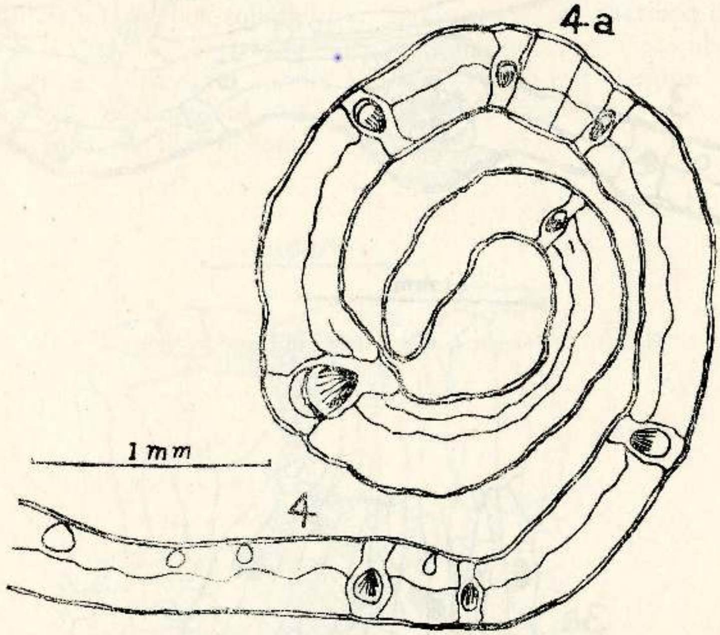


Fig. 4 : Transverse section of roll gall caused by thrips.

Coming to the leaf-rolls, though there is hardly any difference between the degrees of external complexity, significantly enough, two characteristic types deserve to be recognised on the basis of the histological picture (Figs. 4 & 4a ; 5, 5a & 5b), particularly regarding the nature of the mesophyll parenchyma, sclereids and tannin-containing cells. In the first type (Fig. 4, 4a), with the initiation of gall formation a well-differentiated palisade region occurs, with the cells of the spongy mesophyll hypertrophied, closely arranged, completely disfigured from the original armed morphology and the walls thickened. Also at specific places, a few layers of the mesophyll adjacent to the lower epidermis show periclinal divisions resulting in an increase in the number of layers of galled mesophyll, the derivative layers merging with the mesophyll parenchyma (Fig. 4a). In the second type (Fig. 5, 5a & 5b), the cells of the upper epidermis and the following 2—3 layers of mesophyll (by transverse or oblique partitioning of the palisade cells) are dense with tannin, a novel condition known in many thrips galls (Ananthakrishnan & Jagadish, 1969). Following this tanniniferous zone, the mesophyll comprises sclerenchymatous elements, probably developed by the lignification of the hypoplastic parenchyma, with distinct pittings. Perhaps, owing to the combined activity of the inrolling of the lamina by infection and the marginal growth of the leaf, large air cavities are evident along the galled leaf. Towards the inrolled leaf margins, the cells are very closely arranged, devoid of tannin content and have a corresponding increase in their wall thickness (Fig. 5b). In both types of roll galls, the cells of the upper epidermis are little affected.

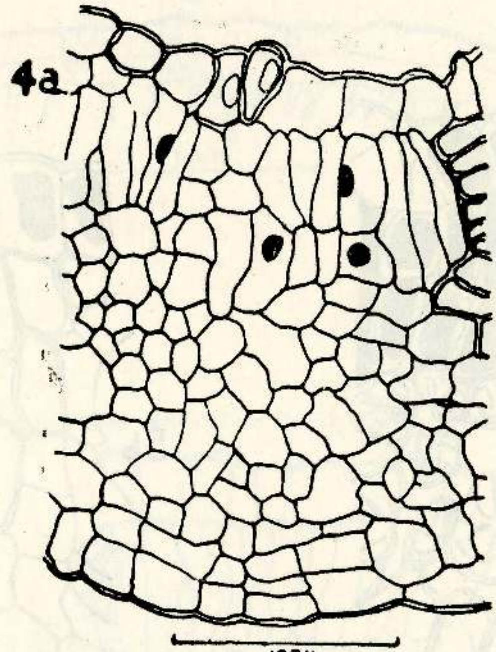


Fig. 4a: Portion shown as inset in Fig. 4, enlarged.

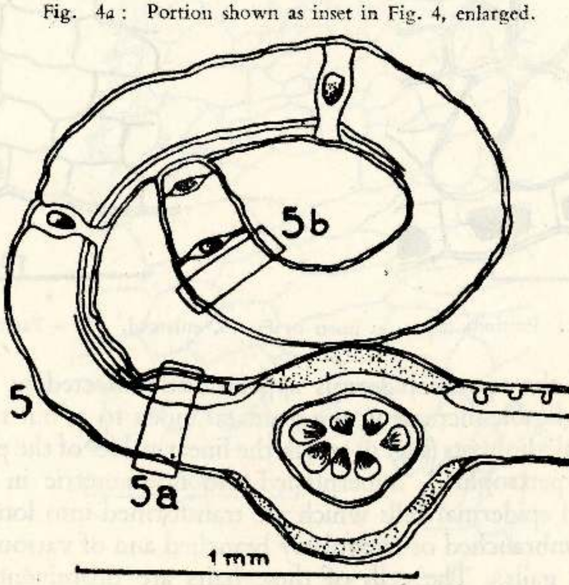


Fig. 5: Transverse section of roll gall caused by thrips.

In general, the vascular bundles of the thrips galls possess unaffected tracheary elements. The ensheathing fibres are considerably stretched in the fold and in the first type of the roll galls, while in the second type of roll galls, the bundle—sheath towards the leaf margins is unrecognisable. The stomatal index of the ventral epidermis of the roll galls decreases to 24 while in the fold galls it remains at 26, as in the normal leaf.

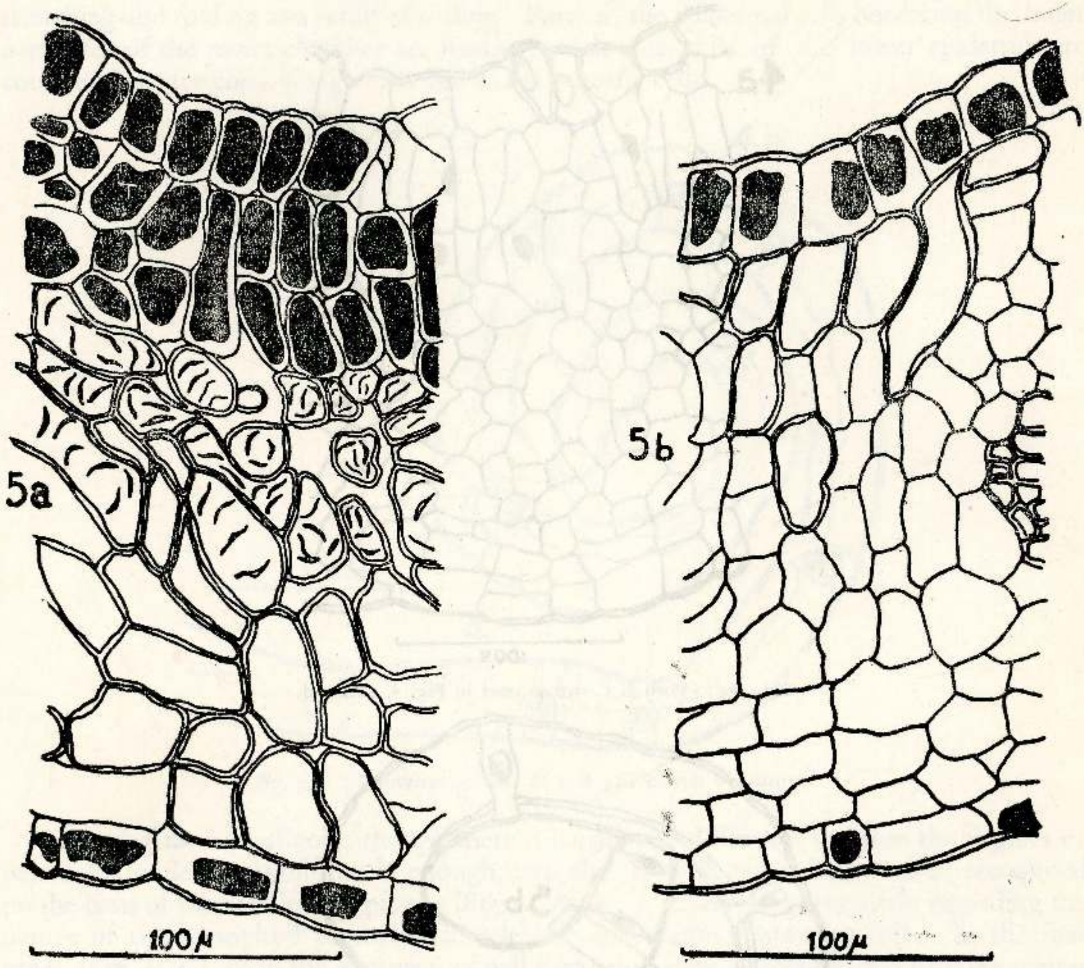


Fig. 5*a* & Fig. 5*b* : Portions shown as insets in Fig. 5, enlarged. (T) = Tannin-containing cells.

The structure of the upper epidermis appears little affected in the laminar galls by mites except for a negligible increase in the stomatal index to 5, but there is a reduction in the frequency of crystal idioblasts (Fig. 6) and in the linear values of the palisade cells ($60 \times 6\mu$). The cells become hypertrophied, hyperplasied and isodiametric in their contour. The occurrence of enlarged epidermal cells which are transformed into long, uniseriately multicellular erineal hairs, unbranched or irregularly branched and of various dimensions, appears characteristic of mite galls. The cells of these hairs are prominently nucleated and are densely cytoplasmic (Fig. 7), suggesting their nutritive role as in *Salvadora* (Kant & Arya,

1970) and *Prunus* (Westphal, 1974) ; however, remaining uninucleate. Stomata of the lower epidermis are morphologically like the normal ones, with their index reduced to 19. As in the previous cases, the vasculer elements are little affected.

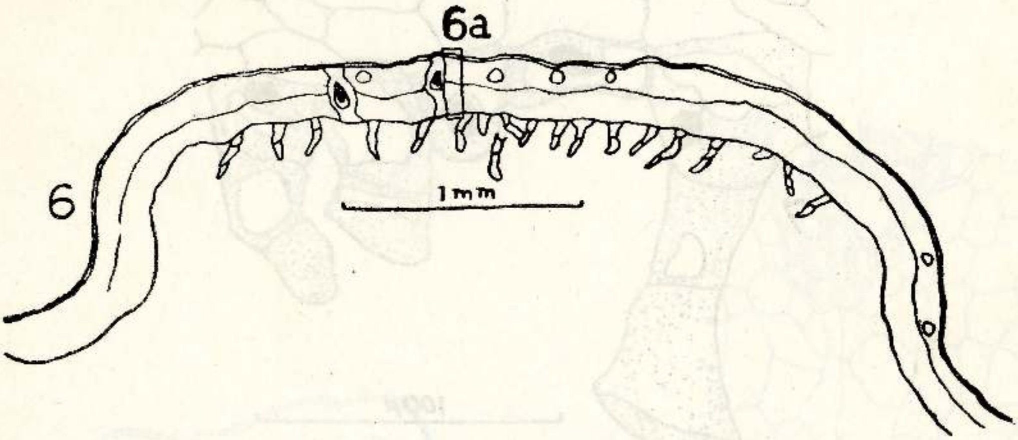


Fig. 6 : Transverse section of the filz gall caused by mites.

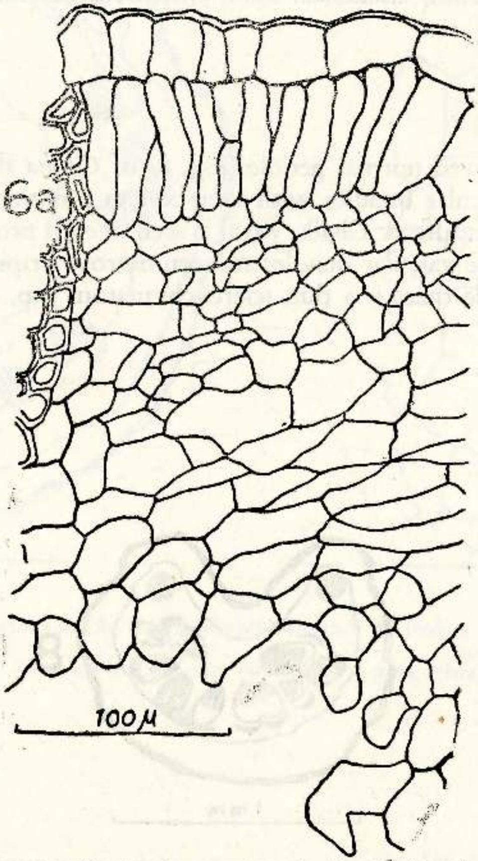


Fig. 6a : Portion shown as inset in Fig. 6, enlarged.

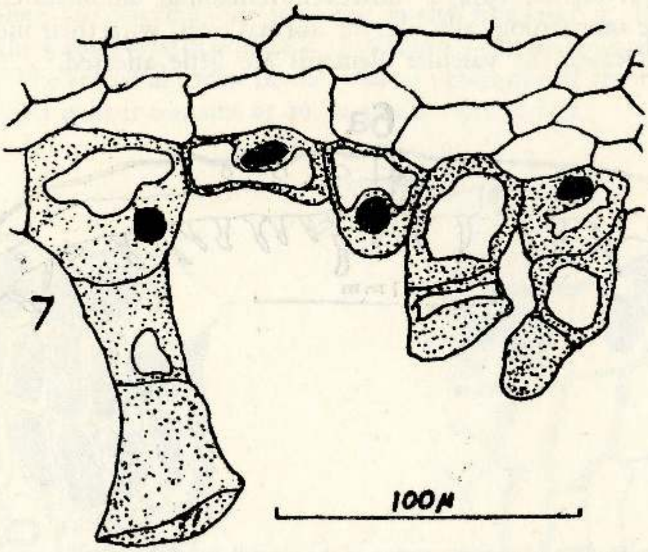


Fig. 7 : Uniseriately multicellular, densely cytoplasmic erineal hairs of the mite galls.

The adaxially grooved normal petiole (Fig. 8) of *Cordia* shows in transverse sections an arc of collateral vascular bundles with their xylem pointing towards the central pith. One centric bundle (Metcalfe & Chalk, 1952) is seen in each projection lateral to the adaxial groove, and between the vascular bundles are seen narrow strips of parenchyma. External to every vascular bundle there is a thin sclerenchymatous cap, and the epidermal cells are tanniniferous.

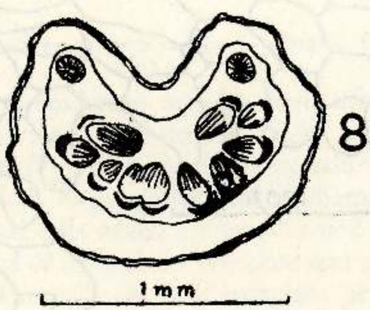


Fig. 8 : Transverse section of the normal petiole.

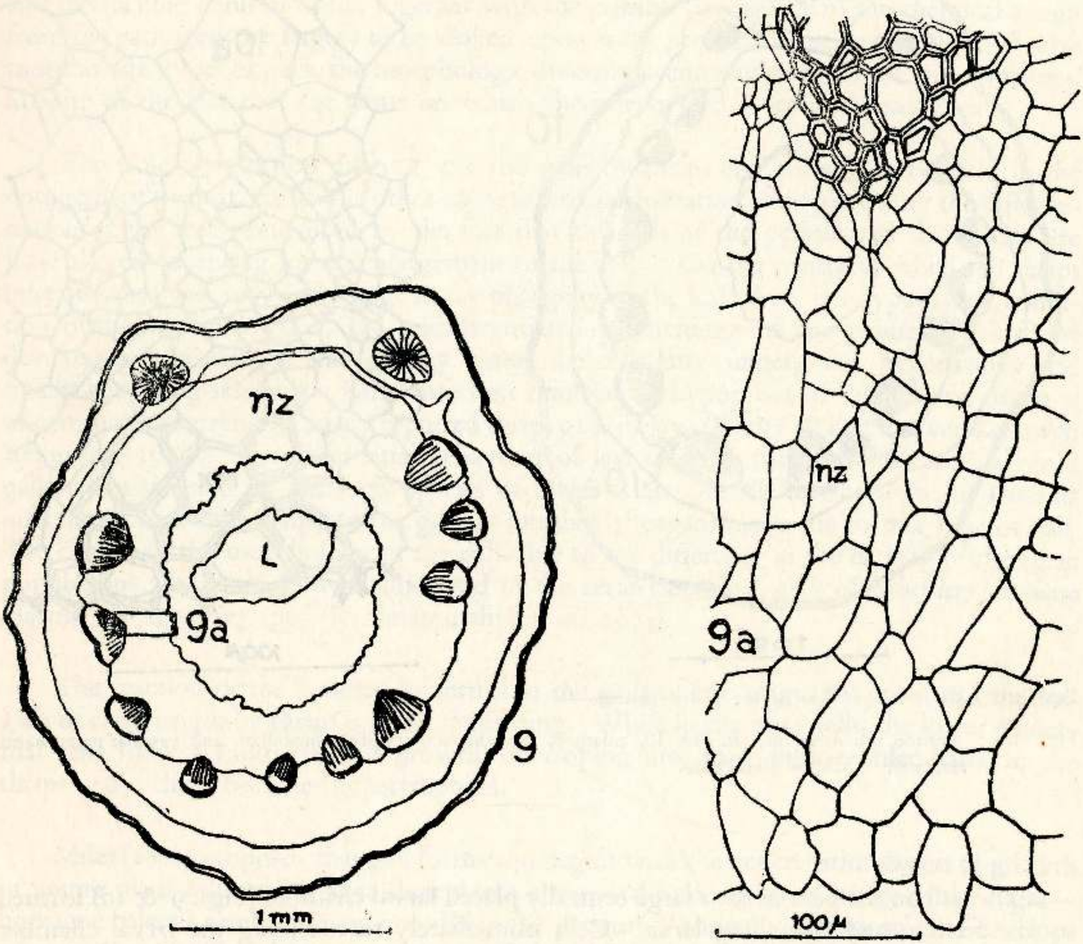
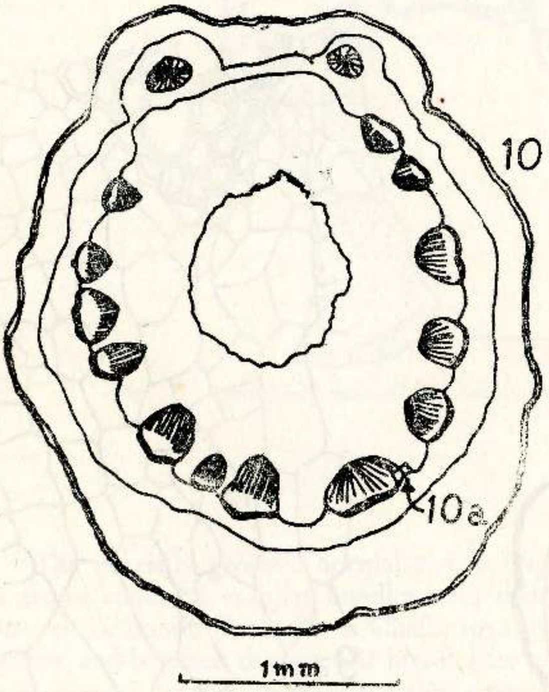


Fig. 9 : Transverse section of the galled petiole, lodging the hinder part of the feeding larva (L).

Fig. 9a : A portion of the hitherto functional nutritive zone (nz), shown as inset, enlarged.



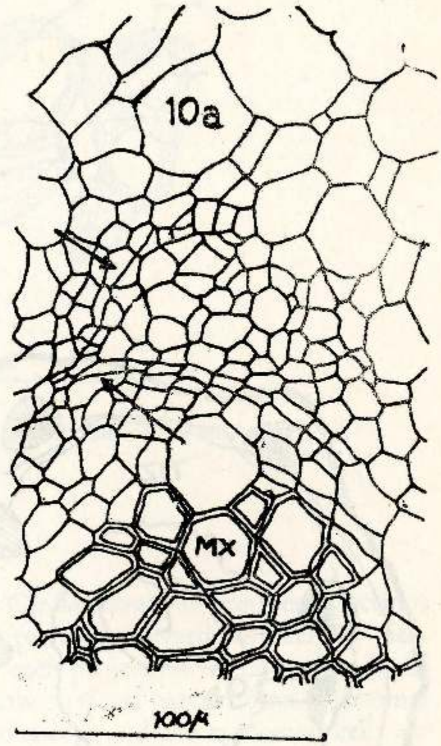


Fig. 10 : Transverse section of the galled petiole.

Fig. 10a : Portion shown as inset in Fig. 10, enlarged, showing activity of the medullary and vascular parenchyma (arrows). (MX) = Metaxylem.

The gall on the petiole has a large centrally placed larval chamber (Figs. 9 & 10) formed by the feeding and tunnelling larva. Cells immediately surrounding the larval chamber are densely cytoplasmic and are in radial files (Fig. 9a), a condition appearing consequent upon cell divisions occurring parallel to the larval cavity, largely by the renewed activity of the vascular parenchyma and parenchyma between the bundles (Fig. 10a). These cells are densely staining and thin-walled, suggesting their role as a nutritive zone. But the cells of the hitherto functional nutritive zone, bordering the larval cavity, with the onward movement of the feeding larva, become sclerenchymatous with uniform thickening of walls and bearing simple pits. The unilateral dimensional increase in the size of the petiole galls is essentially due to these radiating rows of cells of functional and non-functional nutritive zones, while vascular bundles remain little affected except for a consequent displacement in their positions and a little enlargement in the bundle—sheath parenchyma.

DISCUSSION

A comparison of the leaf galls of *Cordia* by weevil, mites and thrips reveals that basically there is a specificity for the infection sites,—the weevil to the petiole and veins ; the mites to the lower sides of the lamina and the thrips to the adaxial laminal margins. Modes of feeding—tunnelling in the tissue by the weevil, superficial rasping and sucking by thrips and the sucking habit of mites, together with the possible divergence of the chemical action from the pathogens are largely to be looked upon as the probable cause for the three diverse morphologic types of galls, the morphologic diversity accompanied by histologic diversities, in spite of the fact that the tissue on which the insects feed is from the same leaf.

The time of infection differs ; the roll galls by thrips are initiated very early in the ontogeny of the leaf, unlike the other cases, where gall initiation takes place after the differentiation of the leaf—evidenced by the fact that the cells of the petiole and the lamina are little altered excepting for an enlargement of the cells. On the contrary, when the thrips infect the leaf at a very early stage in the ontogeny of the leaf, there is a hypoplasied condition of the mesophyll, i.e., the undifferentiated parenchyma of the primordial leaf not developing into palisade and spongy tissue, the cells later undergoing hypertrophy and finally becoming sclereids. Early infection resulting in hypoplasia of the affected organ is of common occurrence in many reported thrips galls of Java (Karny & Doctors van Leeuwen Reijnvaan, 1913). The differential behaviour of leaf tissue in forming both roll and fold galls when infected by the same species of thrips is attributable not only to the time of infection, but also probably to the greater number of organisms in the former type of gall. The change in the morphology of the galls due to the difference in the density of the thrip populations within the galls is illustrated in the ceratoneon leaf galls of *Schefflera racemosa* Harms. by *Liothrips* spp. (Krishnamurthy *et al*, 1974).

The reaction of the laminar epidermis in the galls of late origin by mites and the roll galls of early origin by thrips is quite contrasting. While in the mite galls, the lower epidermal cells show a callus type of growth, developing into long multicellular hairs, in the thrips galls they become hypertrophied.

Miles (1968) proposes, that gall formation begins with the general stimulation of growth in young plant cells which have their starch converted into sugar. Change in the sugar—hormone balance resulting in increased osmotic pressure is known to favour sclereid development in *Camellia* (Foard, 1958) and Sterling's (1954) experiments have shown that a differentiating sclereid stimulates the adjacent cells to become sclereid and it may be surmised that a similar condition happens in the thrips galls as well. It is interesting to note that in the second type of roll galls, there is a few-layered tanniniferous zone, following the upper epidermis, a zone of resistance, followed by the region of sclereids ; this concurs with the conventional view and sucking by thrips at the same point causes a more or less depressed growth at the point but increased growth further away (Miles, 1968). This feature is well exemplified in the first type of roll galls where the feeding is confined to the upper epidermis while the sub-epidermal proliferation is exhibited in the lower epidermis and in the second type of roll galls, where the deposition of tannin takes place in the ventral epidermal cells while the cells of the lower mesophyll lack tannin. In thrips galls, the development of a sclerotic zone around this tanniniferous zone is unique, functioning as a zone of resistance and neutralization to the cecidogenetic stimulus, while in the weevil galls the development of sclereids is a consequence of a direct stimulus, unlike the former, so that it functions more as a zone of protection—as in many midge galls.

ACKNOWLEDGEMENTS

We express our gratitude to Dr. Odette Rohfritsch, Laboratoire de Cecidologie, Institute de Botanique, Universitè Louis Pasteur, Strasbourg, France, for critical reading and constructive criticisms. One of us (A.R) is thankful to Prof. R. Rama Rao, Head of the Department of Botany and Rev. Fr. J. Kuriakose, S. J., Principal, Loyola College for their encouragement and laboratory facilities.

REFERENCES

AGRAWAL, B. D. 1970—Structure of some leaf and stem galls of insects. *Cecid. Indica*, 5, (3) : 181—188.

ANANTHAKRISHNAN, T. N. & JAGADISH, A. 1969—Studies on Indian Gall Thrips. *Marcellia*, 36, (1-2) : 7-103.

*FOARD, D. E. 1958—An experimental study of sclereid development in *Camellia japonica*. *Pl. Physoil.*, Lancaster 33 (Supplm) xli.

KANT, U. & ARYA, H. C. 1971—Anatomy of the leaf gall on *Salvadora persica* Linn. induced by *Eriophyes*. *Marcellia*, 37 (1-2) : 47-58.

KARNY, H.W. AND DOCTERS VAN LEEUWEN REIJNVAAN, 1913—Beitrage zur Kenntnis der Gallen von Java. 5. Uber die Javanischen Thysanoptero-Cecidien and deren Bewohner. *Bull. Jard. Bot. Buitenzorg*, X : 1-54.

KRISHNAMURTHY, K. V., RAMAN A. & T. ANANTHAKRISHNAN, N. 1974—On the morphology of the ceratoneon thrips galls of *Schefflera racemosa* Harms. *Marcellia* (in press).

MANI, M. S. 1948—Cecidozoa and Zoocecidia from India *J. R. Asiatic Soc. Bengal* (*Sci*), : 14: 27-197.

MANI, M. S. 1959—Cecidotheca Indica, *Agra Univ. J. Res.* (*Sci.*) 8, (2) : 91-280.

MANI, M. S, 1973—*Plant Galls of India*, Macmillan India. New Delhi.

METCALFE, C. R. & CHALK, L. 1950—*Anatomy of the Dicotyledons* Vol. II, Oxford.

MILES, P.W. 1968—Insect secretions in plants. *Ann. Rev. of Phytopathology*, 6 : 137-164.

*STERLING, 1954—Sclereid development and the texture of Barlett pears : *Fd. Res.* 19 : 433-443.

WESTPHAL, E. 1974—Cecidogenese et aspects ultrastructuraux de la galle en bourse de l'*Eriophyes padi padi* Nal. sur la feuille de *Prunus padus* L. *Marcellia*, 38. (1) : 77-94.

*Originals not seen.

(MS. received 12.5.75)

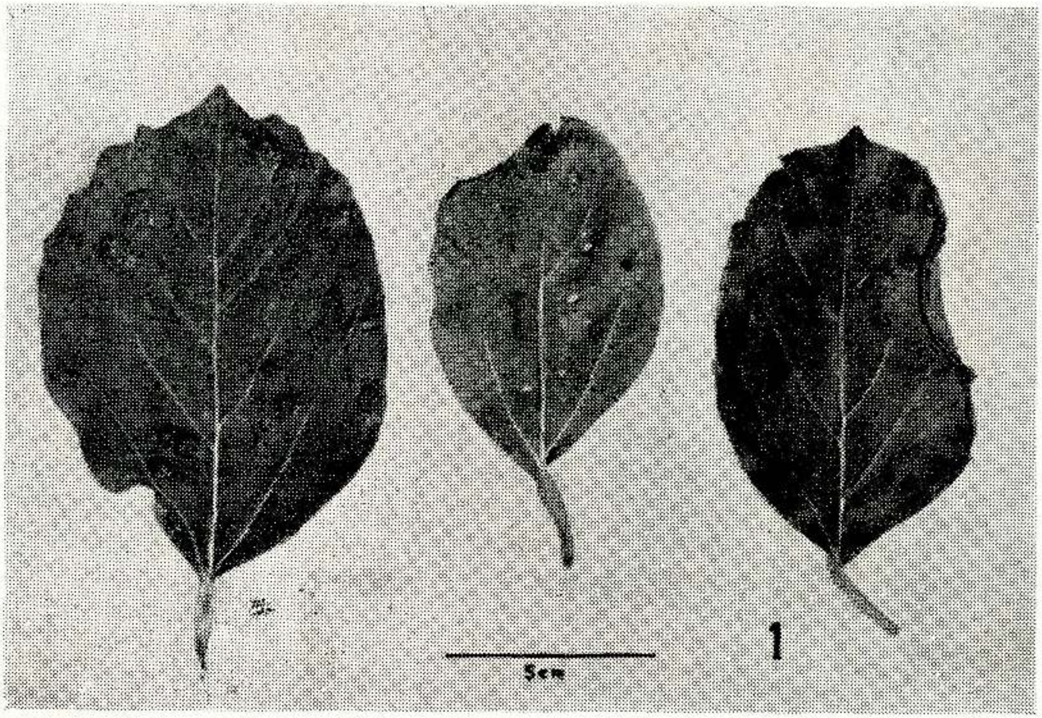


Fig. 1: Photograph showing galled leaves. left: petiole galls caused by the weevil and adaxial view of mite galls; middle: abaxial view of mite galls and petiole gall; right: marginal thrips gall and initial stage of petiole gall with a few mite infections.

Ceylon J. Sci. (Bio. Sci.) Vol. 12, No. 2, November 1977

Lejeuneaceae from Sri Lanka Collected by D. D. Tirvengadum (1974)

by

P. TIXIER

Muséum National d'Histoire Naturelle, Cryptogamie, 12 rue de Buffon, 75005, Paris, France

A list of epiphyllous liverworts collected by Mr. D. D. Tirvengadum during a collecting trip in Ceylon in 1974 is presented below. Some of the species are new records for the Island.

1. *Caudalejeunea reniloba* St.

Ceylon, leg. Tirvengadum.
Tropical Asia and Occania.

2. *Ceratolejeunea thwaitesiana* (Mitt.) St.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, top of Haycock, 700 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 648.
Endemic.

3. *Cololejeunea* sp.

Ceylon, leg. Tirvengadum, material insufficient.

4. *Cololejeunea falcata* (Horik.) Bx.

Ceylon, leg. Tirvengadum.
From Ceylon to Japan and new Caledonia.

5. *Cololejeunea floccosa* (L. & L.) St.

Hiniduma Kande, Galle District, Southern Province, epiphyllous on *Litsea longifolia*, 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 630 ; Kanneliya Forest Reserve, Galle District, Southern Province, lowland in forest clearing, 7-X-1974, leg. Tirvengadum n° 681 (variety with double vitta).
New for Ceylon ; from Sierra Leone and Tanzania to New Caledonia.

6. *Cololejeunea floccosa* (L. & L.) St. var. *aurita* Bx.

Hiniduma Kande, Galle District, Southern Province, epiphyllous on *Litsea longifolia*, 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 630.
New for Ceylon ; Chittagong, Indochina and Western Malesia.

7. *Cololejeunea oshimensis* (Horik.) Bx.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, top of Haycock, 700 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 648.
New for Ceylon ; up to New Caledonia.

8. *Cololejeunea perakensis* P.Tx. nom. sol.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, summit of Haycock, 675 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 645.
Known from Taiping in Malaya.

9. *Cololejeunea triapiculata* (Herz.) P. Tx.

Ceylon, leg. Tirvengadum.
Ceylon, Malaya, Sumatra, Java.

10. *Cololejeunea vidaliana* P.Tx.

Ceylon, leg. Tirvengadum.
Taxon close to *Leptocolea punctata* E. E. Jones, holotype from Bolovens in Laos.

11. *Colura acroloba* (Mont.) S.J.A.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, base of Haycock, epiphyllous on *Litsea longifolia*, 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 630; Beraliya, Proposed Forest Reserve, Galle District, Southern Province, secondary forest in shade, lowland, epiphyllous on *Calophyllum* sp., 20—XI—1974, leg. Tirvengadum & Waas n° 728.
From Ceylon to New Caledonia.

12. *Colura* sp.

Beraliya, Proposed Forest Reserve, Galle District, secondary forest, along path, epiphyllous on bamboo leaf, 20-XI-1974, leg. Tirvengadum & Waas n° 734.

13. *Drepanolejeunea micholitzii* St. var. *dactylophoroides* Herz.

Hiniduma Kande, Galle District, Southern Province, base of Haycock, epiphyllous on *Litsea longifolia*, 400 m, 6-X-1974, leg. Tirvengadum & Waas n° 630, 641, 648.
Indochina, Malesia and New Caledonia.

14. *Drepanolejeunea thwaitesiana* (Mitt.) St.

Beraliya, Proposed Forest Reserve, Galle District, Southern Province, secondary forest along path, lowland, epiphyllous on bamboo leaf, 20-XI-1974, leg. Tirvengadum & Waas n° 688, 734.
From Ceylon to New Guinea.

15. *Drepanolejeunea* sp.

Kanneliya Forest Reserve, Galle District, Southern Province, lowland, logging area, secondary forest, 8-X-1974, leg. Tirvengadum & Waas n° 688.

16. *Drepanolejeunea* sp.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, slope of climb to Haycock, epiphyllous on *Strobilanthes*, 500 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 641.

17. *Leptolejeunea epiphylla* (Mitt.) St.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, base of Haycock, on *Eugenia* sp., 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 631 ; Beraliya, Proposed Forest Reserve, Galle District, Southern Province, epiphyllous on bamboo leaf, 20-XI-1974, leg. Tirvengadum & Waas n° 734.
From Cameroon to New Caledonia.

18. *Leptolejeunea* cf. *grossidens* St.

Beraliya, Proposed Forest Reserve, Galle District, Southern Province, secondary forest along path, on bamboo leaf, lowland, 20-XI-1974, leg. Tirvengadum & Waas n° 728, 734.
New for Ceylon ; New Gunea.

19. *Leptolejeunea rhombifolia* St.

Beraliya, Proposed Forest Reserve, Galle District, Southern Province, lowland secondary forest, epiphyllous on *Calophyllum* sp., 20-XI-1974, leg. Tirvengadum & Waas n° 734 ; Hiniduma Kande, Galle District, Southern Province, lowland wet forest, base of Haycock, epiphyllous on *Litsea longifolia*, 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 630, 631, 632, 650 ; Kanneliya Forest Reserve, Galle District, Southern Province, river bank on sandy soil in forest clearing, 7-X-1974, leg. Tirvengadum n° 678.
L. rhombifolia St., *L. radiata* St. and *L. grossidens* St. are probably synonymous.
New for Ceylon ; Philippines.

20. *Leptolejeunea massartiana* Herz.

Beraliya, Proposed Forest Reserve, Galle District, Southern Province, lowland secondary forest along path, epiphyllous on bamboo leaf, 30-XI-1974, leg. Tirvengadum & Waas n° 734.
New for Ceylon ; Malaya, Java, Sumatra.

21. *Leptolejeunea subacuta* St.

Beraliya Proposed Forest Reserve, Galle District, Southern Province, secondary forest along path, epiphyllous on bambo leaf, 20-XI-1974, leg. Tirvengadum & Waas n° 734 ; Kanneliya Forest Reserve, Galle District, Southern Province, lowland logging area, secondary forest, 8-X-1974, leg. Tirvengadum & Waas n° 688.
Ceylon, Ryukiu, Japan, Vietnam, Cambodia, Malaya, Borneo, Philippines, Formosa.

22. *Leptolejeunea vitrea* (Nees) Herz.

Hiniduma Kande, Galle District, Southern Province, lowland wet forest, base of Haycock, epiphyllous on *Eugenia* sp., 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 631 ; Kanneliya Forest Reserve, Galle District, Southern Province, secondary forest along path, epiphyllous on bamboo leaf, 20-XI-1974, leg. Tirvengadum & Waas n° 734 ; Gilimale Forest, Ratnapura District, Sabaragamuwa Province, clearing in secondary forest, epiphyllous on *Memecylon* sp., 21-XI-1974, leg. Tirvengadum & Waas n° 750.
Mascahenas, Sumatra, Java, Indochina, Philippines, Moluccas, Malaya, New Caledonia.

23. *Microlejeunea cucullata* (Nees) St.

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, base of Haycock, on leaf of *Litsea longifolia*, 6-X-1974, leg. Tirvengadum & Kostermans n° 630. Male plant.
Tropical Asia and Oceania.

24. *Xenolejeunea longiloba* (St.) Kachroo & Schuster

Hiniduma Kande, Galle District, Southern Province, wet lowland forest, top of Haycock, 400 m, 6-X-1974, leg. Tirvengadum & Kostermans n° 645, 648.
From Ceylon to New Caledonia.

25. *Lejeunea micholitzii* Miz.

Kanneliya Forest Reserve, Galle District, Southern Province, river bank on sandy soil in forest clearing, 7-X-1974, leg. Tirvengadum n° 630, 679.
Tropical Asia and Oceania.

REFERENCES

ABEYWICKRAMA, B. A. 1959—The genera of Liverworts of Ceylon. *Ceylon J. Sci.* (*Bio. Sci.*), 2 (1), 33-81.

TIXIER, P. 1973—Bryophytes exotiques. *Bull. Mus. Nat. Hist. Paris* 190, (Bot. 10), 73-96.

(MS. received 29.8.75).

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Notes on Ceylonese Ebony Trees (Ebenaceae)*

by

A. J. G. H. KOSTERMANS†

Herbarium Bogoriense, Bogor, Indonesia

(With one plate)

Ebony is one of the important timbers of Sri Lanka. Its main source is now *Diospyros ebenum* (Kaluwara, Sinhala). It is used mostly for carvings and ebony elephants from Ceylon which are found all over the world.

There are many other kinds of ebony, differing in colour from the jet black of *D. ebenum* to the brown-and-black variegated ones, known as Calamander (a corruption of Kalumediriya), formerly obtained primarily from *Diospyros quaesita*, a very valuable and beautiful timber, which has become very rare nowadays. Other species yield bastard calamander and are sold in small quantities in Colombo.

In Trimen's Flora of Ceylon 4 species of the genus *Maba* (now included in *Diosypros*) are enumerated, of which three are endemic. All three occur in the wettest part of S.W. Lanka and are considered very rare (cf. below) and are little known, with the exception of *Diospyros* (*Maba*) *oblongifolia*. The fourth species (*Maba buxifolia* in Trimen's, Flora, now *Diospyros ferrea*) contrarily occurs in the dry and very dry zones and extends to southern India. Its 3 varieties, enumerated by Trimen, are here treated as species. One of them (*Diospyros rheophytica*) does not occur in the dry zone, but is a rheophyte in the wet forests of S. W. Lanka.

Of *Diospyros* proper, Trimen recognized 20 species, of which no less than 10 are endemic, the latter ones only found in the wetter zones. Those of the dry zone extend to southern India. Only very few extend further northwards in India. *D. malabarica* (now named *D. peregrina*, the "timbeeree"), is the only one with a wider area of distribution in India ; it does not occur in Thailand, nor in Malesia.

Alston (1931) added in the supplement to Trimen's Flora 2 more endemic species, based on the 2 varieties of *D. embryopteris* of Thwaites.

D. opaca Clarke is only mentioned under *D. affinis* in Trimen's Flora. This obscure species is represented by a single specimen in the Kew Herbarium. It seems related to *D. walkeri*, but the lateral nerves on the upper leaf surface are prominulous and not impressed as in *D. walkeri*.

---

* Critical Notes on Ceylon Plants, XXI.

† B. A. Krukoff Botanist of Malesian Botany, Rijksherbarium, Leiden.

As no trace of this species was found, the possibility remains that it does not belong to the Ceylon flora.

In the treatment for the new Flora of Ceylon, a total of 30 species of *Diospyros* are recognized, of which 20 are endemic.

One of the rarest is *D. oppositifolia*, of which perhaps not more than 50 trees grow on the top of Hinidumkanda (Haycock) near Hiniduma in S. W. Lanka.

D. zeylanica is known only in sterile condition.

The genus *Diospyros* has been revised twice, once by Hiern in 1873, the second time by Bakhuizen van den Brink Sr. (Malesian and some extra-Malesian ones) in 1937 to 1941 and is being currently revised by Dr. F. White in Oxford.

Bakhuizen incorporated *Maba* in *Diospyros* and White recently did the same with *Royena*.

The Ceylonese *Diospyros* species have been thoroughly studied by H. Wright and his treatise (in Annals Roy. Bot. Gard. Peradeniya 2, 1904) gives complete descriptions of timber, male, female, and hermaphrodite flowers, germination and seedling characters.

Little can be added to this magnificent piece of work. It is a pity, that Wright did not study also the species of *Maba*. Hence the descriptions of the 6 species, formerly of *Maba*, will be far less complete than those of *Diospyros* proper.

I spent three months (July—Oct. 1974) hunting for *Diospyros* in Ceylon under the auspices of the Smithsonian Flora of Ceylon Project. In this relatively short period I managed to collect fertile material of all species except two. This remarkable feat is certainly partly attributable to my excellent tree climber, Mr. M. R. Sumenaratne (Sumeni) who, during my former explorations in Lanka, had acquired an admirable knowledge of Ceylonese trees. He had a keen eye for ebony trees, found many on his own account and climbed innumerable ones to find flowering or fruiting specimens.

The study of *Diospyros* specimens in the herbarium meets with some difficulties. Most species are dioecious and male and female flowers may differ, not only in size, but especially in the size of the calyx lobes, which in the female flowers are often very much larger and differently shaped. The calyx, moreover, increases continuously during anthesis, the lobes becoming patent or reflexed. A useful character is the flower-bud shape, just before anthesis (cf. Wright). As observed by me in *D. ebenoides*, the buds may remain in their final stage for weeks, before expanding.

The leaves of the trees of different sex are identical. There is no more variation in size, etc. than in other tree families. Young leaves show a peculiar characteristic, that they are reddish on the upper surface only, the underside being green. In *D. peregrina* the flush has flaccid, pendulous, white leaves.

In species belonging even to different sections, the leaves may be strikingly alike, which makes identification of sterile material not easy. Closer observation, however, will usually result in finding differences, however small.

The tomentum of the branchlets, important for identification, can only properly be studied in the flush ; in the resting period, the branchlets, even of species with a very hairy flush, may be glabrous or nearly so.

The position and number of stamens in male and hermaphrodite flowers is rather variable and unstable. In polygamous trees male and female flowers may occur in the same inflorescence or in different ones, or taking a different position in the same one. Wright suggests that there is even a possibility, that the sex of the flowers changes during the successive flowering periods.

The fruiting calyx is the easiest tool to distinguish the species, with the restriction, that only fully-grown ones should be compared ; e.g., in *D. oocarpa* the calyx is barrel-shaped, but under the ripe fruit it has become small, pateriform. In *D. affinis* and *crumenata* the calyx is initially very large and intricately folded, at the fruiting stage it is flattened and more or less smoothed out.

The endosperm may be equable or ruminate. I consider this a constant character, contrarily to Bakhuizen, who mixed (in the section *Maba*) good species with one or the other character. Wright has presented an admirable exposition of the intricacies of the germination of Ceylonese species. Cotyledons may remain within the seed coat and drop early, or they may develop into "normal" leaves, hardly or not distinguishable from the subsequent leaves.

The extraction of the cotyledons from the seed-coat, especially during dry weather, may hamper development, and the scarcity of some species, according to Wright, is attributable to this.

The distribution pattern of *Diospyros* in Ceylon is not different from that of other families which I have studied (*Guttiferae*, *Bombacaceae*, *Sterculiaceae*, *Lauraceae*, *Mimosaceae*). Species occurring in the dry zone are usually also found in adjacent Peninsular India (but usually not further northward !). *D. peregrina*, with a wide distribution, is replaced in Thailand and Indo-China by the closely related but different *D. siamensis*. In Java and Celebes it is replaced by the forma *javanica* (of which the flowers have not been studied properly).

Species of the wet and mountain zones are practically all endemic and I suspect that many which occur in the southern part of Peninsular India actually represent different species (as was proved also in *Cullenia*, Bombacaceae).

1. Diospyros acuminata

(Thw.) Kostermans, comb. nov.—*Macreightia acuminata* Thwaites, Enum. Pl. Zeyl. 424. 1864 (basionym).—*Maba acuminata* (Thw.) Hiern in Trans. Camb. phil. Soc. 12 : 112. 1873.—*Diospyros imbricata* Bakhuizen in Bull. Jard. bot. Buitenz. Ser. 3, 15 : 22. 1937—Type : *C.P.* 3718 (PDA).

Bakhuizen apparently created a new name, because of *Diospyros acuminata* Wallich, Cat. 4129, which is, however, a nomen nudum (it represents *Litsea myristicaefolia*, Lauraceae).

The fruit is up to 2.5 cm diam, much larger than described by Trimen (6 mm).

Locally it is not rare.

2. Diospyros affinis

Thwaites, Enum. Pl. Zeyl. 179. 1860 (excl. *C.P.* 2924, p.p., quoad *D. opaca* Clarke) ; Trimen, Fl. Ceylon 3 : 102. 1895 ; Wright in Ann. R. Bot. Gard. Perad. 2: 194, t. I (4), II (7), X (1—6). 1904 ; Worthington, Ceylon Trees 315. 1959—Typus : *C.P.* 2924 p.p. (PDA).

Part of the collection *C.P.* 2924 has been segregated by Clarke (in Hooker f., Fl. Brit. Ind. 3 : 567. 1882) and described as *D. opaca* Clarke. According to Clarke this male specimen differs by the texture, nervation of the leaves (smooth), its indumentum (early glabrous in *D. affinis*), the very deeply lobed male corolla and the number of stamens (16 against 8—9) : in too many points to be conspecific with *D. affinis*. The only specimen known is conserved in the Kew Herbarium. It resembles *D. walkeri*, but the lateral nerves on the upper leaf surface are prominulous.

3. Diospyros albiflora Alston

Of this very rare species, described after a single specimen collected more than a century ago, and originally considered a variety of *D. embryopteris* (*D. peregrina*), I have found a single tree in fruit in the Morapitiya logging area, which enables me to give a better description of the fruit. Unluckily this tree was blown over and I have never found another one.

4. Diospyros atrata Alston

This species is known from a single collection, and was formerly considered to be a variety of *D. embryopteris* (*D. peregrina*). In the Peradeniya Botanic Garden is a magnificent specimen, of which I have been able to collect ripe fruit, which confirms Alston's opinion that it is different from *D. peregrina* ; once I found a flowering specimen in the Gannoruwa jungle behind the Botanic Gardens. The species is very rare.

5. Diospyros attenuata Thw.

Considered by Trimen a very rare species. This is not entirely true. In the wet evergreen forest area in S.W. Lanka it is rather common.

6. **Diospyros chaetocarpa**

Kostermans, nom. nov.—*Macreightia ovalifolia* Thwaites, Enum. Pl. Zeyl. 424. 1864 (base).—*Maba ovalifolia* (Thw.) Hiern in Trans. Camb. phil. Soc. 12 : 113. 1873.—*Ebenus ovalifolia* (Thw.) O. Kuntze, Rev. Gen. Pl. 2 : 408. 1891.—Typus : *C.P.* 3717.

Described as a small tree by Trimen, which is wrong. The few trees discovered on Hinidumkanda (Haycock) and Godakande near Hiniduma were up to 20 m high and 50 cm in diameter. I was able to collect submature fruit (so far unknown) of this little known species, which occurs in a very restricted area.

7. **Diospyros crumenata** Thw.

I have not been able to collect this species, although some trees were marked.

The description is based on that of Wright. It seems to be very near to *D. affinis*.

8. **Diospyros ebenoides** Kostermans, spec. nov.

Maba buxifolia, var. *Ebenus* Thwaites (non Spr.), Enum. Pl. Zeyl. 183. 1860 (excl. *Maba ebenus* Wight) ; Hiern in Trans. Camb. phil. Soc. 12 : 117. 1873 ; Clarke in Hooker f., Fl. Br. Ind. 3 : 551. 1882 ; Trimen, Handb. Fl. Ceylon 3 : 90. 1895 (excl. syn.).—*Diospyros ferrea*, var. *Ebenus* (Thw.) Bakh. in Bull. Jard. Bot. Buitenz, Ser. 3, 15 : 432 & 438 (quoad specim. Ceylon ceter. exclus). 1941—Typus : *C.P.* 3395 (PDA).

Arbor parva, ramulis tenuis glabris griseis vel sparse minutissime adpresse pilosis, innovationibus sparse adpresse albo sericeis, folliis alternantibus coriaceis glabris ellipticis vel subovato-ellipticis obtusis basi acutis, supra obscure laxe prominule reticulatis nervo mediano tenuis impressis, subtus prominule laxe reticulatis nervo mediano gracilis prominentibus costis filiformis erecto-patentibus prominulis marginem versus arcuato-conjunctis, pedicellis brevis, floribus foemineis solitariis axillaribusque, calyx glabris, campanulatis, lobis tubo 3 × minoribus triangularis acutis, corolla tubuliformis dense adpresse pilosis albis calicyne ½ × longioribus staminidiis 6, filaments et antheris longis, fructibus globosis, calycibus pateriformis vel margine reflexis fere ad basin incisis vel completus, vix incrassatus.

Tree, up to 4 m high and 8 cm diam. Bark black, finely fissured, roughish to the touch, 1 mm thick. Live bark 2—3 mm thick, reddish to light brown. Branchlets slender, flexible, glabrous or apically sparsely, minutely adpressed pilose. End-bud sparsely adpressed pilose. Leaves alternate, glabrous, coriaceous, elliptic to subobovate-elliptic, 1 × 3—2.5 × 6—4 × 9 cm, obtuse, base acute ; above obscurely, laxly reticulate, midrib slender, impressed, below laxly, prominulously reticulate, lateral nerves 6—10 pairs, erect—patent, at some distance from the margin arcuately connected. Petiole 2—3 mm, slender. Young leaves pale reddish above, green below (fresh).

Female flower solitary, axillary, sessile on very short branchlet, calyx pale green (fresh), glabrous, campanulate, 3 mm long. Lobes 3, acute, erect, 1 mm long, inside slightly pilose near apex. Corolla tubular, white, densely white adpressed pilose, 6—8 mm long. Lobes 3, oblong, acute, 1.5—2 mm long. Staminodes 6, filament rather short, another long, slender, acute. Ovary densely pilose.

Fruit globose, 6 mm diam., smooth, yellowish, rarely apiculate. Fruiting calyx flat or reflexed, 5—7 mm diam., lobes inconspicuous or lacerated to the base.

Distribution : Endemic.

Occurrence : Intermediate zone, becoming very rare.

Notes : *Maba ebenus* Thw. is not the same species as *M. ebenus* Spr.; as elucidated by Bakhuizen, the latter represents *D. ellipticifolia* (Stokes) Bakh., (= *D. elliptica* (Forst & Forst) Green) nor is it conspecific with *D. neilgerrensis* (not *neilgherrensis* as spelt by Thwaites, Hiern, and Bakhuizen).

Under *D. ferrea,* Bakhuizen quoted erroneously *Maba buxifolia,* var. *ebenus* (Stokes) Thwaites. Thwaites did not make this combination and Stokes' plant is *D. ellipticifolia.*

The species is distinguished from *D. ferrea* by the large and elliptic leaves and the flat fruiting calyx. It does not occur in the distributional area of *D. ferrea* and is rare.

Diospyros neilgerrensis Wight is a proper species, easily recognizable by the shape of the leaves (cf. *D. rheophytica*).

The name is inappropriate as it does not contain ebony, neither is it related to *D.. ebenum.*

Badulla Distr. : Road Mahiyangana-Bibile, mile 13, along small rivulet, dry in the dry season, June, fl., *Kostermans* 25107 (A, BO, G, K, L, P, PDA, US) ; July, fl., fr., *Kostermans* 25300, 25304, 25305 (id). ; Aug., fl., buds and young ft., *Kostermans* 25331, 25332 A, 25350, 25428 (id.) Colombo Distr. : Mirigama, Kandalama Hill, alt. 100 m, Sept., fl., fr., *Kostermans* 25580 (id.), locality unknown, *C.P.* 3395 (PDA).

9. **Diospyros ebenum** Koenig

Commercial ebony has been imported into Europe since remote times. It is assumed that *D. melanoxylon* was the source of the first ebony of Asia brought to Europe.

The first description of the commonest Ceylon ebony, which is jet black, we owe to Koenig, although the wood was already mentioned by Grimm, a century earlier (Laboratorium Ceylanicum, 1679), and the earliest record of Ceylon ebony from Trinkenemale (Trincomalee) we find in Rumphius' Herbarium Amboinense 3 : 4. 1750.

In an extensive article Howard & Norlindh in J. Arn. Arb. 43 : 94—107. 1962 (they are further referred to here as H. & N.) discussed the typification of *D. ebenum* and the status of *D. ebenaster* Retz. I myself had the opportunity to study all the pertinent material in both the Copenhagen and Lund herbaria in June 1975.

The Lund collection of Koenig has been worked up by Fischer in Kew Bull. 1932 : 49, an article not mentioned by H. & N. ; neither were they acquainted with the important article by Rendle in J. of Bot. 71 : 143—153 ; 175—187. 1933.

The purpose of the authors—as stated—was:1. typification, 2. proper citation of the name and 3. synonymy. I have followed their sequence here (2-1-3).

2. Proper citation. Ceylon ebony was described in Lund physiographiske Sälskapets Handlinger, vol. I, printed in Stockholm in May 1781. The article (no. 25), according to H. & N. does not indicate the author, in contrast to other articles in the periodical. I disagree, as e.g. the next article (no. 26), has exactly the same way of quoting the author.

The title reads : *Diospyros ebenum* or true ebony, described by John Gerhard Koenig. This clearly indicates that Koenig was the author, although the German text of the article had been translated by Retzius into Swedish and the Latin description slightly improved. Moreover, the Editor (Retzius) added in a footnote in small print some comments on the article and gave an eulogy on the work and endeavours of Koenig.

The original manuscript description is conserved in the Copenhagen herbarium (part shown on text figure I in H. & N'.s article).

Hence—in my opinion—the correct author citation should be : *D. ebenum* Koenig and not Koenig ex Retz. as H. & N. want it.

1 and 3. Selection of a lectotype and synonymy. "The original description is a composite one, including unisexual and hermaphrodite flowers and fruit. It was obviously based on a field knowledge of the plant in Ceylon" (H. & N.).

In my opinion this is not so obvious. Koenig had made extensive collections or (more likely) had them brought to him by his assistants, cf. Koenig's letter in Rendle (l.c. 148) and his descriptions are certainly partly based on these. As no specimens are enumerated by Koenig (quite normal at that time !), a lectotype should be chosen from Koenig's material, which fits best with the protologue.

Koenig (born in Kurland in the Baltic, as far as is known) was employed as physician by the Danes in Tranquebar and hence sent material to Rottboell in Copenhagen ; but not only to Copenhagen, as is evident from a sentence in one of his letters: "von welchen Allen ich im vorighten Jahr *auch* nach Copenhagen zureichende Exemplaren übersandt habe". H. & N. omit the important word "auch" (also). Koenig had sent material to many people (cf. Rendle, l.c. 175) and via Copenhagen also to Retzius in Lund.

After Koenig's death his papers and specimens were bequeathed to Banks and H. & N. omitted to inspect this material at the British Museum, London, which may contain the actual type material. Koenig sent—of course—also material to his teacher Linnaeus ; this was worked up by Linnaeus fil., not entirely to the satisfaction of Koenig, who wrote in one of his letters, that he had a lot of remarks on Linnaeus' fil. Suppl. Plantarum.

The following specimens are discussed by H. & N. I have numbered them here, in order to facilitate discussion.

Sheet I in the Retzius herbarium is a male flowering specimen (plate IV b in H. & N) which bears the caption reproduced in plate V d. It was sent by Vahl from Copenhagen. H. & N. assume that this might cover the concept of *D. ebenaster* Retz., in which I disagree, as *D. ebenaster* was based on a specimen from Calcutta (cf. below). At any rate this specimen is part of the type material of Koenig.

Sheet II. This Copenhagen specimen is depicted on pl. IV*a* with its caption on pl. V*c*, a male flowering specimen, which is almost certainly the same collection as sheet I (flowers at the same stage of development) and apparently part was sent by Vahl to Lund. The specimen showed a label of more recent date in the left hand top corner. This has been removed, but traces of removal are still visible (June 1975). It took some time to find out, that this specimen had been used for an exhibition and was hence provided with an explanatory label, which was misread by H. & N. It does not say that the plant was collected in Tranquebar (on the reverse in bold writing it is stated that it was a Ceylon specimen), but simply that this was an original specmen of Mr. Koenig from Tranquebar. Both this and the Lund duplicate are accompanied by wood and bark samples (not reproduced in sheet I).

Sheet iii. In Lund and also in Copenhagen (the latter not seen by H. & N.), one with young and mature fruit (plate I). The duplicate in Copenhagen bears the caption : *Diospyros (ebenum) ebenaster*. However, it cannot be *D. ebenaster* as it has thin leaves and was collected in Ceylon.

H. & N. were not aware that this (plate I) is not *D. ebenum*, but *D. montana* Roxb. !

I assume that this is the base of *D. ebenum* Retzius (non Koenig) which thus becomes a synonym of *D. montana*.

It is not unusual that species were mixed up by Koenig (cf. my remarks on *Garcinia morella* and *G. spicata* in Ceylon J. Sci., Biol. Sci. 12 (1) : 55 – 71. 1976).

The Linnaean material in London has been considered a mixture by Retzius and other botanists. I have not seen this material. Rendle writes, that in Koenig's manuscript there is a mixture of descriptions of *D. melanoxylon* and *D. ebenum*.

The status of *D. ebenaster* Retz. remains—in my opinion—unsolved. We can hardly assume that Retzius was that stupid, that he did not recognize two proper species.

There are two possibilities : (*a*) the base of *D. ebenaster* was indeed a specimen from Calcutta (where Koenig collected !) and the description is correct, in which case a third species is involved, which conforms most with *D. ebenum* Roxb. (non Koenig) as depicted on a Roxburgh plate and copied by Wight, Icones 1 : t. 188, with oblong leaves and very large calyx lobes ; (*b*) Retzius' description is partly wrong or was based on a specimen of *D. ebenum* with obtuse leaves (not unusual) and that the specimen was mislabeled "Calcutta."

The latter possibility with the numerous assumptions was accepted by H. & N.

I believe that it is better not to jump too quickly to conclusions and the only hope is that a duplicate of the Calcutta plant will turn up in London, and/or that more material becomes available from the Calcutta area. Meanwhile I prefer to consider *D. ebenaster* Retz. an obscure species.

Hiern's misinterpretation of *D. ebenaster* has stuck for a long time ; H. & N. have solved this puzzle (l.c. 101).

Sheet IV. The fruiting specimen in the Linnaean Herbarium (plate III b) is annotated : *König* 1777. Ebenus verum ex vastis sylvis Zeylonis. Flores non vidi ! An Diospyros ?

As H. & N. pointed out, this was most likely sent to Linnaeus at the time that Koenig still had no flowering material (Koenig's letter after the first visit to Ceylon, where he arrived on May 19 1777 at Trincomalee and wrote that he had not been able to procure flowers). This material was described by Linnaeus fil. (Suppl. Pl. Syst. Veg. 440, Summer 1781), a couple of months later than Koenig's paper (May 1781).

Sheet V. Rottboell produced in 1783 another description of Ceylon ebony (in Nye Saml. K. Danske vidensk. Selsk.k Skrifter 2 : 540, t. 5) changing the name to *D. glaberrima* Rottb. The holotype is in Copenhagen, a fruiting specimen of Koenig from Ceylon (plate II).

There is no problem here : the specimen is well marked (plate V b).

Howard & Norlindh accept this also as the lectotype of *D. ebenum* Koenig. There is nothing against this, as the sheet is one of the many used by Koenig, although Koenig described more mature fruit, and if such a specimen should be discovered it should have preference.

H. & N. then proceed (p. 100) to discuss Bakhuizen's treatment of *D. ebenum* in his monograph, which they call—rather politely—inconsistent and less than clear. Errors in nomenclature, omissions and inconsistencies, but also mis-interpretations of species abound in Bakhuizen's work. Some of these are mentioned by H. & N.

I shall add here some which have a bearing on *D. ebenum* and refer to only the most blatant errors.

Bakhuizen was apparently unaware that the word *glaberrima* in Linnaeus' fil. protologue was the first word of the descriptive phrase, and hence quoted it as *D. (ebenum) glaberrima* and also as *D. glaberrima* L. f. and made the new combination *D. ebenum*, var. *glaberrima* (L. f.) Bakh.

His argument that *D. ebenaster* Retz., should be conspecific with *D. ebenum* Koen. simply because it was poorly described, needs no comment and although he had in his comment and in the reference list reduced it definitely to *D. ebenum*, under var. *glaberrima* it appears again with an interrogation mark (another illustration of this queer way of reasoning is found in the note on *D. ellipticifolia*, p. 229, where even the expression "hypothetic combination" turns up).

Bakhuizen writes that var. *glaberrima* was first described from Hindustan (sic ! it is Ceylon) and mentions (p. 220) the specimen *Thwaites C.P.* 1912/1913 from Ceylon, which he calls western India !

Many references apparently were never properly checked, e.g. Gaertner f., Suppl. Carp. t. 20. 1807 is not *D. ebenum* Koenig and Sprengel, Syst. Veg. is a mixture of 2 species.

Bakhuizen recognized two varieties (p. 219), but unluckily the specimens of these are mixed in the enumeration and can only be tallied with annotated herbarium sheets. He is wrong in citing *D. ebenum* from the Malay Peninsula.

The var. b. *timoriana* (based on *D. reticulata*, var. *timoriana* DC. = *D. timoriana* (DC) Miq.) is a different species with very large pilose fruit ; even in sterile condition it may be easily recognized by the chocolate, pilose underside of the leaves. *D. timoriana* should be re-instated as a proper species.

Curiously enough ebony is not mentioned by Hermann, although it must have been already an export commodity. Burman (Thesaurus Zeyl. 91. 1737) mentioned only the wood, quoting from Grimm, Laboratorium Zeylanicum, 1679.

A.DC. (in DC., Prodr. 8 : 234. 1844) ascribed *D. ebenum* to Retz., apparently not acquainted with Koenig's paper. He followed Retzius in considering Linnaeus' fil. *D. ebenum* a mixture of two species. He included also Roxburgh's (not Retz.) *D. ebenaster*, which was right.

He doubted whether *D. ebenaster* Retz. was different from *D. ebenum* Koen.

Thwaites likewise attributed *D. ebenum* to Retz. and commented that Roxburgh's plate (copied by Wight, Icon. 188) was not characteristic of *D. ebenum*.

Hiern (l.c. 30) lists the plant as being poisonous for birds and (p. 31) as an edible one. Here again a mixture of several species.

10. **Diospyros ferrea**

(Willd.) Bakhuizen in Gard. Bull. S. S. 7 : 162. 1933 ; in Bull. Jard. Bot. Buitenz, Sér. 3, 15 : 50. 1937 (pro minime parte).—*Ehretia ferrea* Willd., Phytogr. 1 : 4, t. 2, fig. 2. 1794 — Typus : *Koenig* ex Ind. or. in Herb. Willd. (Berlin).

Pisonia ? buxifolia Rottboell in Nov. Act. Haffn. (Nye Saml. Kgl. Danske vidensk. Selsk. Skrifter) 2 : 536, t. 4, fig. 2. 1785.—*Ferreola buxifolia* (Rottb.) Roxb., Pl. Corom. 1 : 35, t. 45. 1795 ; Fl. Ind. ed. Carey 3 : 790. 1832 ; Willd., Sp. Pl. 4 (2) : 798. 1806 (*Ferriola*).—*Maba buxifolia* (Rottb.) A. Juss. in Ann. Mus. Hist. nat. Paris 5 : 418. 1804 ; Wight, Ic. Pl. Ind. Or. 3 (1) : 4, tab. 763. 1843 ; A.DC. in DC., Prod. 8 : 240. 1844 (excl. cit. Burma) ; Thwaites, Enum. Pl. Zeyl. 3 : 183. 1860 (*C.P.* 477 ; excl. vars) ; Hiern in Trans. Camb. phil. Soc. 12 : 116. 1873 (p.p., quoad pl. Ceylon, et Ind. or., caeter. exclus.) ; Beddome, Forest. Man. in Fl. Sylv. 3 : 148, t. 19, fig. 4. 1869 ; Clarke in Hooker f., Fl. Br. Ind. 3 : 551. 1882 (excl. synonyms, excl. cit. Kurz) ; Trimen, Handb. Fl. Ceylon 3 : 89. 1895 (exclus. vars) ; Fischer in Kew Bull. 1932 : 59 ; Anon., Wealth of India 3 : 78. 1952.—*Ehretia buxifolia* (Rottb.) (non Roxb.) Pickering, Chron. Hist. Pl. 746. 1879.—*Ebenus buxifolia* (Rottb.) O. Kuntze, Rev. Gen. Pl. 2 : 408. 1891—Typus : *Koenig* e Ceylon (C).

Diospyros ferrea, var. *buxifolia* (Rottb.) Bakh., l.c. 57, 59. 1937 & 432. 1941, p.p., quoad cit. spec. Ceyl. et Penins. Ind. Or., caeter. exclus.).

Highulhaenda Hermann, Mus. Zeyl. 21. 1717 ; *Highulhaenda folio Myrti*, Burman, Thes. Zeyl. 121. 1737 ; Linn., Fl. Zeyl. 202 n. 430. 1748 ; Moon, Cat. Ceyl. Pl. 68. 1824.

The description of *D. ferrea* was based on material collected by Koenig on the Malabar coast in the Indian Peninsula. Koenig had also sent material to Rottboell in Copenhagen who described it as *Pisonia ? buxifolia*, the oldest name for this plant. Both Willdenow and Rottboell mentioned the vernacular name (Tamil) spelling it Irrumbili and Frambulli from the undecipherable name written by Koenig. Roxburgh recognized the true status of the species and called it *Ferreola buxifolia* in 1795. The type specimens of Rottboell and Willdenow are most likely of the same collection. A.DC. included some specimens from Tenasserim in Burma, which are perhaps *D. littorea* (R. Br.) Kosterm.

Hiern in his monographic treatment included a large number of specimens outside of Ceylon and southern India, some even from Africa and Madagascar. His example was followed by Bakhuizen, who went even a step further, making the species concept a very heterogeneous one.

Fosberg (Occas. Papers B. P. Bishop Mus. 15 (10) : 121. 1939), treating Hawaiian species of this conglomerate, segregated again some species but left *D. sandwicensis* a subspecies of *D. ferrea*.

I have collected *D. ferrea* numerous times in Ceylon and am also familiar with *D. littoralis* in Java and I feel that they are rather easily distinguishable by their leaf shape, being obovate to spathulate in *D. ferrea* and *oblong* in the other. A single (abnormal) leaf may be an exception to the general rule and should not be used to prove that there are intermediate forms.

Bakhuizen's concept of the species is much too broad and many distinguishable species can be recognized in his conglomerate. *D. sandwicensis*, e.g., can easily be recognized by its thick, minutely pitted leaves and should be re-instated as a proper species with all subspecific entities of Fosberg (l.c.). Likewise *D. ferrea*, var. *salomonensis* Bakh. is a proper species and is herewith renamed **Diospyros salomonensis** (Bakh.) Kosterm., comb. et. stat. nov. (basionym: *D. ferrea*, var. *salomonensis* Bakh. in Bull. Jard. bot. Buitenz. Sér 3, 15 : 57. 1937 and 434. 1941).

Thwaites (l. c.) included three varieties, which (Trimen) are sharply separated. I have raised them to specific rank. A big mistake was the inclusion of var. *angustifolia* which has an entirely different ecological habitat, being a rheophyte in the wettest part of Lanka, whereas *D. ferrea* proper occurs solely in the drier and driest parts. They can be easily distinguished by their leaf shape.

Moreover, the var. *angustifolia* (which I renamed *D. rheophytica*) Thwaites is not the same as *Maba angustifolia* Miq. (reduced to var. *angustifolia*), the latter being a plant from the south India mountains with a different tomentum and conspecific with *D. nigrescens* Dalz. (*M. angustifolia* Miq. has priority: cf. below under *D. rheophytica*).

11. **Diospyros koenigii** Kostermans, spec. nov.

Arbor mediocris, ramulis gracilis apicem versus minutissime, sparsissime adpresse pilosis, foliis alternantibus, chartaceis, glabris, oblongis vel ellipticis obscure late brevissime obtuse acuminati vel obtusis, basi in petiolum breven contractus, acutiusculus, utraque dense minuteque prominule reticulatis, fructus ellipsoideus, acutis, calycis cupuliformis nec profundis, lobis incrassatis, late spatulatis, acutis plicatis, reflexis, distantibus.

Typus : *Kostermans* 25355 (L).

Tree, up to 15 m high and 50 cm diam. Buttresses high, small, merging into the fluted bole. Bark black, fissured, strips 2 mm wide, wavy, 2 mm thick. Live bark white to light brown, 3 mm thick. Leaves alternate, chartaceous, glabrous, oblong to elliptic, 3 × 7 —6 × 13 cm, obtuse or obscurely, broadly, shortly, obtusely acuminate, base contracted into the slender, ca. 1 cm long petiole, shortly acutish ; upper surface glossy, midrib slender, impressed, lower surface paler, less glossy, the reticulation rather obscure, midrib prominent, lateral nerves 6—8 pairs, very slender, erect–patent, the 2 or 4 lower ones steeper.

Fruit axillary or on a very short, slender, pilose axillary branchlet, sessile, globose, up to 2½ cm diam. Fruiting calyx green, consisting of a rather shallow cup, densely sericeous inside ; the lobes completely reflexed, not very woody, broadly spathulate, acute, plicate, with a wide interspace ; inside very sparsely, adpressed minutely pilose ; with at their base an upright, 2 mm high, thin, wavy rim. Seeds slender, flat-convex, 14 mm long, 4 mm wide, 2 mm thick, endosperm equable.

Distribution : Endemic.

Occurrence : Thus far only found in the Gannoruwa jungle behind the Botanic Garden, Peradeniya.

Notes : The leaves can easily be mistaken for those of *D. ebenum*, except that they are chartaceous and have a less conspicuous reticulation. The fruits are entirely different in shape and so is the calyx. As the lobes are already completely reflexed, it follows that the fruits are mature.

From *D. crumenata* it differs by the reticulate leaf and different fruit.

Kandy Distr. : Gannoruwa jungle, behind Botanic Garden, Peradeniya, alt. 500 m, wet zone, Aug., fr., *Kostermans* 25353 (A, BO, G, K, L, P, PDA, US), 25355, 25434 (id.), May, young fr., *Kostermans* 24035 (id.) ; cultd in Bot. Gard. Peradeniya (sub *D. crumenatum*), May, young fr., *Kostermans* 24858 (id.).

12. Diospyros montana

Roxb., Pl. Corom. 1 : 37, t. 48. 1795 (except fruit) ; Fl. Ind., ed. Carey 2 : 538. 1832.—Type : Tab. 48, Pl. Corom.

Diospyros montana, var. *montana* (Roxb.) Hiern in Trans. Camb. phil. Soc. 12 : 221. 1873 ; Bakhuizen in Bull. Jard. bot. Buitenz., Sér. 3, 15 : 203. 1937.

Diospyros cordifolia Auct. (non Roxb.), Thwaites, Enum. Pl. Zeyl. 178 & 423. 1860 (Jaffna : Gardner).

Closely related to *D. cordifolia* with which it has been sometimes combined. Gamble keeps it separate and stresses the differences. The two species occur in different areas, only in India there is overlap. The Ceylonese *D. montana* is constant in pilosity characters, only the fruit is variable, the common ones being globose-ovoid, acute and apiculate. Occasionally they are globose. In the very dry northern and northwestern Provinces the fruits are very small, more compressed, only 8 mm in diam. but still acute and apiculate.

According to Gamble *D. montana* should have larger fruit than those of *D. cordifolia*, contrarily to the information given in Wealth of India (3 : 84. 1932).

Worthington (Ceylon Trees 319. 1959) mentioned dentate leaves ; this is pseudodentation caused by folding.

Wight's plate (Icon. t. 1225. 1848) is better than Roxburgh's (the stigmas are not bifid as they should be). In Roxburgh's plate the calyx is pressed against the fruit, entirely different from the completely reflexed calyx lobes in our *D. montana*.

D. montana is quite aberrant among the other *Diospyros* species for two reasons : (1) the bark is almost white, completely smooth (like guava bark) with a greenish yellow thin sap and (2) like *D. chloroxylon* in India it has spines, formed from stumps of branchlets.

13. **Diospyros nummulariifolia** Kostermans, spec. nov.

Maba buxifolia var. *microphylla* Thwaites, Enum. Pl. Zeyl. 183. 1860 ; Trimen, Handb. Fl. Ceylon 3 : 90. 1895.—Type : *C.P.* 1916 (PDA).

Arbor parva, ramulis gracillimis dense foliatis apicem versus sparse, minutissime adpresse pilosis, foliis parvis coriaceis, obovato-cuneatis, apice late rotundatis, basi in petiolum breven sensim attenuatis, supra laevia, subtus obscure laxe prominule reticulata, costis utrique 3—4 erecto-patentibus, fructis ut in D. ferrei sed minoribus cupulis vix vel non incisis.

Typus : Kostermans.

Treelet, up to 3 m high and 5—6 cm in diam. Bark black, finely fissured, smoothish, strips 2 mm wide, 1 mm thick. Live bark reddish brown to brown, 3 mm thick. Crown small, very dense. Wood white. Branchlets slender, stiff, apically with a sparse tomentum of short sericeous adpressed hairs. Leaflets numerous. Leaves coriaceous, obovate-cuneate, 4 × 5—5 × 10 mm, apex broad, rounded, base gradually attenuate, above smooth, below midrib prominulous, laterals 3—4, smooth, broad, obscure, prominulous, reticulation lax, obscure, the veins broad, smooth. Petiole 1—2 mm long.

Flowers not seen.

Fruit brown-red, ellipsoid-ovoid, laterally slightly compressed, 5—6 × 8 mm, apiculate. Pericarp thin, brittle. Calyx cup-shaped, wide, shallow, up to 2 mm deep, the margin entire or slightly wavy, showing the 3 lobes. Seeds usually 2, wedge-kidney-shaped, flattish, 4 mm long, smooth, brown, endosperm equable.

Notes : Very close to *D. ferrea*, but differs constantly in the very small wedge-shaped leaves with few lateral veins and the smaller fruit with a shallow cup with almost entire margin.

It could be treated as a variety of *D. ferrea*, but I prefer to give it specific rank as it occurs in the same (although more restricted) area as *D. ferrea*, remains always smaller and can always in the field be easily picked out from *D. ferrea*.

Vavuniya Distr.: Near Vavuniya, road to Anuradhapura, very dry zone, low scrub, July, fr., *Kostermans* 25112, 25113, 25231, 25216 (A, BO, G, K, L, P, PDA, US) ; Road Vavuniya to Madhu, July, fr., *Kostermans* 25210 (id.); Thunukai near Vavuniya, July, fr., *Kostermans* 25264 (id.) ; E. coast near Kalmunai, low sea dunes, June, fr., *Kostermans* 24349 (id.).

14. Diospyros oblongifolia

(Thw.) Kostermans, comb. nov.—*Macreightia oblongifolia* Thwaites, Enum. Pl. Zeyl. 183. 1860 & 423. 1864.—*Maba oblongifolia* (Thw.) Hiern in Trans. Camb. phil. Soc. 12 : 112. 1873.—*Ebenus oblongifolia* (Thw.) O. Kuntze, Rev. Gen. Pl. 2 : 408. 1891.—Typus : *C.P.* 3396.

15. Diospyros malabarica

(Desr.) Kostel., Allg. med.-pharm. Fl. 3 : 109. 1834 ; Bakhuizen in Bull. Jard. bot. Buitenz., Ser. 3, 15 : 325. 1937 (exclus. vars. *atrata* & *nervosa* Thw., excl. forma *atrata* & *nervosa* Bakh.).—*Garcinia malabarica* Desrous. in Lam., Encycl. 3 : 701. 1791—Typus : Panitsjika maram Rheede, Hort. Mal. 3 : t. 41. 1682.

Diospyros peregrina (non Guerke), Anon., Wealth of India 3 : 85, fig. 47, col. pl. 10. 1952.

Diospyros malabarica, f. *pallida* Bakh., l.c. 329.

Diospyros Embryopteris (non Spr., nec Bojer) Persoon, Syn. 2 : 624. 1807 ; Thwaites, Enum. Pl. Zeyl. 178. 1860 (excl. vars. ; *C.P.* 1915).

Embyropteris glutinifera Roxb., Pl. Corom. 49, tab. 70. 1795 ; Wight, Icon. Pl. Ind. Or. 3 : (4), t. 843, 844. 1848 (*glutinifera* & *glutenifera*).

Embryopteris peregrina Gaertner is a validly published name, accompanied by a crude, but reasonable figure of the fruit and seed. The fact that there are mistakes in the description (calyx considered superior, fruit one-celled and embryo monocotyledonous), which can be easily explained, do not make the name invalid. Gaertner had the fruit upside down (perhaps misled by Rheede's plate), but the plate is very clear, the endosperm was taken for the single cotyledon. It was Persoon who recognized it and reduced it to *Diospyros.*

The type specimen could not be found in Gaertner's herbarium in Tuebingen. It was a detached fruit, sent from Leiden by Berkley, who was the Curator of a small Museum (Rariteiten Kabinet) of animals and animal products. The origin of the fruit is obscure.

As the tips of the fruiting calyx are pointing downward, it represents probably what is now known as *Diospyros siamensis* Hochr.

Gamble used the epithet *peregrina* for the Indian species and so it is named in Wealth of India.

In the plate of *D. glutinifera* Roxburgh the fruit is depicted as green ; this should be rusty or orange-rusty, the 4 stigmas are depicted in a flat cross (quoted by Persoon), instead of being erect, the fruiting calyx is badly drawn and the lateral nerves of the leaves should have been steeper. In his Flora Indica Roxburgh simply changed the name to *D. glutinosa* Koenig.

Hochreutiner pointed out already the differences with the varieties *atrata* and *nervosa* of Thwaites. These were discarded by Bakhuizen, although Alston had raised them both—rightly—to specific rank.

In Rheede's, Hort. Mal. the shape of the leaves is wrong and the fruit depicted upside down.

In Wight Icones tab. 844, the stigmas are wrong ; they are trifid, and too many stigmas are drawn.

Koorders & Valeton (Bijdr. Boomsoorten Java 1 : 43. 1894) pointed out that the Javanese form differed by the rounded leaf base, and created for this the varietal name *javanica* (Koorders in Natuurk. Tijdschr. Ned. Ind. 60 : 382. 1901). Bakhuizen quoted this variety, but overlooked the fact that it was a nomen nudum, as only localities were given, but not a description.

Moreover, Koorders & Valeton pointed out, that the specimen *Koorders* 1718 from Mt. Tilu near Tjemara in the Prov. of Banten might represent another species, which is not mentioned by Bakhuizen. Subsequently Koorders (l. c.) published this as *D. bantamensis* K. & V., a nomen nudum. The name was taken up and the species described by Bakhuizen in Gard. Bull. S. S. 7 : 165. 1933. The Leiden duplicate type sheet has still the fruit attached (which Bakhuizen thought lost).

The Javanese and Celebes specimens differ, apart from the rounded leaf base, also by the patent side nerves (at least the basal part of the nerve) and slight differences in hair length of the inside of the fruiting calyx lobes ; moreover, the end-bud is only sparsely pilose or glabrous and the fruit seems to be smaller. As long as flowers are unknown (Koorders copied the characters from Hiern) I believe that it is advisable to keep the form *javanica**.

Bakhuizen (l. c. 329) established two forms : *atrata* and *pallida*. I assume that *atrata* refers only to Trimen's specimen of var. *atrata* (this is nowhere indicated by Bakhuizen) and the remainder of the enumerated specimens should then be the forma *pallida*. In the Index (l. c. 498) he called them **variety** *atrata* and *pallida*.

16. **Diospyros rheophytica** Kostermans, spec. nov.

Maba buxifolia, var. *angustifolia* Thw. (excl. *Maba angustifolia* Miq.) ; Clarke in Hooker f., Fl. Br. Ind. 3 : 551. 1882 ; Hiern in Trans. Camb. phil. Soc. 12 : 117. 1873 (erroneously quoted as Miq. ex Thw.) ; Trimen, Handb. Fl. Ceylon 3 : 90 . 1895 ; Bakhuizen in Bull. Jard. bot. Buitenz., Sér. 3, 15 : 54, 57, 62, 1937 (p. p., quoad cit. specim. Ceylon).— Typus : *C.P.* 1917 (PDA).

**Diospyros peregrina* Guerke, forma *javanica* Kostermans, f. nov.-Foliis basin obtusis costis sub-patentibus, innovationibus plerumque glabris vel subglabris fructus minoribus. Typus : *Wirawan* 424 (L).

Arbor parva, ramulis gracilis, inovationibus sparse minutissime sericeis, foliis alternantibus, rigide chartaceis, lanceolatis, utrinque acuminatis, supra laevia, nervo mediano sub-impressis, subtus laxe reticulata, costis sat obscuris, petiolis brevis, floribus foemineis solitaris, axillaris, trimeris, calyce campanulatus, dense sericeis, lobis acutis parvis sub reflexis, intus marginem versus dense albo-pilosis, corolla alba tubuliforma dense strigoso adpresse pilosis, lobis elongatis, acutis, intus glabris, staminodiis 6 elongatis, ovario dense piloso, fructus ovoideo-globosus, laevis, calycibus sub-pateriformibus, lobis fere usque ad basin calycicis.

Treelet, 1.5—2 m high, diam. 3 cm. Bark smooth, dark brown to black, 1 mm thick, live bark 3 mm, light red. Branchlets slender, horizontal, glabrous, end-bud minutely sericeous. Leaves alternate, glabrous, rigidly chartaceous, lanceolate, 1.5 × 4—3 × 10 cm, tapered at both ends, upper surface smooth to obscurely laxly reticulate, midrib slender, impressed, lower surface laxly, prominulously reticulate, midrib slender, prominent, young leaves with few, adpressed hairs, lateral nerves 6—10 pairs, erect-patent, at some distance from the margin arcuately connected. Petiole slender, 3—8 mm. Female flower solitary, axillary. Calyx campanulate, except at apical part of somewhat reflexed lobes, 3 mm with large, broad triangular teeth, inside of teeth with a densely white pilose band near the margin. Corolla tubular, 6—8 mm, densely adpressed strigose, lobes 2.5 mm, inside glabrous, lanceolate, acute. Ovary densely pilose, ovoid-globose, apiculate, up to 1.5 cm long, smooth ; staminodes 6, slender, long.

Fruit smooth, yellowish green, ovoid-globose, up to 15 mm long, apiculate, calyx almost pateriform, to 10 mm diam., the triangular large, woody, thin, acute lobes going almost to the centre. Seeds flat-convex or the two inner planes making a very large angle, up to 12 mm long, brownish black, endosperm equable.

Distribution : Endemic.

Occurrence : Wet, lowland forest of S.W. Lanka, in or on the banks of rivulets, liable to inundation.

Notes : Very close to *D. ebenoides,* differing by the lanceolate leaves, the tomentum of the inner part of the calyx lobes. Further collections may prove the two to be only forms of the same species.

It is certainly different from *D. ferrea* and from *D. nigrescens* ; the latter with copiously strigose branchlets now named *D. angustifolia* (Miq.) Kostermans.

Galle District: Road to Hiniduma, near bridge, in rivulet, alt. 50 m, wet, evergreen, fl., *Kostermans* 25544 (A, BO, G, K, L, P, PER, US) ; ibid., Aug., buds, *Kostermans* 25381 (id.) ; ibid., June, fl., *Kostermans* 25003 (id.) ; Kaneliya forest, on river bank of swift rivulet Sept., fr., *Kostermans* 25602 (id.) ; Hiniduma, fr., *Walker C.P.* 1917 (L, PDA).

Maba buxifolia, var. *angustifolia* Thwaites is not the same species as *Maba angustifolia* Miquel, a fact already pointed out by Clarke (in Hooker, f., Fl. Br. Ind. 3 : 551. 1882). Hiern (in Trans. Camb. phil. Soc. 12 : 117. 1873) included Miquel's and Thwaites' plant in *Maba buxifolia* (=*Diospyros ferrea*), but misquoted it as *M. angustifolia* Miq. ex Thw. Bakhuizen (l.c. 54, 57) likewise failed to disentangle both species, but maintained the mixture of two species as *D. ferrea*, var. *angustifolia* and even lumped both later in the addendum to his monograph with *Maba neilgerrensis* (the proper orthography of the name : Bakhuizen followed Hiern and spelt it *neilgherrensis* ; the description of this species by R. Wight, Icon. 4 : text (10), t. 1228 and 1229. 1848, gives the orthography *neilgerrensis*, the caption of the plates was completely wrong (*M. ebenum* Spring. (=Spreng.), referred to in the text (10), first set (there are two pages 10 !) and corrected, as *M. ebinum*. In 1850, Illustr. Ind. Bot., text (10) tab. 148 bis E., the name is spelt *neilgherrensis*, which should be treated as a mispelling. I consider this species a proper one (cf. below).

D. ferrea and *D. rheophytica*(*Maba buxifolia*, var. *angustifolia* Thw.) are not only different in their leaf shape and consistency, but the latter occurs only in or on the banks of swiftly running rivulets, liable to inundation, a habitat unfit for *D. ferrea* and vice-versa.

The name *Maba angustifolia* Miquel antedates *Maba nigrescens* Dal., with which it is conspecific. Hence :

Diospyros angustifolia (Miq.) Kostermans, comb. nov.—*Maba angustifolia* Miquel, Analecta bot. Ind. 3 : 13. 1852 ; Bakhuizen, l. c. 54, 57, 1937, and 432. 1941 (p.p., exclus. cit. *M. buxifolia*, var. *angustifolia* Thw. and excl. specimen Ceylon and New Hebrides). —Typus : *Metz* 389 (U).—*Maba nigrescens* Dalzell in Dalz. & Gibson, Bombay Fl. 142. 1862 ; Gamble, Fl. Madras 768. 1921—*Diospyros buxifolia*, var. *angustifolia* (Miq.) Bakh.

Maba neilgerrensis should be raised again to specific rank.

Diospyros neilgerrensis (R. Wight) Kostermans, comb. nov.—*Maba neilgerrensis* R. Wight, Icon, Pl. Ind. Or. 4 : text (10), t. 1228 & 1229 (sphalm. *M. ebenum*). 1848 ; Illustr. Ind. Bot. 2 : 1476 explanat. of plate, t. 148 bis E. 1850 ; Hiern, l.c. 117 (*neilgherrensis*) ; Clarke in Hooker f., l.c. 551 (as a syn. of *M. buxifolia*) ; Gamble, Fl. Madras 768, 1921 (*neilgerrensis*).—*Diospyros ferrea*, var. *neilgherrensis* (Wight) Bakh., l. c. 57, 62, 1937 & 432, 1941 (erroneously citing only Ceylon as distribution, where it does not occur), 438, p.p. (quoad spec. India).

17. **Diospyros walkeri**

(Wight) Guerke in Engl. & Pr., Nat. Pflfam. 4 (1) : 162. 1897 ; Bakhuizen in Bull. Jard. bot. Buitenz., Sér. 3, 15 : 279. 1937 (*walkerii*) ; Alston in Trimen, Handb. Fl. Ceylon 6 (Suppl.) : 182, 1931.—*Patonia walkerii* Wight, Illustr. Ind. Bot. 1 : 18. 1831.—Typus : *Walker s.n.*

Diospyros gardneri Thwaites, Enum. Pl. Zeyl. 181. 1860.

Bakhuizen included this in *D. undulata* as a variety. None of his varietal characters fit. He missed the characters of the entirely different fruiting calyces of both species, that of *D. undulata* being rather shallow with 3 or 4 thick, sharp large lobes and a tomentum of rather long adpressed hairs, that of *D. walkeri* having a very deep calyx tube with thin rim, with hardly any trace of lobes, the tomentum being extemely small and moreover the calyx has a short, thick neck at the base, not present in *D. undulata*. The leaves of both species are strikingly alike. Also the shape of the calyx lobes especially in the female flower is quite different from that of *D. undulata* ; the lobes look much like the petals in some *Annonaceae* (and hence Wight's mistake : he referred this to *Annonaceae*!).

The original orthography *walkerii* of Wight was improved by Guerke to *walkeri* ; Bakhuizen quoted them wrongly.

18. **Diospyros zeylanica** Kostermans, spec. nov.

Arbor mediocris, ramulis glabris gracilis, foliis alternantibus subcoriaceis glabris ellipticis breve acuminatis basi in petiolum gracilam contractus obtusis vel acutiusculis, utrinque minutissime graciloque reticulatis, supra bullatis nervo mediano costaque et nerviis secundariis impressis, subtus pallidiora nervo mediano valde prominentibus castis gracilis paucis erecto-patentibus arcuatim longe adscendentibus, petiolis supra canaliculatis, floribus ignota.

Tree ? Bark smooth, dark brown, 0.5 mm thick. Live bark 2 mm, red. Branchlets slender, glabrous, drying pale brown. Leaves alternate, subcoriaceous or stiffly chartaceous, glabrous, elliptic, 4 × 8 — 7 × 20 cm, shortly acuminate with sharp tip, base contracted into the petiole, obtuse or acutish; both surfaces densely, minutely reticulate, the veinlets slender ; upper surface strongly bullate ; midrib, lateral nerves and secondary nerves impressed ; lower surface paler, midrib strongly prominent, lateral nerves 4(—6) pairs, erect-patent and very much ascendent, secondary veins prominent, slender. Petiole slender, 1—1.5 cm long, channeled above. Flower and fruit unknown.

Type : *Kostermans* 25660 *A* (G , L).

Although the specimens, collected from a sapling tree of 3 m, are sterile, I have ventured to describe it, because of its striking, bullate, finely reticulate leaves, which makes it easily distinguishable among Ceylon *Diospyros* and by describing it, I hope that somebody will make a search for flowers and fruit.

It seems to be near *D. toposia*, but nothing can be said before fertile material becomes available.

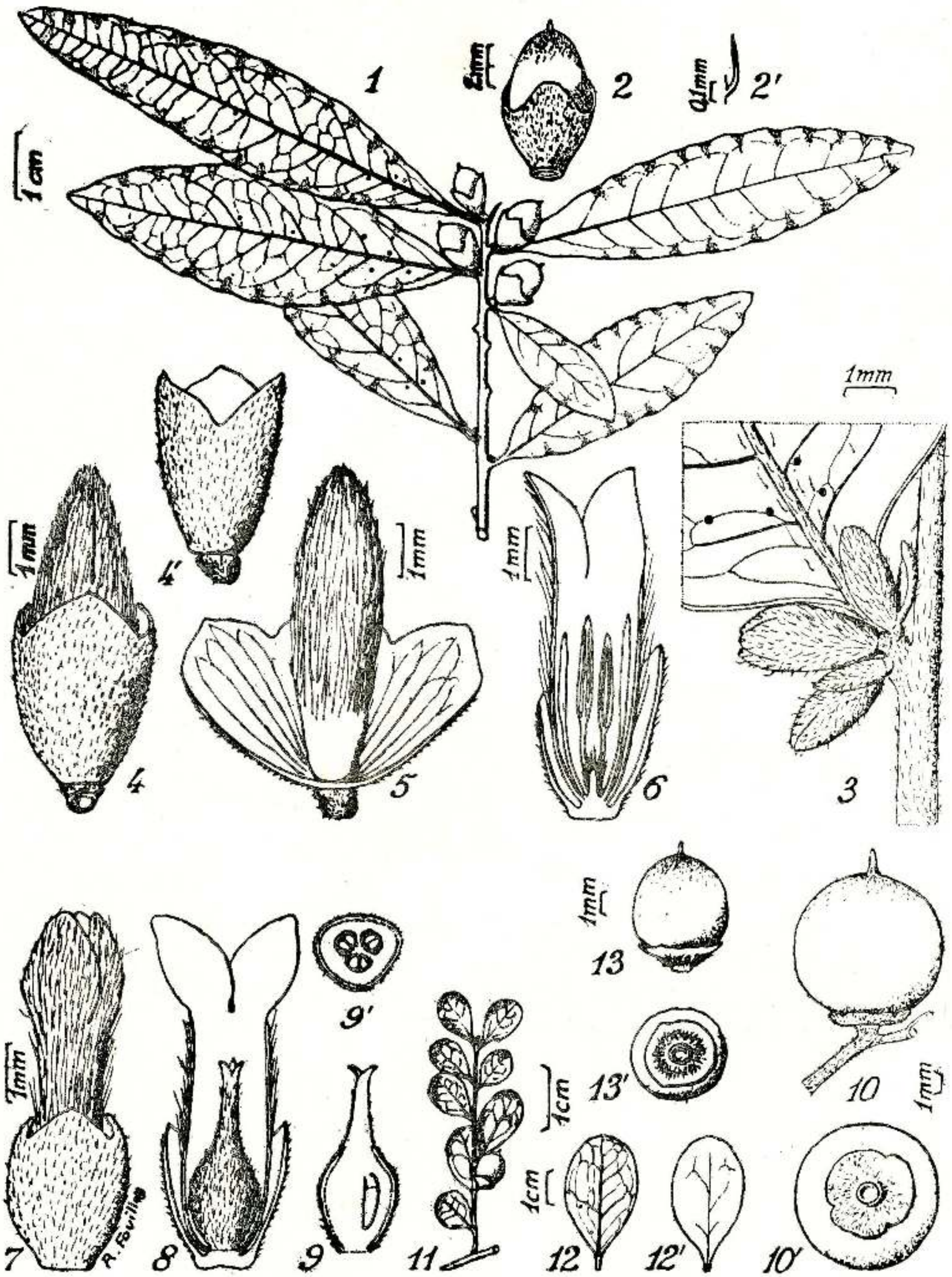
Galle Distr.: Kaneliya forest near Hiniduma, main road from entrance gate of car park of logging company, c. 2—3 km along road in rocky, steep rivulet, Sept., sapling, *Kostermans* 25660 *A* (G, L).

EXPLANATION OF PLATE

PLATE 1

Diospyros rheophytica Kosterm. 1, fruiting branch, leaves to the left showing glands on lower surface ; 2, fruit enlarged; 2, hair of fruit (Kostermans 25100) ; 3, three young buds with bracts and base of leaf with four glands; 4, buds starting to open ; 4, calyx of same, turned 60 degrees ; 5, same, calyx opened ; 6, open flower *Diospyros ferrea* (Wild.) Bakh. 7, ripe bud; 8, open flower ; 9, longitudinal section of pistil ; 9, cross section (Kostermans 24011) ; 10, 10', fruit, lateral and underside (Jayasuriya 10).

(MS. received 15.9.75)


1
2
2'
1cm
1mm
3
4
4'
5
6
7
8
9
9'
10
10'
11
12
12'
13
13'

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Notes on the Genus *Homotages* Burr (Dermaptera : Labiidae) with the Description of a New Species from India

by

G. K. SRIVASTAVA

Zoological Survey of India, Calcutta

(With two text figures)

This genus was erected by Burr (1909) for the reception of *Anechura feae* Bormans (1888) from Burma and placed under the subfamily Anechurinae. He subsequently (1916) transferred it to the subfamily Labiinae on the basis of the male genitalia and the simple, elongate second tarsal segment. Brindle (1971) while giving a key to the subfamilies of the Indo-Australian Labiinae has placed the genus *Homotages* under the subfamily Spongiphorinae.

Hitherto this genus was known by its type-species only. A new species is described in the present paper.

Homotages Burr

1909. *Homotages* Burr, *Deutsch. ent. Z.*, 1909 : 327.

Diagnostic characters:—Build stout, smooth. Head convex, sutures faint ; antennae 15-segmented, long and cylindrical, 1st longer than 3rd which is longer than 5th ; 4th subconical. Legs long, slender, hind metatarsus distinctly longer than the remaining two segments together, 2nd distinct, slightly more than half as long as third. Forceps in male undulate and strongly toothed.

Type species:— *Anechura feae* Bormans.

Distribution :— Oriental Region (India, Burma and Nepal).

Key to the species (on ♂♂ only)

1. (2) Head black ; elytra generally variegated, inner teeth of forceps ventrally placed .... *H. feae* (Bormans).
2. (1) Head orange ; elytra unicolourous ; inner teeth of forceps dorsally placed ....*H. tawangensis* sp.n.

Homotages feae (Bormans)

1888. *Anechura feae* Bormans, *Ann. Mus. Civ. Gen.*, (2) 6 : 445.

1909. *Homotages feae* : Burr, *Deutsch. ent. Z.*, : 327.

1910. *Homotages feae* : Burr, *Fauna Brit. India, Dermaptera* : 156.

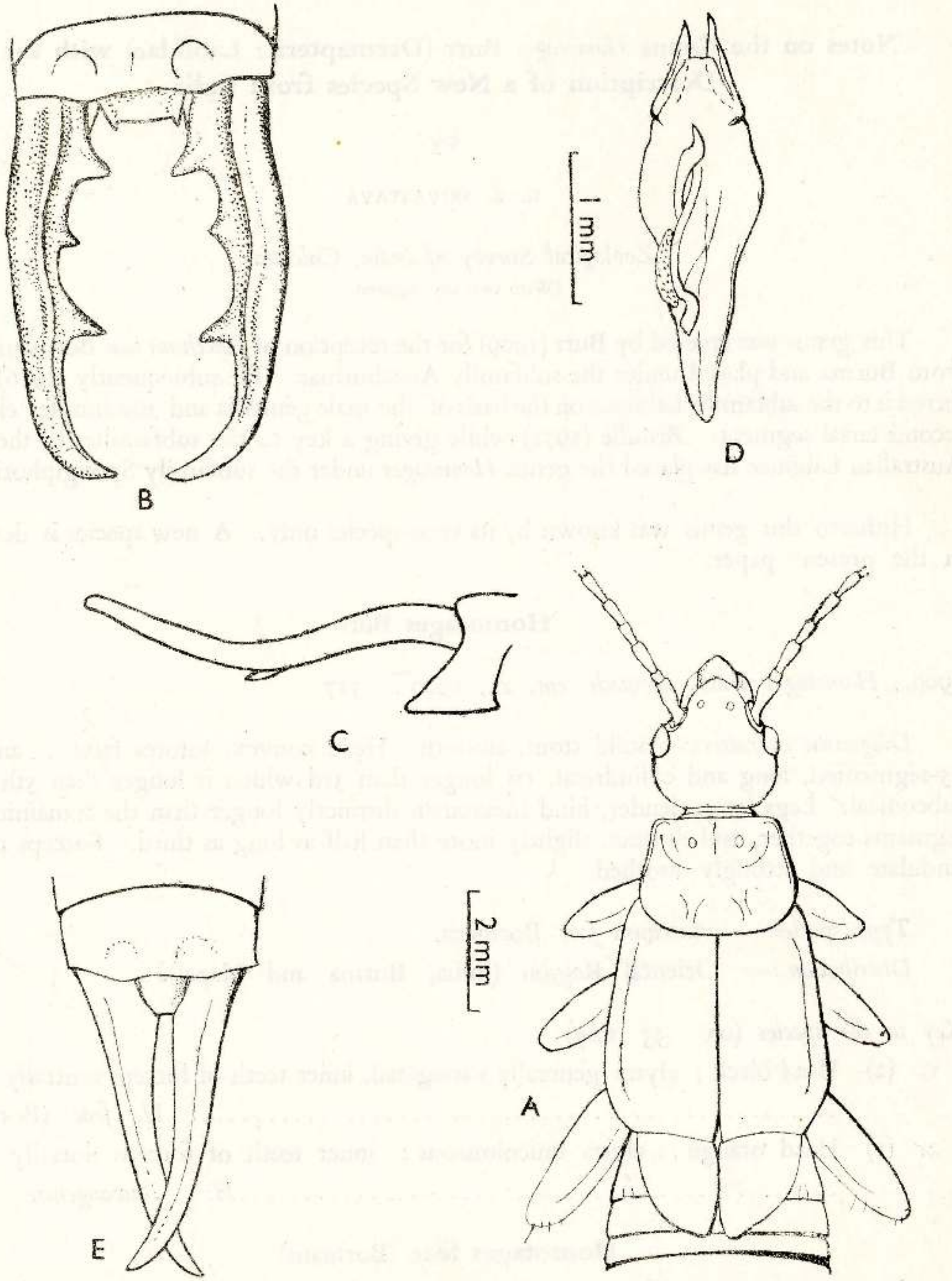


Fig. 1. *Homotages feae* (Bormans), Male : A. Diagram showing head, pronotum and elytra; B. Ultimate tergite and forceps ; C. Forceps seen in profile ; D. Genitalia ; Female : E. Ultimate tergite and forceps.

1916. *Homotages feae* : *J. R. micr. Soc.*, 1915 : 5.

1961. *Homotages feae* : Bharadwaj and Bhatnagar, *Zool. Anz.*, 167 (7–8) : 285.

1972. *Homotages feae* : Srivastava, *Rec. zool. Surv. India*, 66 (1–4) : 136.

Material examined:— INDIA : Arunachal Pradesh, Kameng Dist., Chug, 2 ♂♂, 9 nymphs, 16.iv.1961, 2133 m., Pobrang Chu, 1 ♀, 3 nymphs, 1828 m., Shergaon, 1 ♂, 29.iii. 1961, 2011 m. (*K. C. Jayaramakrishnan*) ; WEST BENGAL, Darjeeling, 1 ♀, 20.v.1910, 2134 m. (*Brunetti*), Kurseong, 1 ♀, 25.iii. 1910, 1524 m. (*F. H. Gravely*) ; UTTAR PRADESH, Nainital, 1 ♂, 1 ♀, 1.x.1906, 1951 m. (*N. Annandale*), Dehra Dun Dist. round about Mussorie, 1 ♂, 15 – 16.vi., 1 – 7.vii.1930 (*B. N. Chopra*).

NEPAL : Chitlong, 3 ♂♂, 3 ♀♀ (*Ind. Mus.*, no further data).

Brief description :— Male : Head and wings black ; antennae, abdomen dark blackish brown. Legs testaceous or black. Pronotum, elytra black, former yellow on sides and latter with a big yellow oval spot in anterior half only. Forceps orange, often shaded with black.

Head smooth, sutures faint ; eyes fairly prominent, shorter than genae in length ; antennae 15 – jointed, segments long, cylindrical, apical segments narrow and rod shaped. Pronotum trapezoidal, gently widened posteriorly. Legs long, slender ; hind metatarsus distinctly longer than 2nd and 3rd together : 2nd slightly more than half as long as 3rd but never dilated, tarsi with yellow pubescence along with a few thick rows of setae on underside. Abdomen slightly enlarged in middle, smooth ; penultimate sternite rounded posteriorly with slight emargination in middle ; ultimate tergite smooth, strongly transverse, tumid above the roots of forceps. Pygidium vertical, squarish, posteriorly truncate or subtruncate, with angles produced into sharp spines often directed upwards. Forceps and genitalia as seen in Fig. 1, D.

Female : Agrees with male in most characters except ultimate tergite in lacking tumid elevations above the roots of forceps ; pygidium subvertical, narrowed posteriorly, with margin straight and forceps with branches long, slender and tapering, apices incurved and crossing.

Measurements:— (in mm.)

	♂♂	♀♀
Length of body	10.6–15.25	10.4–14.6
Length of forceps	3.85–7.1	4.7–5.5

Distribution :— India, Nepal and Burma.

Remarks :— The oval spot of elytra is occasionally absent or at the most represented by a yellow diffused patch. In some specimens forceps are horizontal and pygidium is convex posteriorly with lateral spines directed upwards.

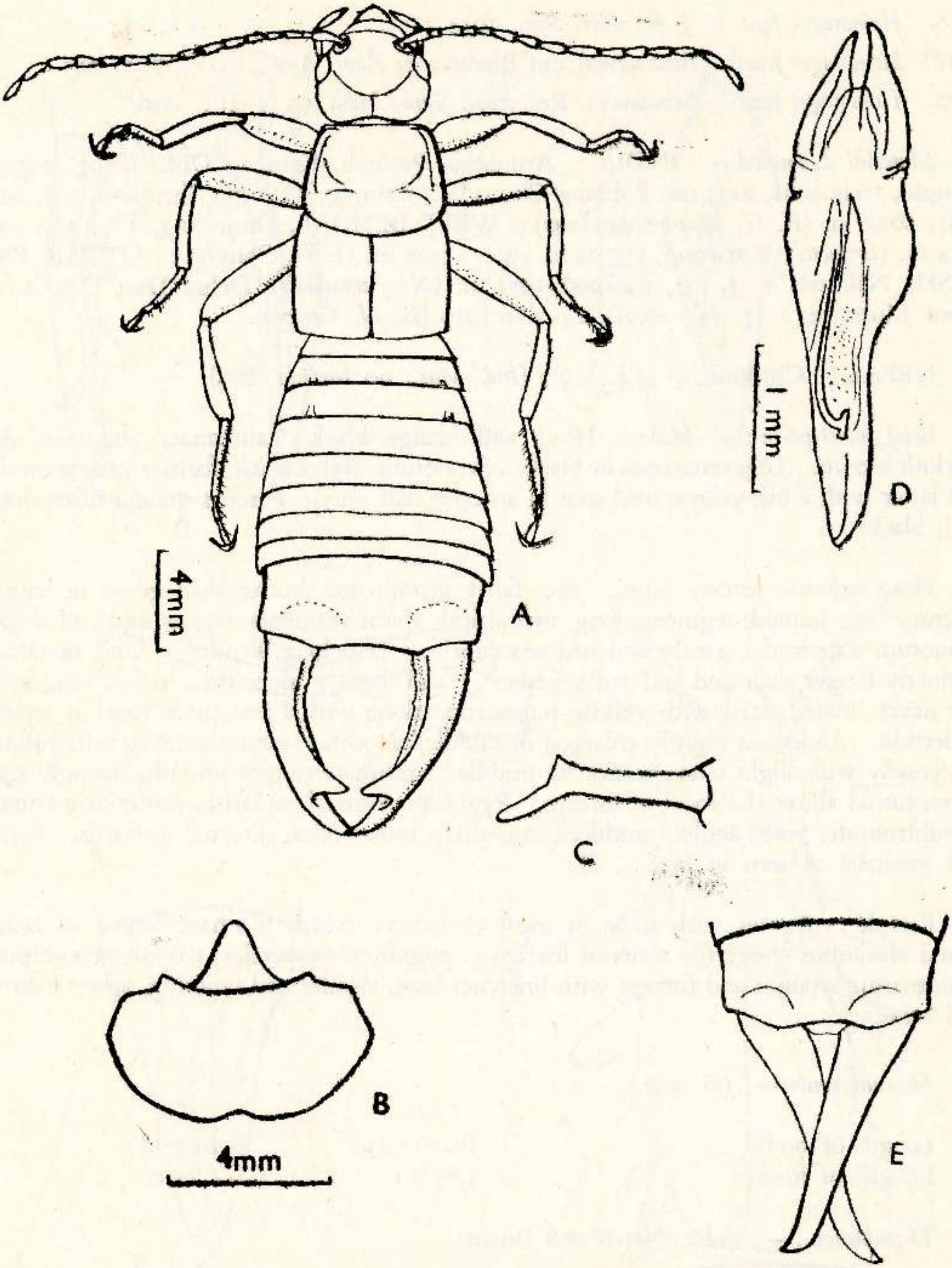


Fig. 2. *Homotages tawangensis* sp. n., Male : A. Holotype; B. Penultimate sternite; C. Forceps in profile; D. Genitalia; Female: E. Ultimate tergite and forceps.

Homotages tawangensis sp. n.

Material examined:— INDIA: Arunachal Pradesh, Kameng Dist., Tawang, Holotype, ♂, Allotype ♀, Paratypes 2 ♂♂, 3 ♀♀, 1 ex. nymph, 12.xii.1965, 3200 m. (*S. K. Bhattacharya*) deposited in the Zoological Survey of India, Calcutta.

Description :— Male : General colour reddish black ; head orange red but blackish laterally ; tibiae and tarsi reddish, testaceous.

Head longer than broad, convex, sutures faint, hind margin emarginate. Eyes small, about half as long as the genae ; antennae 15-segmented, segments long, stout, 1st longer than 3rd which is longer than 4th and 5th, remaining cylindrico-conical, gradually increasing in length distally. Pronotum straight and as wide as head anteriorly, sides straight, weakly reflexed, gently widened posteriorly, angles and margin rounded, median sulcus faint ; prozona tumid and metazona weakly so. Elytra smooth, abbreviated, about as long as pronotum, humeral angles not prominent, hind margin straight. Wings absent. Legs typical of the genus. Abdomen gradually enlarging posteriorly, somewhat depressed, segments 7-9 laterally with striations more pronounced, sides of segments convex. Penultimate sternite strongly transverse, broadly rounded posteriorly with slight emargination in middle ; manubrium shorter than the sternite, of uniform width. Ultimate tergite strongly transverse, smooth, depressed in middle posteriorly, tumid above the roots of forceps, hind margin straight in middle. Pygidium vertical, scarcely visible from above, posterior margin emarginate, angles acutely pointed. Forceps stout, somewhat depressed, gradually curving and tapering from base to gently incurved, pointed apices which meet or cross, internally at base finely crenulate, a stout tooth, directed upwards present at about apical two third, in lateral view branches undulate. Genitalia as seen in Fig. 2, D.

Female : Agrees with male in most characters except penultimate sternite rounded posteriorly ; pygidium subvertical, truncate posteriorly ; ultimate tergite narrowed posteriorly and forceps simple, straight, finely crenulate internally.

Variations:— In the holotype head is blackish laterally but in other specimens it is orange reddish. The internal tooth of forceps is slightly weaker in paratypic males.

Measurements:— (in mm.)

	Holotype	*Allotype*	*Paratype*	
	♂	♀	♂♂	♀♀
Length of body	14.1	12.6	11.6–12.7	12.1–12.8
Length of forceps	4.2	3.9	4.2–4.5	3.6–3.9

Remarks:— The described species can be differentiated from *Homotages feae* (Bormans), the only known species of the genus, by the orange head ; unicolourous and abbreviated elytra, truncate posteriorly. The internal tooth of forceps is dorsally placed and parameres are comparatively broader at base and acute apically, with slightly different virga.

ACKNOWLEDGEMENTS

My thanks are due to Dr. S. Khera, Deputy Director-in-Charge, Zoological Survey of India, Calcutta, for providing necessary facilities.

REFERENCES

BURR, M. 1909—Note on the classification of the Dermaptera. *Deutsch. ent. Z.*, 1909 : 320-328, pl. 4.

BURR, M. 1916—On the male genital armature of the Dermaptera. Part III. Eudermaptera. *J. R. micr. Soc.*, 1916, 1—18.

BRINDLE, A. 1971—The Dermaptera of the Naturhistoriska Riksmuseum, Stockholm. Part IV. *Entomol. Ts.*, 92 (1-2), 1—27.

(MS. received 16.9.75)

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

On a New Gasterostome Trematode *Bucephalus tetratentacularis* n. sp. from an Indian Fresh-water Fish *Sciaena coitor*

by

S. P. SINGH* AND D. P. SINHA

Department of Zoology, Magadh University, Bodh Gaya, Bihar, India

(With one text figure)

Three specimens of a gasterostome trematode were collected from the small intestine of a fresh-water fish *Sciaena coitor* netted at Dinapore (Bihar). A detailed examination of the material revealed that it represented a new species of the genus *Bucephalus* Baer, 1827. The description given below is based on the study of the stained, permanent whole mount of one of the three specimens which showed little variation. All measurements are given in millimetres.

Bucephalus tetratentacularis n.sp.

Description :— Body spinose in the anterior half, elongated, 1.74 long and 0.29 in maximum breadth in the region of ovary and intestinal sac. Rhynchus sucker-like, 0.12 × 0.12, with four tentacles, each carrying near its distal end an inwardly directed blunt process. Mouth opening at the junction of middle and posterior third of body, 1.16 from the anterior end; pharynx globose, 0.08 × 0.08 and muscular ; intestine sac-like and medial to ovary.

Excretory pore at posterior end of the body ; excretory bladder sac-like and extending anteriorly up to a level between the vitellaria and rhynchus.

Tesets two, obliquely placed in the middle of the posterior half of body; anterior testis 0.12 × 0.14 with an anterior concavity accommodating the pharynx ; posterior testis 0.14 × 0.12, postero-medial to anterior testis. Cirrus sac large and tubular, 0.26 × 0.08, extending anteriorly up to the middle of posterior testis, and containing an oval seminal vesicle, a pars prostatica with diffuse prostate glands and a short ductus ejaculatorius ; genital tongue prominent ; genital pore sub-terminal and ventral.

Ovary entire, pretesticular, oval, 0.12 × 0.05, almost marginal in the middle third of body. Uterus extends anteriorly up to a level between the rhynchus and vitellaria, which consist of 12-13 follicles on each side in the pre-ovarian region of body ; metraterm runs medial to the cirrus sac and opens into the genital sinus ; eggs not observed.

Host — *Sciaena coitor*
Location — small intestine
Locality — Dinapore (Bihar, India).

The specimens are deposited in the helminthological collection of the Department of Zoology, Magadh University, Bodh Gaya, India.

*Present address : Dept. of Parasitology, Bihar Veterinary College, Patna-14, India.

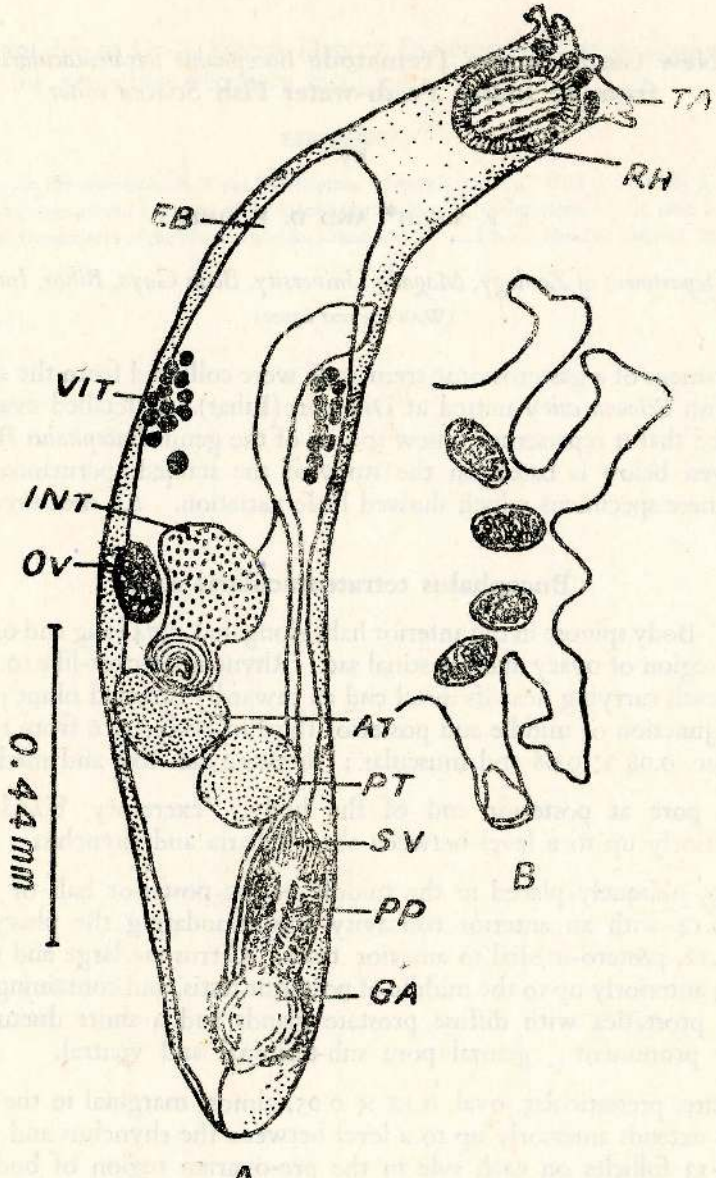


Fig. 1. A. *Bucephalus tetratentacularis* n.sp. (ventral view). B. Tentacles. AT—anterior testis; EB—excretory bladder; GA—genital atrium; INT—intestine; OV—ovary; PP—pars prostatica; PT—posterior testis; RH—rhynchus; SV—seminal vesicle; TA—tentacles; VIT—vitellaria.

DISCUSSION

In the genus *Bucephalus* (Bucephalidae, Gasterostomata, Trematoda), the tentacles associated with the rhynchus show specific differences in shape and number (Chauhan, 1954). A key to the species of the genus *Bucephalus* has been given by Srivastava (1938), Chauhan (1954) and Kakaji (1969). In all, ten species of this genus have been described from India. These are *B. aoria* Verma, 1936, *B. tridenticularia* Verma, 1936, *B. jagannathai* Verma, 1936, *B. indicus* Srivastava, 1938, *B. gangeticus* Srivastava, 1938, *B. barina* Srivastava, 1938, *B. tritentacularis* Srivastava, 1963, *B. allahabadensis* Srivastava, 1963, *B. bagarius* Srivastava 1963 and *B. octotentacularis* Kakaji, 1969. Of these ten species, only *B. gangeticus* Srivastava, 1938 is known to have four tentacles, which are studded with minute pointed spines and are devoid of any processes. Again, in *B. gangeticus* the gonads are situated close together to the right of the median line and the cirrus sac extends anteriorly up to the anterior level of the anterior testis. None of the species described up to date possess a combination of characters shown by the specimens obtained from *Sciaena coitor*. There are four tentacles, but each has an inwardly directed process. The new form described here has an entirely different disposition of testes and structure of the tentacles. Therefore, the authors regard the present form to be a new species to which the name *Bucephalus tetratentacularis* is given.

Srivastava (1963) considered *B. tridenticularia* Verma, 1936 to be a synonym of *B. indicus* Srivastava, 1938, but Kakaji (1969) has revalidated the two species. Srivastava (1938) did not include *B. aoria* Verma, 1936 in his key as he doubted the validity of this species. However, Yamaguti (1958) has considered *B. aoria* to be a valid species. With the description of the present form, the genus *Bucephalus* now includes 11 species, for the identification of which a key is given below :—

KEY TO THE INDIAN SPECIES OF BUCEPHALUS

1. Tentacles 3 in number........................... *B. tritentacularis* Srivastava, 1963.

2. Tentacles 4 in number. Each tentacle simple, unbranched and studded with spines............ *B. gangeticus* Srivastava, 1938.

   Each tentacle with an inwardly directed process..... *B. tetratentacularis* n.sp.

3. Tentacles 5 in number. Each tentacle with numerous rose-thorn shaped hooks at the base..... *B. barina* Srivastava, 1938.

   Each tentacle devoid of hooks but with an apical knob.................................... *B. allahabadensis* Srivastava, 1963.

4. Tentacles 6 in number. Each tentacle with two lateral processes ; cirrus sac extends up to anterior margin of posterior testis............... *B. indicus* Srivastava, 1938.

Each tentacle with a single short lateral process ; cirrus sac extends up to anterior margin of anterior testis .... *B. jagannathai* Verma, 1936.

5. Tentacles 7 in number .... *B. bagarius* Srivastava, 1963.

6. Tentacles 8 in number. Tentacle apex like arrow-head ; cirrus sac extends up to pharynx .... *B. tridenticularia* Verma, 1936.

Tentacle simple and without any process ; cirrus sac extends up to hind end of ovary .... *B. octotentacularis* Kakaji, 1969

7. Tentacles as 14—22 short processes or fimbriae ; testes on two sides of body and separated by pharynx .... *B. aoria* Verma, 1936.

REFERENCES

CHAUHAN, B. S. 1954—Studies on the trematode fauna of India. Part III. Subclass Digenea (Gasterostomata). *Rec. Indian Mus.* **51**, 231-287.

KAKAJI, V. L. 1969—Studies on helminth parasites of Indian fishes. Part III. Some trematode parasites of fresh water fishes of Uttar Pradesh. *Indian J. Helminth.* **21**, 49-80.

SRIVASTAVA, C. B. 1963—On three new species of the genus *Bucephalus* Baer, 1827 (Trematoda : Bucephalidae Poche 1907), with remarks on the systematic position of *B. indicus* Srivastava, 1938. *Indian J. Helminth.* **15**, 36-44.

SRIVASTAVA, H. D. 1938—Studies on the gasterostomatous parasites of Indian food fishes. *Indian J. vet. Sci.* **8**, 317-340.

VERMA, S. C. 1936—Studies on the family Bucephalidae (Gasterostomata). Part I. Description of new forms from Indian fresh water fishes. *Proc. natn. Acad. Sci.* **6**, 66-89.

YAMAGUTI, S. 1958—*Systema Helminthum*, Vol. 1. The Digenetic Trematodes of Vertebrates, Parts I & II. Interscience Publishers Inc., New York.

(MS. received 14.10.75)

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Epidermal Structure and Ontogeny of Stomata in Vegetative and Floral Organs of *Yucca filamentosa* Linn. var. *concava* Baker

by

J. A. INAMDAR, M. GANGADHARA AND R. B. BHAT

Department of Botany, Sardar Patel University, Vallabh Vidyanagar, 388120, Gujarat, India

(With thirty-four text figures and one plate)

ABSTRACT

The epidermal structure and ontogeny of stomata in the vegetative and floral organs of *Yucca filamentosa L.* var. *concava* Baker were investigated. The parts examined were lamina, stem, bract, scape, pedicel, perianth, stamen, filament, anther, ovary, style and stigma. Anomocytic, paracytic and tetracytic stomatal types and stomata with a single subsidiary cell were noticed. The ontogeny of stomata was perigenous and conformed to the mode of development in the Agavaceae as described by Tomlinson. Diverse types of stomata were noticed but the stomatal apparatus varied from organ to organ.

INTRODUCTION

Stebbins and Khush (1961), Pant and Kidwai (1966), Inamdar (1968, 1970), Shah and Gopal (1970, 1972), Gopal and Shah (1970) and Patel (1971) described the structure and ontogeny of stomata in some monocotyledons. Stebbins and Khush (1961) have referred to the ontogeny of foliar stomata in some members of the Agavaceae, and it was thought worthwhile to study the structure and ontogeny of stomata in the vegetative and floral parts of *Yucca filamentosa* Linn. var. *concava* Baker belonging to this family.

MATERIAL AND METHODS

Material of *Yucca filamentosa* var. *concava* was collected from this University campus. The identification was confirmed with the help of the Standard Cyclopedia of Horticulture (Bailey, 1961). Camera lucida drawings were made from epidermal peels taken from fresh material, stained in Delafield's haematoxylin and mounted in glycerin. Microphotographs were taken with a Carl Zeiss trinocular microscope using incandescent light and a yellow filter.

The lamina, stem, bract, scape, pedicel, perianth, stamen (filament and anther), ovary, style and stigma were studied.

OBSERVATIONS

Mature epidermis : Epidermal cells are polygonal, mostly longer than broad, rarely isodiametric, with straight or arched or sinuous anticlinal walls which are thin or thick and often pitted (Figs. 1—34). The pits are more prominent and distinct on the upper surface of the leaf and of the bract (Figs. 2, 7, 8). The stomata are greatly sunken on the leaf and bract while upon the other organs they are situated on the same level as the epidermis. Needle-like calcium oxalate crystals are present in bundles. They are often enclosed in a sac-like cell in the epidermis of the stamen filament (Fig. 27) and the scape (Fig. 10).

Lamina, bract and perianth are amphistomatic, while the stem, scape, pedicel, anther, ovary and style are stomatic. The stigma is astomatic. The stamen filament is flat and stomata are present on both surfaces i.e., facing the ovary (inner) and away from the ovary (outer).

Unicellular trichomes with thickened walls and rough surfaces are abundant on the stamen (Fig. 26) and rarely on the stem (Fig. 3).

Mature stomata : Stomatal types observed are mostly paracytic (Figs. 1, 2, 5, 6, 15, 18, 22), occasionally tetracytic (Figs. 1, 2, 6, 8, 20) and anomocytic (Figs. 4, 9, 11, 29, 32) and rarely with a single subsidiary cell (Figs, 5, 11, 23, 25). Abnormalities noticed are : (i) contiguous stomata which are either juxtaposed (Fig. 12) or superimposed (Figs. 13, 24) or obliquely oriented (Fig. 14). Contiguous stomata develop from the adjacent meristemoids (Fig. 30). Contiguous stomata are observed occasionally on perianth and rarely on ovary wall (Fig. 31) ; (ii) single guard cell (Fig. 16); (iii) degeneration of guard cells (Fig. 29) ; and (iv) cytoplasmic connection between nearby stomata (Figs. 19, 31).

Diverse types of stomata are observed on lamina, stem, bract, pedicel, perianth and stamen.

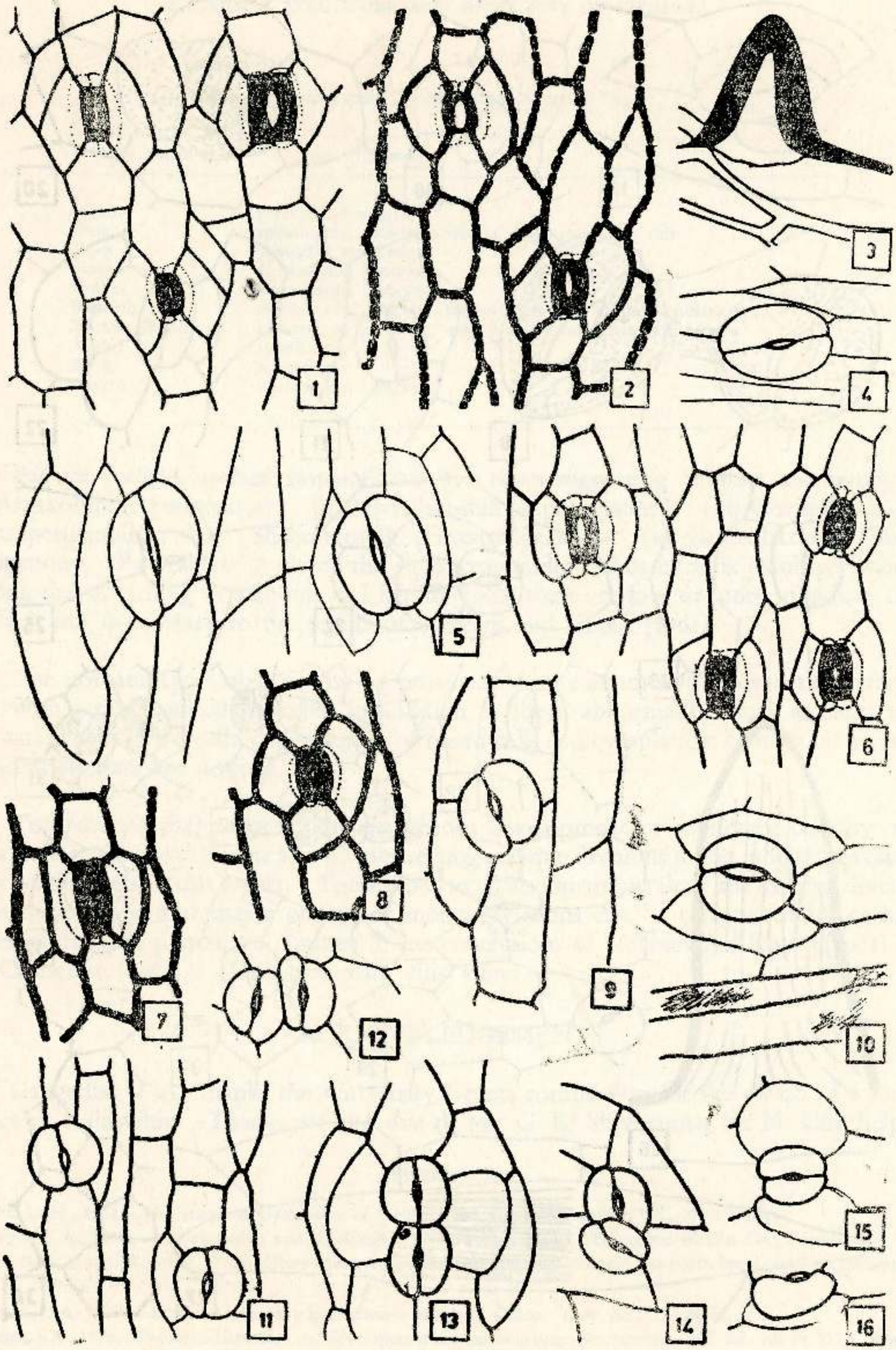
Development of stomata : A meristemoid can be easily distinguished from other epidermal cells by its smaller size, prominent nucleus and dense staining properties (Fig. 30). Here the meristemoid directly functions as a guard mother cell without cutting off any subsidiary cells. It enlarges and divides by a straight wall to produce a pair of guard cells.

During the ontogeny of a paracytic stoma, the two lateral subsidiary cells are cut off by oblique intersecting walls on either side of the guard mother cell or guard cells. The stoma with a single subsidiary cell is flanked by a lateral parallel perigene subsidiary cell. During the development of a tetracytic stoma, the two lateral and two polar subsidiary cells are cut off from adjacent epidermal cells.

DISCUSSION

The present work describes the epidermal structure and structure and development of stomata in the vegetative and floral organs of *Yucca filamentosa* var. *concava* of the Agavaceae.

Stebbins and Khush (1961) classified monocotyledonous families into three categories on the basis of number of subsidiary cells : (i) Families with no subsidiary cells as the predominant condition; (ii) Families with 2 subsidiary cells as the predominant condition and (iii) Families with more than two subsidiary cells as the predominant condition. The family Agavaceae is placed in the first category by these authors. However, the genus *Doryanthes* of the Agavaceae is shown to have (2+) subsidiary cells (*See* Table I. p. 54, Stebbins and Khush, 1961).


1
2
3
4
5
6
7
8
9
10
12
11
13
14
15
16

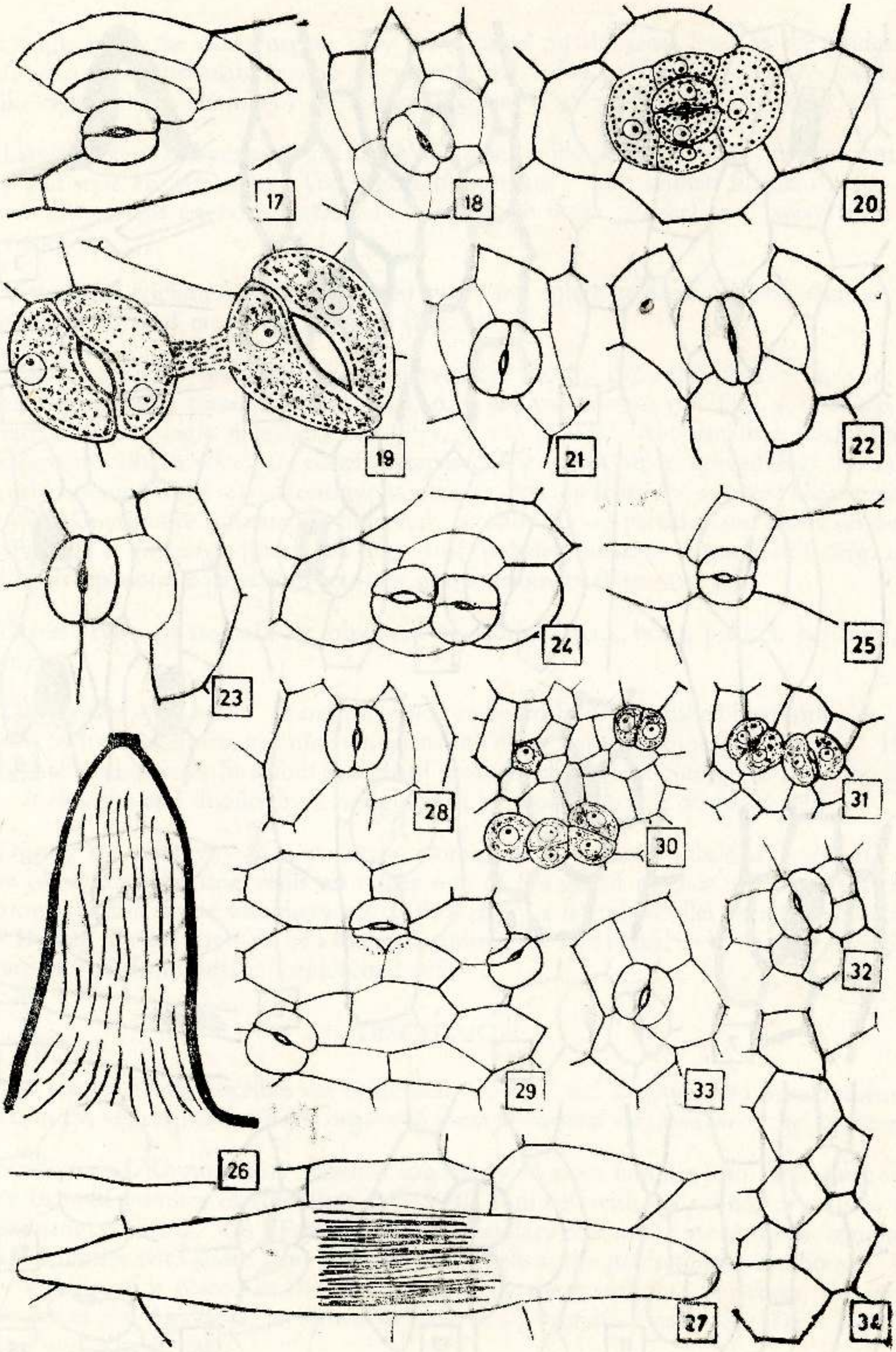

17
18
20
19
21
22
23
24
25
26
28
30
31
29
32
33
27
34

TABLE I

Organographic Distribution of Stomatal Types

Organ studied	*Types of stomata*
Lamina	paracytic, tetracytic
Stem	anomocytic, paracytic, with a single subsidiary cell
Bract	paracytic, tetracytic
Scape	anomocytic, paracytic
Pedicel	anomocytic, paracytic
Perianth	anomocytic, paracytic, tetracytic, with a single subsidiary cell
Stamen filament	anomocytic, paracytic, with a single subsidiary cell
Anther	anomocytic
Style	anomocytic
Stigma	stomata not observed.

Paliwal (1969) classified stomata into five types suggesting Sanskrit terminologies: (i) Asahkoshik (Aperigenous); (ii) Dwisahkoshik (Biperigenous); (iii) Chatushsahkoshik (Tetraperigenous); (iv) Shatsahkoshik (Hexaperigenous); (v) Bahusahkoshik (Multiperigenous). Paliwal (1969) placed the Agavaceae under Bahusahkoshik (Multiperigenous) stating that according to Stebbins and Khush (1961) there are four or more subsidiary cells. In fact, this is contrary to the report of Stebbins and Khush (1961).

The stomatal types observed in the present study are anomocytic, paracytic, tetracytic and with a single subsidiary cell. In addition to these, abnormalities such as contiguous stomata, single guard cells, degeneration of guard cells and cytoplasmic connection between adjacent stomata are noticed.

Tomlinson (1974) reported the perigenous development of subsidiary cells by non-intersecting oblique divisions and by intersecting oblique divisions in the family Agavaceae. Our results confirm this report. Tomlinson (1974) also mentions that "the existing diversity does not suggest that major groups of monocotyledons can be categorised by constant types of stomatal pattern, in contrast to the conclusions of Stebbins and Khush (1961) and of Cronquist (1968)." We agree with this view.

ACKNOWLEDGEMENTS

Gangadhara, M., thanks the University Grants commission for the award of a Junior Research Fellowship. Thanks are also due to Mr. G. K. Shivakumar for his kind help.

REFERENCES

BAILEY, L. H., 1961.—The Standard Cyclopedia of Horticulture, vol. 3, Macmillan Co., New York.

CRONQUIST, A., 1968.—The evolution and classification of flowering plants. Houghton Mifflin Co., Boston.

GOPAL, B. V., AND G. L. SHAH, 1970.—Observations on normal and abnormal stomatal features in four species of *Asparagus* L. *Amer. J. Bot.*, **57**: 665-669.

INAMDAR, J. A., 1968.—Stomatal ontogeny in *Habenaria marginata* Coleb. *Curr. Sci.*, **37**: 24-25.

INAMDAR, J. A., 1970.—Epidermal structure and development of stomata in some Gramineae. *Bull. Soc. bot. Fr.* **117**: 385-394.

PALIWAL, G. S., 1969.—Stomatal ontogeny and phylogeny. I. Monocotyledons. *Acta Bot. Neerl.*, **18**: 654-668.

PANT, D. D., AND KIDWAI, PARVEEN, F., 1966.—Structure of leaves and stomatal ontogeny in some Pandanales and Spathiflorae. *Senck. Biol.* **47** : 309-333.

PATEL, R. J., 1971.—Epidermal structure and ontogeny of stomata in some Dioscoreaceae and Taccaceae. *Flora,* **160**: 562-572

SHAH, G. L., AND GOPAL, B. V., 1970.—Structure and development of stomata on the vegetative and floral organs of some Amaryllidaceae. *Ann. Bot.,* **34** : 737-749.

SHAH, G. L., AND GOPAL, B. V., 1972.—Some observations on the diversity of stomata and trichomes in six species of *Dioscorea* *Ann. Bot.,* **36** : 997-1004.

STEBBINS, G. L., AND KHUSH, G. S., 1961.—Variation in the organization of the stomatal complex in the leaf epidermis of monocotyledons and its bearing on their phylogeny. *Amer. J. Bot.,* **48** : 51-59.

TOMLINSON, P. B., 1974.—Development of the stomatal complex as a taxonomic character in the monocotyledons. *Taxon,* **23** : 109-128.

(MS. received 15.10.75).

EXPLANATION OF FIGURES AND PLATE

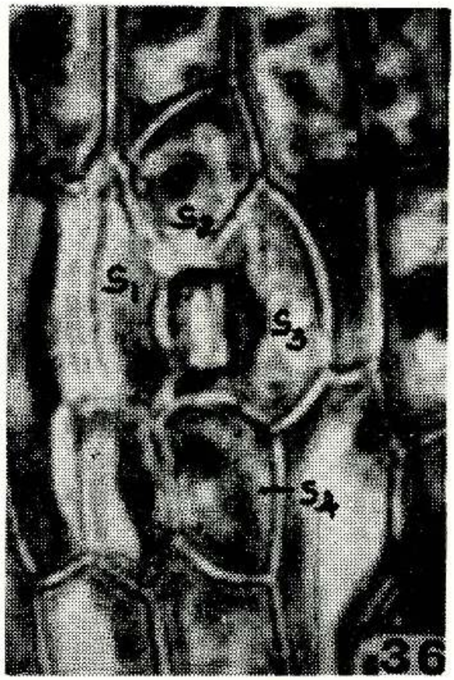
Epidermal peels showing either developing or mature stomata :

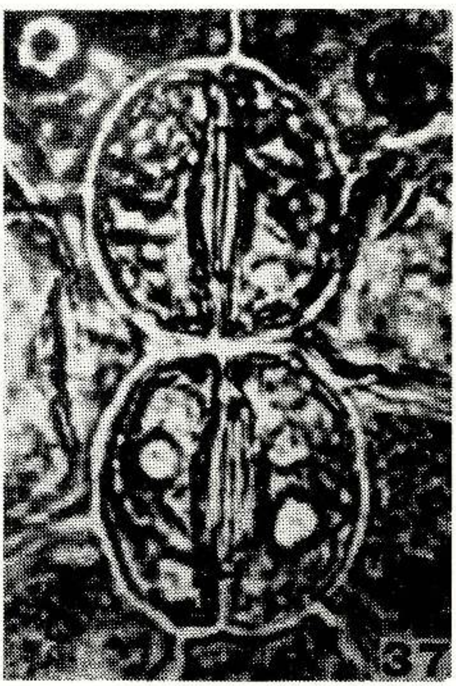
Figs. 1. leaf (Lower) ; 2. leaf (Upper) ; 3—5. stem ; 6. Bract (Lower); 7—8. Bract (Upper) ; 9—10. Scape; 11. pedicel ; 12—19. Perianth (Lower) ; 20—24. Perianth (Upper) ; 25—27. Stamen filament (outer); 28. Stamen filament (inner) ; 29. Anther ; 30—32. Ovary wall (outer) ; 33. Style ; 34. Stigma.

Plate I:

Figs. 35. Leaf upper epidermis—paracytic stoma ; 36. Leaf lower epidemis —tetracytic stoma (s_1, s_2, s_3, s_4,—subsidiary cells) ; 37. Perianth lower epidermis—superimposed contiguous stomata ; 38. Leaf upper epidermis—Note the pitted epidermal walls (marked by arrows).


35


S1
S2
S3
S4
36


37


38

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Miscellaneous Botanical Notes*

by

A. J. G. H. KOSTERMANS†

Herbarium Bogoriense, Bogor, Indonesia

(With three plates)

SUMMARY

Celastraceae : *Bhesa nitidissima*, spec., nov. Ceylon ; Clusiaceae : Note on *Mammea cordata* Stevens ; *Garcinia mammeoides*, spec.. nov., New Guinea : *Garcinia rubro-echinata* Kosterm., spec. nov., S. India ; Cornaceae : *Mastixia macrophylla* (Thw.) Kosterm., comb. nov., Ceylon ; Mimosaceae : *Adenanthera malayana*, spec. nov., Malay Peninsula ; *Thailentadopsis* Kosterm., a monotypic (*T. tenuis* (Craib) Kosterm.) genus of Mimosaceae, Thailand; Sterculiaceae : *Sterculia zeylanica*, spec., nov., Ceylon ; *Brachychiton velutinosum* Kosterm., spec., nov., N. Guinea; *Heritiera polyandra* (L. S. Smith) Kosterm., comb. nov., Australia; Sapotaceae: *Mimusops zeylanica* Kosterm,. spec. nov., Ceylon; Myrsinaceae: *Ardisia lankaensis* Kosterm., spec. nov., Ceylon; Lauraceae: *Litesa keralana* Kosterm., nom. nov., S. India.

Celastraceae

Bhesa nitidissima Kosterm.

In 1956, during the closing excursion of the first UNESCO meeting on the Vegetation of humid tropics in Ceylon, my attention was drawn to the common giant forest tree *Kurrimia ceylanica* Arn. ex Thw. (now *Bhesa ceylanica* Ding Hou), of which it appeared to me by observation with a pair of binoculars, that apparently two different species were involved, currently mixed, as was the case with *Cullenia rosayroana* Kosterm. (which I discovered during the same excursion) and *C. ceylanica*.

It was only in 1974, when a study of Ebenaceae brought me again to Ceylon, that I was able to procure flowers and fruit of both species of *Bhesa*, enabling me to confirm my assumption of long standing, that two species had been mixed up under *Bhesa ceylanica*.

Bhesa nitidissima Kosterm., spec. nov., Plate 1.

Arbor alta, ramulis glabris nitidis, foliis ovatis glabris, basi acutis, apice brevissime acuminatis vel acutis, infra (in vivo) viridia nitidissima, inflorescentiis ut in Bh. ceylanicis sed coloribus albis, fructus flavidus.

---

*Critical Notes on Ceylon Plants, XXII.

†B. A. Krukoff Botanist of Malesian Botany, Rijksherbarium, Leiden.

Typus : *Kostermans* 25601 (L).

Tree, 20—30 m high and up to 60 cm diam. Bark brown, in old trees deeply cracked, the cracks 2 cm apart. Old bark 3 mm thick. Live bark 4 mm thick, whitish. Branchlets glabrous. Stipules slender, up to 4 cm long. Leaves thinly coriaceous, glabrous, ovate, 3.5 × 7—7 × 12 cm, acute or shortly acuminate, base acute, lateral nerves up to c. 12 pairs. Lower leaf surface (in vivo) glossy green. Petiole 1.5—2 cm long. Flowers smaller than those of *Bh. ceylanica* and the inflorescence white. Fruit yellowish.

Southeast Ceylon, wet zone, low alt. Hiniduma area, Sept., fl., *Kostermans* 25601 (A, BO, K, L, P, PDA, US) ; Beriliya forest near Elpitiya, sapling, *Kostermans* 25641 A (L) ; near village Hiniduma, Aug., fl., *Kostermans* 25460 (L) ; ibid., Sept., fr., *Kostermans* 25725 (A, BO, K, L, P, PDA, US).

At sapling stage (1.5 m) the species is easily distinguished from *Bh. ceylanica* by the oblong, rather narrow leaves with acute base and a glossy green lower leaf surface. In *Bh. ceylanica* at this stage, the leaves are broadly ovate with rounded or subcordate base and a dull grey lower leaf surface.

The leaves of our species are smaller than those of *Bh. ceylanica* (on sterile branchlets, near the inflorescences the leaves of both are considerably reduced in size) and the petioles are shorter. The leaves of *Bh. ceylanica* dry naturally a yellow brown colour, those of *Bh. nitidissima* a dark brown one. In vivo they are dull grey underneath.

The fruit of *Bh. ceylanica* are cherry red, those of our species are yellow and smaller and also the inflorescences in *Bh. ceylanica* are red, in *Bh. nitidissima* white.

The aril of *Bh. ceylanica* is described by Trimen as greenish; however, it is transparent and clear with a rather tough consistency, acid in taste.

The two species flower and fruit at different periods. In southeast Ceylon in September *Bh. ceylanica* has ripe fruit, whereas *Bh. nitidissima* starts flowering.

The timber is soft and not durable. Both are among the largest trees in Ceylon.

Clusiaceae

Mammea cordata Stevens

This species was described by Stevens (in Austral. J. Bot. 22 : 414, fig. 1. 1974), who indicated the specimen *N.G.F.* 5760 as the holotype. An isotype of this was available at Leiden.

There are some discrepancies in Stevens' description. The petiole is said to be 4—7 mm long ; this is true for a paratype specimen (*Hartely* 12274) available at Leiden, but the holotype has petioles 15—20 mm long, which is corroborated by the accompanying drawing. The fruit is described as subspherical, but the young fruit of the holotype at Leiden is ellipsoid and distinctly pointed.

Additional material (*N.G.F.* 46916) and the paratype specimen *Hartley* 12274 have the same kind of fruit, but more mature. It seems to be improbable that these fruits should become spherical. The label, moreover, gives the information that the seeds have sharp, longitudinal ridges, not mentioned by Stevens. The holotype had apparently a detached fruit. Does this belong ?

The leaves should be better called thinly coriaceous and the midrib on the upper surface of the leaf is only partly prominulous, the basal part being impressed slightly.

Additional specimen : *Lae* 56315 from Milne Bay District, Junction of Mayu and Ugat Rivers, fl. April.

Garcinia mammeoides Kosterm., spec. nov.

Arbor parva in omnibus partibus glabra, ramis horizontalibus, foliis coriaceis magnis oblongis, acuminatis, basi rotundatis vel subcordatis, utrinque laevibus, supra nervo mediano pro parte prominulis, subtus prominentibus, nervis lateralibus numerosis subpatentibus tenuibus prominulis, rete inconspicuis, petiolis crassis, fructibus terminalibus ovoideo-ellipsoideis attenuatis, saepe subcurvatis, stigmate hemiglobosa multipapillosa, calyx deest, floris non vidi ex collectore rosacea.

Typus : *Katik* N.G.F. 46931 (L).

Small bushy tree, glabrous in all its parts with horizontal branches, 1—2 m high. Bark black, under red ; inner bark brown, bright yellow latex. Wood cream. Branches thick, cylindrical, flattened at the nodes. Leaves coriaceous, oblong, 7 × 40—11 × 50 cm (apical leaves sometimes only 3 × 12 cm), acuminate, acumen broad, 1—2.5 cm long, base rounded or subcordate, above midrib prominulous in its upper part, flat or slightly impressed in its lower one, lateral nerves filiform, prominulous, the reticulation almost invisible, lower surface paler, smooth, midrib prominent, lateral nerves c. 40 pairs, rather patent, filiform, hardly prominulous. Petiole thick, 6—10 mm long, margins of excavations c. 4 mm long.

Fruit apical, solitary, ovoid-ellipsoid, sometimes somewhat curved, up to 8 cm long and 3 cm diam. with elongated seeds ; pericarp fleshy, red when ripe ; stigma dome-shaped, 4 mm diam. with numerous small papillae ; calyx lobes deciduous ; pedicel short, thick.

The species is outstanding amongst New Guinea species of *Garcinia* by the long, oblong leaves and the slender fruit, which resembles somewhat those occurring in *Mammea*.

Although mentioned on the label, flowers were not present in our specimen.

New Guinea : Milne Bay Distr., M. S. Road to Mt. Suckling, alt., 360 m, lower montane forest, July, fr., *Katik* Lae 56324 (L) ; ibid., Rabaraba, alt. 360 m, fl. pink, fr. green, red when ripe, June, *Katik* N.G.F. 46931 (L).

Garcinia rubro-echinata Kosterm., spec. nov.

Garcinia echinocarpa (non Thwaites), Gamble, Man. Ind. Timb. 53. 1902 ; Fl. Madras 73. 1915 ; Brandis, Ind. Trees 50. 1906; Rama Rao, Fl. Pl. Travanc. 29. 1914 ; Wealth of India 4: 101.1956 ; Maheshwari in Bull. Bot. Survey India 6 : 126. 1964 (quoad specim. Ind. austral.).

Arbor in omnibus partibus glabris, remulis crassis apicem versus quadrangularis, foliis rigide coriaceis subobovatis vel late ellipticis obtusis vel retusis, basi breve acutis, nervis lateralibus numerosis erecto-patentibus paralellis tenuibus utrinque prominentibus, nervo mediano supra applanatis, subtus prominentibus, petiolis crassis longis ; floribus masculinis axillaribus vel terminalibus aggregatis, feminis solitariis terminalibus, sepalis 4, magnis coriaceis orbicularibus obtusis, petalis duplo longioribus coriaceis flavis suborbicularibus vel oblongis, staminibus in floribus masculinis 12—40 connatis, in floribus feminis staminodiis uniseriatis basi connatis, ovario papillosa ; fructibus ellipsoideis rubris dentatis, stigmate hemiglobosis papillosis.

Typus : *Bourdillon* 611 (K.)

Medium sized tree, glabrous in all its parts ; branchlets thick, apically quadrangular. No stilt roots or buttresses ; live bark dark red ; bole cylindrical, smooth, dark brown. Wood dark red, very heavy. Leaves thickly coriaceous, sub-obovate to broadly elliptic, $3 \times 8 — 8 \times 15$ cm, obtuse or sub-retuse, base shortly acute, midrib flattened (except basal part) on upper surface, prominent on lower one ; lateral nerves 30—40 pairs, erect-patent, parallel, slender, prominent on both surfaces, leaf margin slightly revolute. Petioles stout, 1—2.5 cm long ; excavations 2×5 mm.

Buds globose, mature ones 5—7 mm across. Male flowers several, axillary or terminal, sessile, subtended by fleshy rather large bracts, slightly smaller than the female ones. Female flower solitary, terminal, with bracts at base. Sepals 4, very fleshy, orbicular, up to 6 mm long, obtuse. Petals 4, almost twice as long as the sepals, fleshy, yellow, suborbicular to oblong. Stamens in male flower 12—40, connate into a short, quadrangular stalk ; anthers linear-oblong, laterally introrse, connected to a thick, clavate connective, dehiscence vertically. Staminodes in female flower in one row, base connate into a ring. Ovary with imbricate, fleshy warts, stigma peltate.

Fruit (mature) ellipsoid, 4×6 cm, dark red, 4-locular, 1—3—seeded ; pericarp very thick, 3—5 mm, covered with broad, short, fleshy spines. Seeds oblong, up to 4 cm long with scanty aril ; stigma hemispherical, 8 mm high, papillose, consisting of 4 close, symmetrical parts.

The species differs in many respects from the Ceylonese *G. echinocarpa*, with which it has been confused. Its flowers are much larger, the petals fleshy and yellow (in *G. echinocarpa* thin and pale green). Its fruit are larger, dark red and have a thick wall (in *G. echinocarpa* pale green at maturity with a very thin pericarp) and have a different stigma.

Oil from the seeds is used as an inferior lamp oil. The leaves and bark are used in cases of dropsical affections and also as a vermifuge.

S. India : Tirunelvelly Hills, common, fl., *Beddome s.n.*, anno 1879 (K) ; above Ambasamuderam, alt, 1500 m, rainforest, rather common, July, fr. Kostermans s. n., (G, K, L, P) ; Travancore : Poonmudi , Strathmore Estate, alt. 1200 m, April, fr., *Bourdillon* 611 (CAL, K) and Chimunjee, alt. 1100 m, *Bourdillon* 559, fl. Apr. (K).

Cornaceae

Mastixia macrophylla (Thw.) Kosterm., comb. nov.

Bursinopetalum arboreum var. *macrophyllum* Thwaites, Enum. Pl. Zeyl. 42. 1858.—Typus: *C.P.* 637 2440.,

Bursinopetalum macrophyllum Thwaites, l.c., nomen alternativum.

Thwaites was not sure about the status of this taxon, because of insufficient material.

I have collected this species in Ceylon (*Kostermans* 24134) in fruiting stage. The tree is entirely different from *Mastixia arborea* which has a dense, oblong crown with erect-patent branches and a very rough bark. *Mastixia macrophylla* is a smooth-barked tree with open crown with long, horizontal branches, bearing ramifications at their ends. It looks similar to *Octomeles sumatrana*. Moreover, the leaves are much thicker, stiffer and larger.

Father B. Matthew S. J. (Tiruchchirapalli, India) who recently revised *Mastixia*, prefers to keep this taxon as a subspecies of *M. arborea* (information in litteris).

The suggested alternative name, being published before 1953 (Article 34, Code of Nomenclature), is validly published.

Trimen (Handb. Fl. Ceylon 2 : 287. 1894) dismissed the variety entirely, mentioning only the larger petioles and broader fruit of the specimen *C.P.* 2440.

I have also collected a kind of *Mastixia* in the wettest part of southwest Sri Lanka, which might be either *M. tetrandra* or an unknown species ; it was collected in fruit (*Kostermans* 23631 *A*).

The fact that *M. tetrandra* var. *thwaitesii* Clarke has a typical vernacular name (Diyataleya) might be an indication for its rank as species (Diya = water), as in the Diya-na (*Mesua ferrea* L.).

Mimosaceae

Adenanthera malayana Kosterm., spec. nov.

Adenanthera bicolor Auct. (non Moon) King in J. Asiat. Soc. Bengal 66 (2) : 243. 1897 ; Ridley, Fl. Malay Pen. 1 : 653. 1922 ; Burkill, Dict. econ. Prod. Malay Pen. 44. 1935 ; Corner, Wayside Trees Mal. 407. 1940 ; Wyatt-Smith, Research Pamphl. 2 : 56—58. 1953; Whitmore, Tree Fl. Mal. 1 : 275. 1972.

Arbor mediocris, foliis alternantibus, 6—8-pinnatis, pinis oppositis, foliolis alternantibus rigide sub-coriaceis ovatis vel ellipticis acutis basi rotundatis, supra glabris, subtus adpresse puberulis glaucis, petiolatis, glandulis nullis, racemis axillaribus vel in panniculum dispositis sub-terminalibus, floribus parvis pedicellatis, lobis calycibus parvis, corolis liberis exsertis, antheris glanduliferis, ovario glabro, leguminis applantis maturitate dehiscentibus contortis seminibus rubris vel partim nigris.

Typus : *Curtis* 2840 (K).

Slender, unarmed tree, up to 10 m tall. End buds densely light brown puberulous. Leaves alternate ; petiole 4—6.5 cm long, rachis puberulous, 7—13 cm long, not produced beyond the last pair of pinnae, ending in a short, thin stipe, no glands. Pinnae puberulous, 6—8, opposite, 6—10 cm long with stalk c. 1 cm long ; folioles alternate, 8—10, ovate or elliptic, base rounded, apex acute, rigidly, thinly coriaceous, $1 \times 2 - 2 \times 3.5 - (4 \times 5)$ cm, bright green, glabrous above, pale glaucous adpressed puberulous beneath ; petiolule 3 mm long.

Racemes shortly peduncled, puberulous, narrow, 7—13 cm long, axillary or forming a terminal panicle. Flowers c. 3 mm long, on slender, 3 mm long puberulous pedicels. Calyx puberulous or almost glabrous, green, lobes small, triangular. Corolla white, petal valvate, elliptic-lanceolate, almost free, glabrous. Stamens 10, free, shortly exserted, anther tipped by a stipitate gland. Ovary glabrous. Pod flattened, bulbous over the seeds, 10—15 cm long, up to 15 mm wide, completely dehiscent, contort. Seeds 8—10, lenticular, red or partly black, smooth, shining, hard.

Differs from *A. bicolor* by the puberulous rachis, pinnae and lower leaf surface, the lack of persistent bracts and the colour of the young flush and flowers.

Malay Peninsula : Penang, waterfall, *Curtis* 2840 ; Perak, Larut, *Kunstler* 3991, *Scortechini* 197, 1849; Assam Kumbang, *Wray* 2124; Pankore : *Scortechini* 1073 ; Singapore: Bukit Timah : Hullet Bukit Mandai, *Ridley* 3636 *A* ; Malacca, *Miller, Griffith, Maingay* 591 ; *Derry* 522.

Thailentadopsis Kosterm., a new monotypic genus of Mimosaceae

Thailentadopsis Kosterm., gen. nov.

Arbor, foliis alternantibus bipinnatis, stipulis duabus spiniformibus foliolis sessilibus, oppositis subtrapeziiformibus basi inaequilateralibus, foliolis basalibus imparibus, rachis rachillis alatis, glandulis sessilibus subcylindricis, inflorescentiis terminalibus paucifloris pauce ramosis ramulis subfasciculatis floribus umbellatis calycibus campanulatis, segmentis parvis, corollis anguste campanulatis, lobis longis, staminibus numerosis exsertis basi vix connatis ; leguminibus tenuibus subbulatis submoniliformibus, valvis dehiscentibus.

Species typica unica : *T. tenuis* (Craib) Kosterm.

Small tree. Leaves spirally arranged, with 2 pinnae, at base with two slender stipular thorns, leaflets sessile, opposite, sub-trapezoid, base unequal, the basal leaflet single, leaflets increasing in size upwards, rachis and rachillae winged, glands conspicuous at insertion of pinnae and between folioles, subcylindrical. Inflorescences teminal, forming a few-branched panicle, the branchlets congested, subfasciculate, flowers in umbels ; calyx campanulate with small lobes ; corolla narrowly campanulate with long lobes ; stamens numerous, hardly connate at the base. Pod straight, flattened, sub-moniliform, bullate over the seeds, the bullate part over the seeds detaching as rectangular pieces, separate from the adjacent ones.

The species has been originally described in *Pithecellobium* by Craib. In my monograph of Asiatic *Pitchecellobium* (Bull. 20, Organization Scientific Research Indonesia 69. Dec. 1954) I referred it to *Acacia*.

The genus combines characters of several other Mimosaceous genera. It has the bipinnate leaves of *Abarema*, the winged rachis of *Inga*, the stipular thorns of *Acacia* and some American *Pithecellobium* species, the flat moniliform pod it has in common with many other genera, but the dehiscence by separate pieces over the seeds with *Entada*.

Thailentadopsis tenuis (Craib) Kosterm., comb. nov.

Pithecolobium tenue Craib in Kew Bull. 1927 : 394.—*Acacia tenue* (Craib) Kostermans in Bull. 20, Organ. Sc. Res. Indonesia : 69. Dec. 1954.—Typus: *Kerr* 6095. (K).

Treelet or shrub, up to 6 m tall. Branchlets slender, glabrous, glossy. Leaves spirally arranged, glabrous with 2 pinnae ; rachis and rachillae winged ; rachis 1.5—2 cm long; glands rather large, subcylindrical, at insertion of rachillae and apical leaflets, rachis and rachillae ending in a minute, acute stipe. Rachillae 1.5—6 cm long ; leaflets 1 or 1.5 or 2.5 pairs per pinna, opposite, chartaceous, the lowest one solitary, 0.5—1.5 × 4 cm, the apical ones 0.5 × 4—4 × 8 cm, somewhat trapezoid, base inaequilateral, apex gradually acute ending in a minute sharp mucro ; both surfaces glossy with prominulous midrib (with few, minute hairs above) and filiform, 6—10 pairs of erect-patent lateral nerves of which the lower pair is somewhat steeper, reticulation lax, prominulous, more so on lower surface. Petioles none or very short, thick. Leaves flanked at base by two stipular sharp thorns, 1—7 mm long.

Inflorescence terminal, up to 9 cm, glabrous, slender, few-flowered, consisting of a main peduncle bearing at long intervals one or more filiform, up to 1—2 cm long branchlets, which bear the sub-umbellate, sessile florets or are again shortly branched. Each bundle of branchlets with 2 thin, thorn-like stipules at its base. Each flower subtended by a minute membraneous, acutish bract. Flowers glabrous. Calyx narrowly campanulate, green, glabrous, 1.5 mm long, the narrowly triangular acute teeth about as long as the tube. Corolla trumpet-shaped, 6 mm long, the lobes ovate-oblong, erect-patent, acutish, up to 2—4 mm long ; filaments numerous, white, up to 1.5 cm long, base slightly connate, anthers green, minute, peltate when opened. Ovary glabrous.

Pods straight, rather thin, smooth, glossy, dark brown, up to 20 cm long, 2 cm wide, indented laterally, indents deep or shallow, base tapered, pedicel 1 cm long ; on one (dehiscent) side bullate over the seeds, other side the bullate part sunk. Dehiscence by a kind of flap (the bullate part over the seed breaks from the adjacent parts and detaches single). Seeds smooth, glossy, brown, oblong, flattened, c. 9 × 12 mm with an impressed line parallel to the margin on both sides.

The pods resemble those of *Cathormion umbellatum*, but they break not at the joints and are dehiscent, somewhat like *Entada*.

Thailand : Southwestern. Kanchanaburi, Erawan National Park between Kwae Noi and Mae Klong Rivers, along path from guesthouse up hill, poor deciduous forest and bamboo jungle, shady places along rivulet, alt. 200—600 m, April, fl., *Beusekom & Phenkhlai* 501 (L) ; ibid., Nov., fl., fr., *Beusekom & Geesink* 3880 (L) ; Kanchanaburi, Dongyai, 700 m, Aug., fr., *CP, BS & BN* 2944 (L) ; between Kritee and Meung Cha, Southwestern, limestone, 800—900 m alt., July, fl., *Geesink & Phengkhlai* 6174 (L) ; Doi Mussoe, 38 km west of Tak, 16 47 N, 98 19 E, alt. 600 m, March, fr., *Hansen & Smitinand* 13013 (L).

Sterculiaceae

Sterculia zeylanica Kosterm., spec. nov., Plate 2.

Arbor parva vix ramosa, foliis chartaceis ellipticis basi obtusis vel truncatis apice obtusis supra glabra nervo mediano gracilis basin versus sub-impressis nerviis lateralibus filiformis prominulis, costis basalibus sub-adscendentibus basin versus sub-impressis, subtus sat dense prominulo-reticulatis nervo mediano prominentibus nerviis laxe minutissime stellato pilosis, petiolis gracilis longis glabrescentibus inflorescentiis pseudo-terminalis ramemiformibus dense minutissime adpresse stellato pilosis, pedicellis gracilis brevis, lobis perianthium lanceolatis acutis extus dense adpresse stellato pilosis intus subglabris, tubo longioribus, androgynophorus glabris perianthemum aequilongis, antheris 10 *irregulariter dispositis ovariis dense minutissime stellato pilosis.*

Typus : *Kostermans* 24056 A (L).

Tree, 1—3 m high, up to 4 cm diam., hardly branched. Bark of the slender branchlets longitudinally furrowed, towards their apices minutely stellate pilose. Leaves chartaceous, elliptic to broadly elliptic, rarely subobovate-elliptic, 6 × 15 — 14 × 22 — 10 × 22 cm, base rounded or truncate, apex obtuse or obscurely shortly acuminate, upper surface glabrous, dull, finely reticulate, midrib slender and like the lower basal laterals slightly impressed towards their bases, laterals 5—7 pairs, slender, prominulous, lower surface shortly, laxly stellate pilose on the nerves, rather densely prominulously reticulate, midrib prominent. Petiole slender, 3—5 cm long, densely, minutely adpressed sub-lanuginose, glabrescent.

Racemes pseudo-terminal, patent, up to 7 cm long, densely adpressed stellate pilose, initially with numerous slender, acute bracts, pedicels slender, 2—3 mm long, densely pilose. Flowers pale pink. Perianth lobes lanceolate, acute, c. 5 mm long, outside densely adpressed stellate pilose, inside subglabrous, the tube c. 3 mm deep, androgynophore glabrous, c. 8 mm long, anthers 10, arranged irregularly in a globose head, ovaries densely pilose.

Sri Lanka (Ceylon), road Laxapane to Maskeliya, just beyond Doublecutting, alt. c. 8—900 m, wet, evergreen forest, May, fl., *Kostermans* 24056, 24056 A (A, BO, K, G, L, AA, US). Rassagalle Forest above Balangoda, alt., 1000 m, May, fl., *Kostermans* 23567 (K, L, US).

Related to *S. guttata*, from which it differs by being a very small tree with a much coarser, more adpressed indumentum, the less dense reticulation of the lower leaf surface and the more slender flowers with their short appressed pilosity.

The species is known so far only from two places. I suspected it immediately to represent a novelty, because of its small size. It is easily distinguishable from *S. guttata* (a medium sized tree) by the much shorter, adpressed tomentum.

Of *S. guttata*, stated by Trimen to be very rare, I have observed some specimens at sapling stage along the main road of the Kaneliya forest near Hiniduma. These young trees have still the very large, lobed leaves. A single, older tree was found at the forest border of Hinidumkande, in this tree the leaves had the mature, entire shape. No flowering specimens were discovered.

The possibility that the Ceylonese *S. guttata* is not conspecific with the Indian one, should not be excluded.

Brachychiton velutinosum Kosterm., spec. nov.

Arbor, ramulis crassis, apicem versus dense minutissime stellatopilosis ; foliis chartaceis vel subcoriaceis, suborbicularibus, apiculatis, basi profunde lobis obtusis cordatis, margine costa nerviisque basalibus et lateralibus projectis triangulariformi producto ; supra glabrescentibus, subtus perdense stellato-pilosis, nervo mediano prominentibus, venis lateralibus 4, e basi prodeuntibus, venis laterilibus caeteris erecto-patentibus strictis ; petiolis perlongis, dense stellato-pilosis ; floribus late campanulatis, rubris extus minutissime brevissimeque stellato-pilosis, intus sparse longioreque stellato-pilosis; lobis brevibus, latis, obtusis, androphoris longis, pilosis, sat crassis; antheris 20 globo irregulariter impositis ; tubo florifero intus ad basin appendiculis 10 unciniformibus perdense griseo-pilosis instructo.

Typus : *Pullen* 6870, mascul. (L).

Tree, up to 20 m high ; trunk sometimes slightly bottle-shaped. Bark rather smooth, cracked vertically, patchy light and medium grey ; outer layer hard, when cut with a bush knife the hard bark shatters and flies ; live bark brown and pink streaked to cream. Wood rich cream, very soft, coarsely cellular in appearance. Branchlets thick with large, almost circular protruding leaf scars ; upper part with a dense layer of pale brown, minute, scaly stellate hairs. Leaves chartaceous to thinly coriaceous, sub-orbicular, 9 × 10—14 × 14 cm, apiculate, base deeply cordate with large, obtuse lobes, the margin with triangular productions at the end of each of the basal and lateral nerves ; both surfaces very minutely, densely, obscurely reticulate, above glabrescent, tardily so on the prominulous midrib and basal lateral nerves, below very densely grey stellate pilose, the tomentum consisting of a basal layer with adpressed stellate hairs and a more sparse upper layer of stellate hairs with longer and erect arms ; midrib prominent ; usually 4 basal lateral nerves, of which the lower pair is sub-horizontal, the upper pair erect-patent, both straight and prominent ; higher up the leaf 3—4 pairs of other erect-patent, lateral straight prominent nerves ; secondary nerves prominulous, slender, sub-parallel, widely spaced. Petioles slender, 7—12 cm long, densely, minutely stellate haired with short arms.

Flower broadly campanulate, red (fresh), covered with extremely small, very short-armed, scaly stellate hairs ; tubular part 25—27 mm long, consisting of a smooth, 1.5 cm high lower part, 2 cm wide at the apex, continued by a 10—12 mm high part, similar to the flower of *Convolvulus*, with groups of 3 longitudinal protruding ribs, ending in the centre of the free apical lobe, the intermediate part membraneous, higher coloured and with smaller stellate hairs ; the free lobes broader than long, obtuse, ca. 7 mm high, 15 mm wide. Inside of flower with scattered longer-armed stellate hairs. Base inside with 10 hook-shaped (incurved at the top), densely grey pilose, almost free, 5 mm long appendages, surrounding the base of the androphore. Androphore cylindrical, rather thick, 1.5 cm long, with a dense layer of thin, slender, stellate hairs, the lower part reddish, the upper part cream. Anthers 20, arranged irregularly on a globose head, ca 4 mm diam. Interior part of tube pale creamy green at base around the cream staminal column (fresh).

Female flower as long as male one with shorter (8 mm) gynophore, the 5 follicles slender, densely stellate pilose with slender, cylindrical apical part, the anthers irregularly arranged in groups of 5 at their base.

The species differs in many respects from the only other known *Brachychiton* (*carruthersii*) of New Guinea. It can be immediately recognized by the dense tomentum of the lower leaf surface. The flowers differ from those of *Br. carruthersii* by being larger and shaped like those of *Convolvulus* with a membraneous part in between ribbed parts, the broader, shorter lobes, the different stellate hairs, the long, pubescent andro- and gynophore and especially by the 10 hook-shaped silvery sericeous appendages at the base of the inside of the flower tube. A bunch of long hairs, as is found on the androphore of *Br. carruthersii* is lacking.

New Guinea, Central Distr., 43 miles S.E. of Port Moresby, Tavai Creek area, monsoon forest on low hills, alt. 200 m, May, male fl., *Pullen* 6870 (L) ; ibid., between the Laloki R. and Mt. Lawes, ca. 8 miles N. of Port Moresby, alt., 30 m, light woodland, July, female fl., *Pullen* 3326 (L).

Heritiera polyandra (L.S. Smith) Kosterm., comb. nov.

Argyrodendron polyandrum L.S. Smith in Contr. Queensl. Herb. 6 : 18. (1969) — Typus : *Webb & Tracey* 6235 (BRI).

The number of stamens—according to me—cannot be used as a characteristic at the generic level, as stressed by Smith, who keeps *Argyrodendron* separate from *Heritiera*. In *Sterculia* (unpublished monograph of Malaysian Sterculia by I. G. M. Tantra, Aberdeen, 1975), the number of stamens varies between 4 and 30 ; the species with few stamens have the anthers regularly in a ring, whereas in those with more stamens the anthers are arranged on a sphere, clasping each other in different directions. Exactly the same conditions are found in *Heritiera*.

Transverse veins of the samara wing are found in *Heritiera javanica, H. borneensis, H. simplicifolia,* etc.

Absence of veins, combined with a much reduced or hardly present wing, gradually merges with species with a longer wing with obscure veins to species with a pronounced wing, where both longitudinal, transverse, and fan-shaped veins occur. Consequently this also cannot be used to upkeep *Argyrodendron*.

Comparison of wood structure of the two species of the two ends of this spectrum (*H. littoralis*, with hardly any wing and *Argyrodendron*, and other *Heritiera* species with the most developed wing structures) does neither prove nor disprove their congenericity, nor does the number of chromosomes of a few species examined. Chromosome numbers as a whole cannot be used for delimitation of genera.

In Malesian *Sterculia* the chromosome number is 40 (3 species), in African (3 species) it is 36. In *Hildegardia barteri* it is 40 ; in *Pterygota alata* it is 40, in *Pt. macrocarpa* it is 36 ; in *Firmiana colorata* and *F. simplex* it is 40, as in *Brachychiton*.

Even in a single individual of a species the chromosome number may be variable (cf. Lewis, Chromosomal drift, Science 168 : 1115—16 . 1970).

Sapotaceae

Mimusops zeylanica Kosterm., spec. nov. Plate 3

Arbor, ramulis tenuibus, juvenilis adpresse pilosis, foliis alternantibus coriaceis, mox glabris, ovatis, breve et late acuminatis, basi rotundatis et breve cuneatis, supra pernitidis, nervo mediano lato prominulis, nervis lateralibus tenuibus prominulis, erecto–patentibus vel sat patentibus, rete sat obscuris, subtus opacis, nervo mediano prominentibus, nervis tenuibus prominulis, rete obscuris, foliis *juvenilibus subtus minutissime, sparse adpresse pilosis, petolis longis, gracilibus, adpresse pilosis, floribus solitariis vel 2-3-ternis, axillaribus vel extra-axillaribus, pedicellis perlongis, apicem versus incrassatis, dense, minutissime adpresse pilosis, sepalis sat coriaceis, anguste ovatis vel lanceolatis, acutis, utrinque adpresse pilosis, tepalis glabris, tenuibus, lanceolatis, acutis vel acuminatis, fructus ovato-ellipsoideus, glabris, nitidis.*

Typus : *Kostermans* 25176 (L.)

Tree, 10 m high and 40 cm diam. Bark deeply fissured, dark, strips 2—3 cm wide, 3 mm thick, hard, easily detached in rectangular pieces ; live bark 5 mm, red with white sap. Branchlets slender, near the flush rather densely, minutely adpressed pilose. Leaves spirally arranged, rather thinly coriaceous, soon glabrous, ovate, 3.5 × 6— 6 × 10 cm, broadly acuminate (acumen up to 1 cm long, obtuse), base rounded and in the centre shortly cuneate, above very glossy, midrib broad, prominulous, nerves very thin, prominulous, erect-patent to rather patent, ca 12 pairs with intercalated ones, reticulum obscure ; below dull, midrib prominent, nerves slender, prominulous or obscure, reticulum obscure. Petioles slender, 1.5 — 2 cm long, soon glabrous, channeled above.

Flowers axillary and extra-axillary (bract at the base), solitary or 2—3 together. Pedicel slender, 3.5—4 cm long, slightly thickened upwards, densely, minutely, adpressed pilose ; buds elongate, sepals rather coriaceous, narrowly ovate or lanceolate, acute, up to 12 mm long, both sides densely adpressed pilose ; petals glabrous, thin, lanceolate, acute or acuminate, attenuate, up to 11 mm long. Fruit ovate-ellipsoid, smooth, glossy, up to 2.5 — 3 × 2 cm., obtuse.

The species differs from the common *M. elengi* L. by its much coarser, deeply fissured, blackish bark, the ovate leaves with fewer nerves, the very long flower pedicels and the much larger flowers. Its large fruit resembles some African species. It is restricted to a small area, the Devulane forest in the Amparai District, which belongs to the intermediate zone. The common *M. elengi* occurs also elsewhere in Ceylon. The flowers are white, but not so fragrant as those of *M. elengi*; the ripe fruit is red orange. A specimen of *M. elengi* from Celebes (Leg. Kariski) has abnormally long pedicels, up to 2.5 cm, but this is still much shorter than in *M. zeylanica*. Superficially our species resembles *M. longipes* Baker from Africa.

In Malesia *M. elengi* is represented with two varieties of fruit, one a globose one, another with an elongate, pointed fruit ; at this stage it is not possible to ascertain, whether these are mere varieties ; geographically they exclude each other, the globose variety occurring in the Lesser Sunda Islands and New Guinea, the acute one in Borneo.

Sri Lanka: Amparai-Kandy Road, Mile 18, Devulane forest, intermediate zone, low alt., June, fl., fr., *Kostermans* 25176 (BO, G. K, L, P, US) ; S. base of Friar's Hood, Nuwaragele For. Res., Devulane forest, Amparai Distr., alt. low, May, fl., fr., *Jayasuriya* 2320 (L, PDA, US).

Myrsinaceae

Ardisia lankaensis Kosterm, spec. nov

Arbor parva, ramulis gracilibus glabris, foliis coriaceis, glabris, ellipticis, margine integris, obscure et breve acuminatis, basi cuneatis in petiolum subdecurrentibus vel subobtusis, utrinque conspicue prominente reticulatis, supra nervo mediano impressis, nervis sat patentibus tenuibus, prominulis, numerosis, subtus pallidioribus, nervo mediano prominentibus, nervis prominulis terminalibus dense minutissime glanduloso-pilosis, remulis paucis, patentii, floribus psevdo-umbellatis, pedicellis sat longis glanduloso-pilosis, sepalis rigidis, ovatis, obtusis fimbriatis, extus minutissime glanduloso-pilosis, pestalis ovatis, glabris, antheris lanceolatis, glabris, ovario glabro, stylo longo, fructus globosis, verruculatis, minute umbonatis.

Typus : *Kostermans* 24993 A (L).

Tree, up to 5 m high ; branchlets smooth, glabrous, slender, thickened at their base. Leaves rather thinly coriaceous, elliptic, 6.5 × 19—8.5 × 16 cm, margin entire, obscurely, shortly acuminate with sharp tip, base cuneate and somewhat decurrent or rounded and centrally cuneate ; both surfaces conspicuously, prominently reticulate ; above midrib impressed, nerves rather patent, 16—27 pairs, slender, prominulous ; below midrib prominent, lateral nerves slender, prominulous, along the margin a band of tiny glandular warts. Petiole 1—2 cm long, concave above.

Panicles terminal, up to 15 cm long, microscopically densely glandular-pilose ; branches few, stiff, patent, up to 5 cm long. Flowers pseudo-umbellate at the end of the branches ; bracts caducous. Pedicel 4—8 mm long. Sepals stiff , ovate, obtuse, fimbriate, outside minutely glandular-pilose, 1.5 mm long. Petals rather fleshy, light red, glabrous, glandular punctate, 3—4 mm long. Anthers broadly lanceolate, glabrous, 3 mm long, apex with 0.25—0.5 mm long awn. Ovary globose, glabrous, style 5 mm.

Fruit globose, glabrous, up to 8 mm diam., with numerous tiny glandular warts in longitudinal rows.

The species is conspicuous by its prominent leaf reticulation, the glandular fruit, etc.

In some flowers the anthers are narrow and devoid of pollen.

Sri Lanka: Galle District. Kaneliya forest near Hiniduma, wet, evergreen forest, alt. low, June, fl., fr., *Kostermans* 24993 A(G, L, PDA, US) ; Hinidumkande (Haycock), alt. 150 m, Aug., fr., *Jayasuriya, Kostermans* & *Bandaranayake* 1789 (L, PDA) ; Kottawa Arboretum, Talgampola, road Galle to Hiniduma, low alt., May, fl., *Kostermans* 23645 (G, L, PDA) ; ibid., fl., *Peeris s.n.* PDA.

Lauraceae

Litsea keralana Kosterm., nom. nov.

Litsea insignis Gamble in Kew Bull 130; 1925: Fl. Madras: 1237. 1925 (reprint 2:866. 1957).—Typus *Bourdillon 1009;* para-typus: *Bourdillon 1009;* para-typus: *Bourdillon 1046; Barber 4064, 5461, 5783, 8473.*

The specific name is antedated by *Litsea insignis* (Bl.) Boerlage, Handl. Fl. Nederl. Ind. 3:142. 1900.

Litsea Keralana is a magnificent tree, up to 1 m in diam., occuring scattered in Kerala (Travancore), where I collected it several times along the road from Thekadi to Mannar, at about 1000 m alt. and the Anamalais.

(MS received 8.12.76)

EXPLANATION OF FIGURES

PLATE 1.

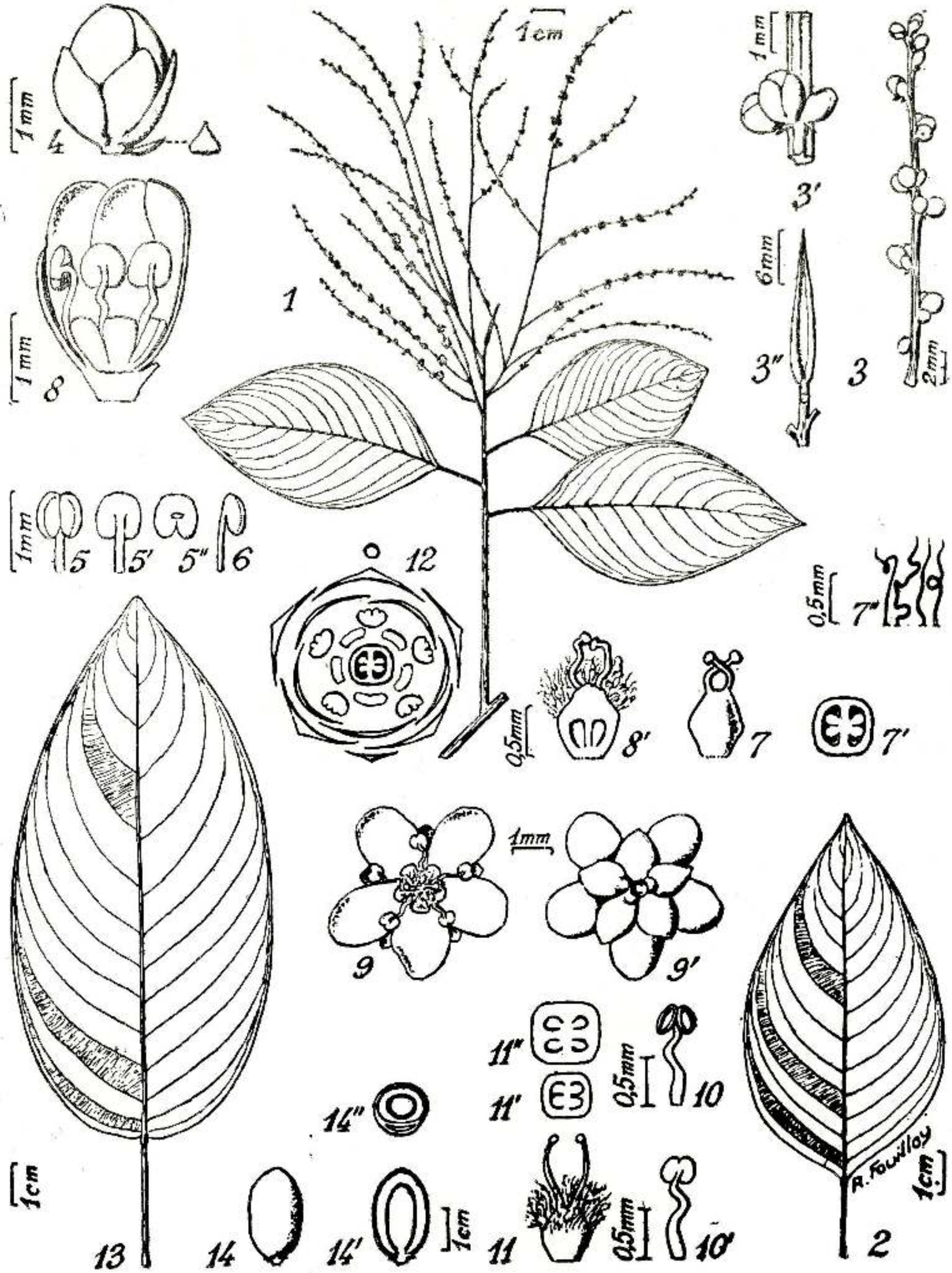
Bhesa nitidissima Kosterm., 1, flowering branch, upper leaf surface left ; 2, lower leaf surface ; 3, apex of inflorescence ; 3, tri-flowered cymule ; 3, bud from inflorescence apex ; 4, bud & bracteole ; 5, stamen from bud, seen from outside ; 5', inside ; 5', anther ; 6, profile ; 7, pistil from bud, pubescence not drawn ; 7', section ; 7", pubescence ; 8, opened flower, pistil detached to show disk ; 8', pistil, sectioned ; 9, opened flower from above ; 9', from below ; 10, stamen of 9, outside ; 10', inside ; 11, pistil of 9 ; 11', sectioned ; 11', in older flower ; 12, diagram (Kostermans 25460) .—*Bhesa ceylanica* D.Hou 13, lower leaf surface ; 14, fruit : sectioned longitudinally ; 14, cross section (Kostermans 25603).

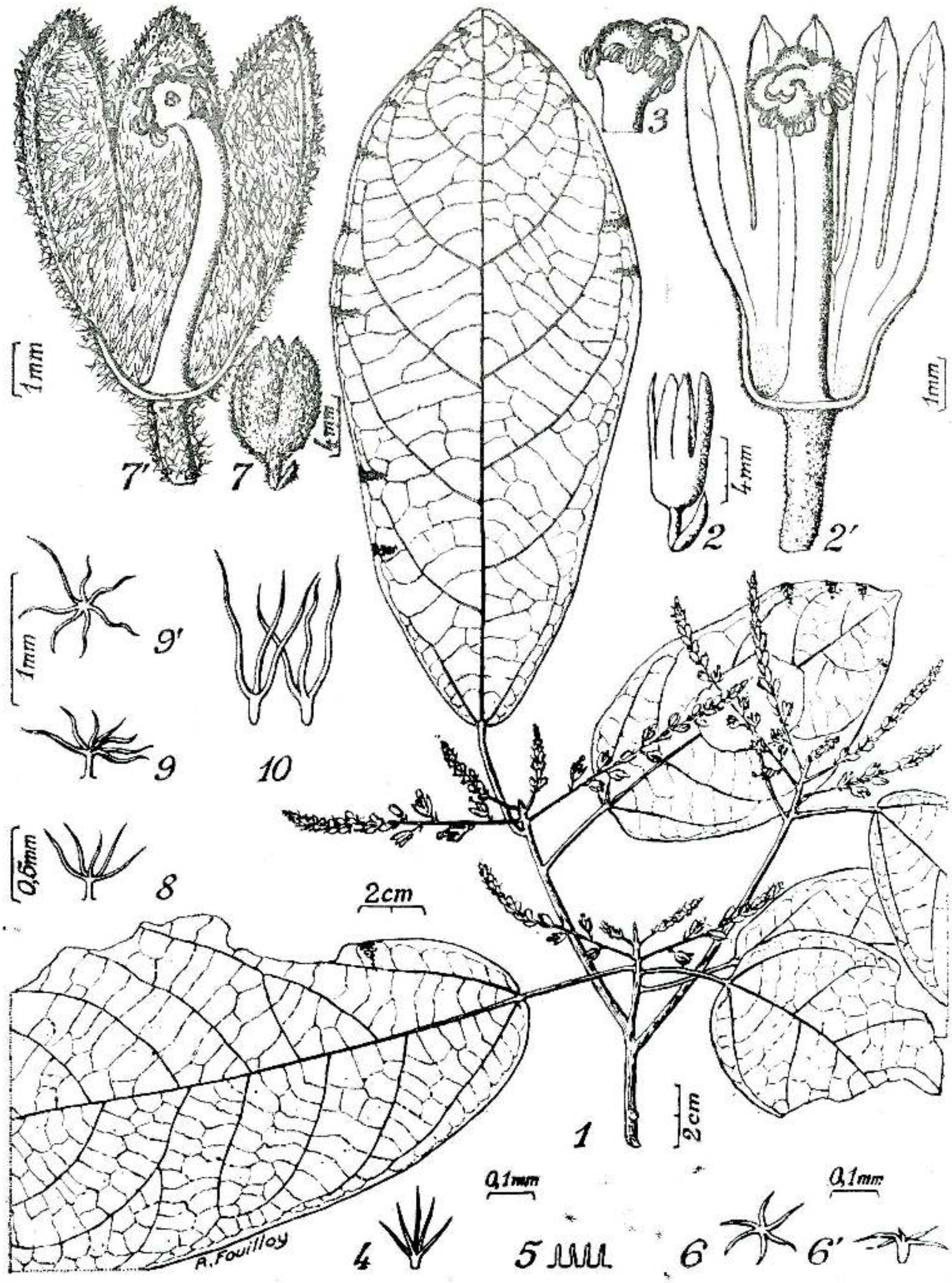
PLATE 2.

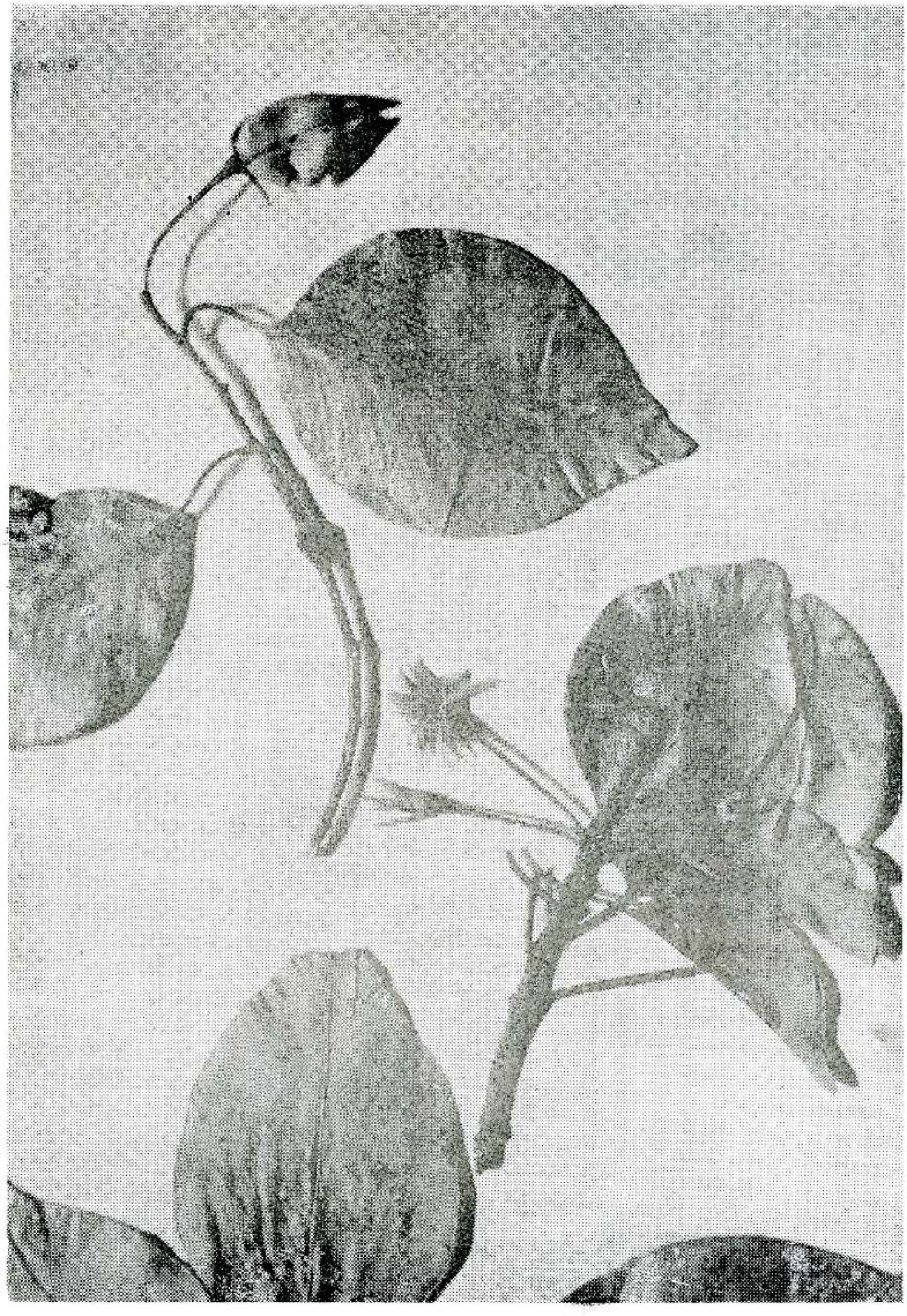
Sterculia zeylanica Kosterm. 1, flowering branch ; 2, opening flower ; 2' same enlarged, opened ; 3, other side of gynostemon ; 4, hair of the lower leaf surface ; 5, interior pubescence of calyx ; 6,6', hair of outside of calyx, face & profile (Kosterman 24062). *Sterculia guttata* Roxb., 7, opening flower ; 7', same enlarged, two sepals detached ; 8, hair of the lower leaf surface ; 9,9', hair of the outside of calyx, face and profile ; 10, hairs of the inside of the calyx (Vajravelu 26238).

PLATE 3.

Mimusops zeylanica. Kosterm Holotypus (L.).


1cm
1mm
4
1mm
8
1
1mm
3'
6mm
3"
3
2mm
1mm
5
5'
5"
6
12
0,5mm
7"
0,5mm
8'
7
7'
9
1mm
9'
11"
11'
0,5mm
10
14"
1cm
1cm
13
14
14'
1cm
11
0,5mm
10'
R. Fouilloy
1cm
2


1mm
7'
7
3
2
4mm
2'
1mm
1mm
9'
9
10
0,5mm
8
2cm
1
2cm
0,1mm
0,1mm
A. Fouilloy
4
5
6
6'



CEYLON J. SCI. (BIO. SCI) Vol. 12, No. 2, November 1977

Some Effects of Three Herbicides on *Bidens chinensis* Willd. and *Tridax procumbens* L.

by

M. A. PEMADASA AND S. KORALEGE

Department of Botany, University of Sri Lanka, Peradeniya, Sri Lanka

(With one text figure)

INTRODUCTION

Bidens chinensis Willd. and *Tridax procumbens* L. are two of the most abundant, widely distributed and troublesome composite weeds in arable lands of Sri Lanka. They are economically very important and ecologically extremely interesting for their strong competitive effects in reducing the yield of crop plants and high rate of colonization which makes their eradication almost impossible.

That the use of herbicides is economically profitable in eradicating weeds is well known. In weed control a herbicide should be used at its lowest effective concentration. On the other hand, since the response of species to herbicides may differ at different stages of the life-cycle, it is necessary to determine the stage of the life-cycle at which a weed is most susceptible to a given chemical.

In the present investigation an attempt was made to examine the effects of contrasting concentrations of three herbicides, which are commonly used in controlling weeds in Sri Lanka, on *B. chinensis* and *T. procumbens* at different stages of the life-cycle, with the object of determining the most effective herbicide in the efficient control of these two species.

EXPERIMENTS

The achenes of *B. chinensis* and *T. procumbens* were collected in early May 1975 from natural populations at Peradeniya, and were stored in glass-stoppered bottles under laboratory conditions. In all experiments the achenes from a single collection were used so that the results are directly comparable.

The herbicides examined were 2, 4-dichlorophenoxyacetic acid (2, 4-D), 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) and-2-methyl 4-chlorophenoxyacetic acid (MCPA). The herbicides were dissolved in about 1 ml of acetone to make them readily soluble in distilled water.

Effect of different concentrations of herbicides on germination

An experiment was performed to determine the effect of contrasting concentrations of the three herbicides on germination. The concentrations of herbicides examined were 5, 10, 50 and 150 ppm. A control was also included, in which the achenes received distilled water only.

The achenes were sown on Whatman No. 3 filter paper in 9 cm diameter plastic Petri dishes. The filter paper was moistened with 5 ml of the appropriate solution at the start, and distilled water, if necessary, was added at each time of recording to re-moisten the filter paper. The experiment was conducted in diffuse day-light in the laboratory, with three replicates of 50 achenes per treatment, and was arranged in a randomized block design. Recordings of germination were made daily for two weeks, and the results are illustrated in Fig. 1.

Both the rates and final percentages of germination of both species were significantly reduced with increasing concentration of herbicides ($P < 0.001$). None of the herbicides was appreciably inhibitory at concentrations lower than 50 ppm, and the detrimental effects on germination differed between herbicides ($P < 0.05$). The degree of inhibition in *B. chinensis* was highest in 2, 4-D and lowest in 2, 4, 5-T. In *T. procumbens*, on the other hand, the maximum inhibition occurred in MCPA and the minimum in 2, 4, 5-T. Further support for these observations is the highly significant species x herbicide interaction ($P < 0.001$). Although the other interactions were also statistically significant, they were relatively less important than the main effects and species x herbicide interaction. At 150 ppm concentration of all the herbicides *T. procumbens* failed to germinate while *B. chinensis* gave 20—50% germination.

Clearly all three herbicides are effective in inhibiting germination of both species, and the degree of inhibition increases with increasing concentration.

In addition to the quantitative information given above the following visual observations were made. The early growth of seedlings was not discernibly affected by 5 ppm of solution of any of the herbicides. At 10 ppm, 2, 4-D was more effective than 2, 4, 5-T and MCPA in retarding seedling growth of both species ; the seedlings remained very small though they appeared healthy. The seedlings turned brown gradually and finally died at 50 ppm regardless of the herbicide, and this was more pronounced in *T. procumbens* than in *B. chinensis*. At 150 ppm in all three herbicides seedling growth was restricted to a slight emergence of the radicle which also turned brown and died by day 3 ; in no herbicide were the plumule and cotyledons able to emerge. In contrast to the seedlings treated with herbicides, 'control' seedlings made healthy growth.

Effect of application of herbicides to the root system of seedlings

In this experiment an attempt was made to investigate the effect of application of contrasting concentrations of herbicides to the root system of seedlings of different ages. The root systems of 8-, 12- and 16-day-old seedlings, grown on moist filter paper in Petri

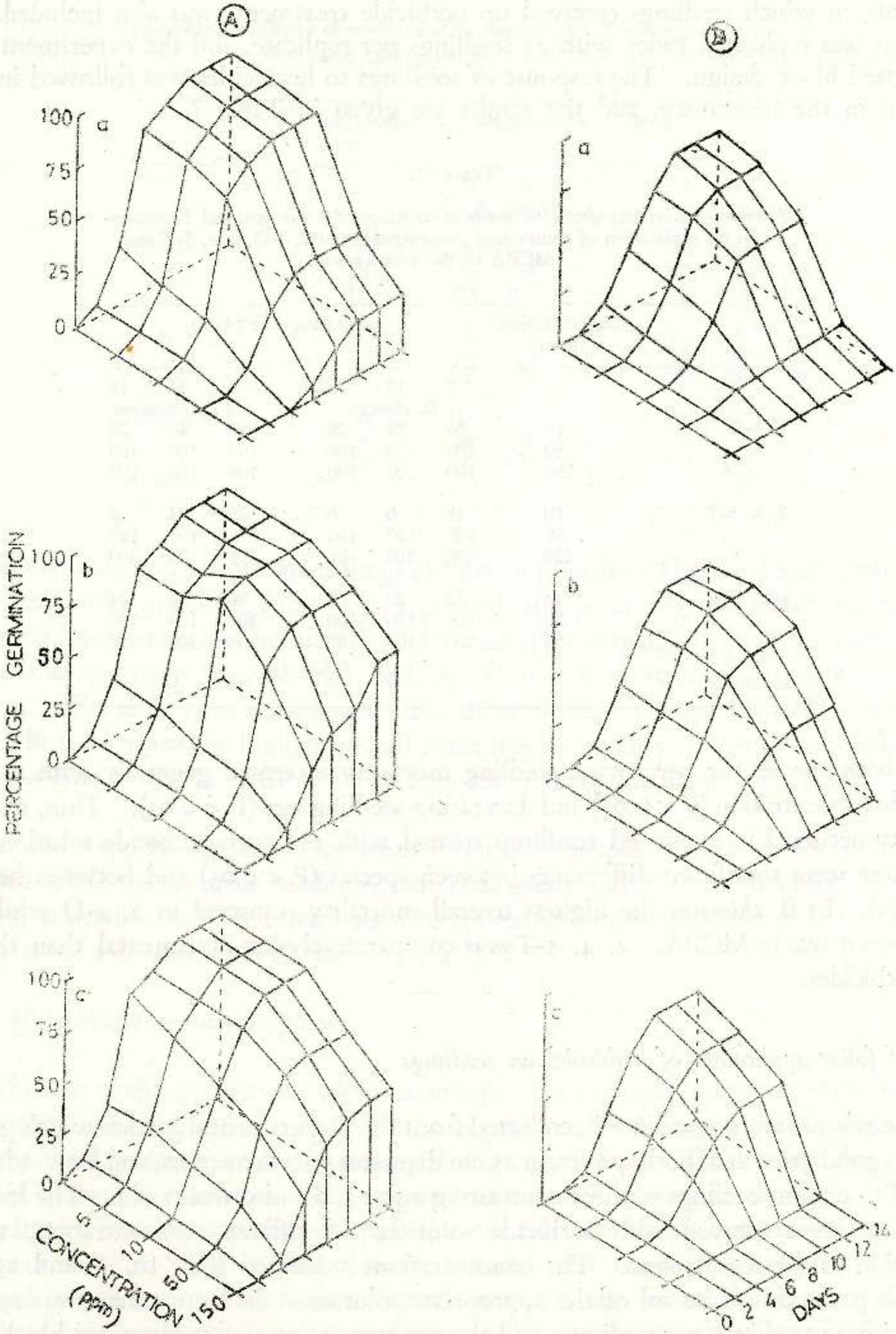


FIG. 1. Effect of contrasting concentrations of (*a*) 2, 4-D, (*b*) 2, 4, 5-T and (*c*) MCPA on germination of (A) *Bidens chinensis* and (B) *Tridax procumbens* in diffuse light in the laboratory.

dishes, were treated with 5 ml of 10, 50 or 150 ppm solution of the appropriate herbicide. A control, in which seedlings received no herbicide treatment, was also included. Each treatment was replicated twice with 25 seedlings per replicate, and the experiment was of randomized block design. The response of seedlings to herbicides was followed in diffuse day-light in the laboratory, and the results are given in Table 1.

TABLE 1.

Percentage mortality after two weeks of seedlings of *B. chinensis* and *T. procumbens* on application of contrasting concentrations of 2, 4-D, 2, 4, 5-T and MCPA to the root system.

	Concentration (ppm)	Seedling age (days)					
		8	12	16	8	12	16
		B. chinesis			*T. procumbens*		
2, 4-D	10	56	38	26	88	40	28
	50	100	100	100	100	100	100
	150	100	100	100	100	100	100
2, 4, 5-T	10	48	0	0	76	24	8
	50	100	100	100	100	100	100
	150	100	100	96	100	100	100
MCPA	10	52	20	8	96	46	34
	50	100	100	100	100	100	100
	150	100	100	100	100	100	100
Control		0	0	0	0	0	4

In both species the percentage seedling mortality increased generally with increasing herbicide concentration ($P < 0.01$) and decreasing seedling age ($P < 0.01$). Thus, maximum mortality occurred in 8-day-old seedlings treated with 150 ppm herbicide solution. However, there were significant differences between species ($P < 0.05$) and between herbicides ($P < 0.05$). In *B. chinensis* the highest overall mortality occurred in 2, 4-D while in *T. procumbens* it was in MCPA. 2, 4, 5-T was comparatively less detrimental than the other two herbicides.

Effect of foliar application of herbicides on seedlings

The achenes were sown in soil, collected from the Departmental garden which generally supports good growth of both species, in 25 cm diameter polythene pots, and kept adequately watered to obtain seedlings of three contrasting ages, 3, 6 and 9 weeks old. The leaves and cotyledons were sprayed with herbicide solutions of different concentration, avoiding application to the root system. The concentrations examined were 10, 50 and 150 ppm, and each pot received 10 ml of the appropriate solution. Each treatment was replicated twice with 25 seedlings per replicate, and the experiment was of randomized block design. The pots were kept adequately watered, and recordings were made of seedling survival for two weeks.

TABLE 2.

Percentage mortality of seedlings of *B. chinensis* and *T. procumbens* two weeks after foliar application of 2, 4-D, 2, 4, 5-T and MCPA.

	Concentration ppm.	Seedling age (weeks)					
		3	6	9	3	6	9
		B. chinensis			*T. procumbens*		
2, 4-D	10	26	8	8	68	46	30
	50	98	90	82	100	100	96
	150	100	100	94	100	100	100
2, 4, 5-T	10	0	0	0	56	32	18
	50	80	20	0	100	100	96
	150	98	90	68	100	100	98
MCPA	10	10	4	0	70	52	36
	50	88	46	26	100	100	80
	150	100	100	78	100	100	96
Control		0	0	0	0	0	2

The detrimental effects on seedlings of foliar application of herbicides are clearly evident from the results given in Table 2. In general, the percentage mortality increased with increasing concentration of herbicide and decreasing seedling age. The maximum mortality occurred in youngest (3-week-old) seedlings treated with strongest (150 ppm) herbicide solution. The severity of detrimental effect differed between species and between herbicides. In *B. chinensis* the highest overall percentage mortality occurred in 2, 4-D while in *T. procumbens* it was in MCPA. The least effective herbicide was 2, 4, 5-T.

In both species the seedlings treated with herbicides turned brown gradually and drooped while the 'control' seedlings remained green and appeared healthy. The rate of seedling mortality increased with increasing herbicide concentration and was somewhat higher in 2, 4-D and MCPA than in 2, 4, 5-T.

Effect of herbicides on mature plants

The aim of this experiment was to investigate the response of mature plants to different concentrations of herbicides. The plants were grown out-of-doors in soil collected from the Departmental garden, in 25 cm diameter polythene pots, for 20 weeks before the commencement of herbicide treatments. Most plants had started flowering by this time. The herbicide solutions (20 ml per pot) were applied to the foliage of one set of plants and to the root system of another. The concentrations examined were 10, 50 and 150 ppm. A control, in which plants received no herbicide treatment, was also included. Each treatment was replicated twice with 25 plants per replicate, and the experiment was arranged in a randomized block design in the Departmental garden. The pots were kept adequately watered, and recordings of survival of plants were made daily for four weeks.

TABLE 3.

Percentage mortality of mature plants (20-week-old) of *B. chinensis* and *T. procumbens* four weeks after (*a*) foliar application and (*b*) application to the root system of 2, 4-D, 2, 4, 5-T and MCPA.

	Concentration (ppm)									
(*a*) Foliar application										
	10	50	150	10	50	150	10	50	150	Control
		2, 4-D			2, 4, 5-T			MCPA		
B. chinensis	6	10	20	0	0	2	0	4	10	0
T. procumbens	10	22	34	0	4	8	8	12	16	0
(*b*) Application to the root system										
B. chinensis	0	4	10	0	0	0	0	0	6	0
T. procumbens	0	8	18	0	0	0	0	4	10	0

The results summarized in Table 3 clearly show that the mature plants of both species are comparatively resistant to the herbicides. No herbicide treatment was effective in causing mortality of more than 35%. In general, the resistance of plants to herbicides decreased with increasing concentration. The severity of the detrimental effects was highest in 2, 4-D and lowest in 2, 4, 5-T.

The herbicides were more detrimental when applied to the foliage than to the root system ; in fact, the mortality caused by the former treatment was almost twice that caused by the latter.

Although most plants were able to survive after the application of herbicides, their growth, both vegetative and reproductive, was arrested considerably. In plants which received the foliar application of herbicides, the leaves started wilting within 48 h, turned yellowish-brown gradually and died by day 7. The degree of leaf mortality was more pronounced at higher than at lower concentrations, and was higher in 2, 4-D and MCPA than in 2, 4, 5-T. On the other hand, the rate of leaf mortality in plants, whose root system was treated with herbicides, was much slower. The inflorescences of plants treated with herbicides drooped gradually and failed to produce seeds. The plants which were able to survive after the herbicide treatments developed new leaves and gradually recovered ; however, they appeared less healthy and weaker than the 'control' plants.

DISCUSSION

It is well known that the susceptibility of plants to herbicides differs between species and between stages of the life-cycle of the same species, and that the degree of toxicity varies between herbicides and depends on the concentration used (Audus, 1963). Blackman, Holly and Roberts (1949)demonstrated that the susceptibility to MCPA of a large number of species decreases considerably as plants become mature. Closely comparable relationships between the toxicity of 2, 4-D and 2,4,5-T and the stage of development of plants have been reported for many species by several previous workers (Templeman and Halliday, 1950). The present experiments demonstrated that the severity of detrimental effects of the herbicides examined on *B. chinensis* and *T. procumbens* is considerably higher at earlier stages of development of plants than at later stages. There is also evidence that 2, 4-D is more toxic to *B. chinensis* and MCPA to *T. procumbens*. The least effective herbicide appears to be 2, 4, 5-T.

In general, germination of both species is inhibited by all three herbicides, and the degree of inhibition becomes increasingly pronounced with increasing concentration of the treatment. According to Audus (1950) 2, 4-D, MCPA and 2, 4, 5-T can remain undecomposed in soil for a fairly long time and are capable of arresting germination of many weed seeds. It may, therefore, appear that efficient control of *B. chinensis* and *T. procumbens* could be achieved by preventing their germination. However, many crop plants are somewhat susceptible, at early stages of development, to 2, 4-D and MCPA, especially at higher concentrations (Audus, 1963), and so it is necessary to apply these chemicals after the crop seedlings have established and weed seedlings are not more than 2—3 weeks old. The seedlings of both weeds are highly susceptible to all three herbicides at concentrations higher than 50 ppm. However, although the emerged seedlings could be eradicated by using 2, 4-D, MCPA or 2, 4, 5-T, it is not known whether these chemicals are toxic to dormant buried seeds. Clearly the longevity of seeds of these species in soils treated with herbicides merits investigation.

Most herbicidal auxins such as 2, 4-D, MCPA and 2, 4, 5-T are known to disturb metabolism of carbohydrates, proteins and nucleic acids (Audus, 1963). 2, 4-D, for example, stimulates respiration to a much greater extent than it stimulates assimilation and growth (Kandler and Neumair, 1954), so giving a low 'synthetic efficiency'. 2, 4, 5-T, on the other hand, inhibits synthesis of adenosine triphosphate and nucleic acids (Moreland, Gruenlagen and Shokari, 1969). According to Rhodes (1952) MCPA enhances utilization of carbohydrates and inhibits translocation of photosynthates from the leaves. All three herbicides have been shown to cause considerable disturbance of metabolism of such essential nutrients as potassium and phosphorus (Wilden, Hamner and Bass, 1957). 2, 4-D arrests stomatal opening (Mansfield, 1967), and there is evidence that MCPA and 2, 4, 5-T also have comparable inhibitory effects (Pemadasa and Jeyaseelan, 1976). Thus, the inhibitory effect of foliar application of these herbicides may, at least partly, be attributed to hindrance of stomatal opening, which would arrest photosynthesis. The stomatal control of photosynthetic efficiency is well known (Balasubramaniam and Willis, 1969 ; Willis and Balasubramaniam, 1968).

From the preceding discussion it is apparent that the inhibitory effects of synthetic auxins on plants operate through a complex of mechanisms. The specific effects of 2, 4-D, MCPA and 2, 4, 5-T on *B. chinensis* and *T. procumbens* are not known, but it is clear that they are highly toxic to these two weeds, especially at early stages of the life-cycle, and that the degree of toxicity depends on the concentration of the treatment.

SUMMARY

The effects of a range of concentrations of 2, 4-dichlorophenoxyacetic acid (2, 4-D), 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) and 2-methyl-4-chlorophenoxyacetic acid (MCPA) on *Bidens chinensis* and *Tridax procumbens*, at various stages of the life-cycle, were investigated experimentally. All three herbicides inhibited germination and caused mortality of seedlings of both species, and the degree of toxicity increased with increasing herbicide concentration and decreasing age of plants. The herbicides were more effective when applied to the foliage than to the root system. In general, 2, 4-D and MCPA were more detrimental than 2, 4, 5-T. The results are discussed in relation to the control of natural populations of the two weeds.

REFERENCES

AUDUS, L. J. 1950—Biological detoxication of 2, 4-dichlorophenoxyacetic acid in soils : Isolation of an effective organism. *Nature, Lond.*, **166**, 356.

AUDUS, L. J. 1963—*Plant Growth Substances*. Interscience Publishers, Inc., New York.

BALASUBRAMANIAM, S. AND WILLIS, A. J. 1969—Stomatal movements and rates of gaseous exchange in excised leaves of *Vicia faba*. *New Phytol.* **68**, 663-74.

BLACKMAN, G. E., HOLLY, K. AND ROBERTS, H. A. 1949—The comparative toxicity of phytocidal substances. *Symp. Soc. Exp. Biol.* **3**, 283-317.

KANDLER, O. AND NEUMAIR, H. 1954—über die Wirkung von 2, 4-dichlorophenoxy-essigsaüre auf den Stoffwechsel in vitro kultivierter Spargelsprosse. *Flora*, **141**, 16.

MANSFIELD, T. A. 1967—Stomatal behaviour following treatment with auxin-like substances and phenylmercuric acetate. *New Phytol.* **66**, 325-30.

MORELAND, D. E., GRUENLAGEN, R. D., AND SHOKRAI, E.H. 1969—Effects of herbicides on RNA and protein synthesis. *Weed Science*, **17**, 556-62.

PEMADASA, M. A. AND JEYASEELAN, K. 1976—Some effects of three herbicidal auxins on stomatal movements. *New Phytol.* **77**, 599-73

RHODES, A. 1952.—The influence of the plant growth-regulator, 2-methyl-4-chlorophenoxyacetic acid, on the metabolism of carbohydrate, nitrogen and minerals in *Solanum lycopersicum*. *J. exp. Bot.*, **3**, 129-41.

TEMPLEMAN, W. G. AND HALLIDAY, D. J. 1951.—Herbicides and selective phytotoxicity. Part II. *A. Rev. Pl. Physiol.* **2**, 210-21.

WILDEN, C. E., HAMNER, C. L. AND BASS, S. T. 1957.—The effect of 2, 4-dichlorophenoxyacetic acid on the accumulation of mineral elements in tobacco plants. *Plant Physiol.* **32**, 243-4.

WILLIS, A. J. AND BALASUBRAMANIAM, S. 1968—Stomatal behaviour in relation to rates of photosynthesis and transpiration in *Pelargonium*. *New Phytol.* **67**, 265-85.

(MS. received 15.1.76)

CEYLON J. SCI. (BIO. SCI.) Vol 12, No. 2, November 1977

Studies on the Fermentation of Kitul (*Caryota urens*) Sap

by

K. THEIVENDIRARAJAH, M. D. DASSANAYAKE AND K. JEYASEELAN

Department of Botany, University of Sri Lanka, Peradeniya Campus

(With one text figure)

INTRODUCTION

Fermented saps of Coconut (*Cocos nucifera*), Palmyrah (*Borassus flabellifer*) and Kitul (*Caryota urens*) are popular beverages in Sri Lanka. Although some work has been done on the chemical nature of the saps from these plants, very little work has been done on the actual fermentation process (Joachim and Kandiah, 1938 ; Molegoda, 1945).

The present study was carried out to investigate the chemical changes and the activities of the microorganisms, specially yeast strains, during the fermentation of kitul sap. Since, yeast is likely to be of much importance in the future for the industrial production of alcohol in Sri Lanka, these investigations were aimed at isolating yeast strains of high fermenting ability.

METHODS AND MATERIALS

Kitul sap collected for two hours in clean clay pots was used. 100 ml. of the fresh sap was transferred into a sterilized 250 ml flask and the changes in pH, reducing sugars, alcohol acidity and yeast population were observed at frequent intervals for 52 hours. For the chemical analysis of the sap, a few ml of the sap was collected as it trickled down from a freshly cut surface.

Estimation of sugar : The assay of sugars was done by the well-known reducing test with copper reagent.

Estimation of alcohol : Alcohol present in the sample was bubbled into a mixture of potassium dichromate and sulphuric acid and the colour change in the dichromate solution was read colorimetrically. The percentage alcohol was then determined using a standard calibration curve.

Estimation of acids : Acids produced during fermentation were estimated as total titratable acids.

Yeast and Bacterial counts : Yeast cell counts were made both by viable plate count on glucose-peptone-yeast extract medium and the haemocytometer counting method. Bacterial density was estimated by direct counting after staining.

RESULTS AND DISCUSSION

The kitul sap as it trickles down from the tree has a pH of 6.5, traces of acids, no alcohol, 0.34 per cent of reducing sugar and a total sugar between 15—16 percent by weight. The changes in pH, reducing sugars, alcohol and yeast cells during fermentation are shown in figure 1. The pH was found to drop from 6.5 to 3.5 in 24 hours and thereafter remained constant. The total titratable acids increased during fermentation and reached a maximum value of 0.1N. The total reducing sugar was found to increase slowly in the first ten hours and then showed a steep increase towards a maximum value of 8.1 per cent after 28 hours. The increase in reducing sugar was found to be correlated with the increase in yeast cells, thus indicating that the breakdown of non-reducing sugars during fermentation is mainly by the yeast cells.

Regarding the microbial population both bacteria and yeast cells were found with concentrations of 1×10^6 and 1×10^4 cells per ml respectively in fresh unfermented saps. Only changes in yeast population were studied during fermentation. Yeast cells reached a maximum density of 1×10^8 cells per ml and then began to decrease slightly. This decrease in the number of yeast cells was not observed when the haemocytometer counting method was used for the estimation of yeast cells. This indicates that the decrease in cell number was due to the death of some yeast strains. The death of these cells may be due to the sensitivity of certain strains of yeast to either a higher level of alcohol or of acid.

Production of alcohol increased with the increase in concentration of reducing sugar and with the increase in yeast cells and reached a maximum value of 5 per cent by volume in 36 hours and thereafter remained constant. Alcohol production continued even after the pH had dropped to 3.5, showing that the lower pH of 3.5 had not affected the fermentation of at least certain strains of yeast.

The yeast cells found in the sap are not all of the same type. Several different types of yeast cells were found. Eight different strains of yeast cells were isolated based on cell morphology and the nature of the colony. These strains were designated K_1, K_2, K_3, K_4, K_5, K_6, K_7, and K_8. When pure cultures of these different strains were grown individually both in artificial liquid culture medium containing 16 per cent sucrose and in sterilized unfermented kitul sap they showed differences in their fermenting ability. The results are shown in table 1. It is clear that K_1, K_2, and K_3 are very poor fermenters under the conditions used. Of the other strains K_4 in particular has an exceptionally good fermenting ability. On a theoretical basis kitul sap with a sugar concentration between 15 and 16 per cent should yield 7 to 8 per cent alcohol. This value is never achieved under natural fermentation because it is not a controlled fermentation ; apart from bacteria, different yeast strains with varying ability to ferment are often found in the sap. The final amount of alcohol produced would largely depend on the types of yeast present and their relative proportions. Two of these strains, K_1 and K_4, have been identified as *Brettanomyces* sp. and *Saccharomyces* sp. respectively.

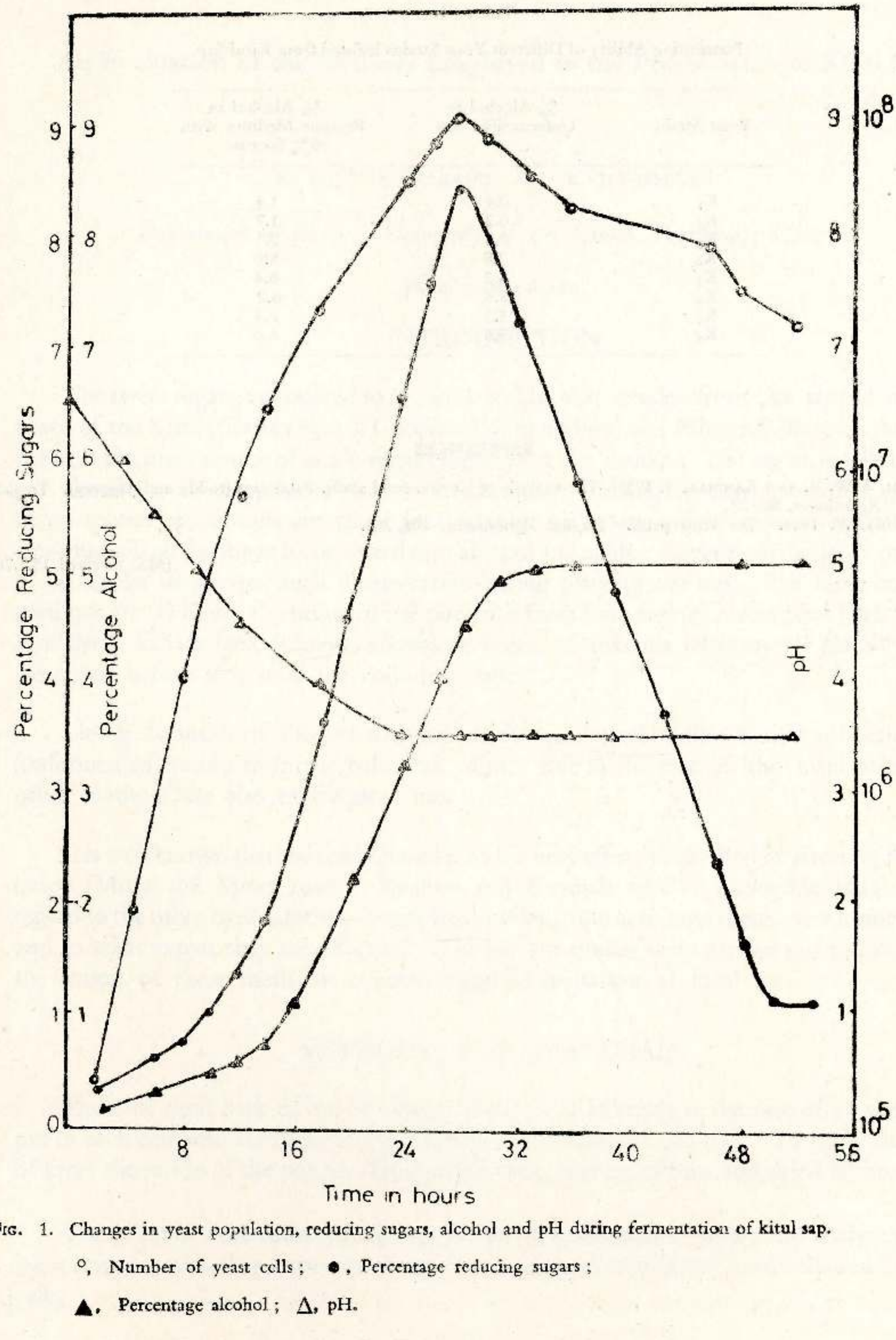


FIG. 1. Changes in yeast population, reducing sugars, alcohol and pH during fermentation of kitul sap.

°, Number of yeast cells ; ●, Percentage reducing sugars ;

▲, Percentage alcohol ; Δ, pH.

TABLE 1.

Fermenting Ability of Different Yeast Strains Isolated from Kitul Sap

Yeast Strain	% Alcohol in Unfermented Sap	% Alcohol in Peptone Medium with 16 % Sucrose
K_1	0.4	1.4
K_2	0.2	1.7
K_3	0.5	2.1
K_4	7.8	8.0
K_5	6.2	6.4
K_6	5.8	6.2
K_7	5.5	6.4
K_8	5.6	6.4

REFERENCES

JOACHIM, A. W. R. AND KANDIAH, S. 1938—The analysis of Ceylon food stuffs. Palm saps (toddy and jaggery). *Tropical Agriculturist*, **90**, 22.

MOLEGODA, W. 1945.—The kitul palm. *Tropical Agriculturist*, **101**, 251.

(MS. received 15.1.76)

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

An Evaluation of the Methods Employed in the Preservation of Kitul Sap

by

K. THEIVENDIRARAJAH AND K. JEYASEELAN

Department of Botany, University of Sri Lanka, Peradeniya Campus

(With one text figure)

INTRODUCTION

The sweet sugary sap refered to as sweet toddy that exudes from the tapped inflorescence of the Kitul (*Caryota urens*), Coconut (*Cocos nucifera*) and Palmyrah (*Borassus flabellifer*) palms is the main source of crude sugar (jaggery) in Sri Lanka. The sap as it falls into the pot placed for its reception is free of fermentation and highly charged with sugar, but unless special precautions are taken fermentation by yeasts and bacteria soon sets in and continues till all the sugar is converted into alcohol and acids. Several methods are practised in Sri Lanka to prevent such fermentation taking place in the sap. The most common methods are (1) lining the inside of the pot with fresh lime and (2) placing hal bark (*Vateria copallifera*), kahata bark (*Careya arborea*) or leaves of ankenda (*Achronychia laurifolia*) in a clean pot before it is used for collecting sap.

Lining the inside of the pot with lime is the usual method that is used to obtain sweet (unfermented) toddy from the palmyrah palm. But in the case of the kitul palm these other methods are also of frequent use.

It is well known that the use of limed pots is a very effective method of arresting fermentation (Mitra and Mitra 1940 ; Joachim and Kandiah 1938 ; Molegoda 1945). With regard to the other methods there is very little information as to how these arrest fermentation and to what extent they are effective. The present studies were carried out to investigate the action of these methods in preventing fermentation of kitul sap.

METHODS AND MATERIALS

Pieces of fresh bark of hal or kahata or leaves of ankenda at the rate of 50 gms were put in each case into the collecting pot before it was hung on the tree. To study the effect of lime, the inside of the pot was lined with a thin coating of lime and dried before use.

The samples were collected after 15 hours, 39 hours and 63 hours and analysed in the laboratory for reducing sugars, total sugars, pH, alcohol, number of yeast cells and bacterial cells.

Estimation of sugar : The assay of sugars was done with the well known reducing test with copper reagent.

Estimation of alcohol : Alcohol present in the sample was bubbled into a mixture of potassium dichromate and sulphuric acid. The colour change in the dichromate solution was read colorimetrically. The percentage of alcohol was then determined using a standard calibration curve.

Yeast cell counts were made by viable plate count on glucose-peptone-yeast extract agar medium, while bacterial cells were counted by the same method but on nutrient agar medium.

TABLE 1.

Changes in pH, Yeast and Bacterial Cells under Different Treatments During Fermentation of Kitul Sap.

		Control	Hal	Kahata	Ankenda	Lime
	15 Hours	6.0	6.5	6.0	6.5	12.0
pH	39 Hours	4.0	4.5	4.0	4.0	12.0
	63 Hours	3.5	4.0	3.5	3.5	12.0
Yeast	15 Hours	2.4×10^6	5.0×10^4	1.3×10^7	8.0×10^6	Nil
cells	39 Hours	3.0×10^8	1.0×10^5	8.0×10^7	1.6×10^8	Nil
per ml	63 Hours	3.4×10^8	6.0×10^7	2.0×10^7	8.0×10^7	Nil
Bacterial	15 Hours	1.9×10^7	1.1×10^8	2.4×10^8	1.4×10^7	1.12×10^4
cells	39 Hours	8.0×10^8	3.0×10^9	1.6×10^8	1.0×10^8	9.8×10^2
per ml	63 Hours	3.0×10^9	2.0×10^9	4.0×10^7	2.4×10^8	3.0×10^2

RESULTS AND DISCUSSION

Table 1 shows the changes in pH, yeast cells and bacterial cells under these different treatments. The changes in pH observed in hal, kahata and ankenda are almost similar to those of the control, whereas in the case of lime, pH was found to be very high (about 12.0) and remained at that value throughout the experiment.

Bacterial cells were found after 15 hours to be in the order of 10^7—10^8 cells per ml in all the treatments except with lime. In the case of lime, the number of bacterial cells was very much lower (1.12×10^4 cells per ml) and this number gradually decreased with time. Decrease in the bacterial population was also observed in the case of kahata. It must be mentioned that our estimate of bacteria in these samples may not be a true estimation because of the use of a particular medium for their isolation.

Regarding the yeast population, no viable yeast cells were found in the limed pot even after 63 hours. The changes in yeast population are shown in the graph (Figure — 1). Yeast cells were found in all treatments except lime ; the concentration of yeast cells in hal

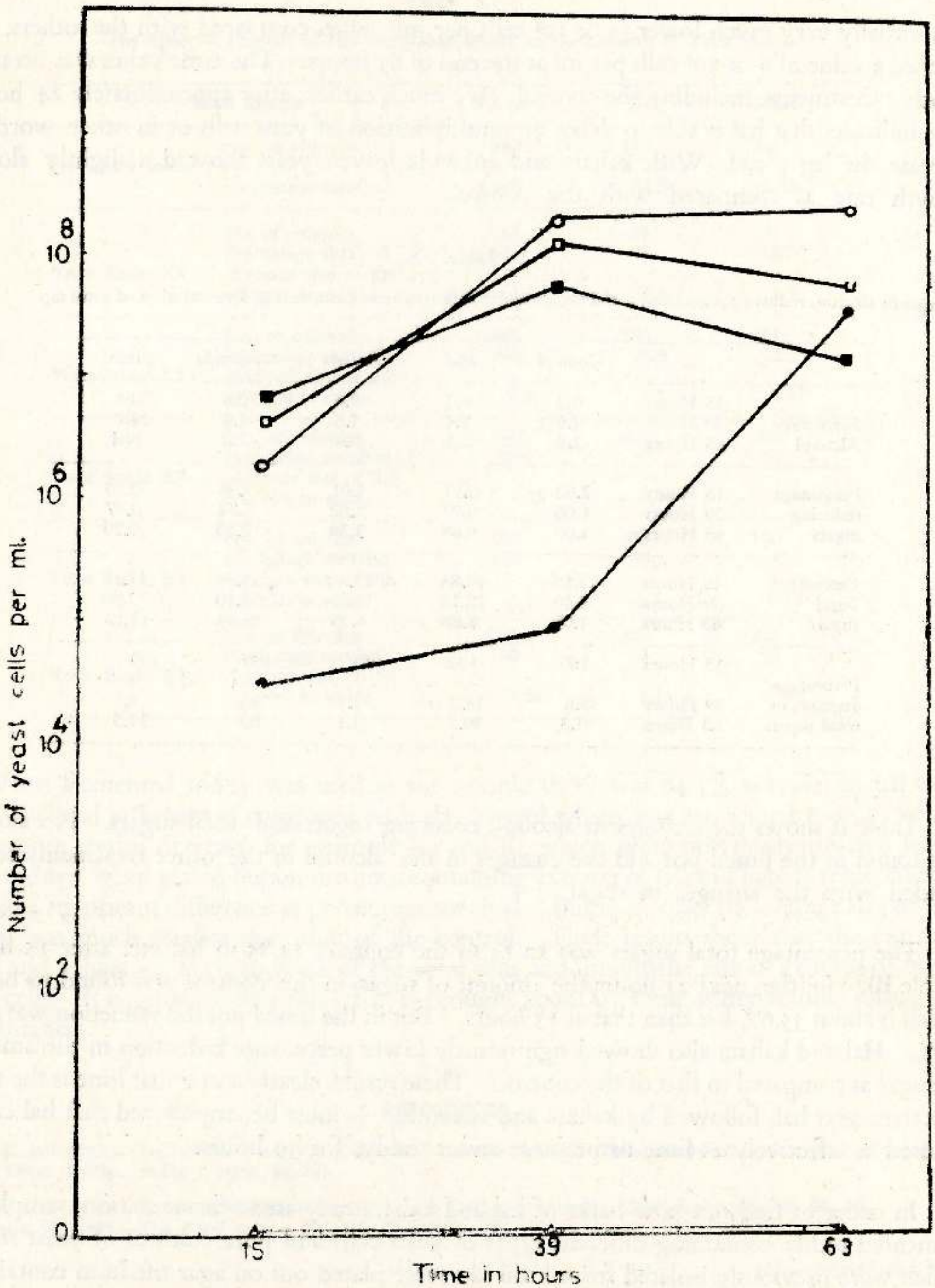


FIG. 1. Changes in yeast population under different treatments during fermentation of kitul sap.

O, Control; ●, Hal; □, Ankenda; ■, Kahata; Δ, Lime.

was initially very much lower (5 × 10^4 cells per ml) when compared with the others, and reached a value of 6 × 10^7 cells per ml at the end of 63 hours. The same value was attained in other treatments, including the control, very much earlier, after approximately 24 hours. This indicates that hal is able to delay the multiplication of yeast cells or in other words to increase the lag phase. With kahata and ankenda leaves, yeast showed a slightly slower growth rate as compared with the control.

TABLE. 2

Changes in alcohol, reducing sugars and totlal sugars under different treatment during fermentation of kitul sap

		Control	Hal	Kahata	Ankenda	Lime
Percentage Alcohol	15 Hours	0.2	0.2	0.4	0.6	Nil
	39 Hours	4.6	1.4	1.6	1.0	Nil
	63 Hours	2.8	2.2	3.6	2.1	Nil
Percentage reducing sugars	15 Hours	2.02	0.17	1.01	2.36	0.50
	39 Hours	1.06	0.27	2.02	5.74	0.67
	63 Hours	1.00	0.68	3.38	2.30	0.70
Percentage Total sugars	15 Hours	12.15	14.85	13.80	13.50	14.15
	39 Hours	5.40	12.15	10.80	8.10	12.80
	63 Hours	1.05	8.80	6.75	5.40	12.13
Percentage decrease in total sugars	15 Hours	100	100	100	100	100
	39 Hours	55.6	18.2	21.7	40	9.5
	63 Hours	91.3	40.7	51.1	60	14.3

Table II shows the changes in alcohol, reducing sugars and total sugars. No alcohol was found in the limed pot and the changes in the alcohol in the other treatments corres ponded with the changes in sugar.

The percentage total sugars was 12.15 in the control, 14.85 in hal etc. after 15 hours (Table II). In the next 24 hours the amount of sugar in the control was found to be 5.4 which is about 55.6% less than that at 15 hours. But in the limed pot the reduction was only 9.5%. Hal and kahata also showed significantly lower percentage reduction in the amount of sugar as compared to that of the control. These results clearly show that lime is the most effective, next hal, followed by kahata and ankenda. It must be emphasized that hal could be used as effectively as lime to preserve sweet toddy, for 39 hours.

In order to find out how barks of hal and kahata may arrest fermentation, samples of fermented toddy containing different types of yeast cells and pure cultures of yeast strains which were previously isolated from kitul sap were plated out on agar medium containing 10% water—extracts of hal and kahata barks. The number of colonies and their average diameters were determined after 3 days of incubation at 30 degrees centigrade. The results are shown in Table III.

TABLE 3.

The Effect of Extracts of Hal and Kahata Barks on the Growth of Yeast Strains

Yeast Sample		Control	Hal	Kahata
Fermented toddy	No. of colonies	840	543	360
	Percentage survival	100	64.3	42.8
Yeast Strain K4	No of colonies	63	59	37
	Percentage survival	100	93	58.7
	Average size of the colonies in m.m.	4.5	2.6	1.9
Yeast Strain K8	No. of colonies	485	380	354
	Percentage survival	100	78.6	72.5
	Average size of the colonies in m.m.	1.6	1.1	0.57
Yeast Strain K7	No. of colonies	590	535	488
	Percentage survival	100	97	86
	Average size of the colonies in m.m.	1.32	0.98	0.84
Yeast Strain K2	No. of colonies	556	178	160
	Percentage survival	100	45	43
	Average size of the colonies in m.m.	2.3	1.5	0.74
Yeast Strain K5	No. of colonies	250	230	225
	Percentage survival	100	92	91
	Average size of the colonies in m.m.	1.38	1.16	0.96

When fermented toddy was used as the sample there was 64.3% survival in hal and 42.8% survival in kahata as compared with the control which was considered 100%. Some of the pure strains of yeast, for example K_2 and K_8 which were previously isolated from kitul toddy, when plated out on medium containing extracts of hal and kahata respectively, showed a significant difference in percentage survival. But in all cases the average size of the colony was much smaller than that of the control. These results show that the extracts of hal and kahata are toxic to some of the yeast cells and inhibit the rate of growth of most other cells. It is probable that this effect is brought about by some water-soluble substance or substances.

REFERENCES

MITRA, K. AND MITRA, H. C. 1940.—Studies on edibles from *Borassus flabellifer* (Palmyrah palm) with special reference to Nira or sweet toddy. *Indian J. Agric.* **10**, 824.

JOACHIM, A.W. R. AND KANDIAH, S. 1938.—The Analysis of Ceylon food stuffs. *Tropical Agriculturist.* **90**, 22.

MOLEGODA, W. 1945.—The Kitul palm. *Tropical Agriculturist*, **101**, 251.

(MS. received 15.1.76.)

Ceylon J. Sci. (Bio. Sci.) Vol. 12, No. 2, November 1977

The Ingestion of Blue-green Algae by Mosquito Larvae

by

K. THEIVENDIRARAJAH AND K. JEYASEELAN

Department of Botany, University of Sri Lanka, Peradeniya Campus

(With one plate)

It is known that mosquito larvae feed on organic matter and algae found in ponds, streams, rivers and stagnant water. Several workers in India and the United States have reported on the basis of field observations that a number of blue green algae control the breeding of mosquito larvae (Singh 1961). These workers believe that the blue green algae may be producing certain metabolites which are toxic to the mosquito larvae. In view of these observations Singh (1961) has suggested that blue green algae could be used to control malaria.

In contrast to these observations larvae of *Culex* species and *Anopheles* species were found to feed quite readily on blue green algae at Peradeniya. This observation was made while we were attempting to grow the blue green algae *Calothrix* sp. and *Anabaena* sp. in pot soil cultures. During our experiments a good growth of these algae was observed, but after some time the alga suddenly disappeared and on close examination of the culture we found a large number of larvae of *Culex* sp. The ingestion of *Anabaena* and *Calothrix* by these larvae was confirmed by the presence of these algae in substantial quantities within the gut (Plate 1).

When some of these larvae were placed separately in test tubes containing unialgal cultures of *Anabaenopsis* sp., *Nostoc carneum*, *Aulosira fertillissima*, *Calothrix* sp., *Tolypothrix tenuis*, *Mastigocladus laminosus* and *Oscillatoria* sp. the larvae not only did feed on these algae but also they were able to complete their life cycle. A single larva consumed a species of *Tolypothrix* at the rate of about 5 mg. fresh weight per day. Larvae of *Culex* species collected from other sources such as sewage tanks, ponds and paddy fields around Peradeniya were also found to feed readily on several different species of blue green algae. Larvae of *Anopheles* sp. collected from clay pits and paddy fields also ingested the different types of blue green algae. No toxic effects were observed.

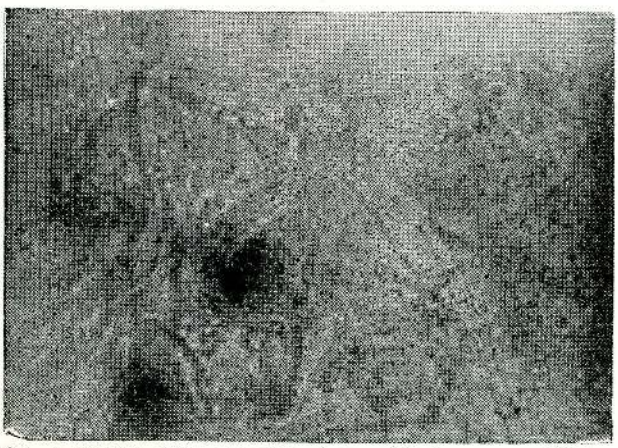
Our observations show that the majority of the blue green algae tested, if not all, could serve as a good source of food for mosquito larvae. The difficulty of establishing a good growth of blue green algae in paddy fields, experienced by many workers trying to grow blue green algae to improve the nitrogen fertility of paddy soils, is usually attributed to factors such as soil texture, pH, availability of nutrients etc. However, the ingestion of blue green algae by mosquito larvae, which are generally found in paddy soils and waters, may also be a reason for such failures.

REFERENCE

Singh, R. N. 1961.—Role of blue green algae in the nitrogen economy of Indian Agriculture. Ind. Coun. Agri. Res., New Delhi

(MS. received 15.1.76)

(A) Gut of the larva of *Culex* sp. showing filaments of the blue green alga *Anabaena* sp.



(B) A portion of the gut of the larva of *Culex* sp. magnified to show the partly digested filaments *Calothrix* sp.

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Factors Affecting Germination of Some Composites

by

M. A. PEMADASA AND N. KANGATHARALINGAM

Department of Botany, University of Sri Lanka, Peradeniya, Sri Lanka

(With three text figures)

INTRODUCTION

That the ecologically characteristic germination of species in nature is determined by interactions of intrinsic properties of seeds and a multitude of external factors has long been known. However, of the many published investigations of germination biology, most have been concerned with the controlling effects of environmental variables (Mayer and Poljakoff-Mayber, 1963). The role of intrinsic properties of seeds such as size, shape and surface characteristics and of type of landing of seeds, for example, has received relatively little attention, although their importance in controlling natural germination has been stressed by several workers (Harper and Benton, 1966 ; Harper, Lovell and Moore, 1970). An attempt was, therefore, made to investigate the influence of some of these hitherto inadequately examined factors, in addition to certain common environmental variables, on germination of a group of composites, and some of the preliminary information is given in the present paper.

EXPERIMENTS

The following nine species were chosen for study : *Ageratum conyzoides* L., *Emilia sonchifolia* (L.) DC., *Erigeron sumatrensis* Retz., *Eupatorium riparium* L., *Mikania scandens* (L.) Willd., *Sonchus arvensis* L., *Tridax procumbens* L., *Vernonia cinerea* (L.) Less. and *V. setigera* Arn. They all belong to the family Compositae and produce achenes bearing pappus.

All experiments were performed at room temperatures (25 ± 1°C) with fully developed achenes collected in November 1974 from natural populations and stored in paper envelopes in the dark under laboratory conditions. The achenes were sown, except where otherwise stated, on Whatman No. 3 filter paper in 9 cm diameter plastic Petri dishes covered with lids. The filter paper was moistened with 5 ml of distilled water at the start, and more water was added as necessary. All treatments were replicated four times with 50 achenes per replicate, and experiments were of randomized block design. Recordings of germination were made daily for five weeks.

Effect of light and darkness

A preliminary experiment was performed to investigate the effect of light on germination. The course of germination was followed both in diffuse light in the laboratory and in continuous darkness. As can be seen from Fig. 1, both the rate and final percentage of germination of all the species were significantly higher in light than in the dark ($P < 0.001$). The species x light regime interaction was also significant ($P < 0.05$) indicating that the photocontrol of germination differed between species. The germination performance in darkness was appreciably lower in *Eupatorium riparium* and *Vernonia setigera* than in the other species.

Effect of 'type of landing'

The presence of a pappus not only enables the achenes of these species to disperse by wind, but also influences the type and degree of contact that the 'achene-proper' makes with the substrate. Usually, the parachute mechanism enables the achenes to land with the achene-proper touching the substrate and the pappus directing more or less upwards. However, field observations showed that a certain proportion of achenes rest with the pappus facing downwards so that the achene-proper is lifted away from the substrate. This could be a result, for example, of animal activity. It was of interest, therefore, to determine whether the type of landing affects germination. The achenes were sown either with the achene-proper touching the filter paper or with the pappus facing downwards so that the achene-proper was lifted away from the filter paper ; these two types of landing are, for convenience, referred to as 'normal landing', and 'accidental landing' respectively. The course of germination was followed in diffuse light in the laboratory, and the results are given in Table 1.

TABLE 1.

Effect of type of landing on germination. The values given are the mean percentage of germination after five weeks.

	Normal landing	Accidental landing
Ageratum conyzoides	87.5	33.5
Emilia sonchifolia	88.0	46.0
Erigeron sumatrensis	90.0	56.0
Eupatorium riparium	79.5	52.0
Mikania scandens	94.0	49.0
Sonchus arvensis	83.0	31.5
Tridax procumbens	78.0	29.5
Vernonia cinerea	95.0	58.0
V. setigera	95.0	33.0

In all the species the percentage germination was significantly higher in achenes with normal landing than in those with accidental landing ($P < 0.001$). However, the response to accidental landing differed between species ; the germination performance was lower in species with large achenes, *Ageratum conyzoides*, *Sonchus arvensis*, *Tridax procumbens* and *Vernonia setigera*, than in the others. Further support for this observation is the significant species x type of landing interaction ($P < 0.05$).

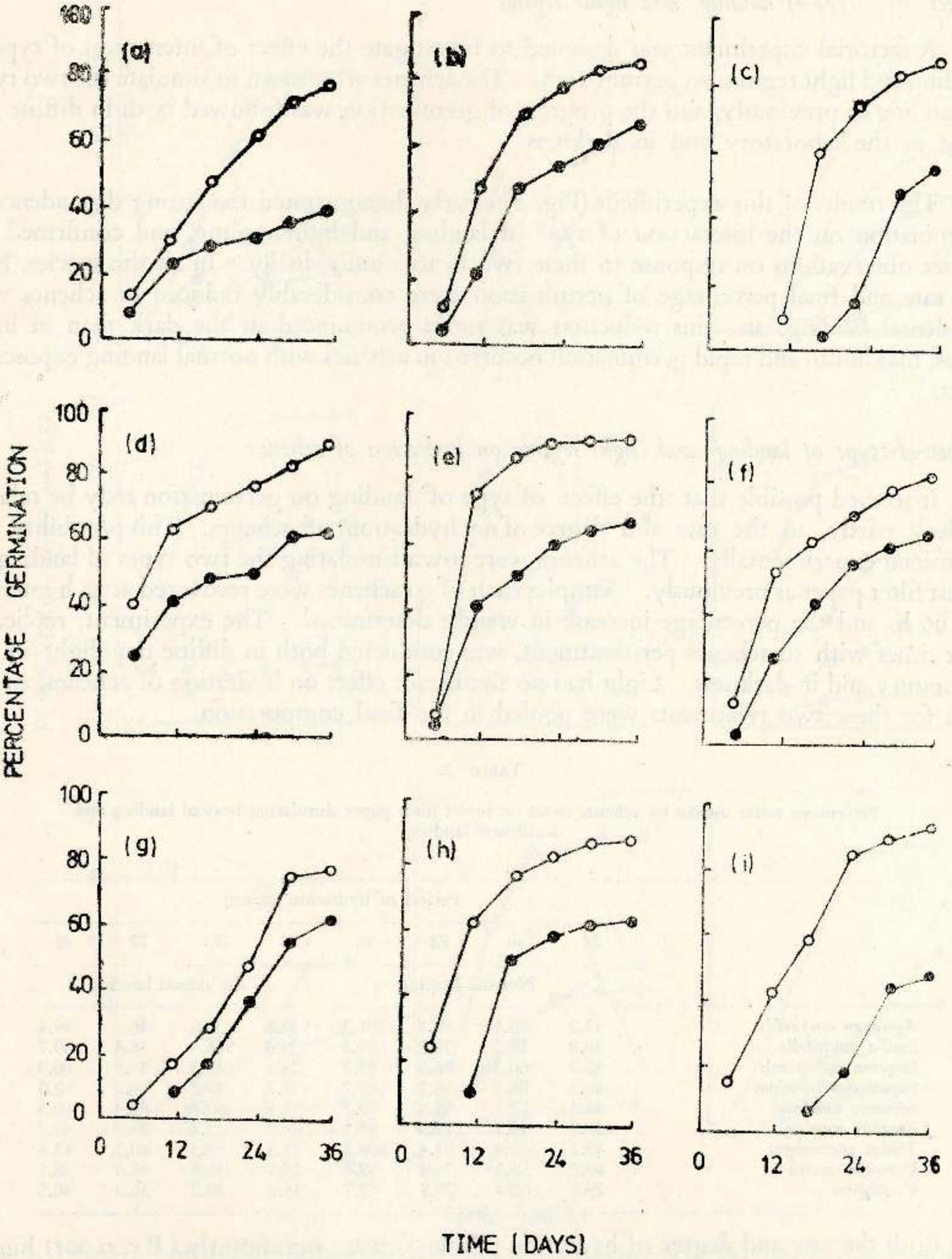


FIG. 1. Progress of germination in diffuse day light in the laboratory (open symbols) and in continuous darkness (filled symbols). (*a*) *Ageratum conyzoides*; (*b*) *Emilia sonchifolia*; (*c*) *Erigeron sumatrensis*; (*d*) *Eupatorium riparium*; (*e*) *Mikania scandens*; (*f*) *Sonchus avensis*; (*g*) *Tridax procumbens*; (*h*) *Vernonia cinerea*; (*i*) *V. setigera*.

Effect of ' type of landing' and light regime

A factorial experiment was designed to investigate the effect of interaction of type of landing and light regime on germination. The achenes were sown to simulate the two types of landing as previously, and the progress of germination was followed both in diffuse day light in the laboratory and in darkness.

The results of this experiment (Fig. 2) clearly demonstrated the strong dependence of germination on the interaction of type of landing and light regime, and confirmed the earlier observations on response to these two factors individually. In all the species, both the rate and final percentage of germination were considerably reduced in achenes with accidental landing, and this reduction was more pronounced in the dark than in light. Thus, maximum and rapid germination occurred in achenes with normal landing exposed to light.

Effect of 'type of landing' and light regime on hydration of achenes

It seemed possible that the effect of type of landing on germination may be related, at least partly, to the rate and degree of net hydration of achenes. This possibility was examined experimentally. The achenes were sown simulating the two types of landing on moist filter paper as previously. Samples each of 50 achenes were recovered at 24 h intervals for 96 h, and the percentage increase in weight determined. The experiment, replicated four times with 50 achenes per treatment, was conducted both in diffuse day light in the laboratory and in darkness. Light had no significant effect on hydration of achenes, and so data for these two treatments were pooled in the final computation.

TABLE 2.

Percentage water uptake by achenes sown on moist filter paper simulating normal landing and accidental landing.

	Period of hydration (hours)							
	24	48	72	96	24	48	72	96
	Normal landing				Accidental landing			
Ageratum conyzoides	43.2	66.1	88.1	101.3	20.1	33.2	46.3	49.4
Emilia sonchifolia	38.2	50.3	75.2	89.4	29.3	46.4	56.4	59.7
Erigeron sumatrensis	35.2	60.3	86.5	93.2	28.1	46.3	59.2	60.3
Eupatorium riparium	46.3	86.3	96.2	107.2	35.2	49.3	60.2	62.3
Mikania scandens	44.3	72.1	91.5	99.7	32.1	60.1	62.4	66.3
Sonchus arvensis	39.2	56.2	79.3	93.1	18.2	32.4	39.3	43.7
Tridax procumbens	49.2	69.4	93.4	108.3	21.3	39.3	40.3	43.4
Vernonia cinerea	40.2	58.3	76.4	89.4	29.1	35.3	46.6	58.1
V. setigera	29.1	60.4	79.5	87.7	16.3	30.2	36.3	40.5

Both the rate and degree of hydration (Table 2) were significantly ($P < 0.001$) higher in achenes with normal landing than in those with accidental landing, and the difference was more pronounced in *Ageratum conyzoides*, *Sonchus arvensis*, *Tridax procumbens* and *Vernonia setigera* than in the other species, and this was further evident from the significant species x type of landing interaction ($P < 0.01$).

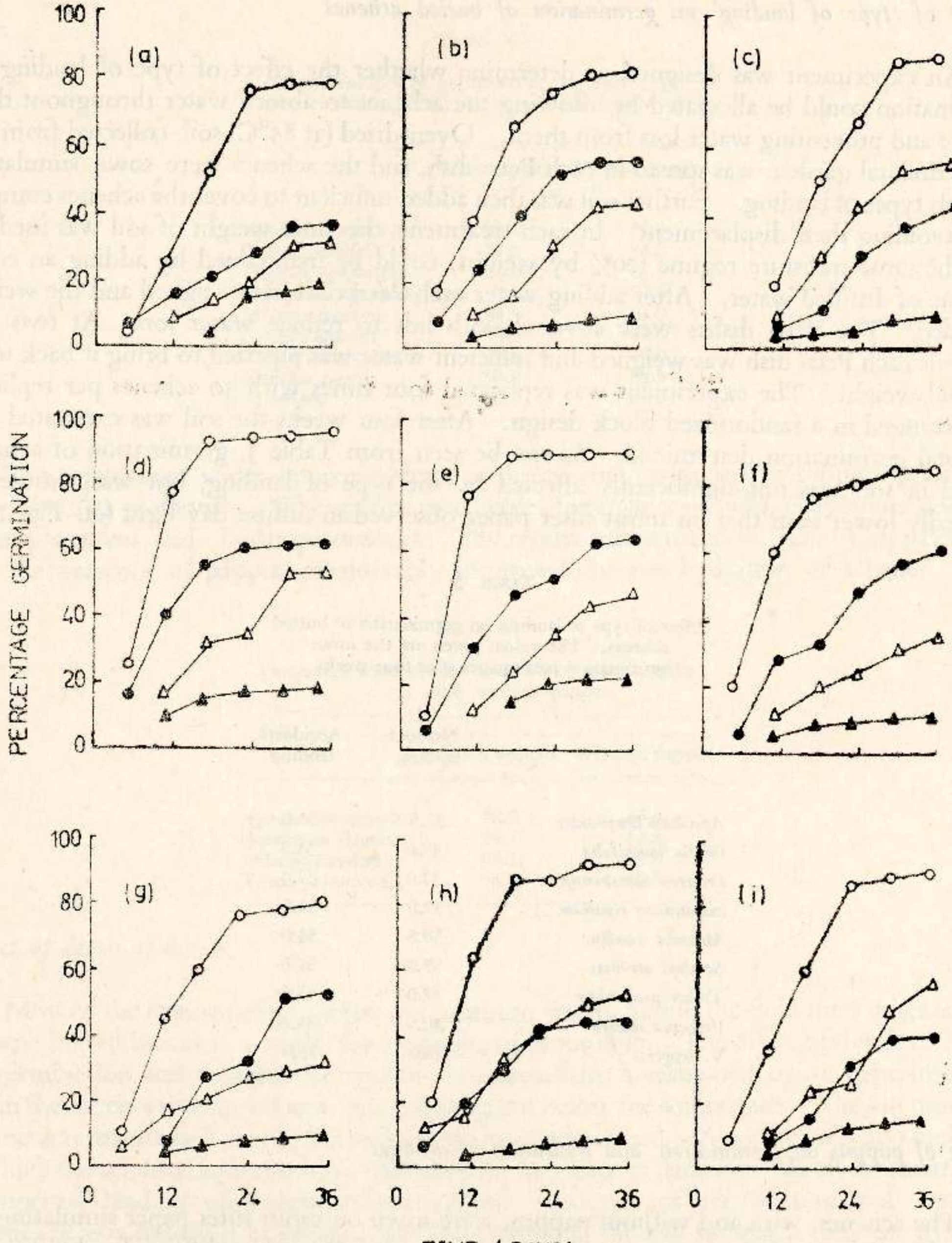


FIG. 2. Progress of germination of achenes sown to simulate normal landing (circles) and to simulate accidental landing (triangles) in diffuse day light in the laboratory (open symbols) and in continuous darkness (filled symbols) (a) *Ageratum conyzoides*; (b) *Emilia sonchifolia*; (c) *Erigeron sumatrensis*; (d) *Eupatorium riparium*; (e) *Mikania scandens*; (f) *Sonchus arvensis*; (g) *Tridax procumbens*; (h) *Vernonia cinerea*; (i) *V. setigera*.

Effect of 'type of landing' on germination of buried achenes

An experiment was designed to determine whether the effect of type of landing on germination could be alleviated by allowing the achenes to absorb water throughout their surface and preventing water loss from them. Oven-dried (at 85°C) soil, collected from the Departmental garden, was spread in each Petri dish, and the achenes were sown simulating the two types of landing. Further soil was then added sufficient to cover the achenes completely, avoiding their displacement. In each treatment, the same weight of soil was used, so that the same moisture regime (20% by weight) could be maintained by adding an equal volume of distilled water. After adding water each Petri dish was weighed and the weight recorded. The Petri dishes were covered with lids to reduce water loss. At two day intervals each Petri dish was weighed and sufficient water was pipetted to bring it back to its original weight. The experiment was replicated four times with 50 achenes per replicate and arranged in a randomized block design. After four weeks the soil was excavated and the total germination determined. As can be seen from Table 3, germination of achenes buried in soil was not significantly affected by the type of landing, but was, however, markedly lower than that on moist filter paper observed in diffuse day light (cf. Fig. 2).

TABLE 3.

Effect of type of landing on germination of buried achenes. The values given are the mean germination percentages after four weeks.

	Normal landing	Accidentl landing
Ageratum conyzoides	32.5	33.0
Emilia sonchifolia	49.0	51.5
Erigeron sumatrensis	39.0	37.0
Eupatorium riparium	52.0	51.5
Mikania scandens	50.5	54.0
Sonchus arvensis	53.0	51.0
Tridax procumbens	47.0	45.0
Vernonia cinerea	40.5	38.0
V. *setigera*	35.0	33.0

Effect of pappus on germination and hydration of achenes

The achenes, with and without pappus, were sown on moist filter paper simulating the normal landing, and the progress of germination was followed in diffuse day light in the laboratory, with the object of determining whether germination is affected by pappus. The final germination percentages given in Table 4 show that the removal of pappus significantly ($P < 0.01$) reduced the germination of *Ageratum conyzoides, Eupatorium riparium, Mikania scandens* and *Tridax procumbens.* No appreciable effect of pappus was observed in the other species.

TABLE 4.

Mean percentages of germination on filter paper of achenes with and without pappus after four weeks.

	With pappus	Without pappus
Ageratum conyzoides	82.0	65.5
Emilia sonchifolia	87.0	84.0
Erigeron sumatrensis	88.0	85.0
Eupatroium riparium	87.0	57.0
Mikania scandens	84.5	53.0
Sonchus arvensis	93.0	94.0
Tridax procumbens	79.0	49.0
Vernonia cinerea	93.0	88.5
V. setigera	87.5	91.0

The percentage water uptake over 96 h by achenes, with and without pappus, was determined as previously. The species used were *Ageratum conyzoides*, *Eupatorium riparium*, *Mikania scandens* and *Tridax procumbens*. The results summarized in Table 5 clearly show that the presence of pappus considerably improved the net hydration of achenes.

TABLE 5.

Percentage water uptake over 96 h by achenes with and without pappus.

	With pappus	Without pappus
Ageratum conyzoides	98.3	68.6
Eupatorium riparium	96.7	60.8
Mikania scandens	93.1	59.6
Tridax procumbens	94.5	56.7

Effect of depth of burial

Most of the experimental species are common weeds, and in the field their achenes may become buried in soil as a result, for example, of ploughing. The effect of depth of burial on germination and seedling emergence was, therefore, investigated by an experiment in which the achenes were sown at 0, 0.5, 1, 2 and 4 cm below the soil surface. The soil moisture regime was maintained at 20% (by weight) as already described. A control was also included in which the achenes, sown on moist filter paper, were kept in darkness. In all the treatments the normal landing of achenes was simulated. Progress of germination and seedling emergence was followed in darkness for four weeks, at the end of which time the soil was excavated and the total germination determined.

Both the seedling emergence and germination were considerably reduced with increasing depth of burial (Table 6); however, burial had a more marked effect on emergence than on germination. Although some germination occurred (always $< 15\%$) below 2 cm, none of the seedlings emerged. In all the species the percentage germination was appreciably lower in achenes buried in soil than in those sown on moist filter paper and kept in the dark.

TABLE 6.

Effect of depth of burial on germination and seedling emergence.

	Percentage germination						Percentage emergence			
	a*	b	c	d	e	f	c	d	e	f
Ageratum conyzoides	56	54	46	14	8	6	33	7	0	0
Emilia sonchifolia	62	59	33	16	7	4	29	3	0	0
Erigeron sumatrensis	53	54	36	19	14	8	30	6	0	0
Eupatorium riparium	39	38	29	18	15	3	21	5	0	0
Mikania scandens	61	58	48	17	12	7	18	6	0	0
Sonchus arvensis	60	62	50	16	13	2	42	10	0	0
Tridax procumbens	57	55	30	11	5	2	26	6	0	0
Vernonia cinerea	59	58	36	19	12	9	21	9	0	0
V. setigera	44	43	30	26	13	8	22	8	0	0

*a, on moist filter paper in darkness ; b, on soil surface in darkness ; c, d, e and f, 0.5, 1, 2 and 4 cm below the surface respectively.

Effect of redrying moistened achenes

In all the previous experiments the achenes received a continuous and more or less constant supply of water throughout the period of germination. However, in the field soil moisture regime may undergo considerable fluctuations, and, consequently, the achenes may subject to alternating hydration and dehydration, and this could affect their germination. An experiment was performed to examine this possibility. The achenes, which received a continuous supply of water for five days, were exposed to the atmosphere for 0 (control), 12, 24, 48 and 72 h on dry filter paper in open Petri dishes. After the drying treatments, the achenes were moistened with 5 ml of distilled water, and the progress of germination was followed in closed Petri dishes in diffuse day light. The type of landing of achenes was normal. The experiment was of randomized block design with four replicates of 50 achenes per treatment.

The desiccation of moistened achenes substantially delayed germination without affecting the final percentage (Fig. 3), and this delay was directly related to the duration of dehydration ; the longer the period of redrying, the more pronounced the delay of germination. Clearly, the achenes of these species require a continuous supply of water for unimpeded germination. Moreover, desiccation of germinating achenes is not detrimental to their viability.

DISCUSSION

The importance of both the individual and integrated effects of certain intrinsic characters and the type of landing on the substrate of achenes, in addition to environmental variables such as light, moisture regime and depth of burial, in affecting germination of the species examined is evident from the experimental results described above.

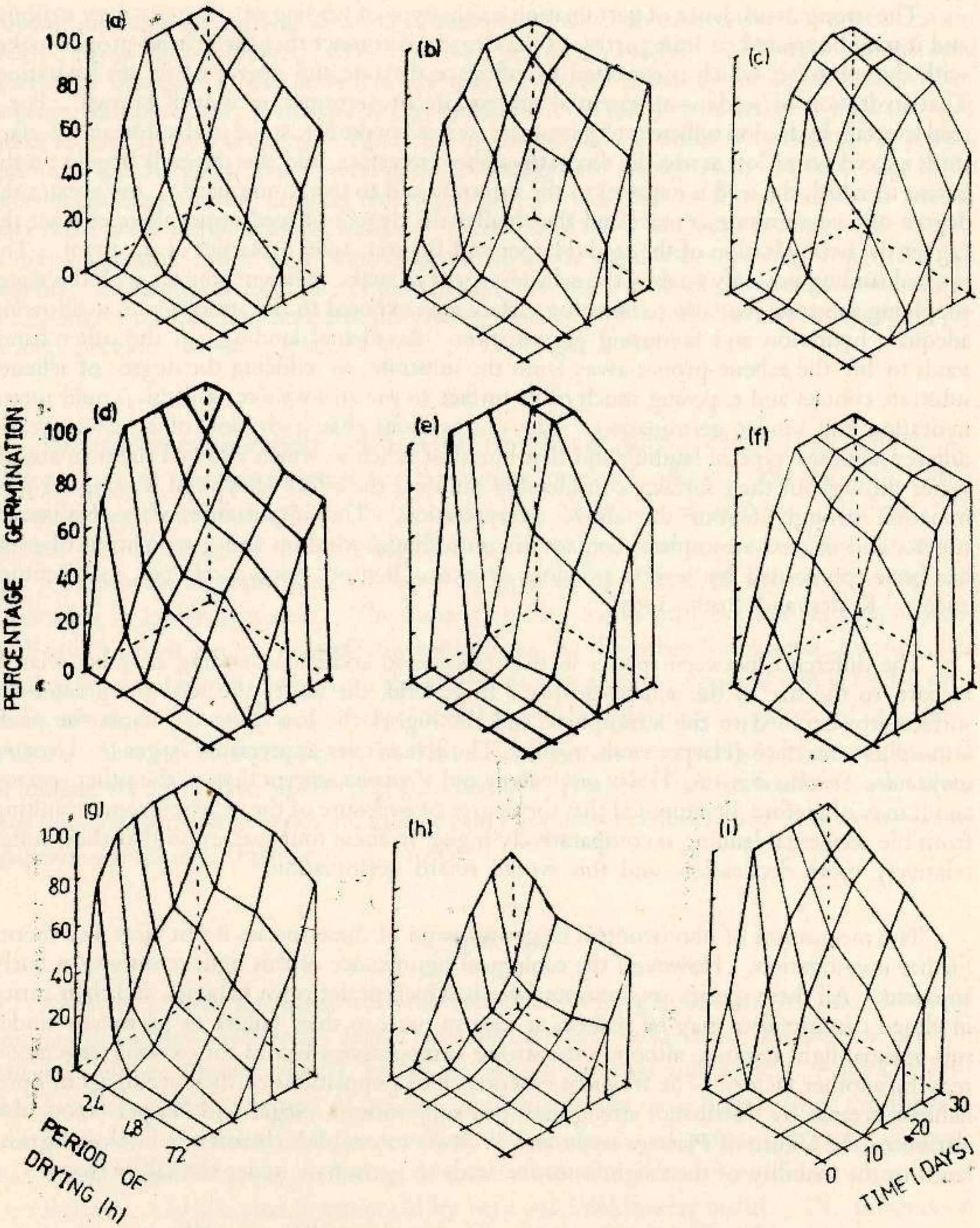


FIG. 3. The effect of different periods of redrying (0 (control), 12, 24, 48 and 72 *h*) of moistened achenes on germination. (The period of redrying is also included in the time course of germination). (*a*) *Ageratum conyzoides*; (*b*) *Emilia sonchifolia*; (*c*) *Erigeron sumatrensis*; (*d*) *Eupatorium riparium*; (*e*) *Mikania scandens*; (*f*) *Sonchus arvensis*; (*g*) *Tridax procumbens*; (*h*) *Vernonia cinerea*; (*f*) *V. setigera.*

The strong dependence of germination on the type of landing of achenes is very striking, and it may be related, at least partly, to the degree of contact that the achene-proper makes with the substrate, which is expected to influence the rate and degree of its net hydration. That hydration of seeds is an essential prerequiste of germination is well known. For a seed to attain hydration sufficient to germinate, water uptake across the seed-substrate interface must exceed water loss across the seed-atmosphere interface, and this depends largely on the extent to which the seed is exposed to the substrate and to the atmosphere ; the greater the degree of seed-substrate contact and the smaller the degree of seed-atmosphere contact the higher the net hydration of the seed (Harper and Benton, 1966 ; Harper et al., 1970). The normal landing not only enables the achene-proper to make sufficient contact with the water supplying substrate, but also reduces the surface area exposed to the atmosphere, so allowing adequate hydration and favouring germination. Accidental landing, on the other hand, tends to lift the achene-proper away from the substrate, so reducing the degree of achene-substrate contact and exposing much of its surface to the atmosphere, and this would retard hydration and hinder germination. The observations that hydration of achenes greatly differed with the type of landing and that burial of achenes, which allowed them to absorb water throughout their surface, considerably nullified the effect of type of landing on germination strongly favour the above interpretation. The importance of seed-substrate contact and of seed-atmosphere contact in controlling hydration and germination of seeds has been appreciated by several previous workers (Benton, 1965 ; Harper and Benton, 1966 ; Koller and Roth, 1963).

The difference between species in the response to accidental landing may be related, in part, to the size of the achene-proper. In general, the larger the seed the greater the surface area exposed to the atmosphere and the higher the loss of water across the seed-atmosphere interface (Harper et al., 1970). The achenes are appreciably larger in *Ageratum conyzoides, Sonchus arvensis, Tridax procumbens* and *Vernonia setigera* than in the other species, and it may, therefore, be supposed that the degree of exposure of the achene-proper resulting from the accidental landing is comparatively higher in these four species, so that they suffer relatively more desiccation, and this would retard germination.

The mechanism of photocontrol of germination of these species is not clear and merits further investigation. However, the ecological significance of this light sensitivity is fairly apparent. All these species are common weeds which prefer open habitats, and their rarity in closed communities may be related, at least in part, to their failure to germinate under sub-optimal light regimes, although the strong competitive effect of the existing vegetation may be another factor. The frequent emergence of populations of their seedlings in open habitats created by distribance strengthens this supposition. Sagar and Harper (1960) also attributed the failure of *Plantago major* and *P. media* to establish themselves in closed grass-lands to the inability of their light sensitive seeds to germinate under the tall herbage.

That seed burial is effective in imposing dormancy is well known (Harper et al. 1970 ; Onyekwelu, 1972 ; Pemadasa and Lovell, 1975), and the literature suggests that the mechanism of this enforced dormancy operates through factors such as light (Wesson and Wareing

1969*a*), moisture regime and aeration (Thurston, 1964), high carbon dioxide concentration (Kidd, 1914) and inhibitors (Wessson and Wareing, 1969*b*). Although the enforced dormancy observed in the present study may be related partly to the light sensitivity of achenes, the appreciably lower percentage germination in soil than in darkness indicates that other factors are also involved. No exact mechanism of the effect of burial on the species examined can be given, but its ecological advantages are readily seen. Firstly, even if the achenes could germinate, seedling emergence is restricted, and so this unsuccessful germination is a waste of potential individuals. Secondly, if the achenes can remain viable in soil, it may be possible for them to contribute to the future populations, provided that they are exposed as a result, for example, of ploughing. The importance of the presence of a viable seed bank in soil for the successful persistence especially of weeds has been emphasized by several previous workers (Harper, 1960 ; Thurston, 1960).

The experimental evidence indicates that the effect of pappus in improving germination performance of *Ageratum conyzoides, Eupatorium riparium, Mikania scandens* and *Tridax procumbens* operates through the enhancement of hydration of achenes. In these fou, species, the pappus remains firmly attached to the achene-proper ; it is likely, thereforer that a proportion of water absorbed by the pappus is transferred to the achene-proper so facilitating its better hydration. The disparity in the degree of hydration between achenes with and without pappus favours this conjecture. In the other five species, on the other hand, pappus tends to separate from the achene-proper once the dispersal unit is landed on a moist substrate. The differential behaviour of pappus in different composites and its possible adaptive value remain unexplained, but this seems to be another example of the importance of intrinsic seed characters in affecting germination. However, 'it is difficult to avoid falling into the teleogical trap of assuming that every feature of anatomy and morphology is of adaptive significance (Harper et al., 1970)'.

SUMMARY

An investigation was made of some factors affecting germination of nine species of composites, *Ageratum conyzoides, Emilia sonchifolia, Erigeron sumatrensis, Eupatorium riparium, Mikania scandens, Sonchus arvensis, Tridax procumbens, Vernonia cinerea* and *V. setigera.* Both the germination and hydration of achenes of all the species were higher when the dispersal unit lands with the achene-proper touching the substrate and pappus directing upwards than when it lands with pappus facing downwards so lifting the achene-proper away from the substrate. Germination is promoted by light and inhibited by burial. The presence of pappus improves both germination and hydration of achenes of *Ageratum conyzoides, Eupatorium riparium, Mikania scandens* and *Tridax procumbens.* The ecological implications of these results are briefly discussed.

REFERENCES

BENTON, R. A. 1965.—*Factors effecting water uptake by seeds from various media.* PhD thesis, University of Wales.

HARPER, J. L. 1960.—Factors controlling plant numbers. In : *The Biology of Weeds* (Ed. by J. L. Harper), p. 119. Oxford.

HARPER, J. L. & BENTON, R. A. (1966). The behaviour of seeds in soil. II. The germination of seeds on the surface of a water supplying substrate. *J. Ecol.*, **54**, 151-66.

HARPER, J. L., LOVELL, P. H. & MOORE, K. G. 1970.—The shapes and sizes of seeds. *A. Rev. Ecol. Systamatics*, **1**, 91-104.

KIDD, F. 1914.—The controlling influence of carbon dioxide in the maturation, dormancy and germination of seeds. *Proc R. Soc.* B, 87, 408-21.

KOLLER, D. & ROTH, N. 1963.—Germination regulating mechanisms in some desert seeds. VII. *Panicum turgidum* (Gramineae). *Israel J. Bot.*, **12**, 64-73.

MAYER, A. M. & POLJAKOFF-MAYBER, A. 1963.—*The Germination of Seeds.* Pergamon Press, Oxford.

ONYEKWELU, S. S. C. 1972.—The vegetation of dune slacks at Newborough Warren. III. *Plantago coronopus. J. Ecol.*, **60** 907-15.

PEMADASA, M. A. & LOVELL, P. H. 1975.—Factors controlling germination of some dune annuals. *J. Ecol.*, **63**, 41-59.

SAGAR, G. R. & HARPER, J. L. 1960.—Factors affecting the germination and early establishment of Plantains (*Plantago lanceolata P. media* and *P. major*). In : *The Biology of Weeds* (Ed. by J. L. Harper), p. 236. Oxford.

THURSTON, J. M. 1960.—Dormancy in weed seeds. In : *The Biology of Weeds* (Rd. by J. L. Harper), p. 69. Oxford.

THURSTON, J. M. 1964.—Germination of *Alopecuris myosuroides*. *Proc. 7th Br. Weed Control Conf.*, 12, 349-52.

WESSON, G. & WAREING, P. F. 1969*a*.—The role of light in the germination of naturally occurring populations of buried weed seeds. *J. exp. Bot.*, 20, 402-13.

WESSON, G. & WAREING, P. F. 1969*b*.—The induction of light sensitivity in weed seeds by burial. *J. Exp. Bot.*, **20**, 414-25

(MS. received 17.1.76)

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

Insects in Paddy and Rice in Storage in the Kandy District

by

V. K. GANESALINGAM*

Department of Zoology, Peradeniya Campus, University of Sri Lanka

(With four text figures)

INTRODUCTION

With the extensive cultivation of crops, particularly grain, in recent times, damage and loss by insect infestation in stored paddy and rice grain pose a major problem. Earlier work has shown the range and extent of infestation of local and imported rice stored in the Government Food stores in the Kandy District (Ganesalingam, 1974). The present study covers the nature of the insect complex found in the different storage placements from the time of harvest to eventual consumption, in the same area, in the Maha-season of 1975.

In the Kandy District (1600 feet above mean sea level), harvesting paddy of the Maha season usually takes place from February to May. A part of the paddy harvested is stored in house stores for the owner's use depending on personal requirements, and the other part is sold to the Multi-purpose Co-operative Society, from where the paddy stock is transported to the Paddy Marketing Board for storage. The rice mill obtains paddy from the Paddy Marketing Board for de-husking. The rice grain is then transported to the Government Food stores where it is stored for a longer period, until transported to the cooperative stores to be sold to consumers. Thus, usually there is a constant flow of paddy and rice in and out of the respective storage places.

MATERIALS AND METHODS

Samples of paddy, harvested during the Maha-season 1975, each weighing about 20 g were collected from the Kandy District, every month from March to August 1975 from four house stores, where the paddy is stored in "atuwas" (Fig. 1) ("Atuwa" is a traditional wooden box resembling a tall rectangular chamber), and from two stores of the Paddy Marketing Board, where paddy is stored in gunny bags arranged in stacks. Similarly, four samples of rice, each of the same volume as that of paddy, were collected every month during this period from a rice mill and from four Government Food stores. Table I shows the places from where the samples were collected.

The collected samples were brought to the laboratory where they were examined for the insects which were identified subsequently.

*Present Address: Department of Zoology, Jaffna Campus, Vaddukoddai.

TABLE I

Home Storage	Paddy Marketing Board	Rice Mill	Government Food Stores
Katugastota	Kundasale	Denuwara	Kaṭugastota
Wattegama	Denuwara		Wattegama
Manikhine			Kundasale
Gampola			Gampola

Samples of paddy were collected from threshing floors of four different places in the Kandy District at the time of harvesting. These samples were kept in cleaned bottles closed with plastic caps having perforations. These samples were observed from time to time for emergence of insects to determine whether the infestation takes place in the paddy field itself.

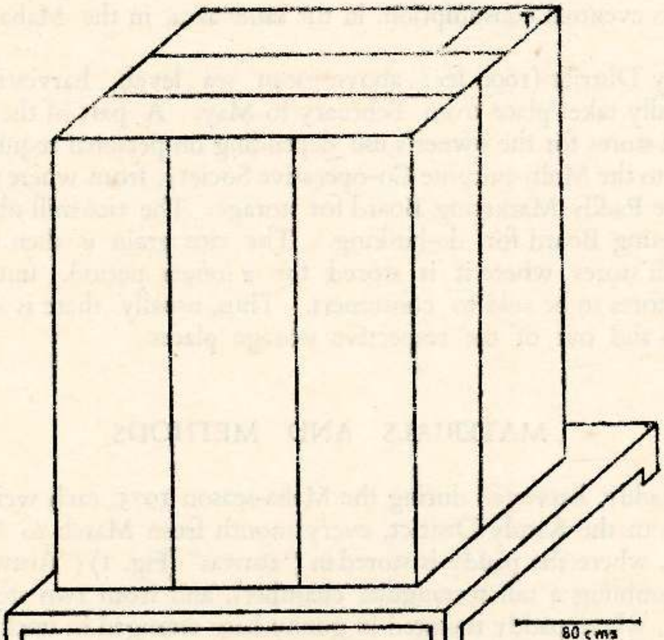


FIG. 1. An "Atuwa" (semidiagrammatic).

The average mean maximum and minimum temperatures and the average mean relative humidity in the Kandy District during the experimental period as recorded by the Colombo Observatory were 28.77°C and 21.05°C, and 93.3% and 69.5%, respectively.

RESULTS

Paddy stored in the house stores ("atuwas") and the Paddy Marketing Board stores, and the rice stored in the rice mills and the Government Food stores are infested with insects of the same species but in different proportions (Table II). Statistically, by analysis of variance, there is a significant difference between the numbers found of the different individual species present in the house storage with regard to live insects (d.f. 5/30, F = 6.14, P > 5%), as well as dead insects (d.f. 5/30, F = 5.43, P > 5%). Similarly, there is a significant difference between the numbers of insect species found in the Paddy Marketing Board stores among the live insects (d.f. 4/20, F = 111.2, P > 0.5%), and dead insects (d.f. 4/20, F = 16.1, P > 0.5%). In both house stores and the Paddy Marketing Board stores, the Angoumois grain moth *Sitotroga cerealella* (Oliver) is the major pest throughout the period of sampling (Fig. 2 & 3). But the incidence of this pest in home stores is statistically greater than that in the Paddy Marketing Board stores (t = 4.02, d.f. 4, P < 2.5%). Although the rice weevils *Sitophilus oryzae* L. and *Sitophilus zeamais* Mostch., *Laemophloeus ferrugineus* (Steph.), *Rhizopertha dominica* (F.) were found in paddy of both stores in order of decreasing abundance, their numbers were insignificant.

TABLE II

Average number of insect population found in the samples of paddy and rice during the Maha season (March—August 1975)

INSECTS	PADDY				RICE			
	Home Store		Paddy Karketing Board		Rice Mill		Government Food Store	
	Living	Dead	Living	Dead	Living	Dead	Living	Dead
S. cerealella	40.5	32.3	11.3	17.6	0	0	0.75	0.25
Rice weevils	8.3	1.7	0.8	1.8	1.4	0.20	4.25	2.0
R. dominica	9.1	4.2	0.8	0	0	0.20	0.75	0.5
T. castaneum	1.5	0.3	0.6	0.20	0.20	0	2.25	0.75
L. ferrugineus	5.5	0.17	0.8	0	0	0	1.0	0.25
T. mauritanicus	0.17	0	0	0	0	0	0.25	0
O. surinamensis	0	0	0	0	0	0	1.0	0.25

In storage of rice in the Government Food stores, although statistically there is no significant difference between the numbers of species of living insects (d.f. 6/21, F = 1.39, P > 5%) as well as dead insects (d.f. 6/21, F = 1.8, P > 5%), found in the rice grain, the rice weevils *S. oryzae* and *S. zeamais* were the major pests, whereas *S. cerealella*, *L. ferrugineus*, *R. dominica*, *T. castaneum*, *O. surinamensis* and *T. mauritanicus* were found occasionally (Fig. 4).

In the rice mills, the degree of infestation of rice by insects is very negligible. However, the rice weevils, and *L. ferrugineus* and *R. dominica*, were found occasionally.

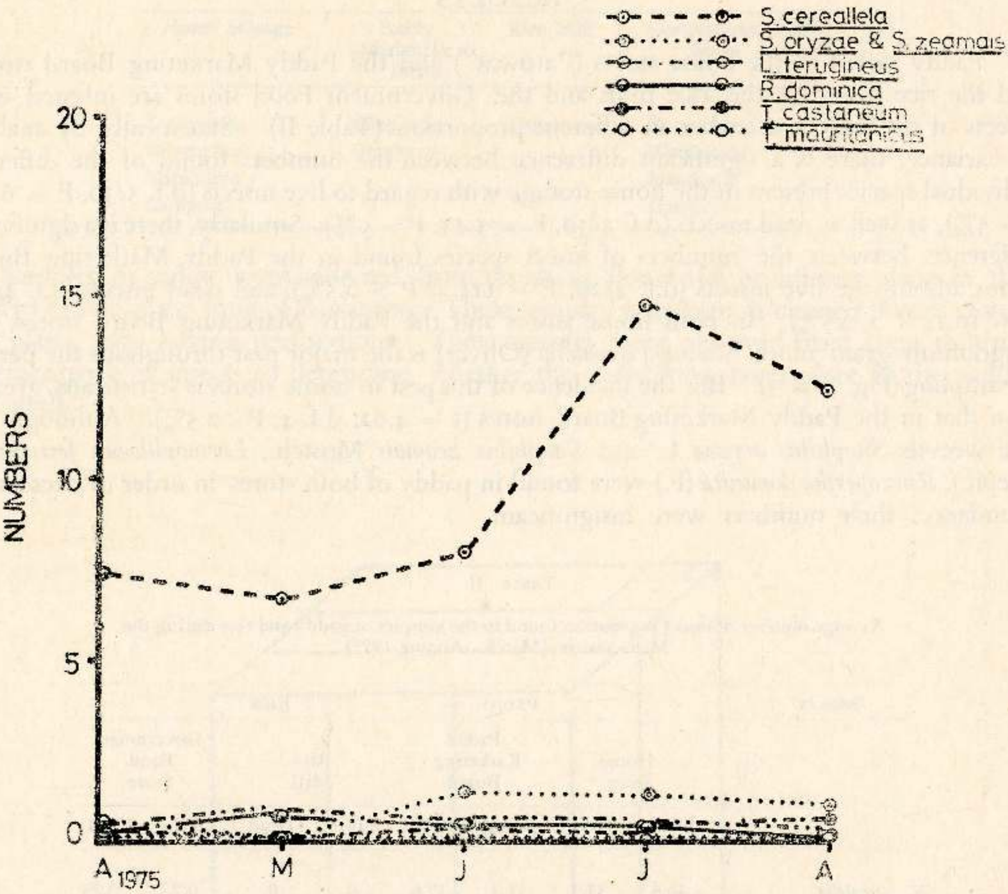


FIG. 2. The insect species that were found in the monthly sample of paddy of Maha season (1975), obtained from home stores (Atuwa).

With regard to the four samples of paddy collected from the threshing floor, no insects were found to emerge from them.

DISCUSSION

The major observation in this study is that, although generally the same species of insects were found in paddy and rice in storage, there is a difference in insect population inhabiting both paddy and rice grain. In this study it was found that *S. cerealella* was the major pest in house stores and Paddy Marketing Board stores, whereas the rice weevils were the major pest in Government Food stores. So it appears that the preference for the grain by the pests depends on the nature of the grain, such as whether the grain is husked or unhusked.

The preference for grain husked or unhusked depends on the habit of the individual pest concerned. In the case of *S. cerealella* the egg is laid on the husk of the unhusked grain and the larva on hatching out burrows into the grain by making a small hole in the husk. The developing larva devours the starchy endosperm of the kernel while the husk is still intact, and passes into the pupal stage. The rice weevils prefer the husked grain. The eggs are laid in the cavities of the husked grain made by the proboscis of the weevil and the development of the young takes place within the husked grain (Hinds and Turner, 1911).

Although it may be considered that the husk is a hard cover, giving protection to the grain, the larva of *S. cerealella* is able to make a hole in it to reach the grain. Whether this hole is made by the mandibles of the larva or by an enzyme produced by the larva, needs further investigation.

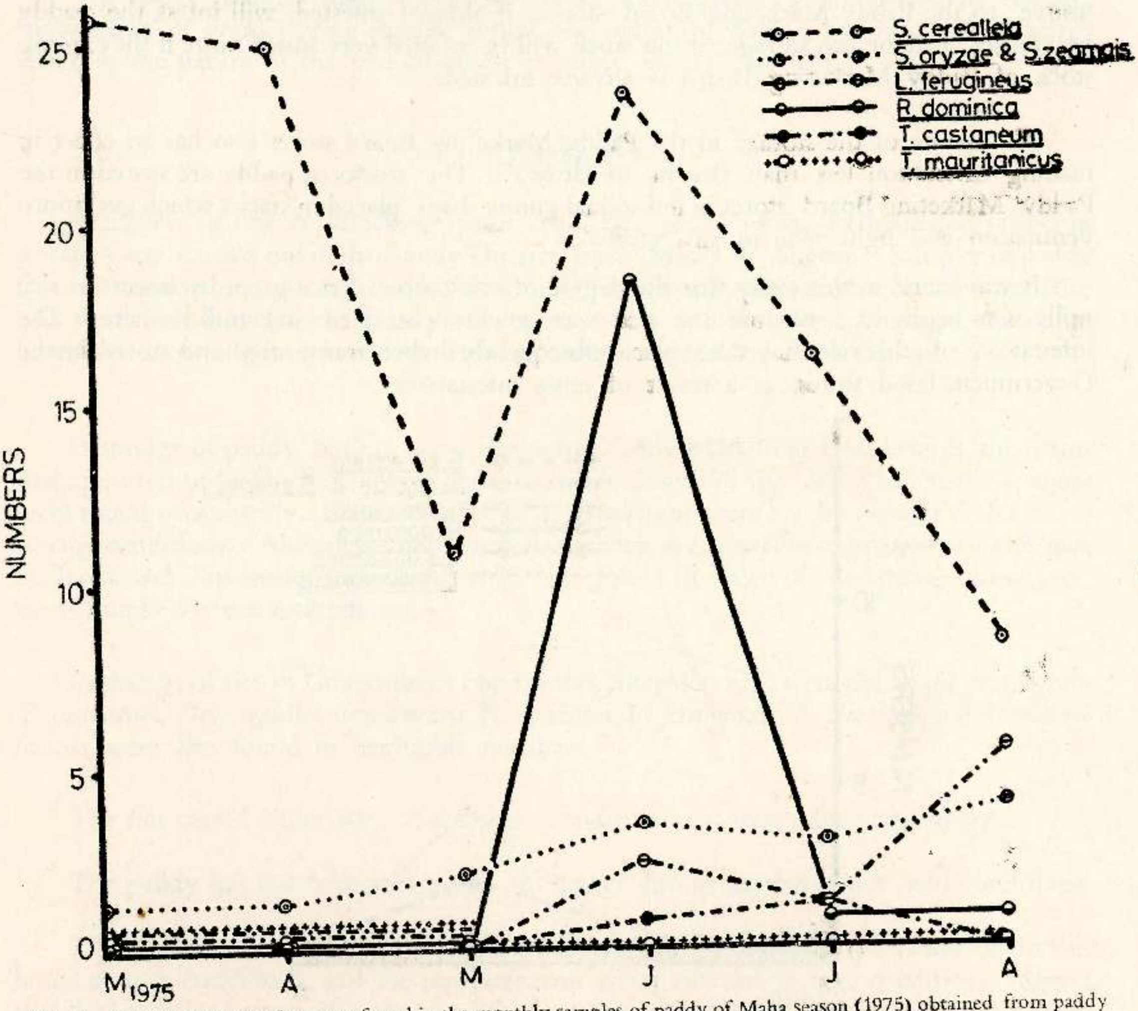


FIG. 3. The insect species that were found in the monthly samples of paddy of Maha season (1975) obtained from paddy Marketing Board stores.

In this study it was observed that the highest incidence of pests occurs in house storage condition. Obviously, this is due to the accumulation of paddy in the "atuwa" for a long period of storage, so that the pest could continue to breed and multiply within the "atuwa", specially because the "atuwa" is not usually emptied and cleaned periodically ; and the inside of the "atuwa" has poor ventilation and poor illumination and has a higher temperature due to grain metabolism (Fernando, 1974).

It was found in this study that the incidence of pests in house storage conditions is significantly greater than that of the Paddy Marketing Board stores. This is probably due to the fact that the stock in the Paddy Marketing Board stores is always fast 'moving' towards Rice Mills for dehusking instead of accumulating in the same chamber such as an 'atuwa' for a long period of time. However, it would appear that the stocks that 'move' to the Paddy Marketing Board stores, if already infested, will infest the paddy previously brought into storage, or this stock will be infested very much more if the existing stock of Paddy Marketing Board is already infested.

The nature of the storage in the Paddy Marketing Board stores also has an effect in making infestation less than that in an 'atuwa'. The stocks of paddy are stored in the Paddy Marketing Board stores in individual gunny bags placed in stacks which get more ventilation and light than in an 'atuwa'.

It was found in this study that the degree of infestation of rice grain by insects in rice mills was negligible, because the rice was quickly parboiled and milled there. The infestation of this rice may take place subsequently when transported and stored in the Government Food stores, as a result of cross infestation.

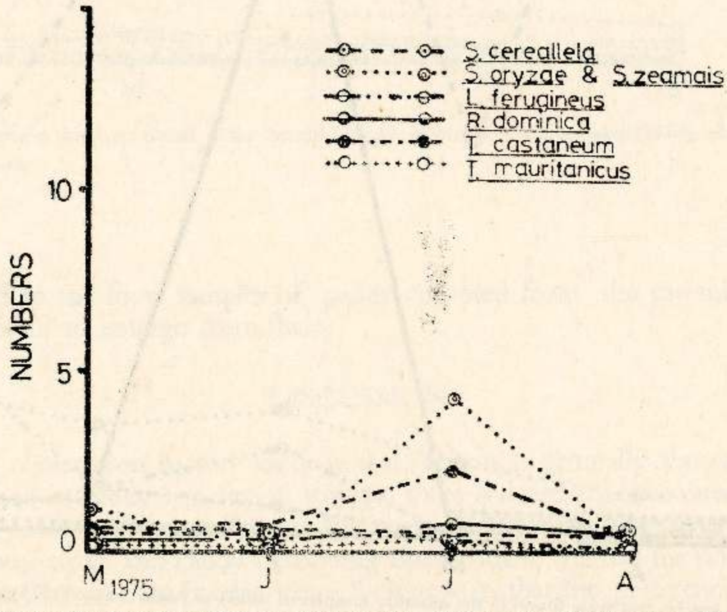


FIG. 4. The insect species that were found in the monthly samples of rice grain of Maha season (1975) obtained from the Government Rice stores.

In this study it was found that the paddy collected from the threshing floor during the harvest, under the field conditions, was not infested by any insects. This suggests that the initial infestation of paddy does not take place in the field. So it may be possible that infestation of newly harvested paddy takes place when stored in houses or 'atuwa', which many species of insects attacking grain and cereals inhabit. Subsequently, when the infested paddy from the houses and 'atuwa' is transported to other storages, the insects find their way to new places of storage. However, if the paddy is transported directly to the Multi-purpose Co-operative stores or Paddy Marketing Board stores from the paddy field soon after harvest, the infestation of the new storage could be reduced.

The above findings suggest that the nature and status of grain, period of storage, 'movement' of stocks during storage period, and nature of storage, form the major factors affecting the nature of the pest-complex in paddy and rice storage.

SUMMARY

A survey of insects attacking paddy and rice grain of the Maha-season (1975) in storage was carried out in the Kandy District from March to August. Samples of paddy from home storage units and Paddy Marketing Board stores, and samples of rice from Rice Mill stores and Government Food stores, were collected to determine the insect infestation in storage according to placement between initial storage and final disposal.

In storage of paddy, both in home stores and Paddy Marketing Board stores, the major pest appeared to be chiefly *Sitotroga cerealella*, while *Sitophilus* spp. and *Rhizopertha dominica* were found occasionally. The incidence of *S. cerealella* appeared to be greatest under home storage conditions. Although some other insects such as *Laemophloeus ferrugineus*, *Tribolium castaneum* and *Tenebroides mauritanicus* were also found in order of decreasing abundance, their numbers were insignificant.

In storage of rice in Government Food stores, *Sitophilus* spp. were the major pest, while *T. castaneum*, *Oryzaephilus surinamensis*, *R. dominica*, *L. ferrugineus*, *S. cerealella* and *T. mauritanicus* were also found in negligible numbers.

The rice stored under Rice Mill storage conditions was least infested by insects.

The paddy has not been infested by any insect during harvest under field conditions.

The differences in pest population in paddy and rice, the highest incidence of pest in home storage conditions, and the least infection under rice mill storage conditions, suggest that the nature and status of grain, period of storage, 'movement' of stocks during storage period, and nature of storage, form the major factors affecting the nature of the pest complex in paddy and rice storage.

ACKNOWLEDGEMENTS

I am most grateful to Prof. B. A. Baptist of the Faculty of Agriculture for his unfailing help in critically reading the manuscript, Mr. U. B. Ekanayake for assisting me in the field collections, and Miss C. H. Bandula for the figures in final form.

This work was supported by a grant from the National Science Council of Sri Lanka.

REFERENCES

FERNANDO, J. 1974—Storage and preservation of grains based on the farm land storage in Sri Lanka. (N.S.C. Report).

GANESALINGAM, V. K. 1974—Insect pests in rice stores. *Proc. Cey. Ass. Advmt. Sci.* (1) 94-95.

HINDS, W. E. & TURNER, W. F. 1911—Life history of the rice weevil, *Calandra oryzae* in Alabama. *Jour. Econ. Ent.* 4, 230-236.

(MS. received 17.3.76)

Ceylon J. Sci. (Bio. Sci.) Vol. 12, No. 2, November 1977

Effect of Feeding Level on the Rate and Efficiency of Food Conversion in the Cyprinodont Fish *Gambusia affinis**

by

KATRE SHAKUNTALA

Department of Zoology, Bangalore University, Bangalore 560001, South India

(With three text figures)

ABSTRACT

Adult male and female *Gambusia affinis* weighing 84.2 ± 4.68 mg were offered different rations (0 to 300 mg wet worm/g live fish/day), of the oligochaete worm *Tubifex tubifex* and the rate and efficiency of food conversion at each level of feeding were recorded. The maintenance, optimum and maximum feeding rates for males were 60, 84 and 100 mg/g/day respectively. The corresponding values for females were 62, 180 and 200/mg/g/day. Absorption efficiency values varied from 82.9 to 89.2% of the total food consumed. Females consumed nearly one and a half times more food than the males and showed marked growth in comparison with the latter. The sex hormones are possibly responsible for controlling the 'appetite' in these fish, which ultimately influence the rate of consumption and growth. The efficiency of the female to convert food into body substance was higher than that of the male, irrespective of the feeding level.

INTRODUCTION

The widely distributed mosquito fish *Gambusia affinis* is known to tolerate harsh environmental situations (Goodyear et al., 1972). In tropical waters where the temperature changes are negligible (Bogorov, 1962), the ecological success of *G. affinis* in different competitive situations may be largely dependent on the availability of food and the ability of the fish to successfully regulate its food intake. Considerable information is available on the effect of ration levels on the rate and efficiency of food conversion in fishes (Gerking, 1955; Pandian, 1967; Pandian & Raghuraman, 1972). These authors studied the effect in particular size groups of the fish. Gerking (1971) chose a wide range of sizes (body weights) in *Lepomis macrochirus* ranging from 14 to 85 g; but he ignored the sex factor and the probable role of gonadal hormones on the food intake regulation. Brett et al. (1969) studied the effects of ration levels in *Onchorhynchus nerka* in long-term experiments but examined only different size groups of the fish and not the sex. In *G. affinis*, growth itself is dependent on food intake (Katre, 1973). Unlike the male, the female *G. affinis* grows even after morphological sex differentiation (Krumholz, 1948). Hence the present study was undertaken to examine the effects of different ration levels on the rate and efficiency of food conversion in both the sexes of *G. affinis*, to evaluate the role of gonadal hormones in the regulation of food intake in this fish.

*From a thesis submitted to the Bangalore University in partial fulfilment of the requirements for a Ph.D. degree.

MATERIAL AND METHODS

Gambusia affinis, an exotic fish (Kulkarni, 1947), is abundant in natural and artificial freshwater habitats of India. For the present study, mature fish were collected from the Bellandur tank (near Bangalore, South India) and stocked in aquaria. Male and female fish of similar body weights (84.2 ± 4.68 mg) were selected from the stock and separately reared in battery jars containing 500 ml of aerated freshwater at 25.0 ± 1°C. The fish were starved for a period of 3 days prior to the experiment, to induce hunger in them. From the fourth day they were fed on different amounts of the oligochaete worm *Tubifex tubifex*. These worms are reported to be highly nutritive (Galinat, 1960) and more easily digested by fish than any other prey (Mann, 1935). The uneaten food was removed, before the onset of feeding, the next day. The 'sacrifice method' of Maynard and Loosli (1972), to test the growth of laboratory animals, was employed in the present study, following the procedure of Gerking (1952). A group of fish (both male and female) were sacrificed at the beginning of the experiment, for initial weights. The feeding experiment at different feeding levels was continued for 30 days and, at the end of the period, the individuals were sacrificed to note the final weight changes.

RESULTS

I. *Food Intake :*

Male and female *Gambusia affinis* were fed individually on different ration levels ranging from 0.0 to 20.0% of the total weight for male (Table I) and 0.0 to 30.0% of the total weight for female (Table II). For comparison with the results of earlier workers, feeding rate is expressed in mg food/g fish/day, as according to Pandian & Raghuraman (1972). In the males fed 160 mg/g fish/day and 200 mg/g fish/day, some surplus food was left uneaten, causing negligible differences in the total ration level eaten (157 mg and 197 mg/g fish/day respectively). Apparently, an amount of worm substance equivalent to 197 mg/g fish/day

TABLE 1

Effects of different feeding levels on growth and conversion efficiency of male *Gambusia affinis*. Each value represents the mean of fifteen fish fed individually.

Feeding level (% live body weight of fish/day)	Feeding rate (mg live worm/g live fish/day)	Feeding rate (mg dry worm/g live fish/day)	Growth rate gain or loss (mg dry/g live fish/day)	Conversion efficiency (K_1) (%)
0.000	0.00	0.00	−4.36 ± 0.34	—
1.009	10.09	1.63	4.12 ± 0.82	—
2.018	20.18	3.25	3.60 ± 0.44	—
4.036	40.36	6.50	2.30 ± 0.98	—
8.072	80.72	13.02	+1.20 ± 0.22	9.28 ± 1.98
10.009	100.09	16.30	0.40 ± 0.90	2.48 ± 1.12
12.108	121.08	19.56	1.10 ± 0.42	5.64 ± 0.98
14.126	141.26	22.82	0.55 ± 0.14	2.41 ± 1.02
16.144	161.44	26.09	0.84 ± 0.04	3.23 ± 0.84
20.180	201.80	32.60	0.21 ± 0.02	0.63 ± 0.22

represents the maximum amount which a 84 mg male *G. affinis* can consume under laboratory conditions. The corresponding value for the females is about 1½ times higher than that of the males. Hess & Tarzwell (1942) also observed that males of *G. affinis* consumed half as much food as that of females of the same size. Interestingly the values of feeding rates obtained in the present experiment seem to be rather high, when compared to those obtained for *Megalops cyprinoides* (90 mg/g/day), *Ophicephalus striatus* (70 mg/g/day; Pandian, 1967), *Gasterosteus aculeatus* (120 mg/g/day; Beukema, 1968), and *Tilapia mossambica* (65 mg/g/day; Pandian & Raghuraman, 1972). The higher value obtained for *G. affinis* is perhaps due to its smaller size (84 mg) as compared to 2.5 g of the fishes mentioned above. In a closely related cyprinodont *Poecilia reticulata* of 37 mg body weight, Davis (1968) recorded a daily food intake of 1.76 mg dry Daphnia/day, which works out to be 48 mg/g/day. The values obtained for *G. affinis* (on the basis of dry weight) are closer to the reported values (Males: 20 mg dry worm/g/day; females: 30 mg dry worm/g/day). Feeding rates equivalent to the maintenance (where there is neither gain nor loss in the original body weight), optimum (where there is best conversion of food into body substance) and maximum levels were derived geometrically for *G. affinis* (cf. Thomson, 1941). For a male, 60, 84 and 100 mg live prey/g fish/day represent the maintenance, optimum and maximum feeding rates respectively. The corresponding values for females were 62, 180 and 220 mg live prey/g fish/day (Fig. 1). Thus, the females differ in having higher optimal and maximal feeding rates than the males.

II. *Food absorption:*

The medium of the aquaria in which the experimental individuals were reared was filtered at the end of 30 days through Whatman No. 1 filter paper, and the feces collected, dried and weighed. By subtracting the feces weight from the net amount of food consumed, absorption efficiency was calculated. Not accounting for the losses of fecal matter through

TABLE 2

Effects of different feeding levels on growth and conversion efficiency of female *Gambusia affinis*. Each value represents the mean of fifteen fish fed individually.

Feeding level (% live body weight of fish/day)	Feeding rate (mg live worm/g live fish/day)	Feeding rate (mg dry worm/g live fish/day)	Growth rate gain or loss (mg dry/g live fish/day)	Conversion efficiency (K1) (%)
0.000	0.00	0.00	—4.92 ± 0.98	—
0.993	9.93	1.60	3.13 ± 0.99	—
1.986	19.86	3.20	1.61 ± 0.42	—
3.972	39.72	6.40	1.20 ± 0.44	—
5.958	59.58	9.60	+0.43 ± 0.08	4.48 ± 1.21
7.944	79.44	12.80	1.24 ± 0.12	9.69 ± 1.84
9.930	99.30	16.00	1.23 ± 0.24	7.69 ± 1.68
11.916	119.16	19.20	1.89 ± 0.28	9.88 ± 2.12
13.902	139.02	22.40	3.52 ± 1.21	15.73 ± 2.78
15.889	158.89	25.60	0.79 ± 0.04	3.09 ± 0.92
19.860	198.60	32.00	7.58 ± 1.92	23.70 ± 2.88
24.825	248.25	40.00	3.11 ± 1.12	7.77 ± 1.88
29.790	297.90	48.00	6.51 ± 1.06	11.49 ± 1.67

degradation and decomposition during the 30 day experimental period (see also: Davies 1963), the absorption efficiency for a male *Gambusia affinis* averaged 86.5% (range : 80.7 to 89.2%) at all levels of feeding, whereas for a female it averaged 82.9% (range : 80.8 to 86.5%).

III. *Food conversion* (K_1) :

The amount of dry substance gained or lost by the test fish after the 30 day feeding experiment was calculated and expressed in mg dry substance increase or decrease/unit weight of fish/day. Incorporating the dry weight gain or loss, the conversion efficiencies (K_1) were computed. The efficiency for a male *Gambusia affinis* was the highest (9.3%) for a fish fed 13.0 mg dry worm/g fish/day ; over and below this ration level, the efficiency was low. The maximum efficiency (23.7%) for the female was exhibited when the fish was fed 32.0 mg dry worm/g fish/day (Tables I and II).

When the rates of feeding, conversion and absorption were known, the apparent costs with reference to energy metabolised for body functions could be estimated. The quantitative relations of the feeding rates to the energy absorbed, metabolised for body functions and converted into body substance in male and female *Gambusia affinis*, are represented in Figure 2. Since the maintenance rates had been estimated from starvelings (see Fig. 1), the level of 'Specific Dynamic Action' (SDA), "an extra heat increment incident to the nutritive process in total, including the energy cost of excretion of the end products", (Brody, 1945), could be calculated. The column of SDA represented in Fig. 2 includes the energy cost of activity of the fish and probable loss of some residual energy into the medium by way of carbon containing compounds (e.g. aminoacids and lactate). This SDA for male increased from 1 to 4 mg/g fish/day from optimum to maximum rates of feeding, while in the female it increased from 7 to 11 mg/g fish/day, i.e., at the highest feeding levels, the apparent energy cost for converting food into body substance increased as much as four times for males and only one and a half times for females.

DISCUSSION

The results obtained on the different feeding levels of *Gambusia affinis* demonstrate that the level of appetite in males influences the food consumption. This consumption, even at maximal level, seems to be just enough for the apparent energy cost on maintenance and thus results in negligible growth. On the other hand, the level of appetite in the female is so high that it could meet the energy cost on maintenance and also contribute considerably towards growth. A reduction in the consumption of food in male *G. affinis* after sex maturation was also observed by Katre (1973), when the diet offered was nauplii of *Artemia salina* (Fig. 3). Differences in growth rates of males and females after sex maturation, as observed in the present study, have also been observed for other fishes like *Salmo gairdnerii* (Nomura, 1963) and *Lebistes reticulatus* (Reddy & Katre, unpublished observations). 'Appetite' in fish is known to be controlled by one or more of the following factors :

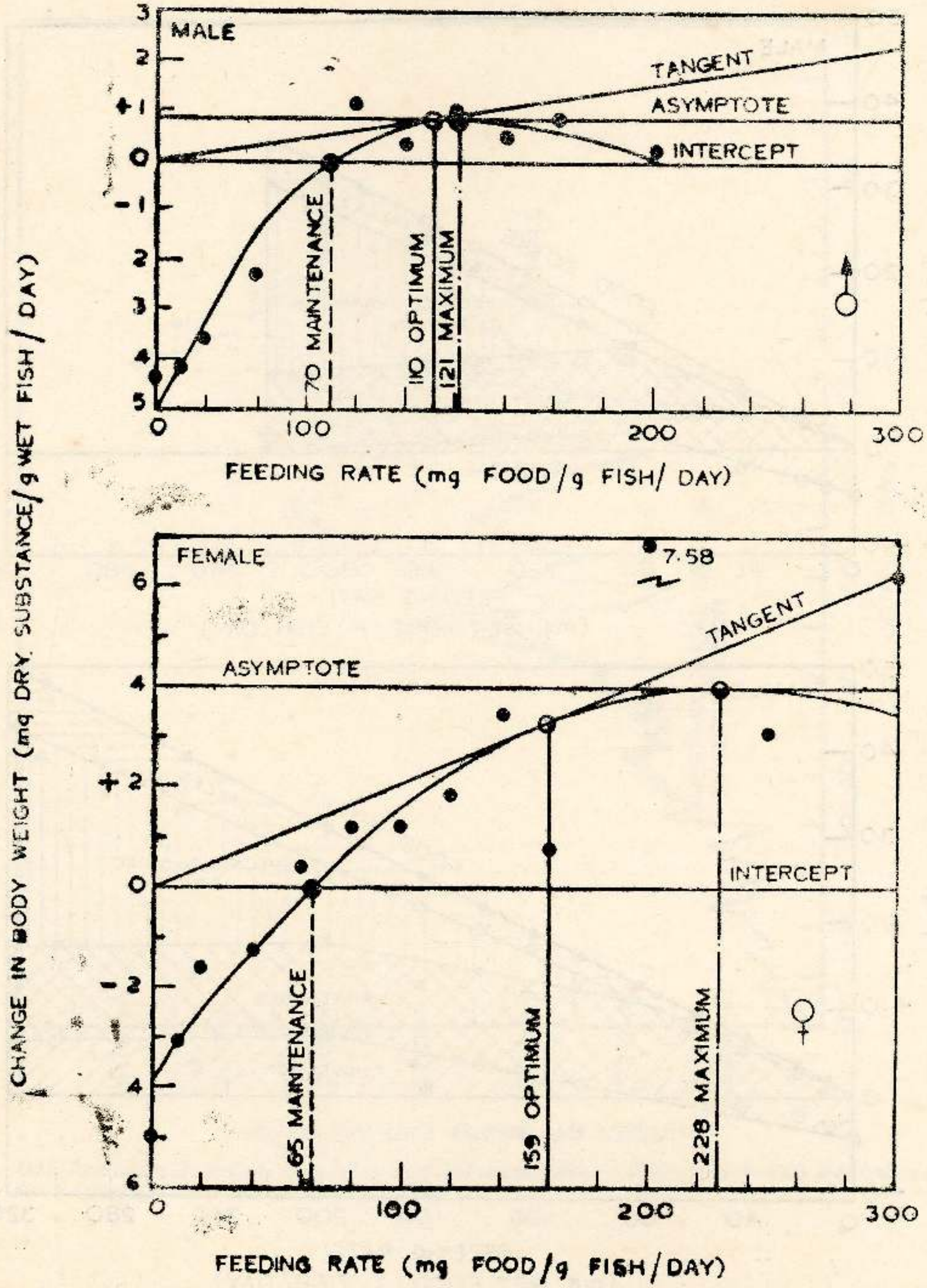


FIG. 1. Geometric derivations of maintenance, optimum and maximum feeding rates of male and female *Gambusia affinis*.

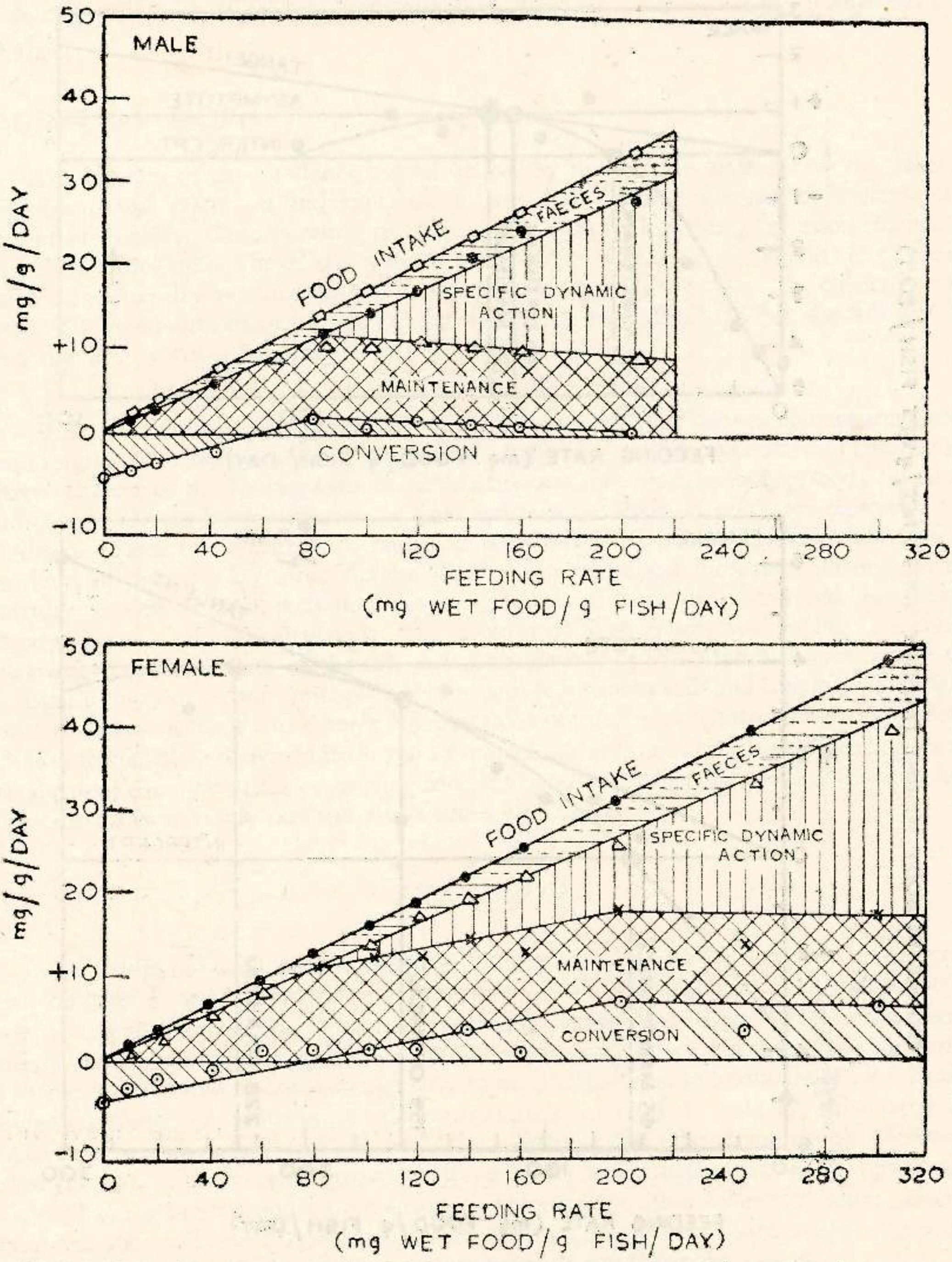


FIG. 2. Effects of feeding levels on scopes for growth (conversion), metabolism (maintenance plus specific dynamic action) and output of faeces in male and female *Gambusia affinis*.

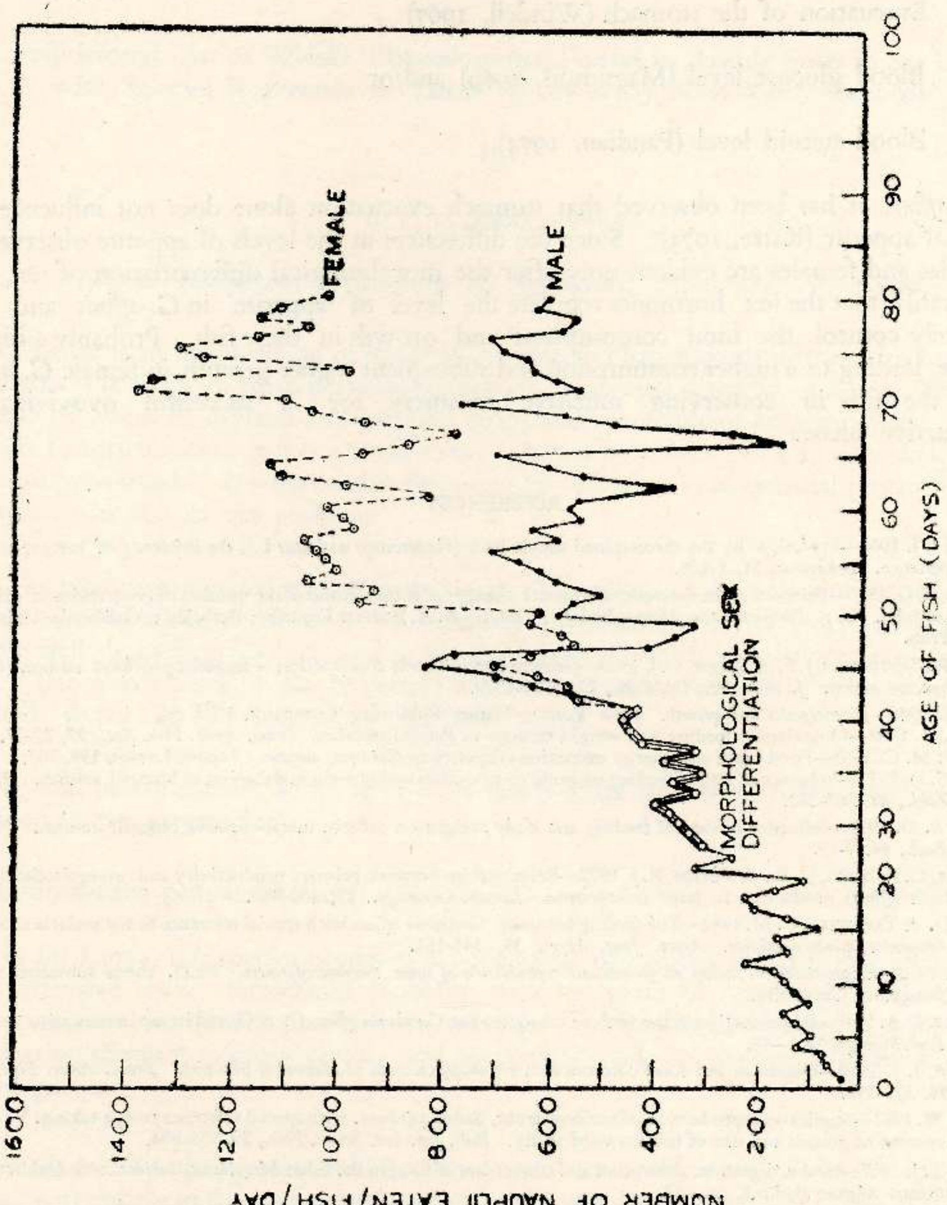


FIG. 3. Daily food intake of *Gambusia affinis* fed on nauplii of *Artemia salina*. Differences in the daily food intakes after the morphological sex differentiation are evident.

1. Evacuation of the stomach (Windell, 1967)

2. Blood glucose level (Magnuson, 1969) and/or

3. Blood steroid level (Pandian, 1974).

In *G. affinis*, it has been observed that stomach evacuation alone does not influence the return of appetite (Katre, 1973). Since the differences in the levels of appetite observed in the males and females are evident only after the morphological differentiation of sex, it is conceivable that the sex hormones regulate the level of 'appetite' in *G. affinis* and thus ultimately control the food consumption and growth in these fish. Probably a higher appetite, leading to a higher consumption and subsequent higher growth, in female *G. affinis* helps the fish in conserving nutritive resources for a successful ovoviviparous reproductive phase.

REFERENCES

BEUKEMA, J. J. 1968—Predation by the three-spined stickle back (*Gasterosteus aculeatus* L.), the influence of hunger and experience. *Behaviour*, **31**, 1-126.

BOGOROV, B. G. 1960—Perspectives in the study of seasonal changes of plankton and of the number of generations of different latitudes. In: *Perspectives in Marine Biology:* Ed. by A. A. Buzzati Trquerro: Berkeley: California University Press.

BRETT, J. R., SHELBOURN, J. E. & SHOOP, C. J. 1969—Growth rate and body composition of fingerling sockeye salmon (*Oncorhynchus nerka*). *J. Fish. Res. Bd. Can.*, **27**, 1767-1779.

BRODY, S. 1945—*Bioenergetics and growth.* New York: Hafner Publishing Company. 1023 pp.

DAVIS, C. C. 1968—Quantitative feeding and weight changes in *Poecilia reticulata. Trans. Amer. Fish. Soc.*, **97**, 22-27.

DAVIES, P. M. C. 1963—Food input and energy extraction efficiency in *Carassius auratus. Nature, London*, **198**, 707.

GERKING, S. D. 1955—Influence of rate of feeding on body composition and protein metabolism of bluegill sunfish. *Physiol. Zool.*, **28**, 267-282.

GERKING, S. D. 1971—Influence of rate of feeding and body weight on protein metabolism of bluegill sunfish. *Physiol. Zool.*, **44**, 9-19.

GOODYEAR, C. P, BOYD, C. E., & BEYERS, R. J. 1972—Relationships between primary productivity and mosquitofish (*Gambusia affinis*) production in large microcosms. *Limno. Oceanogr.*, **17**, 445-450.

HESS, A. D. & TARZWELL, C. M. 1942—The feeding habits of *Gambusia affinis* with special reference to the malaria mosquito *Anopheles quadrimaculatus. Amer. Jour. Hyg.*, **35**, 141-151.

KATRE, S. 1973—*Ecophysiological studies on growth and reproduction of some thermoconformers.* Ph.D. thesis submitted to the Bangalore University.

KRUMHOLZ, L. A. 1948—Reproduction in the western mosquito fish *Gambusia affinis* (B & G) and its use in mosquito control. *Ecol. Monogr.*, **18**, 1—48.

MAGNUSON, J. J. 1969—Digestion and food consumption by skipjack tuna (*Katsuwonus pelamis*). *Trans. Amer. Fish. Soc.* **98**, 379-392.

NOMURA, M. 1963—Studies on reproduction of rainbow trout, *Salmo gairdneri*, with special reference to egg taking. V. Development of gonads and size of fish spawned firstly. *Bull. Jap. Soc. Scient. Fish.*, **29**, 976-894.

PANDIAN, T. J. 1967—Intake, digestion, absorption and conversion of food in the fishes *Megalops cyrinoides* and *Ophiocephalus striatus. Marine Biol.*, **1**, 16—32.

PANDIAN, T. J. 1974—Mechanisms of heterotrophy. In: *Treatise on Marine Ecology*, by O. Kinne, London: Wiley.

PANDIAN, T. J. & RAGHURAMAN, R. 1972—Effects of feeding rates on conversion efficiency and chemical composition of the fish *Tilapia mossambica. Marine Biol.*, **12**, 129-136.

REDDY, S. R. & KATRE, S.—Hormonal control of 'appetite' in the fish *Lebistes reticulatus* (unpublished observations).

THOMSON, D. H. 1941—*The fish production in inland lakes and streams. Symposium Hydrobiol.*, University of Wisconsin, Madison, pp. 206-217.

WINDELL, J. T. 1967—Rates of digestion in fishes. In: *The Biological basis of freshwater fish production.* pp. 151-173., Ed. by S. D. Gerking. Oxford, Blackwell Scientific Publications.

(MS. received 1.7.76).

CEYLON J. SCI. (BIO. SCI.) Vol 12, No. 2, November 1977

A Provisional List of Weeds (Phanerogams) Found in Arable Soils in Sri Lanka with Special Reference to Three Noteworthy New Weed Records*

by

K. L. D. AMARATUNGA

National Herbarium, Department of Agriculture, Peradeniya, Sri Lanka

This list is an enumeration of some of the weeds (Phanerogams) hitherto recorded for Sri Lanka. It is drawn from personal collections made over a period of time. The rapid growth of weeds in dryland and wetland crops and the resultant crop losses are of great concern to agriculturists, and as a result many schemes have been put into operation for the eradication of weeds. It is hoped that this weed list will serve as an essential prerequisite for a better evaluation of the problem.

The weeds enumerated are distributed over 42 families and the families for convenience are arranged in alphabetical order. In the present treatment the term dryland is used to denote well drained soils as opposed to the term wetland which will denote poorly drained soils. The weeds found in the respective areas are therefore referred to as predominantly dryland weeds or predominantly wetland weeds.

Special mention must be made of three noteworthy new weed records for Sri Lanka included in the present list.

1. **Pennisetum polystachyon** (L.) Schult.

In Sri Lanka, this species occurs in a wide range of habitats and it is now naturalized over extensive areas. Introduced probably with the grain of cereals or fodder grasses, this spontaneous introduction was first recorded for Sri Lanka at Melsiripura in 1966. Field observation shows it to grow rapidly and vigorously, able to compete favourably with native grasses.

Economically, the species could be either useful or troublesome. In land under cultivation, particularly in the coconut plantations in the west and south of Sri Lanka, it could be a potentially serious weed, being coarse enough to hinder harvesting operations. In the dry zone, where chena cultivation is practised, it could provide valuable fodder for stock if encouraged to replace the less palatable native grasses which predominate after the initial disturbance of the scrub forests.

*Critical Notes on Ceylon Plants, XXIII.

The species is widespread in tropical regions of the Old World. In India, Bor (The Grasses of Burma, Ceylon, India and Pakistan, 1960) records it as an excellent fodder grass when young, also useful for hay making.

2. **Spermacoce latifolia** Aublet.

First recorded for Sri Lanka in 1963 at Ranmutugala, a quiet and little known village in the Colombo District, this quick-spreading weed is now found chiefly along the coastal belt lying at an elevation from sea level to about 500 feet, particularly in the Western Province of Sri Lanka.

It is found growing luxuriantly both in well-drained, loose sandy soils and red gravelly soils, often forming dense matted masses in the grass and conspicuous because of the pea-green colouration.

Though by no means a troublesome weed in coconut plantations, it is a poor pasture herb, not readily eaten by grazing animals, probably due to its relatively low palatability. Therefore, if allowed to spread unchecked, it could compete successfully with the more useful naturally occurring pasture grasses found beneath coconut.

Widely distributed in tropical America and now naturalized in Singapore and Java.

3. **Aeschynomene americana** L.

Hitherto only two species of the genus *Aeschynomene* have been recorded for Sri Lanka. *Aeschynomene aspera* L., a stout marsh herb common in wet rice fields and *Aeschynomene indica* L., a very slender much-branched annual, often a troublesome weed in both wet and dry rice fields.

Occurring as a weed in rice fields, *Aeschynomene americana* L., was first recorded for Sri Lanka at Narammala in the Kurunegala District in 1967. Probably introduced with the seed of some cover crop, it has assumed weed proportions in the drier parts of the island, particularly in the rice fields of the North-Western and North-Central Provinces of Sri Lanka.

The species is distributed in the warmer parts of the World, chiefly in the Caribbean, Central America and Tropical South America. It is usually found in wet or moist situations.

The writer is grateful to Dr. F. R. Fosberg, Curator of Botany, National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A., for a helpful review of the manuscript and to Dr. C. R. Panabokke, Deputy Director of Agriculture (Research), Department of Agriculture, Peradeniya, for facilities provided.

LIST OF WEEDS

1. ACANTHACEAE

Acanthus ilicifolius L.	(Wetland)
Justicia betonica L.	(Dryland)
Asteracantha longifolia (L.) Nees.	(Wetland)

2. AMARANTHACEAE

Amaranthus spinosus L.	(Dryland)
Achyranthes aspera L.	(Dryland)
Cyathula prostrata (L.) Bl.	(Dryland)
Aerva lanata (L.) Juss.	(Dryland)

3. ANNONACEAE

Annona glabra L.	(Wetland)

4. BALSAMINACEAE

Hydrocera triflora (L.) W. & A.	(Wetland)

5. BORAGINACEAE

Heliotropium indicum L.	(Dryland)
Cordia curassavica (Jacq.) R. & S.	(Dryland)

6. BUTOMACEAE

Limnocharis flava (L.) Buchen.	(Wetland)

7. CAPPARIDACEAE

Cleome viscosa L.	(Dryland)
Cleome burmanni W. &. A.	(Dryland)
Cleome monophylla L.	(Dryland)

8. COMMELINACEAE

Cyanotis cristata (L.) D. Don.	(Wetland)
Cyanotis axillaris (L.) D. Don.	(Wetland)
Commelina diffusa Burm. f.,	(Wetland)
Aneilema spiratum (L.) R. Br.	(Wetland)

9. COMPOSITAE

Tithonia diversifolia (Hemsl.) A. Gray	(Dryland)
Spilanthes calva DC.	(Wetland)
Galinsoga parviflora Cav.	(Dryland)
Cotula australis (Sieb. ex Spreng.) Hk. f.	(Dryland)
Acanthospermum hispidum DC.	(Dryland)
Synedrella nodiflora (L.) Gaertn.	(Dryland)
Elephantopus scaber L.	(Dryland)
Sphaeranthus indicus L.	(Wetland)
Epaltes divaricata (L.) Cass.	(Wetland)
Struchium sparganophorum (L.) Ktze.	(Wetland)
Wedelia chinensis (Osbeck) Merr.	(Wetland)
Tridax procumbens L.	(Dryland)
Xanthium strumarium L.	(Dryland)
Mikania cordata (Burm. f.) Robinson	(Dryland)
Eupatorium odoratum L.	(Dryland)
Vernonia zeylanica (L.) Less.	(Dryland)
Ageratum conyzoides L.	(Dryland)
Vernonia cinerea (L.) Less.	(Dryland)
Blainvillea acmella (L.) Philipson	(Dryland)

10. CONVOLVULACEAE

Aniseia martinicensis (Jacq.) Choisy	(Wetland)
Ipomoea leari Paxt.	(Dryland)
Ipomoea pes-tigridis L.	(Dryland)
Evolvulus alsinoides (L.) L.	(Dryland)
Cuscuta chinensis Lam.	(Dryland)

11. CYPERACEAE

Cyperus iria L.	(Wetland)
Cyperus rotundus L.	(Dryland)
Cyperus polystachyos Rottb.	(Wetland)
Cyperus pilosus Vahl.	(Wetland)
Cyperus haspan L.	(Wetland)
Eleocharis dulcis (Burm. f.) Trin. ex Henschel	(Wetland)
Fimbristylis miliacea (L.) Vahl.	(Wetland)
Fimbristylis tetragona R. Br.	(Wetland)
Fimbristylis schoenoides Vahl.	(Wetland)
Fimbristylis acuminata Vahl.	(Wetland)
Fuirena umbellata Rottb.	(Wetland)
Fuirena ciliaris (L.) Roxb.	(Wetland)

Rhynchospora rubra (Lour.) Makino	(Wetland)
Rhynchospora corymbosa (L.) Britton	(Wetland)
Scirpus juncoides Roxb.	(Wetland)
Scirpus grossus L. f.	(Wetland)
Scleria poaeformis Retz.	(Wetland)

12. ERIOCAULACEAE

Eriocaulon thwaitesii Koern.	(Wetland)
Eriocaulon sexangulare L.	(Wetland)
Eriocaulon quinquangulare L.	(Wetland)
Eriocaulon cinereum R. Br.	(Wetland)

13. EUPHORBIACEAE

Acalypha indica L.	(Dryland)
Croton bonplandianus Baillon	(Dryland)
Croton hirtus L, Heritier	(Dryland)
Euphorbia heterophylla L.	(Dryland)
Euphorbia indica Lam.	(Dryland)
Euphorbia hirta L.	(Dryland)
Tragia involucrata L.	(Dryland)

14. GENTIANACEAE

Nymphoides aurantiaca (Dalz.) Kuntze	(Wetland)

15. GRAMINEAE

Brachiaria mutica (Forsk.) Stapf.	(Wetland)
Coix lachryma-jobi L.	(Wetland)
Coix gigantea Koen. ex Roxb.	(Wetland)
Eragrostis unioloides (Retz.) Nees	(Dryland)
Echinochloa crus-galli (L.) Beauv.	(Wetland)
Echinochloa stagnina (Retz.) Beauv.	(Wetland)
Echinochloa frumentacea Link	(Wetland)
Echinochloa colonum (L.) Link	(Wetland)
Elytrophorus spicatus (Willd.) A. Camus	(Wetland)
Ischaemum indicum (Houtt.) Merr.	(Wetland)
Ischaemum muticum L.	(Wetland)
Ischaemum rugosum Salisb.	(Wetland)
Panicum repens L.	(Dryland)
Paspalum commersonii Lam. (*P. mertzii* Steud).	(Wetland)
Pennisetum polystachyon (L.) Schult.	(Dryland)

Leptochloa chinensis (L.) Nees	(Wetland)
Leersia hexandra Sw.	(Wetland)
Sacciolepis interrupta (Willd.) Stapf.	(Wetland)
Sacciolepis indica (L.) Chase	(Wetland)
Setaria geniculata (Lam.) Beauv.	(Wetland)
Setaria lutescens (Weigel) Hubbard	(Wetland)

16. HYDROPHYLLACEAE

Hydrolea zeylanica (L.) Vahl.	(Wetland)

17. LABIATAE

Anisochilus carnosus (L.) Wall. ex Benth.	(Dryland)
Dysophylla auricularia (L.) Blume	(Wetland)
Hyptis suaveolens (L.) Poit.	(Dryland)
Hyptis capitata Jacq.	(Dryland)
Leucas zeylanica (L.) R. Br.	(Dryland)
Leonotis nepetifolia (L.) Ait. f.	(Dryland)
Ocimum sanctum L.	(Dryland)
Ocimum americanum L.	(Dryland)

18. LEGUMINOSAE

Aeschynomene aspera L.	(Wetland)
Aeschynomene indica L.	(Wetland)
Aeschynomene americana L.	(Wetland)
Crotalaria verrucosa L.	(Dryland)
Cassia occidentalis L.	(Dryland)
Cassia tora L.	(Dryland)
Cassia hirsuta L.	(Dryland)
Cassia alata L.	(Dryland)
Desmodium heterocarpon (L.) DC.	(Dryland)
Flemingia strobilifera (L.) Ait. f.	(Dryland)
Mimosa pudica L.	(Dryland)
Neptunia oleracea Lour.	(Wetland)
Phaseolus lathyroides L.	(Dryland)
Tephrosia purpurea (L.) Pers.	(Dryland)

19. LENTIBULARIACEAE

Utricularia bifida L.	(Wetland)
Utricularia reticulata Sm.	(Wetland)
Utricularia aurea Lour. (*U. flexuosa* Vahl)	(Wetland)

20. LOBELIACEAE

Lobelia zeylanica L. (Wetland)

21. LYTHRACEAE

Rotala indica (Willd.) Koehne (Wetland)

22. MALVACEAE

Abutilon indicum (L.) Sweet (Dryland)
Urena lobata L. (Dryland)
Wissadula periplocifolia (L.) Presl ex Thwaites (Dryland)
Sida acuta Burm. f. (Dryland)

23. NYCTAGINACEAE

Boerhavia diffusa L. (Dryland)

24. NYMPHAEACEAE

Nymphaea nouchali Burm. f. (*N. stellata* Willd.) (Wetland)

25. ONAGRACEAE

Jussiaea repens L. (Wetland)
Ludwigia perennis L. (Wetland)

26. OXALIDACEAE

Oxalis corniculata L. (Dryland)
Oxalis corymbosa DC. (Dryland)
Biophytum reinwardtii (Zucc.) Klotzsch (Dryland)

27. PASSIFLORACEAE

Passiflora foetida L. (Dryland)

28. PEDALIACEAE

Sesamum indicum L. (Dryland)

29. PIPERACEAE

Peperomia pellucida (L.) Kunth (Wetland)

30. POLYGONACEAE

Polygonum minus Huds. (Wetland)
Polygonum pulchrum Bl. (Wetland)
Polygonum barbatum L. (Wetland)

31. PONTEDERIACEAE

Eichhornia crassipes (Mart.) Solms (Wetland)
Monochoria vaginalis (Burm. f.) Presl ex Kunth (Wetland)

32. PORTULACACEAE

Portulaca quadrifida L. (Dryland)

33. RUBIACEAE

Knoxia zeylanica L. (Dryland)
Oldenlandia herbacea (L.) Roxb. (Dryland)
Spermacoce latifolia Aublet (Dryland)

34. SAPINDACEAE

Cardiospermum microcarpum Kunth (Dryland)

35. SCROPHULARIACEAE

Scoparia dulcis L. (Dryland)
Limnophila aquatica (Roxb.) Alst. (Wetland)
Limnophila sessiliflora Bl. (Wetland)
Limnophila heterophylla (Roxb.) Benth. (Wetland)
Dopatrium lobelioides (Retz.) Benth. (Wetland)
Dopatrium nudicaule (Willd.) Buch-Ham. ex Benth. (Wetland)
Bacopa monnieri (L.) Wettst. (Wetland)

36. SOLANACEAE

Datura metel L. (Dryland)

37. SPHENOCLEACEAE

Sphenoclea zeylanica Gaertn. (Wetland)

38. STERCULIACEAE

Melochia corchorifolia L.	(Dryland)

39. TILIACEAE

Triumfetta pilosa Roth	(Dryland)
Triumfetta pentandra A. Rich.	(Dryland)
Triumfetta rhomboides acq.	(Dryland)

40. VERBENACEAE

Phyla nodiflora (L.) Greene	(Dryland)
Stachytarpheta urticifolia (Salisb.) Sims	(Dryland)
Clerodendrum philippinum Schauer	(Dryland)
Clerodendrum paniculatum L.	(Dryland)
Clerodendrum infortunatum L.	(Dryland)

41. XYRIDACEAE

Xyris pauciflora Willd.	(Wetland)
Xyris indica L.	(Wetland)

42. ZYGOPHYLLACEAE

Tribulus terrestris L.	(Dryland)

(MS. received 8.2.76)

CEYLON J. SCI. (BIO. SCI.) Vol. 12, No. 2, November 1977

David Raitt Robertson Burt, Hon. D.Sc. (St. Andrews)

Laureation Address*

by

JOHN M. HOWIE

Faculty of Science, University of St. Andrews, Fife, Scotland, U.K.

(With one plate)

Mr. Vice-Chancellor, I have the honour to present to you for the Degree of Doctor of Science, *honoris causa*, David Raitt Robertson Burt, Bachelor of Science, Fellow of the Linnaean Society, Fellow of the Royal Society of Edinburgh, formerly Senior Lecturer in Zoology in the University.

This is the diamond jubilee of David Burt's connection with the University of St. Andrews, for it was in October, 1916, just sixty years ago, that he entered the University as an undergraduate. It was from Kirkcaldy High School that he came, not the first nor yet the last outstanding student to come to St. Andrews from that source. His studies were interrupted in 1917 by the First World War. In this connection it should be noted that he served in the Black Watch, a fact that all St. Andreans bearing a proper loyalty to their Chancellor might feel was sufficient justification on its own for whatever honour the University might have to bestow.

But there is more. Returning to St. Andrews in 1919, he fell under the spell of one of the greatest wizards of his time, Professor D'Arcy Thompson, then a mere stripling of fifty-nine years. D'Arcy Thompson was quick to recognise the outstanding qualities of his young pupil and in 1921, the year of his graduation, the young David Burt became his assistant. During this period he was able to spend the summer months working in Vienna under Professor Hans Przibram on regeneration and transplantation in hydras, frogs and rats.

In 1924 he went to Colombo, Ceylon, where he was to spend the next twenty-two years, first as Lecturer-in-charge in the Department of Zoology in Ceylon University College, and later as Professor of Zoology. He bore a heavy burden, not only on the teaching side, which involved the preparation of students for London External Degrees and for entry to the Ceylon Medical College, but also on the planning and administration side.

*No sooner had we got news of the conferment on October 13, 1976 of the degree of Doctor of Science, *honoris causa*, on David Raitt Robertson Burt by the University of St. Andrews, one of the three oldest universities in the United Kingdom, than we asked Professor John M. Howie, Dean of the Faculty of Science, if he could let us have a copy of the citation for publication in this journal. This was most kindly and readily sent, and we are pleased to publish it, together with a list of research publications and a recent photograph, as a token of appreciation and gratitude for Dr. Burt's pioneering work in Sri Lanka for the *Ceylon Journal of Science*.—Editors.

He designed the Zoological Laboratories and the Museum and supervised a dramatic development and expansion of the teaching of Zoology. Despite all this he found time for continuing research activity on an impressive scale. In 1946 he was the last European professor to leave the University, having created, almost single-handed, a flourishing Department of Zoology.

When David Burt left St. Andrews in 1924, D'Arcy Thompson was sixty-four, on the eve of his retirement, we would suppose nowadays. But St. Andrews had not then succumbed to the error of supposing that Professors ought to be treated like ordinary mortals, and so in 1946 when David Burt left Ceylon D'Arcy Thompson was still in post, in the prime of life at eighty-six, as overlord of the Department of Natural History in St. Andrews. And it was to St. Andrews that David Burt returned, as Senior Lecturer.

He was a favourite pupil and disciple of D'Arcy Thompson, but it is significant that the major research interests of his life were acquired many thousands of miles away from St. Andrews, in Ceylon. As every schoolboy used to know, rubber is an important product of Ceylon, and it was in 1928 that David Burt discovered a method of injecting rubber latex into blood vessels as an aid to studying and displaying circulation of blood. This has since become a standard technique. Also arising from his time in Ceylon was his work on cestodes, those unattractive and unpleasant parasitic organisms known to the laity as tapeworms. He has for many years been a leading authority on cestodes, and is to this day actively engaged at the Gatty Marine Laboratory in research.

In 1964 he retired, or at any rate he ceased to draw a salary from the University. The retirement at the statutory age of an exceptionally vigorous man can be a misfortune, but in David Burt's case it was a signal for him to begin what is probably the crowning achievement of a full and active life, the restoration and reorganisation of the Bell Pettigrew Museum. This was a labour of love, a labour that gave birth to what is by general consent among the finest, if not the finest small Natural History Museum in the World. The selection of material to display in a limited space could not be bettered ; the presentation is impressively but not oppressively educational ; the entire display seems to radiate the love for the animal kingdom and the boundless enthusiasm of the man who created it.

The work of creating the present Museum from the haphazard and neglected collection that existed beforehand was arduous, even physically speaking, and David Burt acquired some fairly esoteric knowledge in the process. It may interest you to know, Mr. Vice-Chancellor, that if you ever require to restore a dusty piece of coral to the luminous white desired by any houseproud museum curator, it is not, as you might be forgiven for supposing, Tide that will do the trick, or even Surf. It is the biological action of Ariel that will give you the effect that you desire.

In the reorganised Bell Pettigrew Museum David Burt has presented the University of St. Andrews with a priceless asset, an asset that will I trust outlive us all. No man could wish for a better memorial. He has richly earned the gratitude of his Alma Mater and I now invite you to express this gratitude by awarding him the Degree of Doctor of Science *honoris causa.*

RESEARCH PUBLICATIONS OF D. R. R. BURT

1923 — Heteromorphosis in *Hydra*. (British Society for Experimental Biology, inaugural meeting).
— Kopf und Fuss des Süsswasserpolypen *Pelmatohydra oligactis* Pall., als unipotente Systeme. *Ak. Anz. Wien, Mitt.*, Nr. 113.

1925 — The head and foot of *Pelmatohydra oligactis* as unipotent systems. *Arch. f. mikr. Anat. u. Entw.-mech.*, **104**, 421.

1927 — Die Fahigkeit verschiedener Korperregionen der *Pelmatohydra oligactis* Pall. zur Bildung von Kopf oder Fuss. *Ak. Anz. Wien, Mitt.*, Nr. 14.

1928 — A new injection mass—rubber latex. *Nature*. **121**, 497 (March 31, 1928).

1929 — *Hydra zeylanica* nov. sp. *Ceylon J. Sci.* (*B*), **15**, 159–162.
— A new technique for the study of the venation of the wings of insects. (British Association meeting, South Africa).
— A genetic male intersex of *Bos indicus*. (British Association meeting, South Africa).

1930 — A case of intersexuality in *Bos indicus*, with a theory of the significance of the genetic male intersex. *Proc. Roy. Soc. Edin.*, **50**, 113–129.

1932 — The venation of the wings of the leaf-insect, *Pulchriphyllium crurifolium*. *Ceylon J. Sci.* (*B*), **17**, 29-37.

1933 — *Oochoristica lygosomae* sp. nov.—A cestode from the lizard *Lygosoma punctatum*. *Ceylon J. Sci.* (*B*), **18**, 1-7.

1934 — The capacity of different regions of *Pelmatohydra oligactis* Pall. to form head or foot. *J. exp. Zool.*, **68**, 59-93.
— The correlation between climatic factors and the distribution of the geographical races of some Ceylon mammals (British Association meeting, Aberdeen).
— On the amphipod genus *Talitrus*, with a description of a new species from Ceylon, *Talitrus* (*Talitropsis*) *topitotum* sub-gen. et sp. nov. *Ceylon J. Sci.* (*B*), **18**, 181-191.

1936 — A new species of cestode, *Dilepis lepidocolpos*, from the little cormorant (*Phalacrocorax niger*). *Ceylon J. Sci.* (*B*), **19**. 193-200.

1937 — Two new reptilian cestodes of the genus *Proteocephalus* (*Ophiotaenia*). *Ceylon J. Sci.* (*B*), **20**, 157-179.

1938 — New avian cestodes of the family Dilepididae from *Collocalia unicolor unicolor* (Jerd.), the Indian edible-nest swiftlet with descriptions of *Pseudangularia thompsoni*, *P. triplacantha* gen. et. spp. nov. and *Notopentorchis collocaliae* gen. et sp. nov. *Ceylon J. Sci.* (*B*), **21**, 1-14.
— A new avian cestode, *Pseudochoanotaenia collocaliae* gen. et sp. nov. (Dipylidiinae), from *Collocalia unicolor unicolor*. *Ceylon J. Sci.* (*B*), **21**, 15-20.
— New avian cestodes of the sub-family Dilepidinae from the eastern swallow (*Hirundo rustica gutturalis*), with descriptions of *Vitta magniuncinata* and *Vitta minutincinata* gen. et spp. nov. *Ceylon J. Sci.* (*B*), **21**, 21-30.
— The distribution of animals in Ceylon. (Proceedings of the Ceylon Natural History Society, twenty-second annual general meeting, Colombo, February 13, 1934). *Ceylon J. Sci.* (*B*), **21**, 69-71.

1939 — On the cestode family Acoleidae, with a description of a new dioecious species, *Infula burhini* gen. et sp. nov. *Ceylon J. Sci.* (*B*), **21**, 195-208.
— New cestodes of the genus *Paronia*. *Ceylon J. Sci.* (*B*), **21**, 209-218.

1940 — New avian cestodes of the family Davaineidae from Ceylon. *Ceylon J. Sci.* (*B*), **22**, 65-77.
— New species of cestodes from Charadriiformes, Ardeiformes and Pelecaniformes in Ceylon. *Ceylon J. Sci.* (*B*), **2**, 1-63.

1942 — *The Butterfly Fauna of Ceylon* by L. G. O. Woodhouse and G. M. Henry—Chapters II, III, IV and Glossary. Ceylon Government Press, Colombo.

1943 — The praying mantis. *Loris*, **3**, 85-87.

1943-45 — From a Biologist's Notebook—a series of broadcast talks on the natural history of Ceylon: the ant-lion, rats, spiders, lizards, living light, poisonous animals, coral islands, birds' nests, migrating butterflies in Ceylon, sharks, termites, leaf and stick insects. *The Ceylon Radio Times Supplement*. Ceylon Government Press, Colombo.

1944 — A new avian cestode, *Krimi chrysocolaptis* gen. et sp. nov. from Layard's Woodpecker, *Chrysocolaptes guttacristatus stricklandi* (Layard 1854). *Ceylon J. Sci.* (*B*), **22**, 161-164.
— New avian species of *Hymenolepis* from Ceylon. *Ceylon J. Sci.* (*B*), **22**, 165-172.
— Snakes. *Loris*, **3**, 115-118.

1945 — Parasites and pests. (Ceylon Association for the Advancement of Science, first annual sessions, Colombo).

1950 — Men of Science. 3. Natural History. In Veterum Laudes, a tribute to the achievements of the members of St. Salvator's College during five hundred years. Edited by J. B. Salmond. Oliver & Boyd, Edinburgh.

1958 — *Cyathostoma lari* Blanchard, 1849 (Nematoda: Strongyloidea), its anatomy, intra-specific variation and hosts, with a redefinition of the genus. (With J. Margaret Eadie). (Premier Symposium sur la spécificité parasitaire des parasites des Vertébrés. Neuchâtel, 1957). *J. Linn. Soc.* (*Zool.*), **3**, 575-586.

1963 — On *Ditrypanocystis cirratuli* gen. nov., sp. nov., a gregarine possessing undulating membranes, (With M. Denny and P. A. Thomasson). (Proceedings of the British Society for Parasitology, inaugural meeting, 1962). *Parasitology*, **53** (3-4), 12P.
— The germinal layers of cestodes. *Biol. J. St. Andrews*, **3**, 16-20.

1968 — On the adhesive organ of *Macraspis elegans* Olsson, 1869 (Aspidogastrea). (Primo Congresso International di Parasitologia, Roma, 1964, and Proceedings of the British Society for Parasitology, 1968). *Parasitology*, **58**, (4), 13 P.

1970 — *Platyhelminthes and Parasitism. An Introduction to Parasitology.* The English Universities Press, London. 150 pp.

1973 — On a new anoplocephalid cestode *Biporouterina psittaculae* gen. et sp. nov. from Layard's paroquet *Psittacula calthropae* (Layard 1849). *Zool. J. Linn. Soc.*, **53**, 81-86.

1975 — On *Tetrabothrius sulae fuscae* (Baird 1853) and *Tetrabothrius sulae* Szpotanska 1929 from gannets. (Proceedings of the British Society for Parasitology). *Parasitology*, **71**, (2), **XXXIV**.

1976 — On two new tetrabothriid cestodes from the brown gannet or booby *Sula leucogastra plotus* (Forster) from the Indian Ocean. *Zool. J. Linn. Soc.*, **58**, 309-319.

1977 — On a new species of tetrabothriid cestode from the shag *Phalacrocorax aristotelis aristotelis* (L). *Zool J. Linn. Soc.*, **60**, 391—395.

— *Tetrabothrius reditus* sp. nov. (Cestoda) from the small frigate bird *Fregata ariel iredalei* Mathews taken in Ceylon, and an emended account of *Tetrabothrius priestleyi* Leiper et Atkinson from a frigate bird in South Trinidad. *Zool. J. Linn. Soc.* (in press).

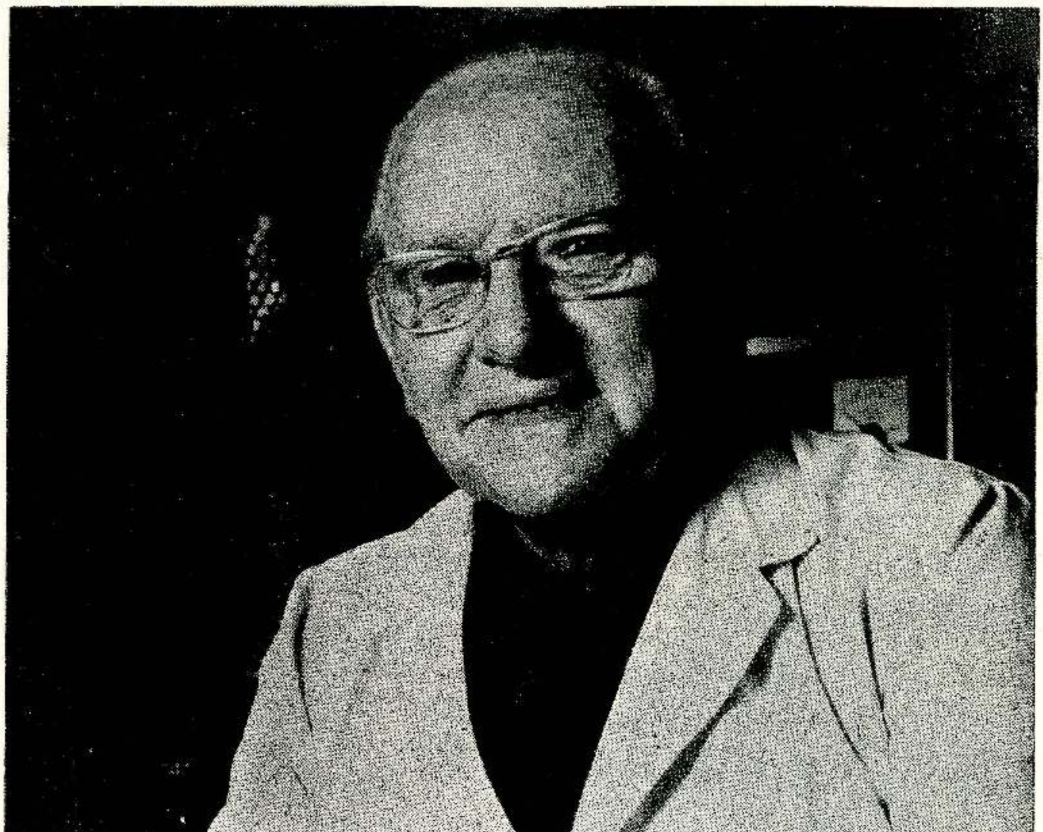
— A reappraisal of 'Taenia heterosoma' including descriptions of two new species of *Tetrabothrius*. *Zool. J. Linn. Soc.* (in press).

— New cestodes of the genus *Eurycestus* Clark 1954 from the avocet *Recurvirostra americana* Gmelin 1788. *Zool. J. Linn. Soc.* (in press).

EXPLANATION OF PLATE

PLATE 1. David Raitt Robertson Burt, Hon. D.Sc., B.Sc., F.L.S., F.R.S.E., F.Z.S., Memb. Amer. Soc. of Sigma Xi. (From a recent photograph).

(MS. received 22.2.77)



Notice to Contributors

Papers submitted for publication in the *Ceylon Journal of Science* should be typed on foolscap sheets, on one side only. Typing should be double spaced. There should be a margin $1\frac{1}{2}$ inches wide at the left hand side of each page. Pages should be clearly numbered, and fastened together in proper sequence. Authors are advised to keep a duplicate copy of their contributions. Papers must be submitted in absolutely final form for printing. Numerous additions, emendations and corrections in the proofs add considerably to the Editor's duties and also to the cost of production. If corrections in the proofs are too heavy, an author may be required to defray a portion of the cost thereof. Normally a paged proof is submitted to authors for correction. All references to literature must be checked by the author, and volume and page numbers quoted. The Harvard system is adopted in the *Ceylon Journal of Science* and references should be given preferably at the end of each paper.

Illustrations should be made by line drawings whenever possible. These are usually more satisfactory and reproduce better than wash drawings or photographs. Whenever possible, the illustrations should be in the text rather than as plates at the end of the paper. Drawings should be made larger than the size required after reproduction, and the amount of reduction desired should be indicated. Legends should be included in their proper place in the typescript, and not written on the drawing. Text figures must be numbered separately for each paper.

The Journal furnishes the author with fifty reprints of the paper gratis. Additional copies may be obtained according to the rates which will be sent on application, after the manuscript has been approved.

CONTENTS

Price Rs. 15/- (£ 1.5 or 30 sh.; $ 4.00)

Printed at the Sri Lanka University Press, Katubedda, by M. Senanayake, Printer, and published by H. A. I. Goonetileke, Librarian, University of Sri Lanka, Peradeniya.