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"The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity; it affords protection to all beings, offering shade even to the axeman who destroys it."—Gautama Buddha.

EDITORIAL

THE CENTENARY OF THE INDIAN FOREST SERVICE—1961

TO commemorate the Centenary in 1961 of the Indian Forest Service, it is appropriate that India's nearest neighbour, Ceylon, should be among the first to pay tribute to the oldest technical Forest Service in Asia. While briefly touching on the landmarks in the history and development of the Indian Forest Service, it is fitting that we should make special mention of the close connexion which has always existed between India and Ceylon and the contribution, in particular, made by officers of the Indian Forest Service to forestry in Ceylon.

The great tradition of forestry which has been built up in India owes much to the pioneer foresters commencing with Sir Dietrich Brandis, the first Inspector-General of Forests in 1862, followed by men of similar calibre in Ribbentrop and Schlich. These officers inculcated the solid principles of German forestry practice into the Indian Forest Service; they were men dedicated to the country and the British Government under which they served. There is hardly a technically trained forester, even of the humble Forest Ranger grade, who has not had at least a nodding acquaintance with one or other of these great names. Schlich's Manual of Forestry has long held its own as a standard text book on forestry and still has a honoured place in the library of many a hoary as well as a budding forester! The fine tradition of continental forest practice extends also to the great French institution at Nancy, where men such as W. R. Fisher had their early training.

It is not our intention to run the gamut of the great names who have been associated with forestry in India and dwell on their individual and collective achievements. Suffice it to mention that many of them have been instrumental in establishing and contributing to the Schools of

Forestry which now exist in the Commonwealth. Many of us who have had our forestry training at Oxford will remember with gratification names such as Troup, Bourne and Champion, all of whom had long and distinguished records in the Indian Forest Service.

It is no exaggeration to state that forest administration in Ceylon has been modelled largely on the Indian Forest Service. The early British period in the first part of the 19th Century in Ceylon as in India was marked by heavy exploitation of the commercial hardwoods, chiefly teak and sal in India, satinwood and ebony in Ceylon. With the establishment of the Indian Forest Service in 1861 with Brandis as Inspector-General, a regular system of forest administration and management was introduced. Until 1882, practically no control existed over the depletion of Ceylon's timber resources in the Dry Zone. The first comprehensive study of the state of Ceylon's forests was made by F. D'A. Vincent of the Indian Forest Service. His report to the Government in 1882 contained information painstakingly and methodically collected and made far-reaching recommendations on the control of shifting cultivation, the need for forest reservation and a clearly defined forest policy. The first Conservator of Forests was A. F. Broun, also of the Indian Forest Service. Among his many achievements may be mentioned the publication of the original "Ceylon Forester" from 1895 to 1897. Broun was also responsible for a valuable account of the "Forests and Waste Lands of Ceylon" in Volume V of Trimen's Flora of Ceylon.

With the establishment of a separate Department of Forestry independent of the Revenue Department in 1899, Ceylon depended almost entirely on Indian technically trained officers to man the Department. J. L. Pigot, also of the Indian Forest Service, followed Broun in 1903 and was responsible for bringing the entire forest estate under the control of the Forest Department. The advice of specialist officers from the Indian Forest Service continued to be sought from time to time. P. M. Lushington in 1921 was responsible for placing the Department on a sound administrative footing. In 1935, H. G. Champion (now Sir Harry Champion) reported on the management and exploitation of Ceylon forests. The establishment of a separate Research Division (with a Silviculturist who specialised in the subject at Dehra Dun under Champion himself) and a Utilisation Division to deal with commercial timber extraction and utilisation were the direct results among others, of his recommendations.

Since 1916, Ceylon has been dependent on India for the training of the Ranger staff in the Madras Forest College; the practice has continued almost uninterrupted till the present time. The Indian training has been the model on which the present training to the subordinate staff is now based, thanks to the services of V. M. Laungani of the staff of the Madras Forest College who was responsible for preparing the schedule of training. Three of our Assistant Conservators have also received their training at the Indian Forest College at Dehra Dun. Recently, we have had the services of N. J. Masani from the Forest Research Institute at Dehra Dun to advise us on the structural uses of Ceylon timbers. The Indian Forest Service has been always prompt to assist us in recent years with substantial supplies of teak seed for our reafforestation schemes in the Dry Zone. Special mention must also be made of the Indian Forest Manuals, especially the Statistical Code as the research forester's vade-mecum. The teak yield tables by Laurie and Sant Ram have been adopted for general use in Ceylon. The series of publications, the Indian Forest Records, have also proved of great value, especially in the field of Utilization Research.

Ceylon and India have followed the same pattern of development since the grant of independence. The Indian Forest Service has shouldered with acceptance and credit the added responsibilities of development and her achievements since 1947 have received international recognition. The fact that India was selected as the venue for the Fourth World Forestry Congress held in 1954 is in itself a distinction and a tribute to the high esteem in which the Indian Forest Service is held. The Editor of the "Ceylon Forester" has great pleasure in publishing the following advance notice sent by the President of the Indian Forest Research Institute and Colleges :

NOTICE

India's forests occupy 2,78,083 sq. miles, forming 22 percent of the total land area (1,266,980 sq. miles). They yield 50,000,000 c. ft. of coniferous softwoods. The annual gross revenue of all Forest Departments in India, for the year 1958-'59 was Rs. 46,37,00,000. The total expenditure of staff and productive works was Rs. 19,45,00,000 leaving a net surplus of Rs. 26,92,00,000. The average net surplus per sq. mile works out to Rs. 968.

Systematic scientific management of India's forests commenced in the year 1861. The Government of India, with the co-operation of State Forest Departments, propose to celebrate the centenary of forest administration in India during 1961, in a fitting manner. At that time, two volumes of centenary publications will be issued, describing India's forests in all their aspects.

It is proposed that articles of general interest on forestry from eminent foresters in India and abroad, should form part of the centenary publications. The President, Forest Research Institute and Colleges, will gratefully acknowledge contributions for the above publications.

THE PERIODICITY OF LEAF CHANGE AND FLOWERING IN THE PRINCIPAL FOREST COMMUNITIES OF CEYLON (contd.) *

K. O. Koelmeyer

PART II

PHENOLOGY OF THE TROPICAL DRY MIXED EVERGREEN FOREST

TROPICAL Dry Mixed Evergreen Forest occurs in the Dry Zone of Ceylon which covers about two thirds of the land area of the Island. It extends from the south-east into the lowland area east of the central hills and expands into the whole of the northern part of the Island. The forest consists of a close canopy of trees varying in height from about 35 to 55 feet with scattered emergents rising about 10 feet above the level of the main canopy.

The most common of the emergent dominants is an evergreen species *Manilkara hexandra*. Other common evergreen emergents are *Alseodaphne semecarpifolia* and *Diospyros ebenum*. A large number of emergent species such as *Cloroxylon swietenia*, *Vitex pinnata*, *Sapium insigne*, *Grewia polygama*, *Pterospermum canescens*, *Ficus tsiela*, *Ficus retusa* and *Berrya cordifolia* are deciduous. The main canopy consists mainly of evergreen species of which *Hemicyclia sepiaria* is perhaps the most abundant. Other common evergreen species of the main canopy are *Lepisanthes tetraphylla*, *Eugenia bracteata*, *Garcinia spicata*, *Gleniea zeylanica*, *Nephelium longana*, *Walsura piscidia*, *Hesperethusa alata*, and *Diospyros* spp. Deciduous or semi-evergreen members of the main canopy frequently met with are *Diospyros ovalifolia*, *Cassia fistula*, *Schleichera trijuga*, *Adina cordifolia* and *Mitragyna parvifolia*.

The undergrowth is well stocked with small tree species and shrubs such as *Mallotus* spp, *Tarana asiatica*, *Polyalthia korinti*, *Ehretia buxifolia*, *Glycosmis pentaphylla*, *Maba buxifolia*, *Murraya koenigii*, *Stenosiphonium* spp., etc. The floor is usually in light grass with scanty litter and a few ferns, e.g., *Adiantum caudatum*. Some epiphytic orchids like *Vanda tessellata* are scattered here and there. Climbers such as *Vitis quadrangularis* are few and more common where the canopy is open.

East of the central hills, conditions are moister than is general for the region of the Dry Mixed Evergreen Forest. Here the forest, while composed principally of Dry Mixed Evergreen Forest species, consists also of representatives of (a) the Intermediate Wet Zone such as *Filicium decipiens*, (b) the "Savannah" forest found just above it at lower elevations on the eastern aspects of the central hills, e.g., *Anogeissus latifolia*, (c) species of the Wet Evergreen Forest such as *Dipterocarpus zeylanicus* at Bakinigahawela and Moneragala. Chapman (1947) recognises two forest types—Moist Tropical Semi-Evergreen Forest and South Tropical Moist Deciduous Forest within 12 miles of each other at Wellawaya and Buttala respectively in this zone. In the present study this type will be considered as "Intermediate" Dry Mixed Evergreen Forest. It is represented by the plot

* Part I appeared in "The Ceylon Forester", Vol. IV., No. 2, July-December, 1959, pages 157-189.

at Daragoda. At Maha Oya within the same climatic sub-type, *Vatica obscura*, the only member of the Dipterocarpaceae within this area, is found. This species is included in the plot at Tiralliodai which is close to Maha Oya.

Climate

Eight Climatic types on the 1948 Thornthwaite classification are represented in the region of the Dry Mixed Evergreen Forests. They are all megathermal types with equable temperature.

- (1) D d a' a'—Semi-arid with no water surplus
- (2) C₁ d A' a'—Dry sub-humid with no water surplus
- (3) C₁ s A' a'—Dry sub-humid with moderate winter surplus of water
- (4) C₁ s₂ A' a'—Dry sub-humid with large winter surplus of water
- (5) C₂ s₂ A' a'—Moist sub-humid with a large water deficit in summer
- (6) C₂ s₂ A' a'—Moist sub-humid with a moderate water deficit in summer
- (7) C₂ r A' a'—Moist sub-humid with little or no water deficit in summer
- (8) B₁ s A' a'—Humid with moderate water deficit in summer.

The climatic types of the plots under observation are given in Table 10 along with the figures for the average monthly rainfall from 1942 to 1951.

Rainfall

The distribution of the Dry Mixed Evergreen Forest coincides approximately with the limits of the Dry Zone of Ceylon, i.e., the area with less than 20 inches of rain from May to September. The mean annual rainfall varies from 50 to 75 inches generally. At Madhu (48.69 in.), Puttalam (41.27 in.), the annual rainfall is less than this general range while at Tiralliodai (83.85 in.) and Daragoda (76.62 in.) the annual rainfall is higher.

About 50 per cent of the rainfall takes place during October/December when the north-east monsoon blows over the island. In January the rainfall decreases to about 4 inches except at stations round the east coast where 6.82 inches (Andankulam) to 9.76 inches (Lahugala) were recorded during this month from 1942 to 1951. In February/March there is a short dry season during which the monthly rainfall is about 2.05 to 3.5 inches. At stations on the east coast the February/March rainfall is higher than in the other parts of the Dry Zone and averaged over 4 inches during the 10 years of the present study. In March/April there is generally a slightly higher incidence of 4 to 6 inches of rain associated with the unsettled weather conditions which precede the break of the south-west monsoon. The south-west monsoon in June/July which brings rain to the Wet Zone blows over the Dry Zone without depositing much rain. The desiccatory character of the wind is adequately described by the local word "kachchan". June/September is the main period of drought at all stations in the Dry Zone.

The average monthly rainfall during June/July is less than 2 inches while in August/September it is generally below 4 inches. The detailed monthly values of rainfall from 1942 to 1951 are given in Appendix 2.*

Humidity

Average monthly humidity figures for 6 months in the Dry Zone from 1945 to 1951 are given in Table 11. At Mannar, Puttalam and Jaffna the average monthly humidity reaches a minimum value of 71 to 73 per cent during February/March. The humidity increases during April/June and during the main period of drought is about 77 to 79 per cent. It continues at this level up to December and in January shows a slight drop to between 74 and 77 per cent. The low humidity associated with the spell of low rainfall in February/March, the relatively high humidity during the drought in June/September and the absence of any marked increase in the humidity during the heavy rains in October/December are features of particular interest. The humidity during February/March at these stations is of the same order as that at Ratnapura in the Wet Zone during these months, but is lower during the rest of the year.

At Anuradhapura the relative humidity drops from about 77 to 81 per cent during November/January to about 67 to 70 per cent during February/April. From May to September the humidity remains between 64 and 67 per cent unlike the other 2 stations referred to above where it is relatively high. The 2 stations on the east coast, Trincomalee and Batticaloa show a gradual decrease in relative humidity from 81 to 83 per cent during the rainy months November/December to a low value of 63 to 69 per cent during the drought in June/July. There is no marked decrease in humidity during February/March as at the other stations in the Dry Zone. Detailed monthly values of the relative humidity from 1945 to 1951 are given in Appendix 2.

Table 11—Average Monthly Humidity 1945 to 1951

Plot	J	F	M	A	M	J	J	A	S	O	N	D
Mannar	.. 76 ..	73 ..	73 ..	76 ..	76 ..	77 ..	78 ..	78 ..	77 ..	78 ..	79 ..	79
Puttalam	.. 77 ..	73 ..	72 ..	76 ..	75 ..	77 ..	76 ..	76 ..	74 ..	78 ..	79 ..	79
Jaffna	.. 74 ..	72 ..	71 ..	75 ..	78 ..	78 ..	79 ..	78 ..	79 ..	79 ..	78 ..	77
Anuradhapura	.. 77 ..	70 ..	67 ..	70 ..	65 ..	67 ..	64 ..	65 ..	64 ..	73 ..	79 ..	81
Trincomalee	.. 80 ..	77 ..	77 ..	74 ..	69 ..	63 ..	64 ..	66 ..	66 ..	75 ..	83 ..	82
Batticaloa	.. 80 ..	79 ..	79 ..	78 ..	74 ..	64 ..	64 ..	70 ..	70 ..	76 ..	79 ..	82

Temperature

Table 12 sets out the average monthly temperature during 1945/1951 and the average potential evapotranspiration in inches in the Dry Zone.

*It has not been found possible to reproduce these Appendices, as originally intended, on account of the voluminous data involved. These may be consulted, by anyone interested, in the Editor's office.

Table 10.—Average Monthly Rainfall in Inches for the Period 1942 to 1951 in the Dry Zone

Plot Rainfall Station	Climatic type	J	F	M	A	M	J	J	A	S	O	N	D	Year
Madhu Madhu Road	CdA 'a' /CsA 'a'	3.15 ..	2.05 ..	3.41 ..	5.31 ..	3.13 ..	0.02 ..	0.43 ..	0.79 ..	1.54 ..	7.57 ..	10.62 ..	10.67 ..	48-69
	CsA 'a' /CsA 'a'	4.91 ..	2.49 ..	3.07 ..	5.30 ..	5.50 ..	0.18 ..	0.70 ..	3.39 ..	3.28 ..	8.43 ..	10.92 ..	13.65 ..	61-52
	CdA 'a' /CsA 'a'	3.06 ..	1.71 ..	3.09 ..	4.82 ..	2.85 ..	0.86 ..	0.41 ..	0.82 ..	1.77 ..	6.90 ..	7.94 ..	7.04 ..	41-27
Iranamadu and Kilinochchi		3.67 ..	2.65 ..	2.63 ..	3.40 ..	5.58 ..	0.19 ..	0.61 ..	1.66 ..	3.30 ..	7.85 ..	14.32 ..	17.88 ..	63-61
		4.04 ..	2.71 ..	3.23 ..	4.90 ..	5.94 ..	0.00 ..	1.09 ..	2.09 ..	3.06 ..	7.34 ..	11.53 ..	19.00 ..	64-93
Vavuniya & Tonigala	C ² s ² A 'a'	..	4.24 ..	2.38 ..	5.77 ..	4.92 ..	0.09 ..	0.65 ..	1.96 ..	2.86 ..	7.74 ..	10.42 ..	14.13 ..	57-63
		..	7.25 ..	4.29 ..	2.77 ..	3.62 ..	2.92 ..	0.23 ..	1.38 ..	3.07 ..	2.60 ..	8.26 ..	12.29 ..	67-90
		6.82 ..	2.41 ..	2.66 ..	3.45 ..	3.02 ..	0.62 ..	1.44 ..	4.29 ..	3.40 ..	7.32 ..	13.40 ..	18.60 ..	67-03
Anuradhapura (Nuwaragam and Mihintale)		3.99 ..	2.41 ..	3.50 ..	5.83 ..	3.19 ..	0.38 ..	0.92 ..	1.79 ..	2.33 ..	7.72 ..	10.26 ..	9.56 ..	51-90
		4.58 ..	2.35 ..	2.63 ..	5.39 ..	3.77 ..	0.23 ..	0.98 ..	1.83 ..	3.27 ..	9.30 ..	10.34 ..	10.18 ..	54-85
		7.36 ..	3.63 ..	3.84 ..	4.61 ..	3.80 ..	0.09 ..	0.94 ..	2.23 ..	2.48 ..	8.60 ..	8.41 ..	12.06 ..	58-05
Minneriya (Galoya and Hurulu)		..	6.40 ..	2.55 ..	2.44 ..	4.21 ..	6.10 ..	0.13 ..	1.63 ..	3.79 ..	4.23 ..	8.13 ..	11.20 ..	67-32
		7.37 ..	4.27 ..	2.74 ..	5.36 ..	4.26 ..	0.16 ..	1.31 ..	4.30 ..	3.63 ..	7.71 ..	12.06 ..	16.88 ..	70-05
		9.76 ..	6.42 ..	6.14 ..	4.47 ..	2.49 ..	0.37 ..	1.97 ..	1.92 ..	2.65 ..	6.45 ..	9.25 ..	11.19 ..	62-78
Dambulla (Iranabuwana)		5.01 ..	1.11 ..	4.09 ..	4.76 ..	2.79 ..	1.62 ..	1.75 ..	3.94 ..	0.59 ..	7.50 ..	7.35 ..	10.25 ..	50-76
		10.24 ..	3.31 ..	5.72 ..	7.64 ..	4.19 ..	1.54 ..	2.44 ..	3.85 ..	4.18 ..	10.65 ..	12.28 ..	10.23 ..	76-22
		..	15.58 ..	4.34 ..	4.29 ..	5.18 ..	4.18 ..	1.77 ..	2.75 ..	4.47 ..	4.39 ..	7.90 ..	12.05 ..	16.95 ..
Tiraliodai (Maha Oya)	BsA 'a'													

Table 12—Average Temperature and Potential Evapotranspiration

AVERAGE TEMPERATURE IN DEGREES FARENHEIT

Plot	J	F	M	A	M	J	J	A	S	O	N	D
Mannar	.. 78.3..	79.4..	82.2..	84.0..	85.5..	84.6..	83.2..	83.1..	83.3..	82.0..	80.4..	78.5
Puttalam	.. 77.4..	78.9..	81.7..	82.5..	84.1..	82.9..	82.4..	82.4..	82.6..	80.8..	79.6..	77.7
Jaffna	.. 77.3..	78.7..	82.9..	85.1..	85.4..	84.3..	83.4..	83.2..	83.0..	82.0..	79.9..	77.8
Anuradhapura	.. 76.2..	78.2..	81.8..	83.3..	84.8..	85.5..	83.8..	83.7..	84.0..	81.6..	79.0..	76.5
Trincomalee	.. 77.8..	78.8..	80.9..	83.6..	86.2..	86.2..	85.5..	84.9..	85.1..	81.9..	79.3..	77.8
Batticaloa	.. 77.3..	78.0..	80.0..	82.2..	84.0..	85.3..	84.3..	85.5..	83.2..	81.1..	79.4..	77.7

AVERAGE POTENTIAL EVAPOTRANSPIRATION IN INCHES

Plot	J	F	M	A	M	J	J	A	S	O	N	D	Year
Mannar	.. 5.0..	4.9..	6.1..	6.4..	6.9..	6.6..	6.6..	6.5..	6.2..	6.0..	5.3..	5.0..	70.5
Puttalam	.. 4.6..	4.6..	5.9..	6.1..	6.6..	6.3..	6.4..	6.3..	6.0..	5.7..	4.9..	4.6..	68.0
Jaffna ..	.. 4.4..	4.7..	6.1..	6.6..	6.9..	6.7..	6.6..	6.3..	6.0..	5.9..	5.3..	4.4..	69.9
Anuradhapura	.. 3.8..	4.2..	5.9..	6.3..	6.8..	6.4..	6.8..	6.5..	6.2..	5.7..	4.7..	4.0..	67.3
Trincomalee	.. 4.4..	4.9..	5.8..	6.3..	6.9..	6.9..	6.9..	6.6..	6.4..	5.9..	4.9..	4.4..	70.3
Batticaloa	.. 4.5..	4.2..	5.6..	6.1..	6.7..	6.7..	6.7..	6.8..	6.2..	5.9..	4.9..	4.5..	68.6

Table 13.—Monthly Water Surplus and Deficit in Inches

Station		J	F	M	A	M	J	J	A	S	O	N	D
1. Madhu	{ Surplus	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	0.6..	2.7..	1.1..	3.8..	6.6..	6.2..	5.7..	4.7..	— ..	2.9..	5.7
2. Puwarasankulam	{ Surplus	.. 1.1..	.. — ..	.. — ..	0.5..	1.0..	1.3..	6.2..	6.1..	2.6..	2.9..	.. — ..	4.9.. 5.7
	{ Deficit	.. — ..	.. — ..	.. — ..	0.5..	1.0..	1.3..	6.2..	6.1..	2.6..	2.9..	.. — ..	4.9.. 5.7
3. Iranamadu	{ Surplus	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	2.2..	3.2..	1.3..	6.5..	6.0..	4.6..	2.7..	.. — ..	3.0.. 13.5
4. Mankulam	{ Surplus	.. — ..	.. — ..	.. — ..	1.3..	1.7..	1.0..	6.7..	5.5..	4.2..	2.9..	.. — ..	3.4.. 14.6
	{ Deficit	.. — ..	.. — ..	.. — ..	1.3..	1.7..	1.0..	6.7..	5.5..	4.2..	2.9..	.. — ..	3.4.. 14.6
5. Vavuniya	{ Surplus	.. 0.4..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	1.2..	0.5..	1.9..	6.3..	6.1..	4.5..	5.3..	.. — ..	1.7.. 10.1
6. Andankulam	{ Surplus	.. 2.4..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	1.6..	2.8..	3.9..	6.3..	5.5..	2.3..	3.0..	.. — ..	1.0.. 14.2
7. Allai	{ Surplus	.. 2.9..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	2.3..	4.0..	6.7..	5.5..	3.5..	3.8..	.. — ..	.. — ..	5.8.. 14.8
8. Anuradhapura	{ Surplus	.. 0.2..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	0.2..	0.5..	3.6..	6.0..	5.9..	4.7..	3.9..	.. — ..	3.6.. 5.6
9. Minneriya	{ Surplus	.. 3.6..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	0.4..	3.0..	6.3..	5.9..	4.3..	3.7..	.. — ..	.. — ..	2.6.. 8.1
10. Kantalai	{ Surplus	.. 3.0..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	0.6..	2.6..	6.7..	5.6..	2.3..	2.3..	.. — ..	.. — ..	5.0.. 12.5
11. Lahugala	{ Surplus	.. 5.3..	2.2..	0.6..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	1.8.. 6.7
	{ Deficit	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	1.8..	6.3..	4.7..	4.7..	3.5..	.. — ..	.. — ..
12. Dambulla	{ Surplus	.. 1.2..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..	.. — ..
	{ Deficit	.. — ..	.. — ..	.. — ..	0.9..	1.5..	4.0..	4.8..	5.0..	2.6..	5.6..	.. — ..	0.5.. 6.3

The temperature rises gradually from a minimum average value of 76.2 to 78.3° F in December/January to a maximum of 84.1° to 86.2° during May/June. The minimum average monthly value in January is of the same order as the corresponding temperature in the Wet Zone while the maximum monthly value is about 5° F higher than in the Wet Zone. The combination of high temperature with low rainfall and relative humidity is a characteristic feature of the climate of the region in which the Dry Mixed Evergreen Forest occurs.

Potential Evapotranspiration

The annual potential evapotranspiration in the Dry Zone varies from 68.0 inches to 70.5 inches. The minimum monthly values (3.8 to 4.5 ins.) are in January and the maximum monthly values (6.6 to 6.9 ins.) in May/July corresponding to the similar range of temperature. Average monthly values of water deficit and surplus for 12 stations computed from the relation between rainfall and potential evapotranspiration, are given in Table 13. At most stations the period of water deficit commences in February or March and continues up to August. In January/February the moisture stored in the soil is used for evapotranspiration while in September the soil moisture is replenished. In November and December there is a surplus of about 8.6 to 17 inches. At the stations in the east coast the period of water surplus may extend to February and even to March while soil moisture utilization takes place in the following month. The period of water deficit lasts from 5 to 7 months.

Leaf change

Average monthly values of phenological indices for leaf-fall and reflush for the 10 year period 1942 to 1951 are given in Tables 14 and 15. As would be expected, in this dry seasonal climate the values of leaf-fall and reflush are higher than in the Wet Evergreen Forests. 15 of the 30 species under observation were deciduous, while leaf shedding by the evergreen species was more pronounced in these forests than in the Wet Evergreen Forest.

Table 14—Average monthly Indices of Leaf-fall in the Dry Evergreen Forest

Plot	J	F	M	A	M	J	J	A	S	O	N	D
1. Madhu	0.9	4.1	2.7	1.7	1.3	0.7	1.3	2.1	4.1	4.7	1.2	0.9
2. Puwarasankulam	0.2	6.2	10.6	4.5	1.5	2.8	3.8	1.6	0.5	0.1	0.0	1.0
3. Kilinochchi	13.1	16.0	15.3	9.6	6.6	1.7	0.8	0.4	3.1	3.5	2.5	4.8
4. Iranamadu	10.3	14.5	16.4	14.7	6.4	2.2	1.1	1.5	3.5	3.7	4.2	4.2
5. Vannivilankulam	1.6	11.4	8.4	1.3	10.5	13.2	0.1	13.7	—	—	—	—
6. Terravil-Oddusudan	2.9	6.7	10.3	7.2	10.8	7.9	2.0	2.2	3.5	6.3	0.8	4.2
7. Nagancholai	0.4	4.1	16.8	12.6	5.7	1.0	—	—	10.4	0.4	—	0.1
8. Tonigala	0.8	2.6	3.1	0.8	1.6	2.2	4.0	1.8	0.5	1.3	1.4	1.0
9. Vellamalai	1.5	0.5	1.9	3.7	1.4	0.2	0.4	—	—	—	0.1	0.1
10. Thirucholai	—	1.1	2.2	3.9	1.8	0.7	0.3	0.1	0.2	0.2	0.2	0.9
11. Nuwaragam	4.3	9.2	3.6	5.6	1.2	1.5	2.1	1.0	1.9	1.2	5.3	0.7
12. Mihintale	12.6	8.6	9.5	4.5	4.3	8.1	10.1	14.1	10.2	5.4	6.4	5.6
13. Medawachchiya	5.4	9.3	8.4	7.6	7.7	6.7	2.5	0.7	2.2	1.3	8.0	2.4
14. Galoya	27.5	13.1	10.6	3.3	3.5	17.3	15.8	6.2	15.2	7.2	10.8	7.1
15. Hurulu	27.1	11.6	8.5	4.8	6.3	10.8	15.9	8.4	14.7	14.9	9.2	7.9
16. Padawiya	13.0	3.4	12.4	2.6	0.5	2.2	2.5	3.4	0.6	0.5	1.0	1.3
17. Kayanwadi	0.1	1.3	0.9	2.1	0.7	0.5	0.1	0.2	0.3	0.7	1.8	—
18. Lahugala	2.2	1.6	1.2	4.7	4.5	1.5	0.5	1.7	3.5	2.0	0.6	0.1
19. Inamaluwa	2.5	4.7	5.2	29.8	15.8	4.2	3.2	3.6	1.1	1.1	1.1	1.1
20. Daragoda	0.4	—	—	—	—	2.5	3.4	13.5	8.6	8.1	4.8	0.6
21. Tiraliadai	6.8	0.1	—	6.4	3.8	2.0	2.1	0.3	0.1	0.1	3.3	—

Table 15—Average monthly Indices of Reflush in the Dry mixed Evergreen Forest

Plot	J	F	M	A	M	J	J	A	S	O	N	D
1. Madhu	12.3	11.7	9.4	6.3	3.0	0.8	0.6	0.5	1.5	4.2	5.2	5.5
2. Puwarasankulam	2.7	4.7	3.8	10.5	12.8	2.0	1.1	1.7	2.0	1.7	2.8	1.8
3. Kilinochehi	27.5	8.0	10.6	9.2	15.2	8.3	6.0	2.3	2.8	10.7	7.1	6.9
4. Iranamadu	22.2	10.5	8.6	10.7	11.6	15.3	8.4	1.0	3.1	8.4	7.5	8.4
5. Vannivilankulam	3.7	—	20.0	21.3	1.3	1.6	4.5	8.7	14.5	11.4	11.4	—
6. Terravil-oddusudan	5.7	2.1	4.6	24.8	18.5	17.2	20.4	25.6	8.6	33.6	24.1	13.1
7. Nagarcholai	18.6	22.9	10.9	7.7	2.7	16.3	9.2	7.6	7.6	14.9	20.1	21.4
8. Tonigala	1.5	3.0	5.1	1.9	1.3	3.5	2.4	3.3	2.8	1.1	1.9	0.3
9. Vellamalai	0.2	2.5	3.1	5.3	6.4	5.4	3.3	0.3	0.1	0.1	0.0	0.6
10. Thirucholai	0.8	8.3	2.8	6.2	9.5	11.2	2.2	0.8	0.2	0.4	0.4	0.1
11. Nuwaragam	41.6	34.5	7.1	10.7	11.0	0.4	6.9	2.3	9.3	18.1	15.4	13.1
12. Mihintale	20.2	23.1	21.6	20.1	12.1	6.5	8.3	13.4	16.5	18.4	9.9	15.9
13. Medawachchiya	35.8	14.6	15.7	9.7	7.9	6.0	9.7	10.5	15.4	15.4	16.3	21.7
14. Galoya	25.2	41.8	43.3	18.2	15.3	14.5	14.5	0.4	1.8	4.0	2.5	21.0
15. Hurulu	44.7	33.3	30.2	7.9	12.4	11.0	17.5	5.5	0.2	0.8	18.4	21.0
16. Padawiya	37.9	0.7	6.6	6.5	3.2	2.2	3.0	2.2	1.2	7.9	5.0	8.1
17. Kayanwadi	2.1	4.8	2.1	6.6	6.4	4.8	1.8	2.0	1.9	0.5	2.7	3.1
18. Lahugala	11.9	3.5	3.1	9.2	10.4	8.2	3.1	2.3	1.3	3.2	4.2	2.9
19. Inamaluwa	19.5	8.2	12.7	12.8	29.0	21.7	23.6	21.3	8.0	5.7	4.8	23.6
20. Daragoda	17.7	7.9	4.4	3.1	2.5	2.5	10.9	1.3	4.9	3.6	11.4	9.7
21. Tiralliodai	3.0	12.7	6.9	7.6	10.5	3.2	0.8	7.1	7.1	0.6	1.7	1.4

Figures 5 to 7 illustrate the average annual trend of foliar activity and its relation to the climatic conditions—rainfall, humidity and temperature—for 6 plots (Madhu, Iranamadu, Mihintale, Hurulu, Lahugala and Vellamalai)

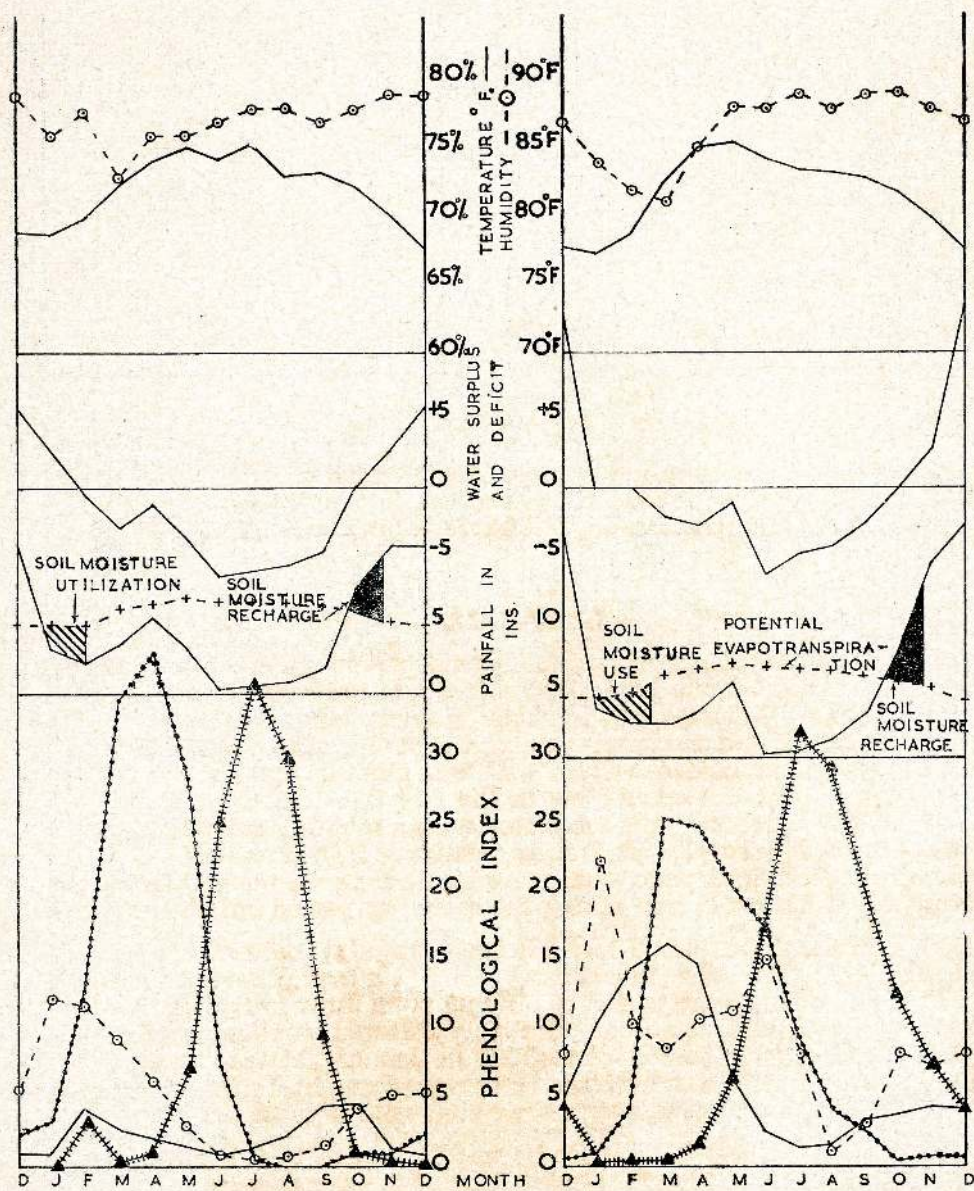
LEAF-FALL

THE maximum incidence of leaf-fall was observed during the short dry period in January/March, generally February, at the beginning of the year in most plots. At Vellamalai, Thirucholai, Kayanwadi and Lahugala on the east coast of the island and Inamaluwa on the border of the "Intermediate" zone the maximum incidence of leaf-fall took place in April, a month later than is general for the other plots in the Dry Zone. In the plots on the East coast this behaviour was associated with a monthly rainfall of over 4 inches during January/March and/or relatively high humidity. At Daragoda where conditions were even more moist than on the east coast the season of leaf-fall took place during the main dry period July/September.

Besides the main season of leaf-fall there was also increased activity of leaf-shedding later in the year at most plots. This took place either during or at the end of the main period of drought from June to September. The intensity of leaf-fall was quite high at this time and was comparable with that during the main season of leaf-fall in January/March. In the plots on the east coast with a shorter and less severe drought, leaf-shedding was much less pronounced at this time than in the other plots.

The 2 periods of leaf-fall cannot be said to be due to the behaviour of different species. In many cases individuals of the same species which had not had their leaves in one period did so during the other. The details of the asynchronous behaviour of individuals and species will be dealt with later.

During the high incidence of leaf-fall in January/March the monthly rainfall in at least two of these months was less than 4 inches. The relative humidity generally dropped to between 75 and 77 per cent and the mean monthly temperature increased by about 1.0 to 1.5° F from that of the previous months.



MADHU (LEAFFALL—REFLUSH --O--; FLOWERING +---+; FRUITING #---#) IRANAMADU
 FIG. 5—AVERAGE (1942–51) PHENOLOGICAL AND CLIMATIC CURVES
 (TROPICAL DRY MIXED EVERGREEN FOREST)

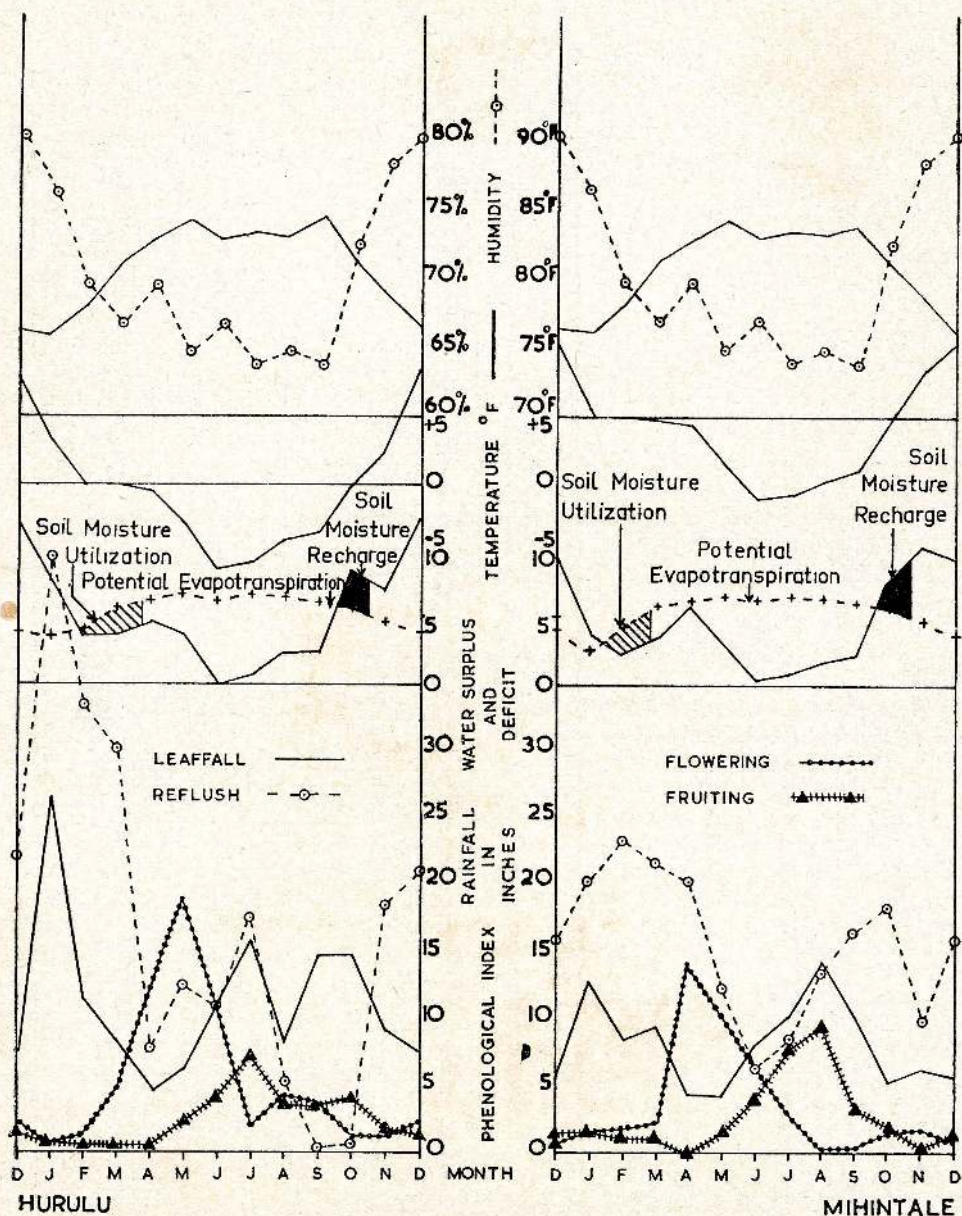


FIG.6-AVERAGE (1942-51) PHENOLOGICAL AND CLIMATIC CURVES
(TROPICAL DRY MIXED EVERGREEN FOREST)

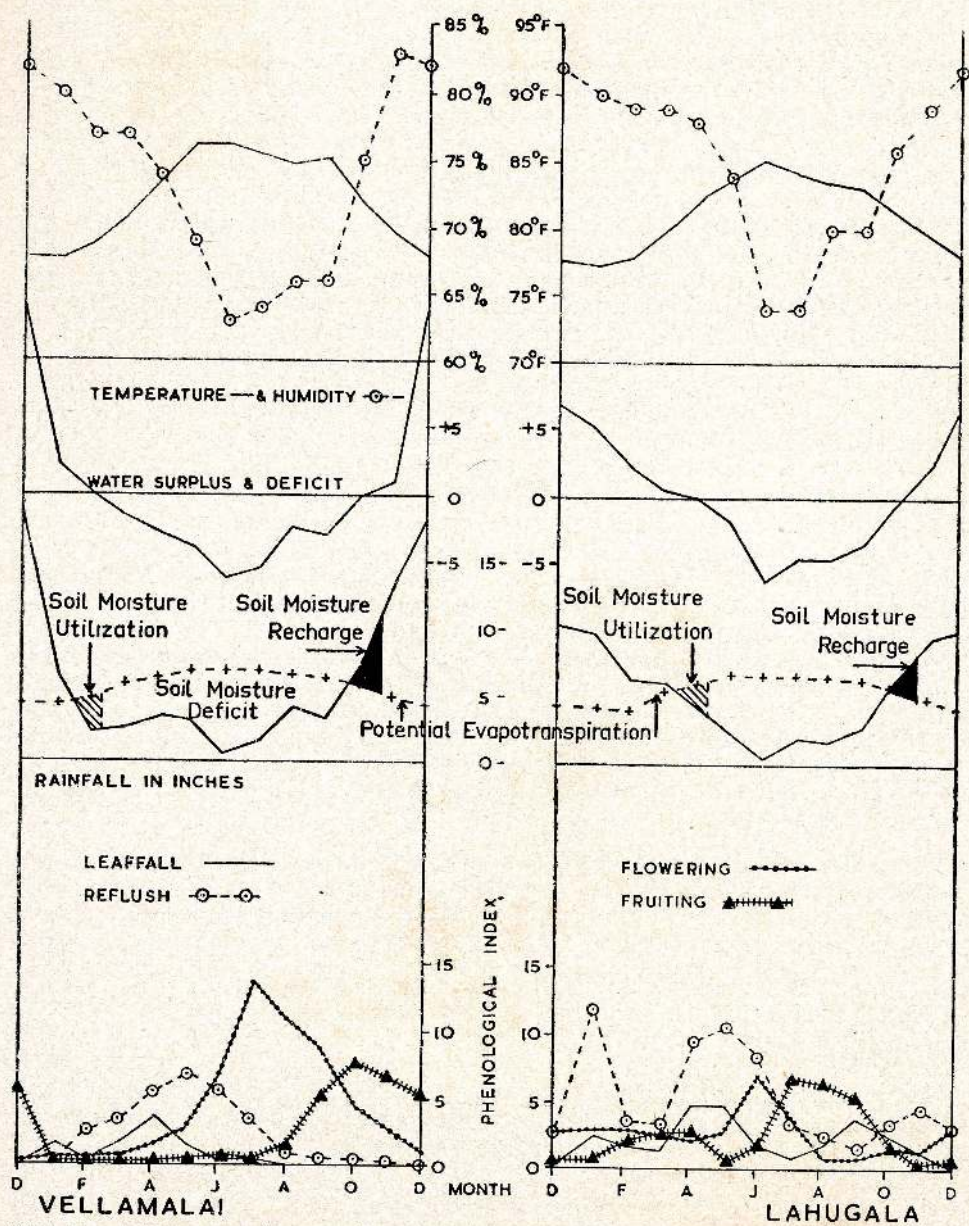


FIG. 7 — AVERAGE (1942-51) PHENOLOGICAL & CLIMATIC CURVES
(TROPICAL DRY MIXED EVERGREEN FOREST)

The behaviour of the plots on the east coast where maximum leaf-fall activity is delayed till April under conditions of heavier rainfall and higher humidity during January/March has been referred to above. At Padaviya, Galoya and Hurulu the maximum leaf-fall index was in January when the monthly rainfall was over 6.40 inches. This may be due to the fact that observations were recorded at the end of the month while most of the rain took place in the earlier part of the month. Besides the relative humidity decreased from 79 per cent in December to 77 per cent in January.

REFLUSH

TABLE 15 gives the average monthly values of phenological indices for reflush activity. The maximum incidence of reflush or foliar renewal took place from January to March about the same time as the main leaf-fall period. Besides the main season of reflush there were in many plots e.g. Mihintale, Vannivilankulam, Terravil-Oddusudan, subsidiary peaks of foliar renewal during the main period of dry weather from May to August or slightly later with the break of the north-east monsoon rains in October/November. The latter period invariably merged into the main season of reflush in January/March. The subsidiary peaks of reflush generally followed peaks of leaf-fall activity. In some plots, e.g. Madhu, Kilinochchi and Mihintale, the highest incidence of reflush was reached a month ahead of maximum leaf-fall activity. Another feature of the behaviour of the plots was that the intensity of reflush was generally higher than that of the corresponding peaks of leaf-fall. The main reflush in January/March and subsidiary peaks of reflush in the dry period June/September took place during climatic conditions of low rainfall and humidity. This is in agreement with the observations made in the Wet Evergreen Forests and those of Smith (1909) and Krishnasamy and Mathauda (1954) referred to earlier. However, in these forests, pronounced reflush activity was also observed during the north-east monsoon rains in October/November. This upsets the general association of foliar renewal with dry weather conditions. It is necessary to examine the detailed monthly behaviour before any conclusions can be reached.

The foliar behaviour of individual trees and species in these forests shows considerable variation. Details of such behaviour will be referred to later. For the present it may be noted that new leaf was observed almost every year in the individual tree irrespective of whether it shed its leaves or not. When leaf shedding took place it was invariably followed by reflush, even during a dry period. In the absence of leaf-fall, reflush was more likely to occur during the north-east rains in October/December or during the rains in April.

The detailed monthly values of the phenological indices of leaf-fall and reflush from 1942 to 1951 for 22 plots is given in Appendix 1. The corresponding date of rainfall, humidity and temperature are given in Appendix 2. Figures 8, 9 and 10 illustrate the monthly leaf change behaviour and its relation to temperature, rainfall and humidity for 3 plots, Iranamadu, Mihintale and Lahugala.

At all three plots it is evident that leaf-fall activity is distinctly periodic but the periodicity is irregular. At Iranamadu (Figure 9) leaf-fall activity took place in different months in different years. Irrespective of the time of occurrence, peaks of leaf-fall occurred at the same time as or immediately after troughs in the rainfall and/or humidity regime. For example in January 1945 the index was 21.7 along with 0.20 inches of rain and 72 per

cent relative humidity. In February that year the index dropped to 14.6 when the rainfall was 1.80 inches and humidity rose to 76 per cent. In March that year the leaf-fall index increased to 25.7 corresponding to a relative humidity of 72 per cent which represents a decrease of 4 per cent from that in February while the rain-fall was 2.95 inches. In 1949 the maximum index of 12.6 for the year was in November when the rain fall was 14.51 inches. However, in November the relative humidity decreased to 78 per cent from 80 per cent in October. In general maximum leaf-fall activity was associated with rainfall below 4 inches and/or humidity below 76 per cent which occurred either at the same time or one to two months previous to maximum leaf-fall activity. It will be noticed that the intensity of leaf-fall activity was most marked in these years in which the low rain-fall and humidity coincided as in 1945, 1950 and 1951. The relation between leaf-fall activity and temperature is not evident.

At Mihintale (Figure 9) peaks of leaf-fall activity took place both during January/March and again later in the year during July/September. During the 10 years 1942 to 1951, high leaf-fall was noticed in 8 years in January/March and in 5 years in July/September. As at Iranamadu high leaf-fall activity coincided with or took place 1 to 2 months after a month of low rainfall, generally below 4 inches and or low humidity generally below 75 per cent.

At Lahugala (Figure 10) although the rainfall is better distributed throughout the year than at other stations, the same relation between peaks of high rainfall and low rainfall (below 4 inches) and/or low humidity (below 80 per cent.) is evident. This relation is also borne out by examination of the data from the other plots. It is interesting to note that leaf-fall activity commenced when the soil moisture, according to Thornthwaite was in deficit or being utilised by the plant for evapotranspiration.

To test this relationship further the regression of leaf-fall and humidity was determined in a similar manner to that described earlier. (See "Ceylon Forester" Vol. IV. No. 2 pages 174-176). The 2 highest values of the leaf-fall index for each year from 1945 to 1951 in three plots, Madhu, Kilinochchi and Nuwaragam were plotted against the corresponding values of rainfall and humidity (Figure 11). The values of rainfall and humidity were 'corrected' to those of the previous month if they were lower than those during the month of leaf-fall activity.

The 5 per cent. level of significance of the limits of the distribution of rainfall and humidity i.e. the limits within which two-thirds of the values are included, are 0.15 to 4.6 inches monthly rainfall and 68.5 to 76.0 per cent relative humidity. The significant values of these factors obtained by omitting one third of the values from the highest are 3.0 inches and 75 per cent respectively. As pointed out previously these values are more likely to be applicable to plant behaviour than the range of values obtained by omitting one sixth of the values from both the upper and lower ends of the whole range of distribution of the plants. The probability of a chance occurrence of a monthly rainfall of 3.0 inches and below is 1 in 1.9 and that of a relative humidity of 75 per cent is 1 in 2.

The 'equivalence' of humidity and rainfall is as follows:—7.5 per cent humidity (68.5 per cent to 76.0 per cent) is equivalent to 4.45 inches (0.15 to 4.6 ins.) of rainfall, or 1 per cent humidity is equivalent to 0.66 inches of rainfall. The equivalent values of humidity and rainfall are expressed on the abscissa of Figure 12. In plotting the values to express the interaction of rainfall and humidity, the value of whichever factor was

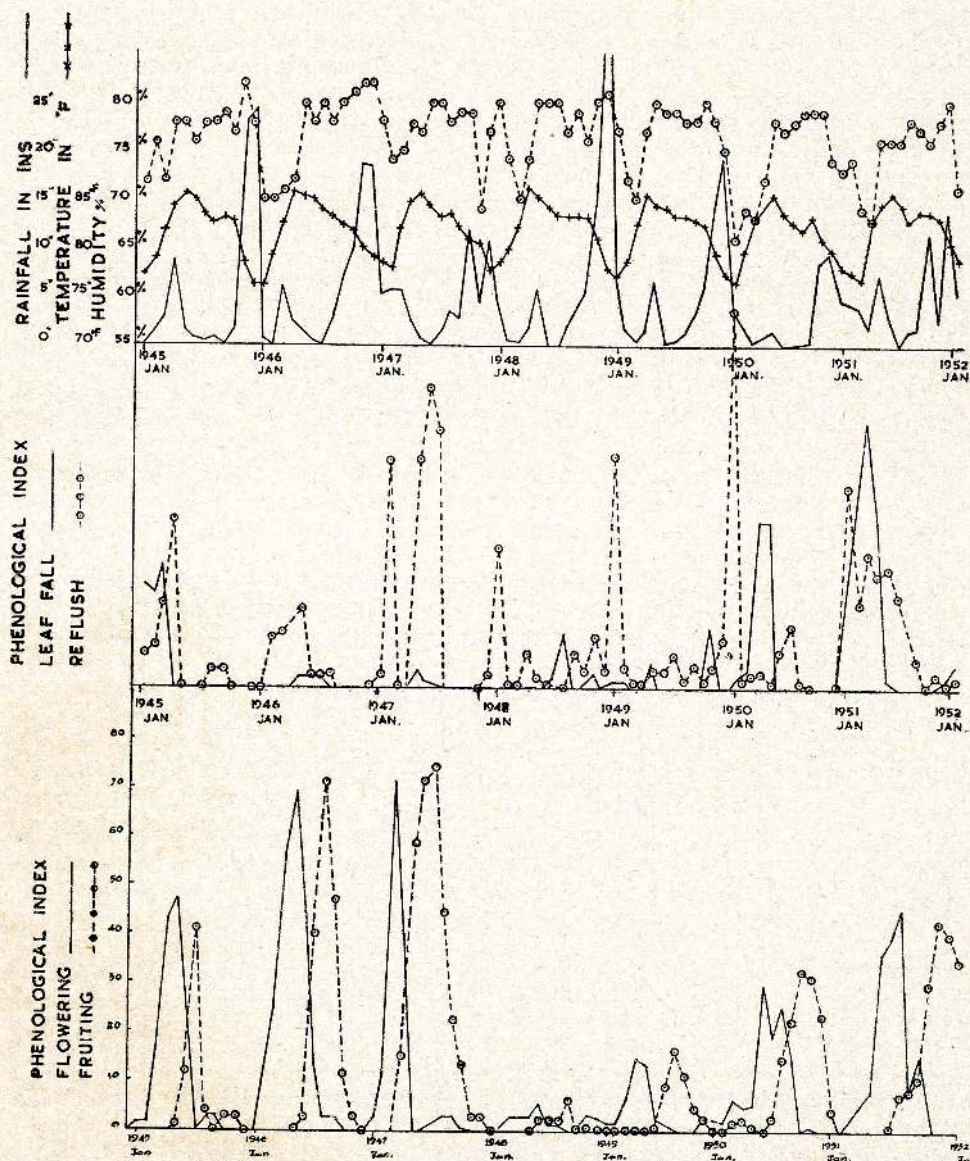


FIG 8 - PHENOLOGICAL AND CLIMATIC CURVES AT IRANAMADU FROM 1945 TO 1951
(TROPICAL DRY MIXED EVERGREEN FOREST)

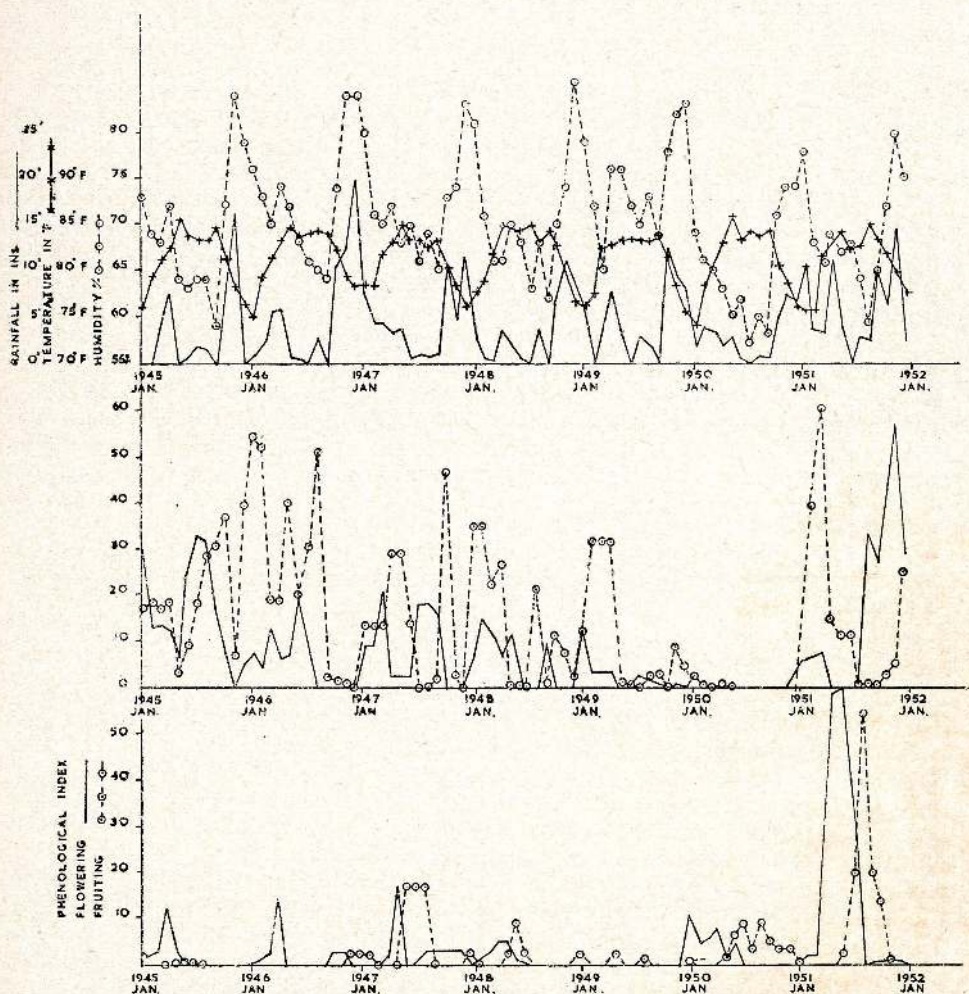


FIG.9- PHENOLOGICAL AND CLIMATIC CURVES AT MIHINTALE FROM 1945 TO 1951
(TROPICAL DRY MIXED EVERGREEN FOREST)

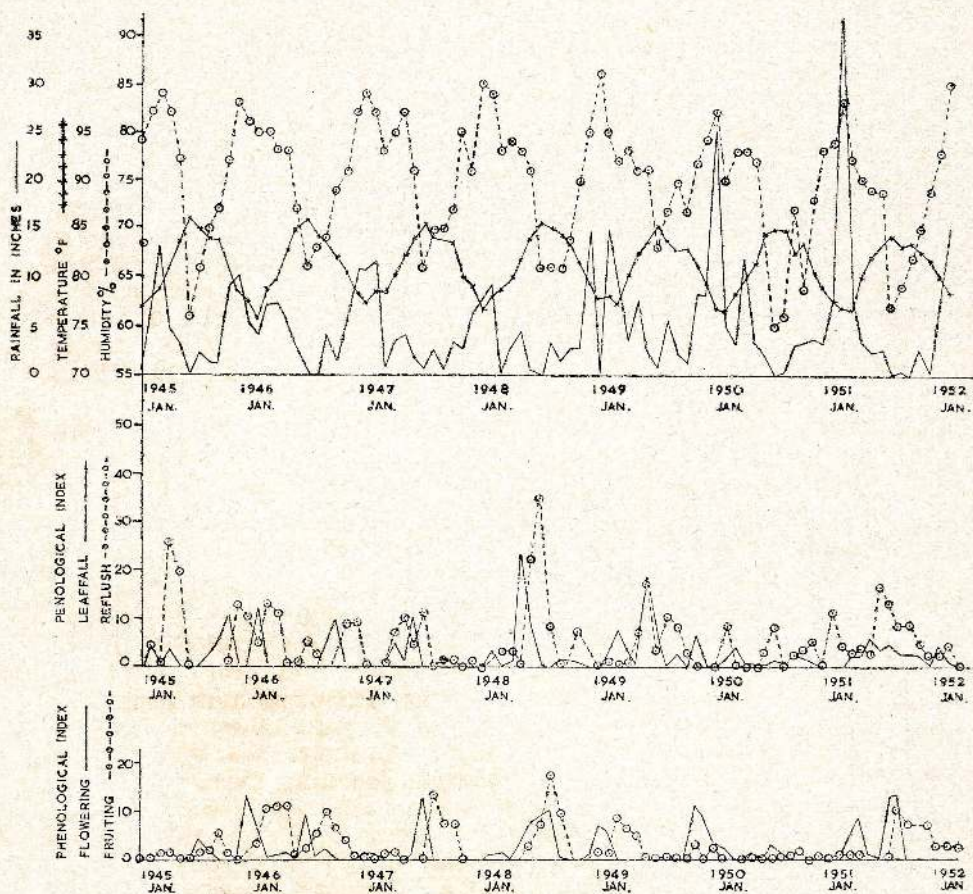


FIG.10 — PHENOLOGICAL AND CLIMATIC CURVES FROM 1945 TO 1951
AT LAHUGALA (TROPICAL DRY MIXED EVERGREEN FOREST)

lower on the equivalent scale was plotted. Figure 12 shows the distribution of the parts plotted on this basis. The critical limits of the 2 factors operating together are 2.2 inches monthly rainfall and 72.3 per cent relative humidity. The probability of a chance coincidence between a monthly rainfall of 2.2 inches and less, and maximum leaf-fall is 1 in 2.2, while that for 72.3 per cent relative humidity is 1 in 3.3. Eighteen values of relative humidity and 22 values of rainfall were used in the expression of the interaction of these 2 factors on leaf-fall. These figures indicate the relative importance of humidity and rainfall in the control of leaf-shedding in these forests.

Figures 8 to 10 illustrate the close relation between peaks of rainfall and reflush activity. Reflush activity generally commenced during the rains. At Iranamadu the average values for the 10 years 1942 to 1951 (Figure 5) indicate that maximum reflush activity coincides with low rainfall and decreasing relative humidity in January. It is also noticed that the trend towards increased reflush activity commences during the rains in October. Similarly the secondary peak of reflush in June took place immediately after the premonsoon rains in May. The detailed monthly values in Figure 8 illustrate the relationship further. Reflush activity commenced during peaks of rainfall and reached its maximum intensity generally a month later. Where a drop in humidity after a peak of rainfall was steep as in January-February, 1946, the intensity of reflush activity was not as high as when a peak of humidity coincided with the time of maximum reflush as in June, 1947. The same relationship between rainfall, humidity and foliar renewal is shown in Figures 9 and 10 for Mihintale and Lahugala.

THE BEHAVIOUR OF THE SPECIES

FIFTEEN of the species under observation were obligate deciduous species which shed most or all their leaves every year. They were *Holoptelea integrifolia*, *Grewia polygama*, *Cassia fistula*, *Mitragyna parvifolia*, *Berrya cordifolia*, *Chukrasia tabularis*, *Adina cordifolia*, *Bridelia retusa*, *Vitex pinnata*, *Chloroxylon Swietenia*, *Sapium insigne*, *Pterospermum canescens*, *Premna tomentosa*, *Anogeissus latifolia* and *Pityranthe verrucosa*. The following species though not under observation in the present investigation were observed to be deciduous:—*Gyrocarpus jacquini*, *Tetrameles nudiflora*, *Vitex leucoxydon*, *Albizzia odoratissima*, *Albizzia lebbek*, *Albizzia amara*, *Crataeva roxburghii* and *Thespesia populnea*. Wright (1905) mentions the following other species of the Dry Mixed Evergreen Forest as deciduous:—*Polyalthia coffeoides*, *Sterculia balanghas*, *Pongamia pinnata*, *Albizzia stipulata*, *Terminalia arjuna*, *Diospyros montana*, *Diospyros melanoxylon*, *Oroxylum indicum*, *Stereospermum chelonoides*, *Phyllanthus emblica*, *Antiaris toxicaria* and several species of the genus *Ficus*.

The other species under observation were 'evergreen' or 'semi-evergreen'. 3 species were 'semi-evergreen':—*Schleichera trijuga*, *Syzgium cumini*, and *Diospyros ovalifolia*. Wright (1905) consider these to be deciduous species. Although they shed their leaves to a marked extent and had a minimum crown density of 1/4 to 1/2 in some years, in other years these species were more or less evergreen.

Although there are over 40 deciduous species in the Dry Mixed Evergreen Forest, the abundance and density of the evergreen species are responsible for the evergreen character of these forests. The most widespread

and abundant of the species is *Hemicyclia sepiaria*. An enumeration of all trees over 18 inches in girth in a strip 3 chains long by $\frac{1}{2}$ chain wide was done by the writer in 1952, in Sellankandal Forest Reserve near Puttalam. There were in all 289 trees belonging to 11 species. 4 of these (*Vitex pinnata*, *Chloroxylon swietenia*, *Sapium insigne* and *Pterospermum canescens*) were deciduous species which included 53 trees or 18.1 per cent of the trees. Of the evergreen species *Hemicyclia sepiaria* alone accounted for 183 trees or 62 per cent. Figures of 1 per cent enumerations done by the Forest Department in 1937-1939, in various forests show that the percentage of all deciduous species varied from 6 to 8, while that of *Hemicyclia sepiaria* varied from 15 to 60 per cent of all the trees over 18 inches girth in the Dry Mixed Evergreen Forest.

Many of the evergreen species, for example, *Gleniea unijuga*, *Manilkara hexandra*, and *Diospyrus ebenum*, were observed to have a more pronounced incidence of leaf-fall than evergreen species in the Wet Evergreen Forest. In some years, individual trees of these species shed as much as half the leaf on the crown. This behaviour, however, was not general for all the species and more often less than on-third of the leaf was shed. In fact there was a considerable range of behaviour of foliar activity from that of evergreen species like *Hemicyclia sepiaria*, when shed only a small proportion of leaf, to the semi-evergreen species.

TIME AND NATURE OF LEAF-FALL

ONE or other of the deciduous species were observed shedding leaf in every month of the year as the seasons of leaf-fall in Table 16 indicate. All except two of the deciduous species, i.e., *Premna tomentosa* and *Bridelia retusa*, were observed shedding their leaves during March-July. December, January and February were the months with the least number of species shedding leaf.

Some deciduous species had a pronounced period of leaf-fall once in the year. The length of the period varied from 2 to 3 months in *Chukrasia tabularis*, *Adina cordifolia*, *Premna tomentosa* and *Pityranthe verrucosa* to 4 to 7 months in *Holoptelea integrifolia*, *Grewia polygama*, *Mitragyna parvifolia*, *Vitex pinnata* and *Sapium insigne*. Other deciduous species like *Cassia fistula*, *Berrya cordifolia* and *Chloroxylon swietenia* showed pronounced leaf-fall in 2 periods. The length of these 2 periods varied. In *Pterospermum canescens* there were 3 seasons of two months each in December-January, May-June and August-September.

Besides the variation in the species there was also considerable variation in the behaviour of the individual trees of a species. The general cycle of leaf-fall was 11 to 16 months but leaf-fall did not occur regularly each year on every tree of a species. In some years some trees failed to shed their leaves while other trees of the same species did so.

In species with 2 or more pronounced periods of leaf-fall, this behaviour was not generally due to the individual tree shedding leaf twice or three times in a year but due to shedding of leaves by some trees of the species during one period while the other trees of the same species did so in the next period. The same individuals did not necessarily shed their leaves during the same period in successive years but varied irregularly between the two periods. The seasons of leaf-fall and reflush of the evergreen and semi-evergreen species is given in Table 17. Most species were observed

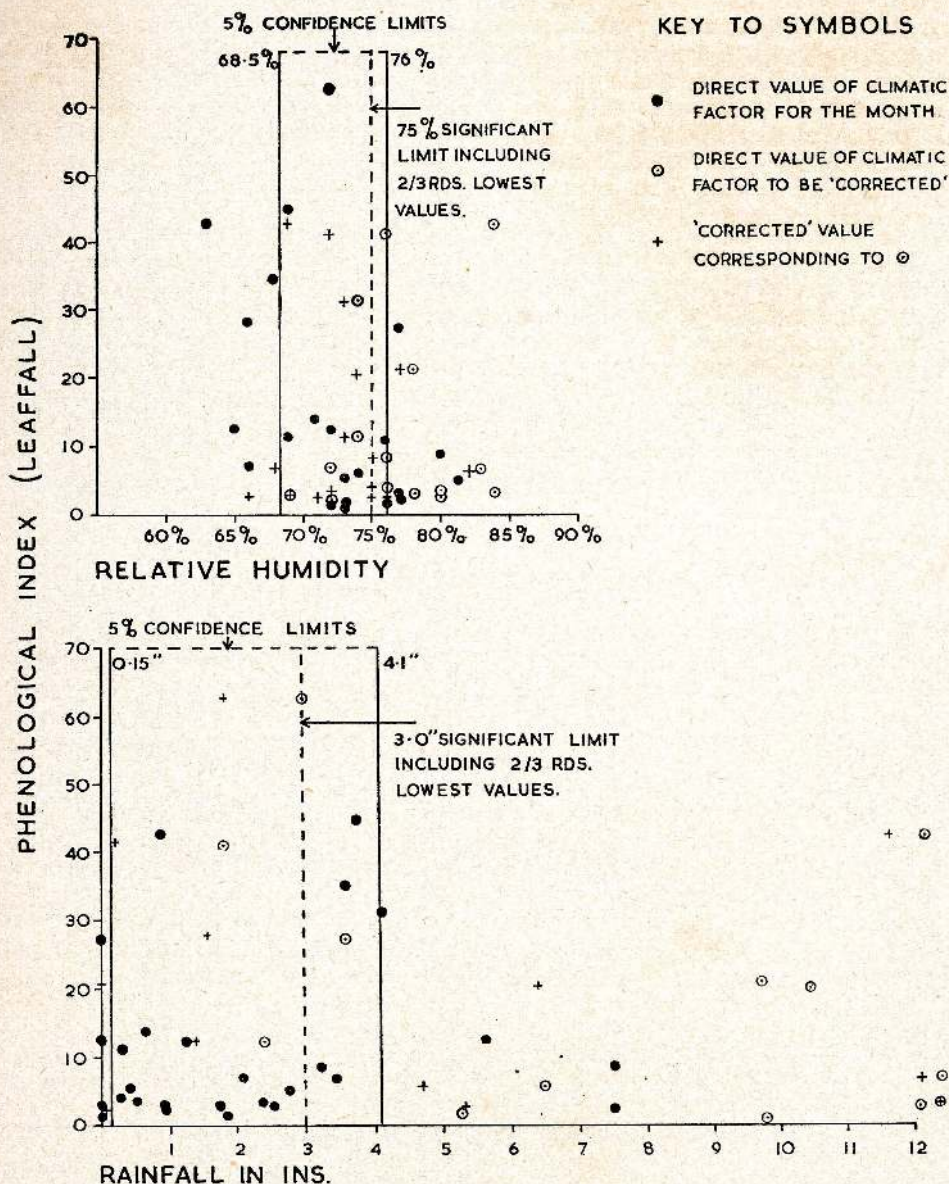


FIG.II - REGRESSION OF LEAFFALL ON RAINFALL AND HUMIDITY IN THE TROPICAL DRY MIXED EVERGREEN FOREST.

(PLOTS - MADHU, KILINOCHCHI & NUWARAGAM)

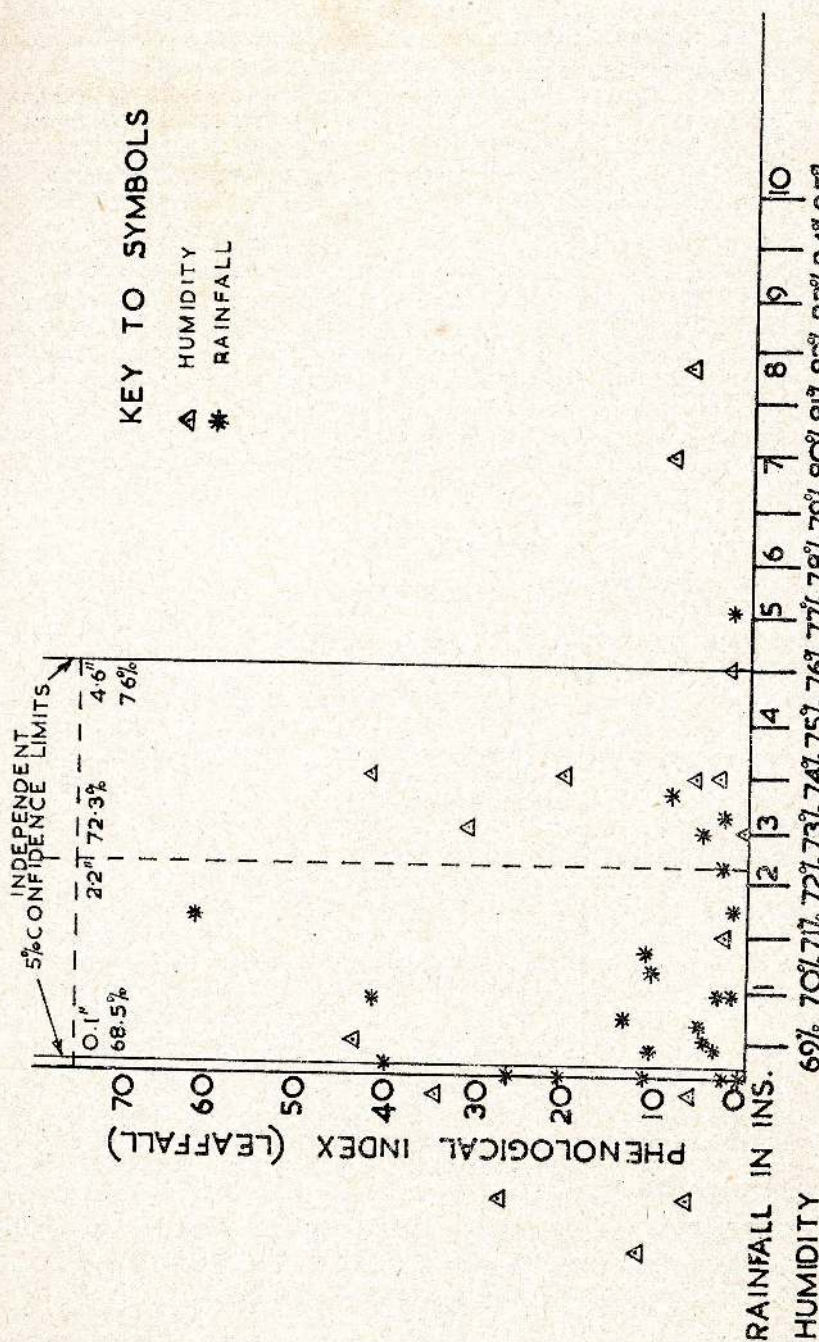


FIG.12-REGRESSION OF LEAF FALL ON RAINFALL AND HUMIDITY
IN THE TROPICAL DRY MIXED EVERGREEN FOREST
(PLOTS - MADHU, KILINCHCHI AND NUWARAGAM)

shedding their leaves in January, February and March. 7 species were observed shedding their leaves and reflushing at all times of the year.

Table 16.—Seasons of Leaf-fall and Reflush of the Deciduous Species
(Leaf-fall — x ; Reflush — o)

<i>Species</i>	<i>J</i>	<i>F</i>	<i>M</i>	<i>A</i>	<i>M</i>	<i>J</i>	<i>J</i>	<i>A</i>	<i>S</i>	<i>O</i>	<i>N</i>	<i>D</i>
1. <i>Holoptelea integrifolia</i> ..			x	x	x	x	x	o	o	o		
2. <i>Grewia polygama</i> ..					x	x	x o	x o	o			
3. <i>Cassia fistula</i> ..	x o	o	x o	x	x	x		o	o	o	x o	x o
4. <i>Mitragyna parvifolia</i> ..	o			o	o	o	x	x	x	x	x o	o
5. <i>Berrya cordifolia</i> ..	o			x	x o	x o	o		x	x	x o	o
6. <i>Chukrasia tabularis</i> ..		o	x o	x o	x o	o	o		x	x	x o	o
7. <i>Adina cordifolia</i> ..				o	o	x o	x o					
8. <i>Bridelia retusa</i> ..	o	o	o							x	x o	x o
9. <i>Vitex pinnata</i> ..			x	x	x o	x o	x o	x o	o	o	o	
10. <i>Chloroxylon swietenia</i> ..	x o	x o	x o	x o	x o	o		x	x o	x o	o	o
11. <i>Sapium insigne</i> ..	x o	x	x	x	x	x	x	o	o	o	o	o
12. <i>Pterospermum canescens</i> ..	x o	o	o	o	x o	x o			x	x		x
13. <i>Premna tomentosa</i> ..									x	x	x	
14. <i>Pityranthe verrucosa</i> ..					x	x	x					
Total { Leaf-fall ..	4	2	6	7	10	9	7	4	5	6	5	3
{ Reflush ..	7	5	5	5	7	6	5	5	6	5	7	6

Table 17.—Seasons of Leaf-fall and Reflush of the evergreen and Semi-evergreen Species

(Leaf-fall — x ; Reflush — o)

<i>Species</i>	<i>J</i>	<i>F</i>	<i>M</i>	<i>A</i>	<i>M</i>	<i>J</i>	<i>J</i>	<i>A</i>	<i>S</i>	<i>O</i>	<i>N</i>	<i>D</i>
1. <i>Eugonia bracteata</i>	.. x o	x									x	x
2. <i>Diospyros ebenum</i>	.. x o	x o	x o	o								
3. <i>Aglaia roxburghiana</i>	..								x	x	o	o
4. <i>Walsura piscidia</i>	.. x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o
5. <i>Nephelium gardneri</i>	.. x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o
6. <i>Gleniea unijuga</i>	..		x	x o	o	o						
7. <i>Pleurostylia opposita</i>	.. o	o	o	o	o	o	x o	x o	x	x	x	x
8. <i>Lepisanthes tetraphylla</i>	.. x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o
9. <i>Sapindus emarginatus</i>	..	x o	x o				x o	x o	x o			
10. <i>Alseodaphne semecarpifolia</i>	x o	x o	x o	x o	x o	o	o	o	o	o	o	x o
11. <i>Manilkara hexandra</i>	.. x o	o	o								x	x o
12. <i>Hemicyclia sepiaria</i>	.. x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o
13. <i>Vatica obscura</i>	.. x	x	o	o	o	o						x
14. <i>Schleichera oleosa</i>	.. x	x	x o	x o	o	o						
15. <i>Diospyros ovalifolia</i>	.. x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o	x o
16. <i>Syzygium cumini</i>	.. x o	x o	x o	x o	x o	x o	o					
Total	{ Leaf-fall Reflush	.. 12	12	11	9	7	6	7	7	8	7	10
		.. 11	11	13	12	11	11	9	8	7	6	8

REFLUSH

IN the deciduous species in general, foliar renewal took place more regularly than leaf-fall. Pronounced foliar renewal was observed at the same time or immediately after leaf-fall and took place at about this time even in years in which leaf-fall activity was not marked. In addition reflush also took place later in the year during the rains. In some years this second period of reflush took place on some trees in addition to the earlier flush. In most trees the individual trees had only one or other of these periods of reflush. The result of this variation in the behaviour of the individual trees is the extended periods of reflush of the species.

Table 16 sets out the seasons of reflush of the deciduous species. More species were observed in new leaf during the rains in May-June and November-January than in other months but in every month of the year, at least 5 out of the 15 species were observed putting on new leaf. Table 16 only included pronounced activity in foliar renewal. In many cases if less intense foliar activity were taken into account, most species, particularly *Vitex pinna'ta*, *Chloroxylon swietenia*, *Grewia polygama* and *Pterospermum canescens*, were observed reflushing throughout the year. This was due to the asynchronous behaviour of the individual trees and not to extended periods of flush on the individual tree. Each tree generally puts on new leaf for 2, 3 or 4 months after leaf-fall, during the rains or rarely at both times.

Most evergreen species were observed in new leaf from January to June (Table 17) but a fair number of species were observed reflushing in every month of the year. Species like *Hemicyclia sepiaria*, *Lepisanthes tetraphylla* and *Sapindus emarginatus* did not show a pronounced period of leaf-fall. The individual tree flushed for 2 to 3 months once or twice in the year. In general, foliar renewal took place every year and was more regular than leaf-fall. Details of the leaf change behaviour of the individual species is given in the phenological notes on species.

CONCLUSIONS

THIS survey of the foliar activity in the Dry Mixed Evergreen Forest illustrates the irregular periodicity, the considerable variation and lack of synchronisation in the behaviour of species and individuals. The same general relationship was noted in the Wet Evergreen Forest where it was concluded that foliar activity is an expression of the internal physiological requirements of the species which in turn is influenced by the climatic factors. The evidence of foliar activity in the Dry Mixed Forests suggests a similar conclusion. Under the relatively more seasonal climate, the influence of rainfall and humidity on this behaviour is more obvious than in the Wet Evergreen Forest.

Leaf-fall takes place after low monthly rainfall (below 4.6 ins.) and/or low humidity (below 76 per cent) while the critical limits of the two factors acting together are 2.2 inches of monthly rainfall and 72.3 per cent relative humidity. Wright's (1905) conclusion of the importance of rainfall and relative humidity in explaining foliar phenomena in the Tropics has been referred to earlier.

Krishnasamy and Mathauda (1954) find that in the sub-tropical climate of Dehra Dun "there is no universal leafless period at the New Forest and it appears that the inherited traits are more powerful than the influence

of the factors of the locality". Examination of the data given by them (Table 18) show that four of the 20 species start shedding their leaves in November when the rainfall is 0.1 inch, the relative humidity 66 per cent and the temperature 61° F. During December and January when the mean temperature is below 55° F and much lower absolute temperatures prevail and the relative humidity rises to between 75 and 76 per cent, only 3 other species started shedding leaf. In February with a general increase in the mean temperature and a drop in the relative humidity, 4 species commenced leaf-shedding while in March with the mean monthly temperature at 64° F and a relative humidity of 62 per cent, 8 species began to shed their leaves. The influence of low humidity and related rainfall on leaf-fall would appear to be evident. The small number of species which shed their leaves during December and January may possibly be due to the low temperatures in those months.

It is interesting to note the relation between the soil moisture regime as computed by Thornthwaite's (1948) method and leaf-fall. From Figures 5 to 7, it is seen that the trend of water surplus and deficit in the soil expresses the interaction between relative humidity and rainfall. It is also noticed that leaf-shedding activity is pronounced when the moisture stored in the soil is being used by the plants or about the time the soil moisture deficit sets in. The soil moisture regime appears to offer a suitable explanation for the influence of rainfall on leaf-shedding. Apparently when the soil moisture reaches a certain level the plants commence to shed their leaves. The prevailing humidity and the physiological conditions of the species determine the level of soil moisture at which each species starts to shed its leaf. Table 18 compiled from the data of Krishnasamy and Mathanda (1954) illustrates this explanation for the species at Dehra Dun. It will be noticed that the species commence shedding leaf when soil moisture is being utilized and the humidity low. Another feature of interest in evaluating the significance of the Thornthwaite classification is the similarity of the foliar behaviour of plots in the same climatic type.

Table 18.—Summary of Phenological and Climatic data at Dehra Dun

(compiled from Krishnasamy and Mathanda, 1954)

	J	F	M	A	M	J	J	A	S	O	N	D
No. of species shedding leaves ..	6 ..	6 ..	12 ..	12 ..	4 ..	— ..	— ..	— ..	— ..	— ..	3 ..	5
No. of species which start shedding leaves ..	2 ..	4 ..	8 ..	1 ..	— ..	— ..	— ..	— ..	— ..	— ..	4 ..	1
No. of species in new leaf ..	— ..	2 ..	6 ..	11 ..	16 ..	13 ..	7 ..	— ..	— ..	— ..	— ..	—
No. of species which start putting on new leaf ..	— ..	2 ..	6 ..	5 ..	7 ..	— ..	— ..	— ..	— ..	— ..	— ..	—
No. of species in flower ..	— ..	2 ..	12 ..	7 ..	1 ..	1 ..	2 ..	3 ..	3 ..	— ..	— ..	—
Rainfall in inches ..	2.7 ..	2.3 ..	1.3 ..	0.9 ..	1.7 ..	8.1 ..	26.1 ..	26.8 ..	11.3 ..	1.3 ..	0.1 ..	1.2
Humidity % ..	79 ..	76 ..	72 ..	48 ..	43 ..	61 ..	85 ..	89 ..	82 ..	68 ..	66 ..	75
Temperature °F ..	51 ..	55 ..	64 ..	73 ..	81 ..	81 ..	78 ..	77 ..	75 ..	69 ..	61 ..	54
Water surplus * ..	— ..	0.5 ..	— ..	— ..	— ..	— ..	18.1 ..	21.6 ..	6.8 ..	— ..	— ..	—
Water deficit * ..	— ..	— ..	— ..	— ..	3.1 ..	— ..	— ..	— ..	— ..	— ..	— ..	—

* Compiled according to Thornthwaite (1948).

The evidence of the influence of rainfall and humidity on foliar renewal in the Dry Mixed Evergreen Forest is similar to that in the Wet Evergreen Forest and leads to similar conclusions. Under the prevailing temperature conditions, high rainfall and humidity provide suitable climatic conditions for the initiation of reflush activity which may take place during the dry ensuing weather.

FLOWERING

TABLE 19 and Table 21 set out the average monthly values for the period 1942 to 1951 of the phenological indices for flowering and fruiting in the 22 plots under observation in these forests. Figures 5 to 7 illustrate the average monthly trend of flowering and fruiting and the climatic factors—rainfall, humidity, temperature and soil-moisture at 6 plots.

As compared with the relatively aseasonal character of flowering in the Wet Evergreen Forest, flowering in the Dry Mixed Evergreen Forest was markedly seasonal. Although a slight incidence of flowering was noted in almost every month, the intensity during 3 to 4 months was so pronounced even in the average figures for the 10 years 1942 to 1951, as to characterise it as a season of flowering.

The maximum incidence of flowering took place in most plots during March/April and May about the same time as the main season of foliar change. In the 4 plots on the east coast Vellamalai, Thirucholai, Kayanwadi, and Lahugala, maximum flowering was in June/July. A similar lag was observed in leaf change activity in these plots. At Inamaluwa on the border of the intermediate Zone, there were 2 peaks of a flowering. The first was in February about the same time as maximum flowering in the Wet Evergreen Forest, while the second peak was in August/September which is intermediate between the period of flowering of the plots on the East Coast and the start of the main flowering period in November in the Wet Evergreen Forest. Schimper's (1903) analysis of the times of flowering of woody plants in the dry districts of Ceylon recorded in Trimen's Flora (Table 20) indicates 2 seasons of flowering in February/April and July/September respectively. This is not borne out by the average values of the phenological indices for flowering (Table 19) or by the seasons of flowering of the species (Table 20) which indicate a single season of flowering in April/July in these forests.

Table 19.—Average (1942-1951) Monthly Values of the Phenological Indices for Flowering in the Dry Mixed Evergreen Forest

Plot	J	F	M	A	M	J	J	A	S	O	N	D
1. Madhu	3.5	13.2	34.2	37.7	28.4	7.4	0.5	0.1	—	0.9	0.9	2.2
2. Puwasankulam	9.7	10.1	13.0	20.5	15.1	6.2	1.5	2.2	2.9	5.3	5.1	7.6
3. Pnttalam	1.7	2.8	3.3	35.7	64.8	38.8	13.9	1.6	0.2	0.1	0.4	1.9
4. Kilinochchi	1.4	5.1	17.5	25.0	25.2	14.4	7.8	1.4	2.4	0.2	0.3	0.3
5. Iranamadu	0.8	4.2	25.3	24.8	20.5	17.1	9.4	4.0	2.7	0.2	0.6	0.5
6. Vannivilankulam	31.7	14.3	28.0	10.0	17.0	20.0	5.8	1.6	1.6	4.8	4.8	4.6
7. Terravil-Oddusudan	1.0	—	2.5	10.6	7.0	8.3	2.4	0.5	0.8	1.7	1.4	2.7
8. Nagancholai	5.0	6.4	9.6	9.4	11.2	14.5	9.9	9.0	4.0	2.9	2.4	2.3
9. Tonigala	1.9	0.4	1.9	12.5	12.7	9.3	4.4	7.8	4.2	6.5	6.5	2.6
10. Vellamalai	0.4	0.8	0.6	1.3	2.9	6.8	13.6	10.8	8.8	4.3	2.6	0.3
11. Thirucholai	1.0	2.1	3.9	7.4	6.2	6.1	9.9	6.9	7.7	4.8	1.9	1.0
12. Nuwaragam	8.3	11.4	14.3	21.1	16.3	12.8	6.5	5.9	4.2	2.6	3.1	8.0
13. Mihintale	1.5	1.5	2.0	14.0	10.0	6.8	3.0	0.1	1.3	1.3	1.3	0.8
14. Medawachchiya	0.6	1.3	3.4	6.7	11.3	11.5	4.9	3.0	5.2	2.0	3.6	1.9
15. Galoya	0.2	0.6	0.9	7.9	10.6	7.0	1.0	0.5	0.5	0.5	0.8	0.9
16. Hurulu	0.5	1.3	5.0	12.4	18.8	11.7	2.1	4.4	3.9	1.4	1.4	1.6
17. Padawiya	0.2	0.1	1.1	5.7	8.1	1.9	14.4	8.0	4.0	2.4	1.1	1.6
18. Kayanwadi	0.6	0.8	1.8	2.4	3.6	5.6	4.9	3.3	2.8	3.2	0.3	1.6
19. Lahugala	2.8	2.7	2.3	1.7	2.8	7.0	3.7	0.6	0.3	1.2	1.0	2.7
20. Inamaluwa	1.1	8.0	0.6	0.1	2.1	3.5	1.9	7.6	12.8	6.1	4.9	0.2
21. Daragoda	2.6	0.7	0.3	1.9	2.8	0.4	0.4	1.9	2.1	3.6	1.6	1.2
22. Tiralliodai	0.8	1.7	1.5	7.6	18.2	18.2	7.4	6.9	2.0	1.7	4.2	2.1

Although the maximum intensity of flowering was in April/May, for most plots of the Dry Zone a marked increase in the incidence of flowering took place about February/March. This was about the same time as maximum leaf-fall activity and was associated with similar climatic conditions, namely, 1 to 2 dry months with rainfall below 4 inches during the short dry period before the main season of drought and sharp decrease in the relative humidity to between 67 to 73 per cent from 76 to 81 per cent in December/January. The delay in the incidence of flowering in plots on the East Coast was associated with higher relative humidity and rainfall at these plots than was general for the other plots. It seems most likely that low rainfall and humidity provided conditions suitable for flowering. It is also interesting to note that flowering commenced when the moisture in the soil, computed according to Thornthwaite (1948), was being used or in deficit (Figures 5, 6 and 7).

The maximum intensity of flowering was reached during the rainy weather which followed the dry weather at the beginning of the year. At this time there was over 4.5 inches of rain during the pre-monsoonal rains.

Detailed monthly values of the phenological indices for flowering and fruiting from 1942 to 1951 in the 22 plots under observation are given in Appendix 1 while the corresponding data for rainfall, temperature and humidity are given in Appendix 2. Examination of the detailed monthly values shows that flowering is irregularly periodic. The irregularity of this periodicity is less so than in the Wet Evergreen Forests and was more regular in the drier plots, e.g., Madhu, Iranamadu.

The detailed record also confirms the general relation between the low rainfall and humidity and flowering noted earlier from a study of the average data for the 10 year period 1942 to 1951. Figures 8, 9, and 10 illustrate this relationship from 1945 to 1951 at Iranamadu, Mihintale and Lahugala. Flowering commenced when the relative humidity was below about 75 per cent and/or the monthly rainfall below 4 inches and reached its maximum intensity at all plots one to 2 months later during a peak of rainfall and/or peak of relative humidity. The intensity of flowering was low when either the rainfall or humidity or both were particularly high at the time of maximum flowering, e.g., Iranamadu (1949).

The relationship between rainfall and relative humidity and flowering was tested by plotting the regression of the 2 highest values of the flowering index from 1945 to 1951 against the corresponding monthly rainfall and relative humidity (Figure 13). The values were 'corrected' (as explained earlier) by using the lower of the values of rainfall and humidity during the month of maximum flowering and the previous one. The scatter of the points show that there is no relation between the intensity of flowering and the values of rainfall and relative humidity, but maximum flowering irrespective of its intensity was associated with a certain range of monthly rainfall and relative humidity. The 5 per cent significance limits of this range were 68 to 76 per cent relative humidity and 0.2 to 3.8 inches of rainfall. If, as pointed out earlier, the distribution of the points at the lower end of the scale were discounted and the third of the points of maximum flowering associated with the highest values of rainfall and humidity were excluded, the significant limit of monthly rainfall is 3.3 inches and that of relative humidity 73.2 per cent. The probability of a chance occurrence of a monthly rainfall of 3.3 inches was 1 in 2 and of relative humidity 73.2 per cent 1 in 2.6.

The interaction of the rainfall and humidity on flowering by determining equivalent values, as explained earlier, is expressed in Figure 14. All the values of flowering now fall within the original 5 per cent significance

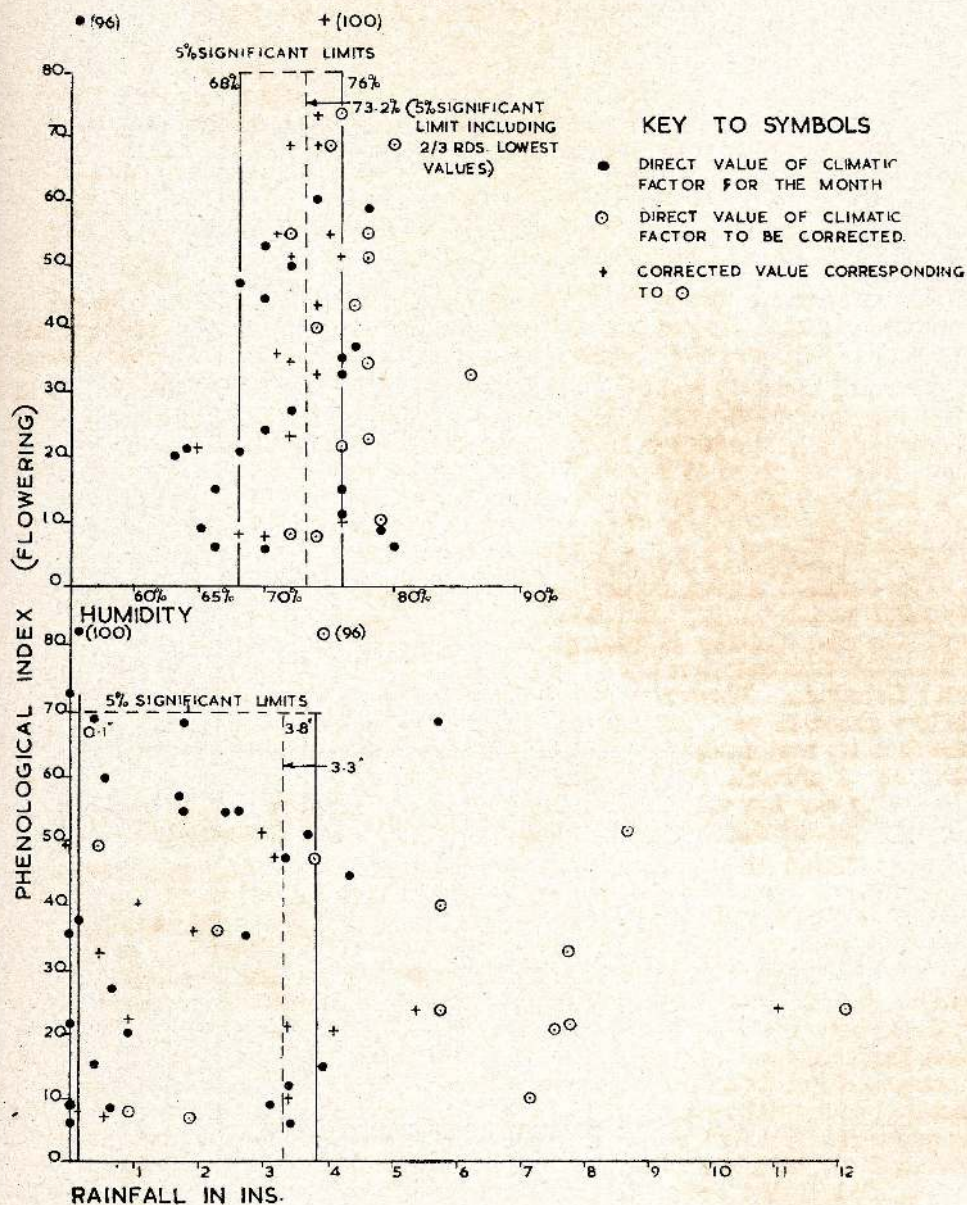
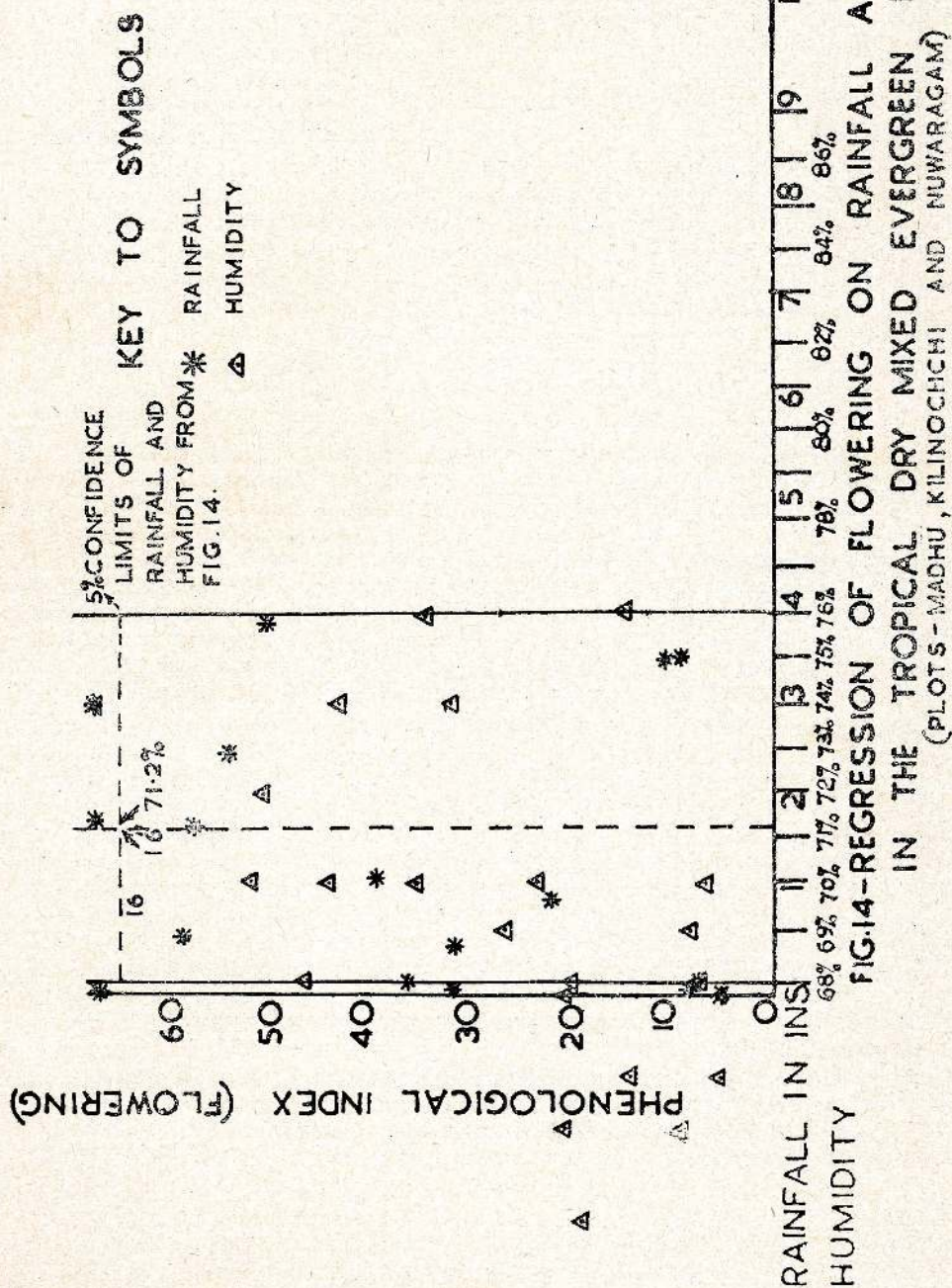


FIG.13 REGRESSION OF FLOWERING ON RAINFALL AND HUMIDITY
IN THE TROPICAL DRY MIXED EVERGREEN FOREST
(PLOTS MADHU KIIINOCYCHI AND NUWARAGAM)



limits of either rainfall or humidity. The 5 per cent significant limits of the 2 factors operating together is 1.62 inches of rainfall and 71.2 per cent relative humidity. 21 values of relative humidity, 17 values of rainfall and 2 points in which the equivalent values of rainfall and humidity were considered, were used in the expression of the interaction of these 2 factors on flowering.

TABLE 20.—Seasons of Flowering and Fruiting of the Species in the Dry Mixed Evergreen Forest

(Flowering—x Fruiting—0)

Species	J	F	M	A	M	J	J	A	S	O	N	D
<i>Deciduous Species</i>												
1. <i>Holoptelea integrifolia</i> ..						x	x	x0	0		0	
2. <i>Grewia polygama</i> ..	0	0	0	x	x	x	x	0	0	x	0	x
3. <i>Cassia fistula</i> ..	0	0	0		0	x	0	x	0	x	0	0
4. <i>Mitragyna parvifolia</i> ..					x	x	x	0	x	0	0	0
5. <i>Berrya cordifolia</i> ..						x	x	x	x	0	0	0
6. <i>Chukrasia tabularis</i> ..						x	x	x	x		0	0
7. <i>Adina cordifolia</i> ..	0	0	0	0	0	x	x	x		x	x	x
8. <i>Bridelia retusa</i> ..				x	x	x	x	0	0	0		
9. <i>Vitex pinnata</i> ..	x	0	0	0		x	x	x	0	x	0	x
10. <i>Chloroxylon swietenia</i> ..			x	x	x	x	0	0	0			
11. <i>Pterospermum canescens</i> ..					x	x	x	0	x	0	0	0
12. <i>Sapium insigne</i> ..			x	x	x	0	x	0	0			
13. <i>Premna tomentosa</i> ..				x	x	x	x		0	0	0	
14. <i>Pityranthe verrucosa</i> ..	x	0	x	0	0							
Total (Flower ..	2	1	2	5	8	12	11	8	4	3	3	3
Fruit ..	5	5	5	2	3	3	5	10	10	10	8	7
<i>Semi-evergreen Species</i>												
15. <i>Schliechera oleosa</i> ..			x	x	x	0	x	0	0			
16. <i>Diospyros ovalifolia</i> ..	x	0	0	0					x	x	x	x
17. <i>Syzygium cumini</i> ..						x	x	x	x	0	0	0
<i>Evergreen Species</i>												
18. <i>Eugenia bracteata</i> ..					x	x	x	x	0	0	0	
19. <i>Diospyros ebenum</i> ..			x	x	x	x	0	0	0			
20. <i>Aglais roxburghiana</i> ..			x	x	x	x	0	0	0			
21. <i>Walsura piscidia</i> ..		x	x	x	x	0	0	0	0			
22. <i>Nephelium gardneri</i> ..				x	x	0	x	0	0	0	0	0
23. <i>Gleniea unijuga</i> ..	0	0	0						x	x	x	x
24. <i>Pleurostylia opposita</i> ..				x	x	x	x	0	0	0	x	0
25. <i>Lepisanthes tetraphylla</i> ..				x	x	x	0	0	0	0		
26. <i>Sapindus emarginatus</i> ..			x	x	x	0	x	0	0			
27. <i>Alseodaphne semecarpifolia</i> ..			x	x	x	0	x	0	0	0	0	
28. <i>Manilkara hexandra</i> ..	x	x	x	x	x	0	0	0	0			
29. <i>Hemicyclia sepiaria</i> ..			x	x	x	0	0	0	0	0	0	
30. <i>Vatica obscura</i> ..				x	x	x	x	0	0	0	0	
Total (in flower) ..	2	2	8	12	13	11	6	2	3	3	3	3
Evergreen and Semi-evergreen (in fruit) ..	2	2	2		6	6	11	13	11	6	3	2
Total Species (in flower ..	4	3	10	17	21	23	17	10	7	6	6	6
in fruit ..	7	7	7	2	9	9	16	23	21	16	11	9
Number of woody species in flower according to Schimper ..	57	92	77	77	49	48	83	79	61	20	25	39

BEHAVIOUR OF THE SPECIES

TABLE 21 gives the periods of flowering of the species under observation in the Dry Mixed Evergreen Forest. Schimper's analysis of the numbers of woody plants in the dry lowlands flowering in the different months of the year, compiled from Trimen's Flora of Ceylon, are included for comparison. As pointed out earlier the 2 flowering periods in Schimper's analysis are not borne out by the evidence in the present study. Perhaps the inclusion of the woody shrubs and sub-storey species, which are generally less seasonal in their behaviour, in Schimper's analysis, may be responsible for the difference noted.

Most of the deciduous species flowered during May/August while the evergreen species flowered mainly from March to June. This was associated with the earlier season of leaf change in the deciduous species. *Vitex pinnata*, *Cassia fistula* and *Berrya cordifolia* were recorded in flower throughout the year although flowering was pronounced during the season of 3 to 4 months. The other deciduous species had a more definite flowering season of 3 to 4 months in the year. On the other hand in the evergreen species, flowering was restricted to a definite season, March/June, except *Pleurostyliya opposita* which was observed in flower in April/July and November/December.

The diffused flowering periods of species was due to the asynchronous behaviour of the trees. No individual tree was observed in flower throughout the year. Each individual flowered once for about 2 to 3 months in a year. In *Berrya cordifolia*, *Diospyros ebenum* and *Pleurostyliya opposita*, some individuals flowered twice in a year in 1 or 2 of the 10 years they were under observation.

There was variation in the frequency of flowering in different species. Individual trees of most species flowered in about 6 of the 10 years. Many individuals of *Vitex pinnata*, *Chloroxylon swietenia*, *Berrya cordifolia* and *Chukrasia tabularis* did so in about 8 to 9 of the 10 years. Trees of *Pterospermum canescens* were variable in their behaviour. Some individuals flowered only twice while others in the same plot did so more often.

The individual trees had a fairly regular cycle of about 10 to 16 months, mostly about 11 to 12 months. *Diospyros ovalifolia* had a cycle of 11.5 months, with a standard deviation of ± 1.05 . Other species with similar regular cycles were *Chukrasia tabularis*, *Adina cordifolia*, *Chloroxylon swietenia*, *Pterospermum canescens*, *Alseodaphne semecarpifolia*, *Hemicyclia sepriaria*, *Eugenia bracteata* and *Diospyros ebenum*. The cycle was interrupted irregularly by 1 to 2 years without any flowering.

RELATION BETWEEN FOLIAR AND FLOWERING ACTIVITY

There was usually a constant relation between flowering and foliar change in the individual tree. In most of the deciduous species, flowers occurred after the flush of new leaf while leaf-fall followed fruiting. In *Chloroxylon swietenia* and *Sapium insigne*, flowering occurred when the trees were bare or just putting on new leaf, while fruiting occurred just before leaf-fall. In all the evergreen species under observation, flowering took place while the trees were putting on new leaf or immediately after they had reflushed. In fact, as was noted in the behaviour of the species in the Wet Evergreen Forest, perhaps the most uniform characteristic of the phenological behaviour of the species in the Dry Mixed Evergreen Forest was the sequence of foliar and flowering activity.

FRUITING

The phenological indices for fruiting for the period 1942 to 1951 are set out in Table 21. Figures 5 to 7 illustrate these values and the corresponding values of rainfall, temperature and humidity in 6 plots. The detailed monthly values of the phenological indices for fruiting in the 22 plots under observation is given in Appendix 1. Figures 8, 9, and 10 illustrate the detailed values of the fruiting indices from 1945 to 1951 and the corresponding values of rainfall, humidity, and temperature at Iranamadu, Mihintale and Lahugala. Peaks of fruiting follow flowering and shows a similar irregular periodicity. The maximum incidence of fruiting was associated with the hot dry weather during the main period of drought and took place 1 to 3 months after a peak of rainfall. According to the soil moisture regime (Figures 5 to 7), fruiting commenced and reached a peak during the period of water deficit in the soil.

Table 21.—Average (1942-1951) Monthly Values of the Phenological Indices for Fruiting in the Dry mixed Evergreen Forest

Station	J	F	M	A	M	J	A	S	O	N	D		
1. Madhu ..	..	—	3.3	0.7	1.5	7.4	25.5	36.6	30.6	9.8	1.4	0.3	0.0
2. Puwarasankulam	..	4.4	5.8	4.1	1.9	1.4	6.3	12.7	8.3	3.5	0.7	0.6	0.8
3. Puttalam	..	—	—	1.9	0.7	3.3	8.8	21.6	33.9	33.0	28.8	23.8	2.8
4. Kilinochchi	..	0.2	0.2	0.7	1.0	8.2	15.7	30.1	29.2	18.9	9.2	4.5	2.4
5. Iranamadu	..	0.1	0.2	0.2	3.0	6.1	18.0	32.0	29.2	20.6	12.5	7.9	4.3
6. Vannivilankulam	..	1.6	1.6	4.7	31.6	14.3	14.8	14.8	33.7	7.1	7.1	0.1	—
7. Terravil-Oddusudan	..	4.6	4.8	6.9	4.0	2.0	2.8	3.7	4.3	2.4	2.5	—	0.5
8. Nagancholai	..	4.1	0.4	—	0.1	2.9	11.5	18.5	26.6	16.0	7.3	—	6.8
9. Tonigala	..	8.9	5.5	3.7	2.3	0.4	3.1	14.0	7.7	6.2	3.6	3.3	3.5
10. Yellamalai	..	0.3	0.3	0.2	0.1	0.4	0.6	0.8	1.7	5.2	7.6	6.6	5.6
11. Thirucholai	..	1.8	1.2	0.4	0.5	0.9	0.8	1.3	1.2	0.5	2.0	3.2	3.7
12. Nuwaragam	11.7	5.3	7.0	7.1	10.8	9.8	14.3	13.3	4.7	3.9	2.9	2.2	
13. Mihintale	..	1.6	1.0	0.8	—	1.5	3.9	7.8	9.0	3.2	1.9	0.4	1.5
14. Medawachchiya	13.5	6.0	4.6	5.2	7.4	8.2	1.3	13.1	9.1	6.8	4.1	3.6	
15. Galoya ..	..	0.6	0.5	0.5	0.7	1.8	1.1	5.7	3.6	2.3	3.0	0.9	0.5
16. Hurulu	..	0.8	0.6	0.6	0.7	2.5	4.2	7.2	3.9	3.6	4.1	1.9	1.7
17. Padawiya	..	4.0	—	0.2	1.4	4.5	4.1	4.6	10.0	14.3	13.6	8.8	4.2
18. Kayanwadi	..	1.7	1.7	0.7	0.2	0.4	1.9	2.6	2.1	3.6	3.6	2.3	1.2
19. Lahugala	..	0.5	2.0	2.4	2.7	0.4	1.9	6.7	6.2	5.1	1.6	0.3	0.6
20. Inamaluwa	10.3	9.7	10.7	3.6	1.3	2.4	1.1	1.0	8.9	7.7	8.7	11.7	
21. Daragoda	..	2.6	3.3	2.7	1.6	1.3	3.6	7.4	5.3	1.6	0.8	1.9	2.5
22. Tiralliodai	4.0	1.6	0.4	0.5	0.2	2.2	6.7	7.1	7.1	5.8	3.6	3.0	

Table 20 gives the seasons of fruiting of the individual species. The main season of fruiting in most species was in July/September during the main period of drought and immediately preceding the north-east monsoon rains. Three of the 30 species, *Adina cordifolia*, *Pityranthe verrucosa* and *Gleniea unijuga* were in fruit during January/March in time for the premonsoonal showers in August/May. *Grewia polygama*, *Cassia fistula*, *Berrya cordifolia* and *Vitex pinnata* were also in flower at this time but the main season of fruiting of these species was later in the year.

Germination studies by Holmes (1954) shows that seed of many of the tree species of the Dry Mixed Evergreen Forest e.g. *Berrya cordifolia*, *Cassia fistula*, *Chloroxylon swietenia*, *Manilkara hexandra*, *Vitex pinnata*, and *Hemicyclia sepiaria*, retain their viability for over 2 months. Seed of *Alseodaphne semecarpifolia* and *Diospyros ebenum*, on the other hand does not keep for long. These species fruit in August/September just before the rains. The suggestion by Holmes (1942) that fruiting of most species is not appropriate to the rainfall is not necessarily well founded, nor can such evidence be accepted as indicating that climate has no influence on fruiting.

RESPONSE TO THE FREEING OF THE CROWNS

COMPARISON of the observations of the flowering and fruiting from 1942 to 1946 with those for 1947 to 1951 after isolation of the crowns was done indicates that no species showed any marked response. As pointed out earlier, all that was done was the freeing of crowns of trees under observation from interference by neighbouring trees. No attempt was made to isolate the crowns completely as in "Seeding-Fellings", until the phenological behaviour of the species and its relation to the climatic conditions was studied. The considerable variability of the behaviour of trees in different years which is evident from the present study, further emphasises the need for a proper control plot in the immediate vicinity of the treated plot. Further, the phenological record of the trees compiled in the present study will be a means of assessing the suitability of trees and plots for such a study.

SUMMARY AND CONCLUSIONS

THE survey of the evidence on flowering and fruiting in the Dry Mixed Evergreen Forest shows the irregular periodic nature of this behaviour. Flowering commences about the same time as the peak of leaf-fall and was associated with similar climatic conditions namely 1 to 2 dry months with less than 4 inches of rain and/or 76 per cent relative humidity under the relatively high equable temperatures prevailing. The critical limits of the 2 factors working together is 1.62 inches rainfall and 71.2 per cent relative humidity.

The soil moisture regime according to Thornthwaite [1948] shows that flowering and fruiting took place when soil moisture regime was in deficit. The soil moisture regime offers a probable explanation for the manner in which rainfall controls flowering behaviour.

The variation in the flowering behaviour of species and individuals and the tendency towards a constant cycle of flowering indicate the influence of internal conditions. The most plausible explanation for the flowering

behaviour in the trees of the Dry Mixed Evergreen Species is that suggested by J. R. & I. Baker (1936). The readiness to flower is determined by the physiological rhythm of the plant while the time of flowering is the result of the influence of climatic factors.

There have been very few observations of fruiting in forest formations. Schimper (1903) found that : (1) in Java 63 percent of the species flowered in the dry season ; (2) in India 51.2 percent of the species flowered in March/May during which months the rainfall was only 6.4 percent of the total rainfall for the year.

Krishnasamy and Mathauda (1954) in a study of the phenological behaviour of 17 tree species at Dehra Dun conclude that "higher mean temperature in the short period preceding the normal date of occurrence of the phenomenon tend to advance new leafing and flowering. Low rainfall and low relative humidity also appear to exercise a similar influence, though it may not be marked in some cases. Low temperatures, high rainfall and humidity have an opposite effect". The relation between the number of species in flower in the different months, the corresponding values of rainfall temperature, humidity and the water surplus and deficit, according to Thornthwaite (1948) is given in Table 18. The maximum number of species were in flower in March when there was a deficit of rainfall on the potential evapotranspiration and the moisture stored in the soil was being used to offset this deficit. It is interesting to note that despite different conditions of the climatic factors, the relation between the soil-moisture regime and the flowering of the trees species in the Dry Mixed Evergreen Forest of Ceylon and in the sub-tropical climate of Dehra Dun is similar. This further confirms the findings of the present study on the influence of the climatic factors on flowering and the phytoclimatic significance of Thornthwaite's concept of potential evapotranspiration.

PHENOLOGICAL NOTES ON SPECIES OF THE DRY EVERGREEN FOREST

Phenological notes on 1,261 trees of 25 species are given below. (Local names in brackets ; S = Sinhalese T = Tamil)

Dipterocarpaceae

1. *Vatica obscura*, Trim — (T. Tumpalai).

Distribution :—32 trees at Tiraliadai.

This is an evergreen species. It is the only member of the Dipterocarpaceae in the Dry Zone. Shedding of leaves was observed from December to February especially January and new leaves in March/June.

The pronounced season of flowering was in April/May. Flowers were recorded from April to July. In 1949 flowers were recorded a second time in the year in November/December on 14 trees. Trimen records flowers in June. The main season of fruiting was in September/November with a few observations in July and August.

Flowering takes place in great profusion and the trees are very conspicuous in flower. Fruiting is abundant but fruits may fall off before maturity. The fruits are generally attacked by insect borers.

Sterculiaceae

2. *Pterospermum canescens*, Roxb. — (S. Velang).

Distribution : 50 trees at Sellankandal, Terravil-Oddusudan, Vellamalai, Kayanwadi, Thirucholai, Gal-oya, Iranamaduwa and Nikaweratiya.

This is a facultative deciduous species. Leaf shedding has been recorded in every month of the year on one or other tree of this species. The individual tree sheds its leaves gradually for one or two months and had a crown density of $\frac{1}{4}$ to $\frac{1}{2}$. In some the intensity of leaf-fall was much less. The time of leaf shedding varied from one plot to another. Most observations were in May/June.

The season of flowering was from May to August particularly June/July. Flowers were also observed in April and September. Trimen records flowers in May. Fruits were seen from July to December mostly from August to November. The frequency of flowering in the individual tree varied from regular flowering almost every year to sporadic flowering in only 1 or 2 of the 10 years they were under observation. Flowers and fruits were observed in 4 year old plants of this species planted in the research gardens.

Tiliaceae

3. *Grewia polygama*, Roxb.—(S. Boradaminia).

Distribution : 37 trees at Sellankandal, Tonigala, Gal-oya and Mihintale.

A deciduous species. Leaf-fall was recorded at all times of the year mainly during May/August. All the trees in a plot generally shed their leaves at the same time. The cycle of leaf-fall varied from 7 to 17 months. Reflush followed a month or two after leaf-fall. Most observations of reflush were from September to March, mainly January.

Flowers were observed at all times of the year due to the variation in the time of flowering in the different plots. At Sellankandal flowering was mainly in May/June, at Galoya and Mihintale in October/December, at Tonigala in July/August in some years and October/November in others. At Sellankandal some trees flowered twice in a year. Flowering took place in about 5 to 10 years of the 10 year period of observation. Fruiting followed flowering and was recorded in every month of the year particularly from November to January. It took place on average in about 5 of the 10 years.

4. *Berrya cordifolia*. Burret—(S. Halmilla).

Distribution : 33 trees at Vellamalai, Kayanwadi, Thirucholai, Lahugala and Nikaweratiya.

A deciduous species with leaf-fall during April/June and September/November. There was no definite cycle of leaf-fall on the individual tree. For example, tree number 15 at Lahugala showed the following behaviour :—

1942—October, 1943—September, 1944—Nil, 1945—September, 1946—Nil, 1947—Nil, 1948—April, 1949—May, 1950—October, 1951—May. In general in most trees the variation in the time of leaf-fall was around the main season of leaf-fall April/June and September/November without

many observations in the intermediate months. Reflush followed leaf-fall with May/July and November as the main seasons of foliar renewal for the species in general. Wright (1905) records a leafless period of 3 to 10 weeks in 2 trees of this species at Peradeniya.

Flowers were observed in every month of the year. The main season of flowering was from June to September with most observations in July/August. Fruiting was more pronounced during October/December than at other times of the year.

Individual trees were in flower in 4 to 8 out of the 10 years they were under observation. The time of flowering varied regularly. In most years it was in June/August but in some years it took place in March/April. In a few cases flowers were observed twice during the year. Flowering earlier in the year was not generally followed by fruiting. Fruiting took place on average in about 5 of the 10 years of observation.

The individual trees bore flowers for 2 to 3 months just after the flush of new leaf while leaf-fall began about the time when the mature capsules were shedding their seed.

Meliaceae

5. *Walsura piscidia*, Roxb. (S. Kirikon).

Distribution : 39 trees at Madhu, Kilinochchi, Iranamadu, Kayanwadi, Thirucholai and Nikaweratiya.

An evergreen species. Leaf shedding is not pronounced but from time to time there is a perceptible shedding of a fair proportion of leaf. This did not take place in any regular cycle. Most observations of leaf-fall were in January/February. Reflush was observed throughout the year particularly during February.

Flowering took place from February to May and was at its height in March/April. Flowers were also observed in January and June/July. Ripe fruits were observed from May/September particularly during the dry season in July/August. The results confirm these determined earlier by Holmes (1942) from en masse observation.

Analysis of the behaviour of individual trees shows that flowering took place in 7 out of the 10 years on most trees on a cycle of approximately 12 months or a multiple of 12. Flowers set fruit in the same year. Fruiting took place almost every year in which flowers were observed.

6. *Chukrasia tabularis*, A. Juss. (S. Hulanhik).

Distribution : 10 trees at Vellamalai and Daragoda.

A facultative deciduous species it shed its leaves during March/April at Vellamalai and during July/August at Daragoda. The intensity of leaf-shedding varied. In 4 to 5 of the 10 years more than half the leaf on the crown was shed. In other years the intensity of leaf shedding was much less.

Flowers were observed during July/September at Vellamalai and during September/October at Daragoda. Fruiting took place in October/December and February/May respectively.

7. *Chloroxylon swietenia*, D. C.—(S. Buruta, T. Mutirai).

Distribution : 194 trees at Madhu, Puwarasankulam, Puttalam, Kilinochchi, Iranamadu, Tonigala, Vannivilankulam, Terravil-Oddusudan, Nagancholai, Vellamalai, Nuwaragam, Mihintale, Gal Oya, Hurulu, Medawachchiya, Lahugala and Inamaluwa.

This is a deciduous species which sheds all its leaves and is completely bare for two weeks to a month. Leaf-fall was observed to be prominent during January/May. A few observations of leaf-fall were made in other months of the year. At most stations there was a secondary peak later in the year about August/October. The two periods of leaf-fall were not observed on the individual tree in one year but was due to leaf-fall in one period in some years and in the other period in other years. Leaf-fall does not take place in every year in every tree. Many trees failed to shed their leaves prominently in 2 to 3 years out of the 10 years. Exfoliation takes place from top downwards.

New leaf was recorded in every month of the year with the least number of observations during July/August. The individual tree put on most of its new leaf immediately after leaf-fall so that the tree was bare for about a month. Wright (1903) records leaf-fall in February and reflush in March at Peradeniya.

Unlike foliar activity, the season of flowering was more definite in March/June. Various times of flowering in this species are given by different authors—February/March (Anon—Ceylon Forester Vol. 2, No. 12, page 191) April/June (Trimen) and March/July (Holmes 1942). Wright (1903) points out that this species like most deciduous species which flower when the tree is leafless shows “a time relationship between the floral and foliar activities on parts of the same tree”. Ripe fruit was observed from June/August and even September. During July/October the capsules open and shed the winged seed.

Celastraceae

8. *Pleurostylia opposita*, Wall—(S. Panakka)

Distribution:—Thirty-three trees at Sellankandal, Madawachchiya, Mihintale and Nagancholai.

An evergreen species. Leaf-fall takes place from July/December, mainly October, and reflush from January-August particularly January-March.

Flowers were observed during April/July but some trees flowered also during November/December, either in the same year or in different years. Fruiting was scanty in the trees under observation and was recorded in August/September and December/January corresponding to 2 seasons of flowering.

Sapindaceae

9. *Schleichera oleosa*, Merr. (S. Kon)

Distribution:—Forty-one trees at Terravail-Oddusudan, Padawiya, Vellamalai, Kayanwadi, Thirucholai and Lahugala. This species is commonly regarded as evergreen but Wright (1903) considers it a deciduous species.

Leaf-fall was pronounced in February/March but may commence a month earlier in January or continue into April. The tree was never entirely bare but the extent of exfoliation varied from year to year. The minimum crown density is $\frac{1}{4}$ but the same tree may shed only half its leaves or less another year. It is best considered a semi-evergreen species. Leaf-fall took place at a regular cycle of about 12 months.

A conspicuous flush of new leaf which changes from quickly light brown to light green, followed leaf-fall. Reflush however, was not restricted to the period March/June following leaf-fall but took place also during other months of the year, particularly about October at the start of the north-east monsoon rains. This flush of new leaf was independent of leaf-fall and was responsible for the heavy dense crowns characteristic of the species.

Flowers were observed during April/May along with the flush of new leaf but were observed also in March and July. The individual trees flowered on average in about 6 of the 10 years on a cycle of about 11 to 13 months. Fruits were observed from May to September particularly during June/August. Fruits were recorded on average about 5 out of 10 years. At Vellamalai, trees which failed to fruit during 1942-1946 did so in 2 to 3 years during 1947 to 1951.

10. *Gleniea unijuga*, Hkf.—(S. Kuma)

Distribution :—Sixteen trees at Vellamalai, Kayanwadi and Thirucholai. An evergreen species. In some years the trees of this species shed their leaves prominently in March/April. Reflush was conspicuous in April/June. Flowers were observed in 2 to 7 of the 10 years mainly during September/December and fruits during January/March.

11. *Sapindus emarginatus*, Vahl—(S. Penella)

Distribution :—Twenty trees at Hurulu, Kayanwadi and Thirucholai.

An evergreen species. Leaf-fall and reflush were observed at all times of the year. Individual trees shed some of their leaves either once or more often twice a year. This took place during February/March and July/September. The variation of a month or two in the time of leaf-fall in successive years resulted in an extended period of leaf-fall for the species as a whole. Reflush followed a similar pattern to that of leaf-fall.

Flowering was observed from March to June particularly in April/May. Some trees flowered every year ; others did so in 3, 4, or 5 of the 10 years on a cycle of about 11 to 14 months. Fruiting took place May to August particularly during June/July.

12. *Lepisanthes tetraphylla*, Radlk—

Distribution :—Nineteen trees at Gal-Oya and Hurulu.

An evergreen species. Leaf-fall was recorded at all times of the year. Leaf-shedding took place for 3 to 4 months once or twice a year on a tree but the time of leaf-fall varied from one year to another. Flowers were observed about once in 2 years about April/June and fruits from July/October.

13. *Nephelium gardneri*, Thw—(S. Mora)

Distribution :—Twelve trees at Sellankandal.

An evergreen species. Flowers were observed every year in April/July particularly May/June on a regular cycle of 12 months. Fruits were available in July/November, mainly August/October.

The species *Nephelium longana*, Camb, has an edible fruit which is available at the same time. A bumper harvest of this fruit was collected in 1954 in the forests of the North-Central Province and Trincomalee.

Leguminosae

14. *Cassia fistula* L. (S. Thela).

Distribution :—Thirty-five trees at Vellamalai, Hurulu, Medawachchiya and Nuwaragam.

A deciduous species in which the trees are bare for a short period. Leaf-fall was recorded at all times of the year with a slight increase in the number of observations during November/January. Wright (1903) noted leaf-fall in January/February at Peradeniya. Many trees shed their leaves in about 4 to 6 of the 10 years but some did so on fewer occasions. Holtum (1940) recorded definite cycle of 9.1, 10.5 and 9.0 months in the trees of this species at Singapore. There was no definite cycle in the trees under observation in this study. Besides variation in the month of leaf-fall from one year to another, there was an irregular alteration of a number of years with leaf-fall and 1 to 2 years with no leaf-fall.

Flowering was observed in every month of the year with a higher incidence during May/September particularly June/July than at other times. The conspicuous yellow flowers are borne generally when the trees are bare or along with new leaf. Fruits were recorded throughout the year. The long black pods remain on the tree for a long time. Flowering in the individual tree took place on a regular cycle of 10 to 12 months which was interrupted occasionally by a longer period of varying length even up to 17 months.

Myrtaseae

15. *Syzygium cumini*, Skeels—(S. Madan)

Distribution :—Thirty-six trees at Iranamadu, Medawachchiya, Hurulu, Vellamalai and Thirucholai.

A semi-evergreen species. Leaf-fall was recorded from January to June particularly April/June with a few observations in November/December. The month and intensity of leaf-fall varied in the individual tree. On many occasions the minimum crown density was between $\frac{1}{4}$ and $\frac{1}{2}$. Reflush too was observed throughout the year and was most frequent during January/July.

Flowers were observed from June to October, mainly July/September, while fruits were recorded from September to December. Most trees flowered at intervals of 11 to 13 months in 6 to 8 of the 10 years. Fruits were found in 4 to 7 of the 10 years.

16. *Eugenia bracteata*, Roxb.—(S. Deduwa)

Distribution :—Thirteen trees at Sellankandal and Puttalam.

An evergreen species. Leaf-fall was observed during November/December at Sellankandal and January/February at Padawiya. Reflush was prominent in January. Flowers were recorded from May to August.

Flowering took place every year at Sellankandal but only in 3 to 4 of the 10 years at Padawiya. Fruiting was observed in August, September and October.

Rubiaceae

17. *Adina cordifolia*, Hk. f.—(S. Kolon)

Distribution :—Seventeen trees at Terravil-Oddusudan and Thirucholai.

A deciduous species. Leaf-fall was pronounced from May to July. Reflush followed leaf-fall and took place mainly during May/August. Wright (1903) considers it as a deciduous species with a short leafless period.

Flowers were recorded at all times of the year. Most observations of flowering were in June/August and October/November. Fruiting took place from December to May. Wright (1903) noted flowering of this species in July.

18. *Mitragyna parvifolia*, Korth—(S. Helamba)

Distribution :—Twenty-one trees at Kayanwadi, Thirucholai, Lahugala Tirallioddi.

A facultative deciduous species in which leaf was shed gradually over a period of 3 to 4 months before the crown was bare. At Lahugala the 10 trees under observation shed their leaves every year about July/August during the drought. Leaf-shedding continued in August and September and even up to October, in some trees. Reflush followed leaf-fall and took place during the north-east monsoon rains in October/January. At the other stations pronounced leaf-fall was not recorded regularly every year. The plants failed to shed their leaves to any marked extent sometimes for 2 to 3 years.

Flowering was more seasonal than leaf-fall and took place during May/August at all stations. Fruits were recorded at all times of the year with most observations in August/November.

Sapotaceae

19. *Manilkara hexandra*, Dubard—(S. Palu)

Distribution :—127 trees at Madhu, Puwarasankulam, Iranamadu, Kilinochchi, Vannivilankulam, Nuwaragam, Mihintale, Medawachchiya, Kayanwadi, Vellamalai, Lahugala and Inamaluwa.

An evergreen species, which showed pronounced leaf-fall during November/January. The intensity of leaf-shedding varied. In general the minimum crown density was never much less than $\frac{1}{2}$ and was often about $\frac{3}{4}$. Reflush was observed at all times of the year mainly during December/March.

Flowering took place during January/May while fruits were observed from May to July and even up to August. The edible fruits are eaten by man and beasts alike. Individual trees were in flower in 8 to 9 out of the 10 years on a cycle of 11 to 13 months. Fruiting likewise occurred frequently.

Ebenaceae20. *Diospyros ovalifolia*, Wright—(S. Kunumella)

Distribution :—Seventy-one trees at Sellankandal, Puwarasankulam, Terravil-Oddusudan, Tonigala, Gal-Oya, Hurulu, Thirucholai, Kayanwadi, Vellamalai and Nikaweratiya.

A semi-evergreen species. The intensity of leaf-shedding varied from year to year on the individual tree. In most years it retained a large proportion of leaves and was evergreen while in some years half or more of the leaves on the crown were shed. The minimum crown density was $\frac{1}{4}$ on a few occasions. Wright (1903) observed this species to be partially deciduous in the dry northern districts of Ceylon. Leaf-fall was observed in every month of the year and was never pronounced at any time. Reflushing followed a similar pattern. The individual tree did not have a constant foliar cycle and sometimes shed its leaves twice in the year. The variation in the behaviour of the individuals from one year to another and the variation between plots resulted, in the extended period of foliar change for the species as a whole.

Flowers were observed mainly during September/January at all plots except Puttalam where flowering took place during April/July. Wright (1903) noted flowers in January/April and Trimen in January/March except at Puttalam where fruiting was in August/November. Flowering took place every year at Puttalam and in 7 out of 10 years at Puwarasankulam but was very low at the other stations. Flowers were observed in 2 out of 10 years at Terravil-Oddusudan and Galoya and were never observed in 9 trees at Hurulu during the 10 years of observation. Fruiting was poor. At Sellankandal it was observed in 4 to 7 out of the 10 years while in other plots fruits were observed only in 1 or 2 years.

At Sellankandal and Puttalam the cycle of flowering was fairly regular. The mean of 28 values is 11.5 months with a standard deviation of ± 1.05 or 9.1 per cent of the mean. Flowers were observed for 2 to 3 months in a year and fruiting for 3 to 4 months in a year on the individual generally while it was in full leaf.

21. *Diospyros ebenum*, Koenig—(S. Kaluwara, English. Ebony)

Distribution :—122 trees at Madhu, Puwarasankulam, Sellankandal, Kilinochchi, Iranamadu, Tonigala, Nuwaragam, Mihintale, Vellamalai, Medawachchiya, Galoya Padawiya, Kayanwadi, Lahugala and Inamaluwa.

An evergreen species. Wright (1903) points out that in general trees of genus *Diospyros* shed their leaves and reflushed at irregular intervals, the leaf-fall being so slight compared with the flush of new leaf that the nett result of the leaf production is an increase of foliage from year to year. He records reflushing of trees of this species for 4 to 5 months from December. In the trees under observation, leaf-fall, while never depleting the crown to any considerable extent, was observed to be particularly pronounced during January/March. This was followed by a prominent reflush about January/April. The individual tree has a fairly regular rhythm of leaf-fall which occurs at intervals of 12 months but this cycle was interrupted irregularly by years in which no leaf-fall was observed. The trees in a plot generally behaved similarly.

Flowers were observed during March/June and fruits in July/September. Wright (1903) points out that Trimen, Thwaites and most forest officers

were of opinion that the majority of trees of the genus *Diospyros* in Ceylon remain flowerless for long periods. He attributed this to lack of proper records than to the lack of flowering. The behaviour of individual trees during 1942-1951 indicates that the behaviour is variable. At Puwarasankulam and Sellankandal almost all trees flowered regularly every year. At other plots the trees flowered for 1 or 2 years, they did not flower for 2 to 3 years and flowered again so that on average most trees were in flower during 5 to 6 of the 10 years. At Madhu and Lahugala flowers were observed in 3 of the 10 years. Fruits were recorded on average in about 3 to 4 years.

The cycle of flowering in the individual tree was about 12 months or a multiple of 12 when a period of non-flowering intervened. Flowers were borne for 2 to 3 months and fruits for 3 to 4 months in a year. The trees in a plot were generally synchronous in their behaviour.

According to Broun (1895) this species is said to seed twice an year occasionally. Tree No. 31 at Tonigala flowered twice (April/May and August/September) in 1944 but only once in other years. All 10 trees under observation at Gal Oya were in flower in March/April and November/December in 1942.

Verbenaceae

22. *Vitex pinnata* L.—(S. Milla)

Distribution:—204 trees of this species were under observation 49 in the Wet Zone at Yagirala, Ingiriya, Kurana-Madakada, Muwagankanda, Dandagamuwa and Halpankanda and 155 in the Dry Zone at Madhu, Puwarasankulam, Kili-nochchi, Iranamadu, Tonigala, Vellamalai, Nuwaragam, Medawachchiya, Padawiya, Kayanwadi, Lahugala, Inamaluwa, Tiralliodai and Daragoda.

A deciduous species. The time of leaf-shedding varies in the different zones as shown in the following table:—

Zone and type	Leaf-fall	Reflush	Flowering	Fruiting
1. Arid zone	.. June/August	.. Sept./November	Oct./Jan.	.. Jan./March
2. Dry zone	.. March/June	.. May/July	.. June/Jan.	.. Aug./March
3. Dry zone (Intermediate)	.. July/Oct.	.. Nov./February	.. August/Jan.	.. Nov./Jan.
4. Wet zone (Intermediate)	.. ?	.. ?	.. May/August	.. Sept./Feb.
5. Wet Zone	.. Nov./Jan.	.. Feb./April	.. April/July	.. Aug./Oct.

The individual trees were observed to shed their leaves and flower and fruit regularly on a cycle of 10 to 16 months. Flowers were recorded in 8 out of 10 years and fruits in 6 to 7 of the 10 years.

Lauraceae

23. *Alseodaphne semecarpifolia*, Nees—(T. Ranai)

Distribution:—Sixty-five trees at Kilinochchi, Iranamadu, Nagancholai, Vellamalai, Thirucholai, Nuwaragam, Lahugala and Nikaweratiya.

An evergreen species, Leaf-fall took place mainly during December/May while reflush was observed at all times of the year. The individual tree shed some of its leaves during 2 months of the year followed by a flush of leaf for about 2 months.

Flowers were recorded mainly during March/June. Fruits were observed during May to October particularly during June/September. The individual tree had a regular cycle of 10 to 14 months and flowered in 5 to 7 of the 10 years.

Euphorbiaceae

24. *Hemicyclia sepiaria*. W & A—(S. Wira)

Distribution :—Thirty-two trees at Sellankandal, Hurulu, Galoya, Tiralliodai and Nikaweratiya.

An evergreen species. This is the most abundant species in the Dry Mixed Evergreen Forest and more than any other species contributes to the evergreen character of these forests. Slight shedding of leaf and reflush was observed at all times of the year.

Most observations of flowers were during March/May but flowers have been observed from January to June. Flowers were recorded on average in 5 out of 10 years. The cycle of flowering varies from 10 to 14 months. Fruits were available from May to August and even up to October but were abundant in June/July.

25. *Sapium insigne*, Trim—(S. Thilla)

Distribution :—Twenty-four trees at Sellankandal, Medawachchiya and Mihintale.

A deciduous species. Leaf-shedding was observed from January to July when the trees were completely bare for about a month. Reflush was conspicuous during July/January.

Flowers were observed mainly from March to June with most observations in April and May. Flowers were observed occasionally in January and July. Fruiting took place from May to August. Flowering took place when the leaves were being shed.

PART III

PHENOLOGY OF THE SUB-TROPICAL MONTANE EVERGREEN FOREST

SUB-tropical Montane Evergreen Forest occurs above 5,000 feet in the central hill massif of the island. The height of the main canopy varies from about 30 feet to 50 feet in the better sites. The trees of the main canopy are of poor form with dense spreading, flat-topped crowns. The canopy is variable and quite open in patches. In exposed situations the height of the canopy is low and the trees have a twisted, gnarled appearance.

The main tree species are *Elaeocarpus glandulifer*, *Elaeocarpus serratus*, *Mastixia tetrandra*, *Michelia nilagirica*, *Syzygium* spp., *Adinandra lasiopetala*, *Semecarpus coriacea*, *Litsea iteodaphne*, *Neolitsea involucrata*, *Pygeum zeylanicum*, etc. Below the main canopy are small tree species of *Symplocos spicata*, *Actinodaphne ambigua*, *Plectronia montana*, *Cinnamomum litseaefolium*, etc. The shrub layer is dense and consists of such

species as *Psychotria nigra*, *Maesa perrottetiana* and *Rauwolfia densifolia*. *Strobilanthes* spp., the small hill bamboos *Teinostachyum attenuatum* and *Oxytenanthera* spp. are dense especially where the canopy is open. The floor is moist and covered with low shrubs and herbs such as *Pogostemon heyneanus*, *Polygonum chinense*, *Cyanotis villosa*, *Amomum involucreatum*, and grasses and ferns including the tree ferns. *Toddalia asiatica*, *Smilax zeylanica* and *Asparagus falcatus* are common small climbers usually found in the shrub layer. *Ipea speciosa*, the Daffodil Orchid is found in these forests.

Black "patana" grassland is found in poorly drained sites within the region. The forest is considered a relict forest and natural regeneration is poor and tardy.

Climate

The average monthly rainfall from 1942 to 1951 at Nuwara Eliya and Hakgala which are close to the 2 phenological plots Sita Eliya and Pattipola are given in Table 22 along with corresponding values for temperature, humidity, potential evapotranspiration and water surplus and deficit.

The main annual rainfall during the period 1942 to 1951 was 86.17 inches at Hakgala and 80.16 inches at Nuwara Eliya. At Hakgala the rainfall was evenly distributed throughout the year and except during February the monthly rainfall was more than 5 inches. The highest monthly rainfall was during the north-east monsoon from October to December. At Nuwara Eliya the highest monthly rainfall was in June during the south-west monsoon. Here there was over 7 inches of rain during the month from May to August and October to December. Relatively low rainfall was recorded from January to March. The lowest monthly rainfall was in February with 2.73 inches of rain.

Associated with the wet climate is the high relative humidity throughout the year. During most of the year the relative humidity was above 80 per cent. and reached a maximum of 85 to 86 per cent. during the rains. In February and March there was a pronounced drop in the relative humidity to about 70 to 71 per cent.

January and February were the coldest months with a mean monthly temperature of 56.1°F at Nuwara Eliya and 58.7 at Hakgala. The daily temperature is highest at this time and ground frosts are common. May was the hottest month with a temperature of 61.0°F at Nuwara Eliya and 65.2°F at Hakgala.

The potential evapotranspiration was low corresponding to the relatively low temperature. The maximum monthly values were 2.4 inches and 2.7 inches in May at Nuwara Eliya and Hakgala respectively. Owing to the well distributed rainfall there was no month in which water was in deficit.

The importance of the influence and wind is evident from the wind-swept form of the trees. Unfortunately no data for wind at these stations was available from the Department of Meteorology. Some idea of the general conditions may be obtained from the measurements made in connection with preliminary shelter-belt trials conducted by the author in 1952 at Erabedde (4,000 feet) which lies immediately to the east of the central mountain ridge between Pattipola and Haputale. Measurements of wind speeds, using cyclo-type anemometers for 15 minutes each day

during May/August, 1952, showed that wind velocities of 40 to 50 miles per hour were common during that period. The measurements were made when the wind speed was high. These high velocities are not maintained throughout the day but last only for short spells. Nevertheless their effect on the vegetation would be pronounced.

Table 22.—Average Monthly Values of the Climatic Factors in the Sub-Tropical Montane Evergreen Forest

RAINFALL IN INCHES

<i>Plot</i>	<i>J</i>	<i>F</i>	<i>M</i>	<i>A</i>	<i>M</i>	<i>J</i>	<i>J</i>	<i>A</i>	<i>S</i>	<i>O</i>	<i>N</i>	<i>D</i>
Pattipola (Hakgala)	7.85	4.26	5.58	8.05	6.71	6.51	5.01	5.43	5.35	9.86	10.20	11.38
Sita Eliya (Nuwara Eliya)	4.47	2.73	4.60	5.97	7.09	10.37	7.76	7.56	6.29	8.59	7.08	7.65

HUMIDITY %

Pattipola (Hakgala)	.. 83..	73..	71..	78..	76..	85..	83..	84..	80..	81..	83..	86
Sita Eliya (Nuwara Eliya)	.. 76..	71..	70..	80..	79..	86..	85..	85..	83..	82..	83..	81

TEMPERATURE ° F

Pattipola (Hakgala)	58.7	59.8	61.2	63.7	65.2	62.7	62.9	62.5	62.7	62.7	61.0	60.1
Sita Eliya (Nuwara Eliya)	56.5..	59.8	57.7	59.7	61.0	59.6	59.5	59.8	59.2	58.9	58.5	57.9

POTENTIAL EVAPOTRANSPIRATION IN INCHES

Pattipola (Hakgala)	.. 1.7..	1.7..	2.2..	2.4..	2.7..	2.3..	2.2..	2.3..	2.3..	2.2..	2.0..	1.7
Sita Eliya (Nuwara Eliya)	.. 1.3..	1.8..	1.9..	2.1..	2.4..	2.2..	2.2..	2.2..	2.1..	2.1..	2.3..	1.7

WATER SURPLUS IN INCHES

Pattipola (Hakgala)	.. 6.2..	2.6..	3.6..	5.6..	4.0..	4.2..	2.8..	3.1..	3.1..	3.7..	8.2..	9.7
Sita Eliya (Nuwara Eliya)	.. 3.2..	0.9..	2.7..	3.9..	4.7..	8.2..	5.6..	5.4..	4.2..	2.5..	4.8..	2.0

Phenological observations on 204 trees of 21 species were recorded at 5 plots—Sita Eliya, Kandapola, Pattipola, Bulu-Ela, Mahakudugala—Unfortunately the loss of the records for the last 3 plots restricts the present study to only the first 2 plots which include 115 trees of 15 species.

LEAF CHANGE

Table 23 sets out the monthly values of the phenological indices for leaf change at Sita Eliya and Pattipola. The leaf-fall record at Pattipola was incomplete and has been omitted. Figure 15 illustrates the average (1942-1951) values of leaf-change and the climatic factors. Figure 16 illustrates the detailed monthly values for Sita Eliya from 1945 to 1950.

LEAF-FALL

At Sita Eliya leaf-fall was mainly during October/November. The relatively high average value of the leaf-fall index in January is due to the behaviour of the trees in 1951. The north-east monsoon rains failed in

1950 and there was only 2.92 inches of rains in December 1950. The increase in the incidence of leaf-fall during October/November took place at the same time as in the Tropical Wet Evergreen Forest. It would appear from the average figures that leaf-fall took place when the monthly rainfall was over 7 inches, relative humidity between 82 and 85 per cent. and the temperature below 59°F.

Table 23.—Phenological indices for Leaf-fall and Reflush

PLOT : SITA ELIYA—LEAF-FALL

Year	J	F	M	A	M	J	J	A	S	O	N	D
1942	0.1	0.4	1.1	—	—	—	—	0.6	0.6	2.6	0.9	—
1943	4.6	15.4	23.1	16.4	19.3	1.0	1.0	1.7	0.1	0.1	0.1	3.9
1944	—	—	—	—	—	—	—	—	2.3	22.3	18.1	13.7
1945	1.1	—	—	—	—	0.9	0.9	4.0	25.0	33.1	28.0	—
1946	—	—	—	0.6	0.6	—	—	28.0	13.7	0.9	0.9	0.7
1947	0.4	—	—	—	—	—	—	—	—	13.7	14.0	6.4
1948	—	—	—	—	—	0.1	4.3	—	—	—	—	—
1949	—	—	0.3	—	—	0.1	—	—	—	0.1	0.3	—
1950	—	—	—	—	—	—	—	—	—	—	—	—
1951	14.3	4.3	—	—	—	—	—	—	—	—	—	—
Average	9.0	2.2	2.7	1.7	2.2	1.2	0.7	3.8	4.6	8.1	6.9	2.7

PLOT : SITA ELIYA—REFLUSH

Year	J	F	M	A	M	J	J	A	S	O	N	D
1942	14.6	12.0	15.0	26.3	12.0	12.0	48.0	2.3	2.0	5.7	12.9	12.9
1943	10.3	12.0	12.1	16.4	6.4	37.0	37.0	42.3	5.1	1.7	—	2.7
1944	50.1	—	42.4	18.9	25.7	15.4	—	—	—	0.7	3.9	30.9
1945	81.4	78.6	62.9	34.0	—	—	—	1.1	1.1	4.0	9.4	4.8
1946	77.1	59.1	21.4	1.7	0.4	0.4	—	—	12.9	30.0	31.0	40.0
1947	20.6	1.7	16.4	—	36.0	8.0	2.0	—	—	21.0	27.4	30.0
1948	22.0	3.0	1.7	—	—	43.4	6.4	74.3	0.6	0.1	0.1	0.1
1949	33.1	—	—	1.4	0.4	—	—	—	—	—	0.6	—
1950	—	—	—	—	—	—	—	—	—	—	—	—
1951	—	6.0	34.0	38.6	15.0	8.6	—	—	—	—	1.7	5.1
Average	34.3	19.2	22.9	15.3	10.7	13.9	10.4	13.3	2.4	7.0	9.7	14.1

PLOT : PATTIPOLA—REFLUSH

Year	J	F	M	A	M	J	J	A	S	O	N	D
1945	100.0	56.6	53.8	37.1	20.6	21.7	2.1	—	0.1	1.4	1.4	4.6
1946	4.0	4.0	5.7	5.7	5.7	8.6	5.1	3.4	8.6	4.0	1.7	2.1
1947	0.1	0.6	0.6	0.6	—	—	—	5.0	4.6	1.7	1.7	0.3
1948	0.1	0.1	0.1	0.1	0.1	—	—	—	2.6	1.4	—	2.6
1949	79.4	2.3	2.3	5.7	0.1	—	—	—	—	—	—	—
1950	11.4	45.6	8.6	26.4	9.3	20.6	1.7	5.7	7.7	—	0.6	—
1951	0.1	27.0	48.7	48.7	23.6	10.7	4.6	6.4	7.7	0.1	—	0.1
Average	26.4	19.3	17.1	18.0	8.5	8.8	1.9	2.9	4.5	1.2	0.8	1.4

The detailed monthly record (Figure 16) however shows that in general an increase in the incidence of leaf-fall took place a month or two after low rainfall. The irregular periodicity of leaf-fall behaviour is also evident. In 1943 the maximum leaf-fall index was in February/April after rainfall of 1.6 inches in January and 2.02 inches in February. In 1944 the leaf-fall index of 22.3 in October took place after 2.63 inches of rain in August and 3.99 inches in September. A similar increase in the incidence of leaf-fall following a month of low rainfall was shown in 1945, 1946, 1948 and 1951. In 1947 the maximum leaf-fall was in October with 10.14 inches of rain, and November with 1.15 inches of rain. This took place after a rainfall of 5.16 inches in September. The relation between leaf-fall activity and relative humidity and temperature is not evident. Further since maximum leaf-fall took place at all times of the year during one or other of the 10 years of observation the influence of the photoperiod on such behaviour is not evident.

REFLUSH

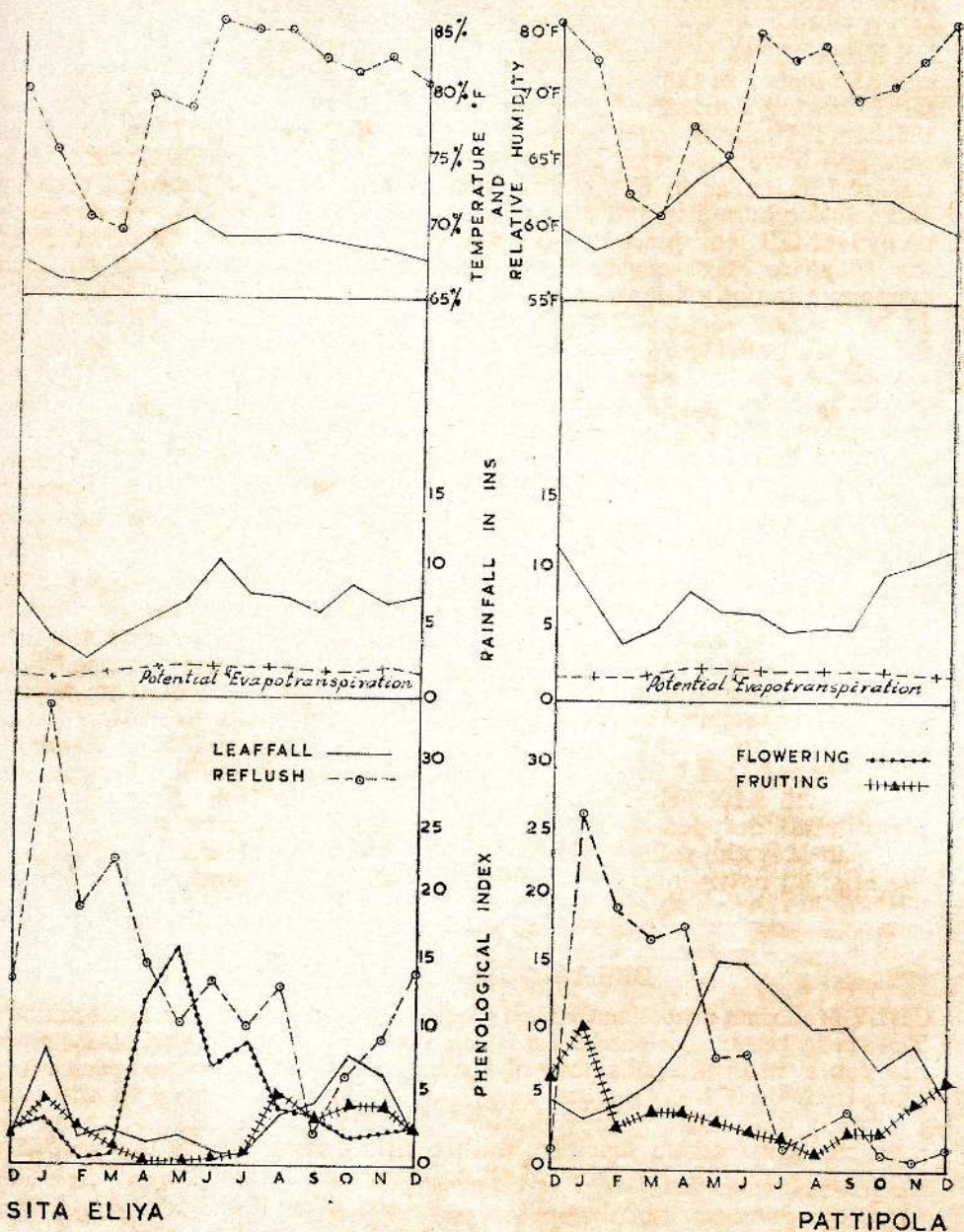
THE average intensity of leaf-fall was highest during January/March (Fig. 16) during the driest season of the year when the monthly rainfall was below 4 inches, the relative humidity 70 to 76 per cent and temperature 56.5 to 57.7°F. The increase in the intensity of reflush commenced as in the Tropical Wet Evergreen Forest during the north-east monsoon rains in October/December.

The detailed record of reflush at Sita Eliya (Fig. 16) shows that reflush generally commenced along with or immediately after a peak of rainfall. The maximum was often but not always reached in the dry weather following the rains so that Smith's (1909) observation of the increase in the number of species opening their leaves in the dry weather would not appear to be as surprising as he considered it. The behaviour in 1947 is interesting. The high reflush index (over 20) from October 1946 to January, 1947 dropped to 1.7 in February when the rainfall was 0.49 inches. In March with 5.10 inches of rain the index rose to 16.4. In April when the rainfall dropped to 2.56 inches no leaf-fall activity was observed. Again in May the reflush rose to 36.0 and 5.06 inches of rain. At Pattipola the relation between reflush activity and rainfall is similar.

BEHAVIOUR OF SPECIES

ONLY *Meliosma arnottiana*, of the species under observation was deciduous. The evergreen species shed their leaves irregularly and showed no synchronisation even in the behaviour of the individuals of the same species in a plot. Individual trees put on new leaf for about 3 months in the year but many did so again for a shorter time later in the year. Some species such as *Ternstroemia japonica*, flushed in 3 bursts during the year like *Dillenia retusa*, in the Tropical Wet Evergreen Forest.

A large percentage of the species under observation in these forests had pink or reddish young leaf for example *Syzygium* spp., *Gordonia zeylanica*, *Ternstroemia japonica*, *Elaeocarpus glandulifer*, *Calophyllum walkeri*. Beard (1946) finds that reddish flush leaves are uncommon in the montane forests of Trinidad. He observes that in seasonal forests the deciduous species flush green and considers that reddish flush leaves are characteristic of the evergreen species in such forests. Smith (1909) has shown that the presence of anthocyanin raises the internal temperature of the leaves. It



SITA ELIYA

PATTIPOLA

FIG 15- AVERAGE (1942 - 51) PHENOLOGICAL AND CLIMATIC CURVES (SUB-TROPICAL MONTANE EVERGREEN FOREST)

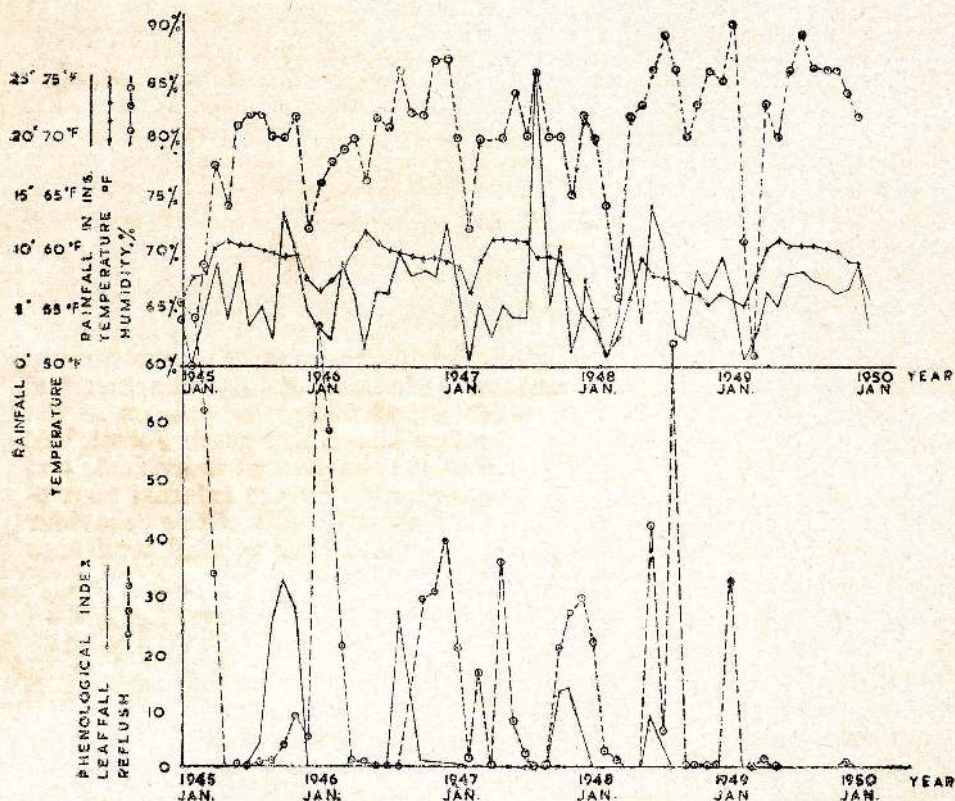


FIG. 16 - DETAILED MONTHLY PHENOLOGICAL AND CLIMATIC CURVES FROM 1945 TO 1949 AT SITA ELIYA (SUB-TROPICAL MONTANE EVERGREEN FOREST)

is interesting to note that in Ceylon a large percentage of species in the Sub-tropical Montane Evergreen Forest, compared with the Tropical Wet Evergreen Forest, have reddish young leaf. The rain-fall in these 2 communities is similar and it is likely that the higher proportion of species with reddish young leaf is associated with the relatively low temperatures in the Sub-tropical Montane Evergreen Forest. This would be of advantage to the plants since flushing is pronounced during the cold weather in January/March when the range of daily temperature is high and ground frosts are common.

CONCLUSIONS

THIS survey of the leaf change activity of the species in the Sub-tropical Montane Forest illustrates the irregular periodicity of this behaviour and the influence of rainfall on leaf shedding and foliar renewal. As in the Tropical Wet Evergreen Forest and the Dry Mixed Evergreen Forest, leaf is shed after low rainfall. The asynchronous behaviour of individuals and species indicates that foliar activity is controlled by the internal physiological rhythm of the individual. The irregular periodicity of this behaviour by which peaks of activity are associated with similar rainfall conditions indicates the influence of rainfall on this rhythm.

FLOWERING

FLOWERING was more distinctly seasonal than leaf change in the sub-tropical Montane Wet Evergreen Forest. The maximum incidence of flowering was in April/June (Tables 24 and 25) during the hottest month of the year immediately following a period of relatively low rainfall and low humidity in February/March (Figure 15). Maximum flowering took place immediately after high reflush activity.

The detailed monthly values of the phenological indices for flowering and fruiting from 1945 to 1951 at Sita Eliya and the corresponding values of monthly rainfall, temperature and humidity are given in Figure 16. The irregular periodicity of flowering in this plot is evident. It is noticed that peaks of flowering took place either along with or immediately after depressions in either the rainfall and relative humidity curves or a rise in the temperature curve. Examination of the detailed values at Pattipola shows a similar trend.

This relation is illustrated in the regression of the 2 highest annual values of the indices for flowering from 1945 to 1949 on the corresponding monthly values of rainfall, relative humidity and temperature. The values were "corrected" as explained earlier (in Part I) by using the values of the previous month if lower, in the case of rainfall and relative humidity. The values of temperature were not corrected. From Figure 17 it is seen that two thirds of the values of maximum flowering were associated with a monthly rainfall of 3.1 to 7.6 inches, relative humidity of 70 to 81.5 per cent and temperature of 59.2 to 63.5°F. If as explained earlier, one third of the highest values were excluded instead of one-sixth of the highest and one-sixth of the lowest values, the significant value of monthly rainfall is 5.1 inches and relative humidity of 77.5 per cent. Since temperature appears to work in an opposite manner to rainfall and humidity, i.e., high temperatures are associated with flowering, the significant value is determined by omitting one third of the lowest values. The value is 60.1°F.

The probability of a chance occurrence of values below 5.1 inches monthly rainfall is 1 in 3 of a value below 77.5 per cent relative humidity 1 in 5 and of a value above 60.1°F is 1 in 2.5.

Table 24.—Phenological Indices for Flowering and Fruiting

PLOT: SITA ELIYA—FLOWERING

Year	J	F	M	A	M	J	J	A	S	O	N	D
1942	.. 0.9..	0.9..	0.1..	0.1..	—	.. 2.0..	5.6..	2.9..	2.3..	2.6..	8.0..	3.4
1943	.. 0.3..	—	.. 0.1..	0.3..	0.9..	3.1..	3.1..	5.6..	15.7..	0.9..	5.6..	5.6
1944	.. —	.. —	.. —	.. 2.9..	12.0..	6.9..	4.3..	10.3..	10.7..	0.6..	—	—
1945	.. —	.. —	.. 0.6..	0.7..	9.0..	9.4..	21.4..	10.0..	12.0..	3.9..	1.7..	—
1946	.. —	.. 0.7..	2.9..	20.7..	20.7..	17.9..	8.6..	5.7..	3.9..	1.4..	1.4..	0.7
1947	.. 2.3..	2.3..	0.4..	—	.. 3.1..	9.0..	9.0..	—	.. —	.. 1.4..	1.3..	2.1
1948	.. —	.. —	.. —	.. 70.0..	75.7..	0.1..	—	.. 0.3..	0.1..	1.7..	4.0..	15.0
1949	.. 27.0..	—	.. 1.1..	14.6..	25.1..	16.0..	30.9..	3.0..	—	.. 5.1..	0.1..	?
1950												
1951	.. —	.. —	.. —	.. 1.7..	1.7..	1.7..	—	.. —	.. —	.. —	.. —	—
Average	.. 3.4..	0.4..	0.6..	12.3..	16.5..	7.4..	9.2..	4.2..	3.8..	2.0..	2.5..	3.0

PLOT: SITA ELIYA—FRUITING

Year	J	F	M	A	M	J	J	A	S	O	N	D
1942	.. 1.4..	1.4..	1.4..	0.6..	—	.. —	.. —	.. 0.3..	0.3..	3.0..	12.1..	6.4
1943	.. 23.1..	18.0..	6.3..	1.0..	1.0..	—	.. —	.. —	.. —	.. 2.0..	1.1..	1.1
1944	.. 11.4..	?	.. —	.. —	.. —	.. —	.. —	.. 1.7..	1.7..	0.9..	0.3..	0.3
1945	.. 0.6..	0.1..	0.1..	0.1..	0.6..	0.9..	1.7..	3.4..	3.4..	3.0..	3.0..	3.0
1946	.. 0.4..	0.4..	—	.. —	.. —	.. —	.. 2.3..	9.7..	12.9..	12.9..	12.9..	4.7
1947	.. 3.9..	3.4..	0.3..	—	.. —	.. 3.1..	2.9..	30.4..	—	.. 1.0..	1.1..	6.9
1948	.. 2.1..	2.1..	2.1..	0.1..	—	.. —	.. —	.. —	.. 0.9..	0.6..	0.6..	0.1
1949	.. 1.1..	0.4..	0.1..	0.1..	—	.. —	.. 4.3..	1.7..	0.1..	17.0..	8.0..	?
1950												
1951	.. —	.. —	.. —	.. —	.. —	.. —	.. —	.. —	.. —	.. —	.. —	—
Average	.. 5.0..	2.9..	1.1..	0.2..	0.2..	1.4..	1.2..	5.2..	3.3..	4.5..	4.3..	2.5

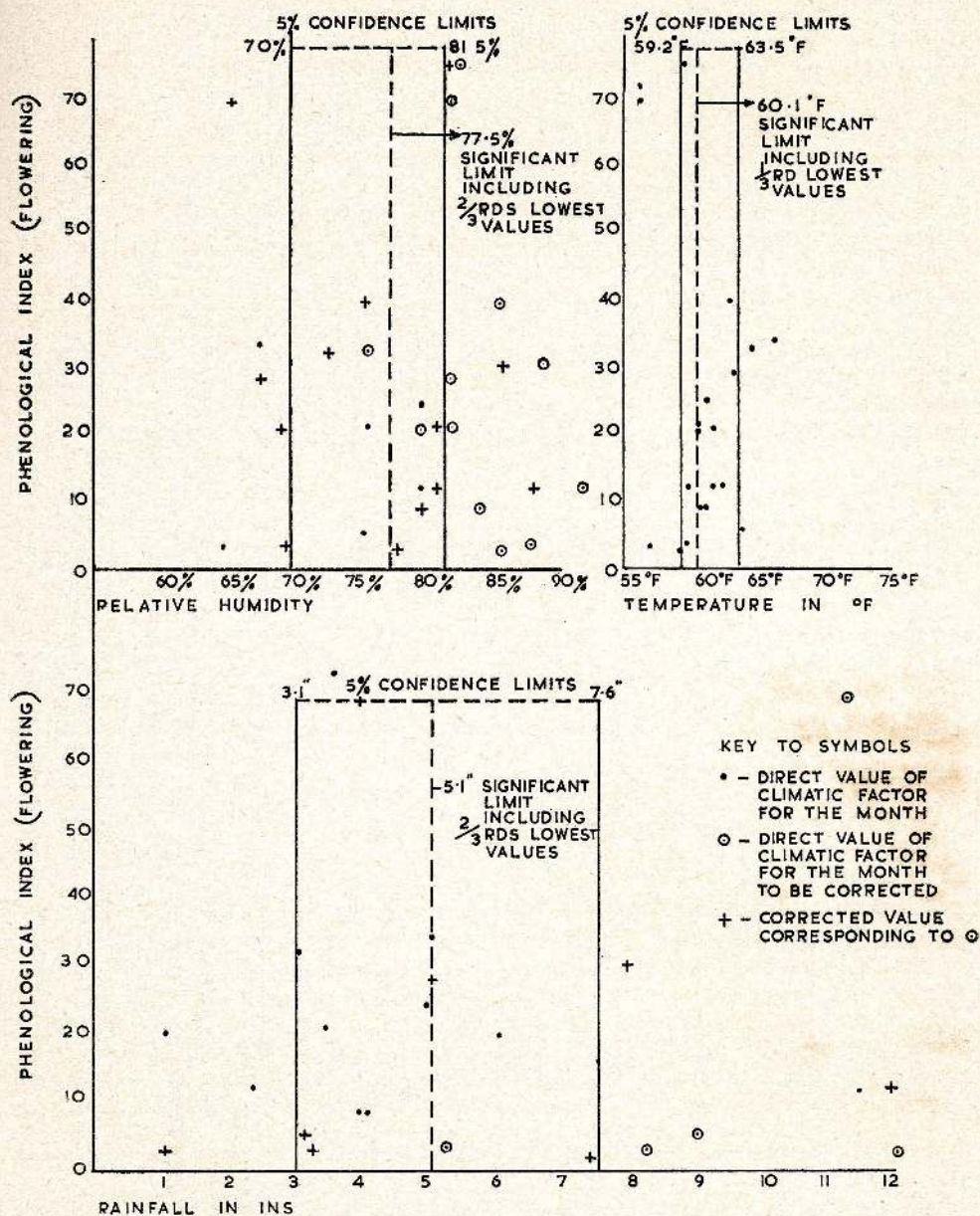


FIG. 17 - REGRESSION OF FLOWERING ON RAINFALL, TEMPERATURE AND HUMIDITY IN THE SUB-TROPICAL MONTANE EVERGREEN FOREST (PLOTS- SITA ELIYA AND PATTIPOLA)

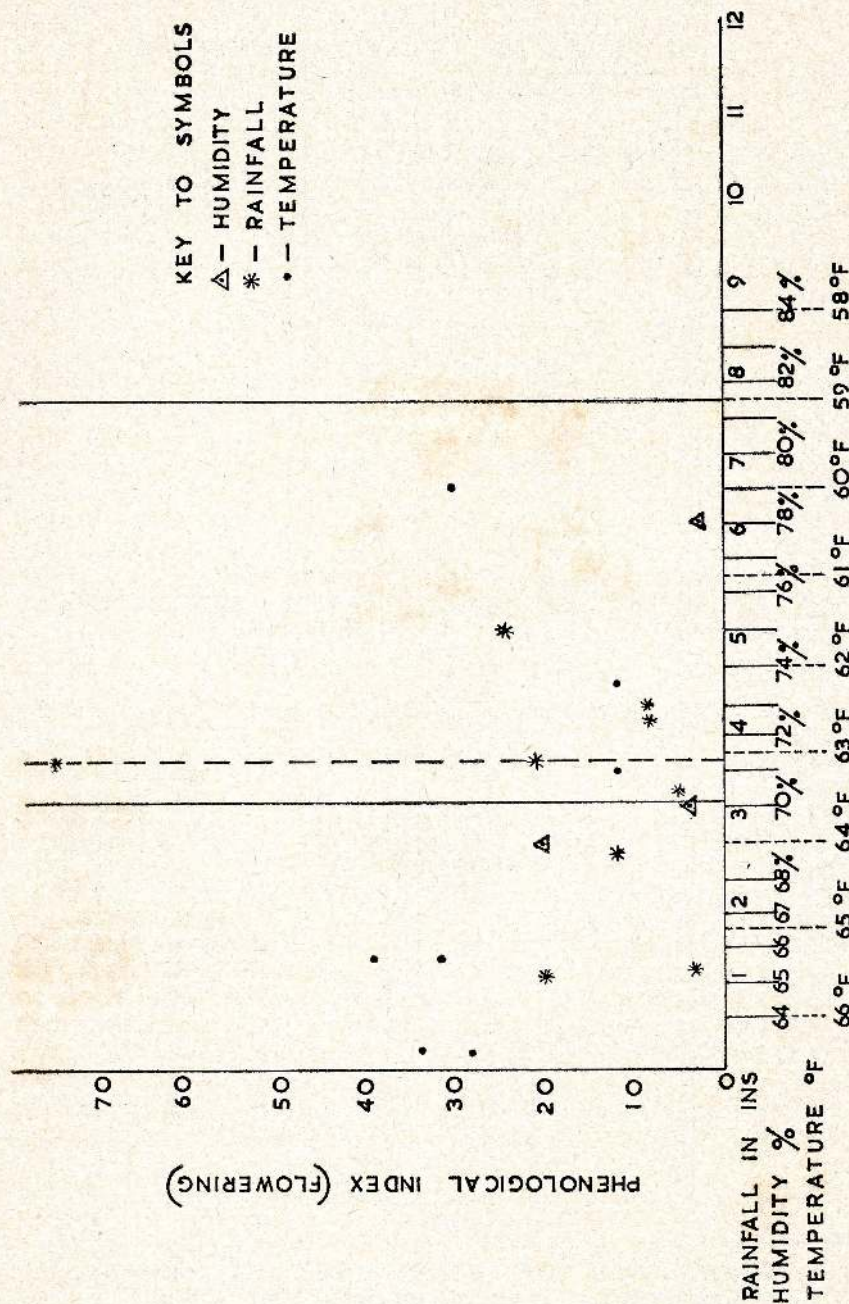


FIG. 18 - REGRESSION OF FLOWERING ON RAINFALL, TEMPERATURE AND HUMIDITY IN THE SUB-TROPICAL MONTANE EVERGREEN FOREST

Table 25.—Phenological Indices for Flowering and Fruiting

PLOT: PATTIPOLA—FLOWERING

Year	J	F	M	A	M	J	J	A	S	O	N	D
1945	.. —	19.0..	21.0..	20.6..	34.3..	28.3..	5.1..	8.6..	8.6..	7.9..	12.0..	0.7
1946	.. 3.0..	2.6..	1.7..	0.6..	0.6..	4.6..	5.7..	6.4..	5.7..	10.3	12.0..	12.0
1947	.. 0.3..	0.3..	0.3..	0.3..	1.7..	0.6..	0.6..	1.7..	0.7..	5.7..	1.7..	3.4
1948	.. 2.1..	2.1..	3.4..	1.3..	0.6..	1.3..	0.6..	—	—	—	1.4..	2.6
1949	.. 2.6..	0.9..	4.3..	25.1..	32.9..	40.0..	19.0..	6.0..	11.1..	0.6..	—	—
1950	.. 2.3..	2.9..	5.0..	14.9..	9.4..	11.0..	28.3..	16.0..	32.1..	13.7..	20.6..	6.0
1951	.. 11.4..	6.4..	10.0..	4.0..	29.6..	22.0..	30.1..	36.0..	17.0..	15.4..	16.7..	12.6
Average	.. 3.9..	4.6..	6.3..	9.5..	15.6..	15.4..	12.9..	10.7..	10.9..	7.7..	9.2..	5.3

PLOT: PATTIPOLA—FRUITING

Year	J	F	M	A	M	J	J	A	S	O	N	D
1945	.. 0.1..	0.1..	—	3.4..	5.7..	7.7..	1.7..	0.1..	0.1..	0.1..	0.1..	1.3
1946	.. 7.9..	7.1..	6.4..	1.4..	0.6..	—	—	—	—	—	0.1..	0.1
1947	.. 3.7..	3.7..	3.7..	3.7..	3.7..	2.1..	0.9..	—	—	—	0.7..	0.6
1948	.. 0.7..	0.7..	0.7..	1.7..	1.1..	1.1..	0.9..	0.1..	—	—	—	—
1949	.. —	—	—	—	1.7..	0.6..	9.4..	2.9..	4.0..	3.0..	17.1..	18.0
1950	.. 52.9..	36.6..	16.0..	18.0..	10.7..	2.3..	0.6..	2.3..	0.6..	2.3..	0.6..	2.6
1951	.. 11.1..	7.1..	4.6..	3.0..	2.6..	6.9..	3.4..	2.0..	16.0..	20.6..	17.0..	24.0
Average	.. 10.9..	3.2..	4.5..	4.5..	3.7..	3.0..	2.4..	1.1..	3.0..	2.9..	5.1..	6.7

The interaction of these factors in their influence on maximum flowering is illustrated in Figure 18. For this purpose the "equivalence" of the 3 factors was determined as explained in Part I from the limits of the 5 per cent significant range of these factors, i.e.

7.6 — 3.5 inches rainfall	=	81.5—70% relative humidity.
∴ 1 inch rainfall	=	2.6% relative humidity.
and 7.6—3.5 ins. rainfall	=	63.5—59.2°F.
∴ 1 inch rainfall	=	1°F.

In locating the equivalent values of rainfall and relative humidity on the scale of the graph the same procedure as outlined earlier was used. Since temperature works in an opposite manner to the other 2 factors in its influence on maximum flowering, the temperature scale reads in the opposite direction to that of rainfall and relative humidity. The upper limit of the significant range of temperature was located on the graph at the lower limit of the significant range of rainfall. The significant values of rainfall, humidity and temperature working together are 3.5 inches monthly rainfall, 71.4 per cent relative humidity and 63.4°F temperature. Nine values of rainfall, seven values of temperature and four values of relative humidity were used in plotting the regression of flowering on the 3 factors working together. These figures indicate the relative number of times each factor was most important of the three in the control of flowering.

BEHAVIOUR OF THE SPECIES

ONLY *Meliosma arnottiana* and *Syzygium assimile* had a definite flowering season. In some species, e.g., *Adinandra lasiopetata*, *Elaeocarpus serratus*, observations of flowering were recorded on one or other of the

trees of this species so that no definite season of flowering could be recognised. However, no tree was in flower throughout the year to be described as everflowering in the sense used by Corner (1940). In the other species although observations of flowering were recorded at all times of the year, the number of observations in April/July were large enough to characterise it as the season of flowering. The individual tree flowered for about 2 to 3 months in a year.

Meliosma arnottiana flowered regularly every year; *Syzygium assimile*, *Adinandra lasiopetata* and *Gordonia zeylanica* flowered in 5 to 6 out of 7 years while most of the other species under observation were in flower in 3 to 4 years. *Meliosma arnottiana* and *Syzygium assimile* flowered on a regular cycle of 11 to 13 months while the other species had a varied cycle.

Flowering was generally at a peak immediately after a pronounced period of reflush.

FRUITING

FRUITING followed flowering and took place during hot wet weather. The intensity of fruiting was poor especially when the rainfall during maximum flowering was heavy. The regeneration of the species is poor. In 1952 an experiment was set out by the author to determine whether this was due to the absence of viable seed at the onset of the rains. Scrapings of top soil were taken from 4 milliacre quadrats located at random in the natural regeneration plot at Bulu Ela before the south-west monsoon and the north-east monsoon. The top soil was spread on nursery beds in Kandapola nursery and watered regularly as in usual nursery practice. No germination was recorded.

CONCLUSIONS

FLOWERING in the Sub-tropical Evergreen Forest and the Dry Mixed Evergreen Forest is irregularly periodic. The asynchronous behaviour of individuals and species indicates that flowering is determined by the internal physiological rhythm of the individual. The irregular periodicity by which peaks of activity in different years were associated with similar conditions shows the influence of the climatic factors on the time of flowering. The evidence of the influence of climate on flowering shows that a monthly rainfall below 5.1 inches, temperature above 60.1°F and relative humidity of 77.5 per cent was significantly associated with seasons of flowering. In the control of the time of flowering these 3 factors operated together and the effect of whichever of the 3 factors was limiting was predominant. This is illustrated by the regression of flowering on the 3 factors together in Figure 18. The significant values of the 3 factors working together on flowering were 3.5 inches monthly rainfall, 71.4 per cent relative humidity and 63.4°F. There was no relation between the intensity of flowering and the values of the climatic factors. This would not be expected if the intensity of flowering were determined by the internal physiological conditions of the plant.

PHENOLOGICAL NOTES ON SPECIES

PHENOLOGICAL notes on 93 trees of 11 species of the Sub-tropical Montane Evergreen Forests are given below.

Local Names (S=Sinhalese, T=Tamil)

Magnoliaceae

1. *Michelia milagirica*, Zenk.—(S. Wal Sapu)

Distribution :—Six trees at Sita Eliya.

An evergreen species. Reflush took place mainly from December to March. Flowers were recorded at all times of the year. Most observations of flowering were in May and August/September. Fruiting was pronounced in June/July and October/November.

Guttiferae

2. *Calophyllum walkeri*, Wright—(S. Kina)

Distribution :—Eight trees at Pattipola and Sita Eliya.

An evergreen species. The reddish young leaf was conspicuous about January/April. Flowering took place in 3 out of 7 years and not necessarily at the same time in successive years on a tree. Most observations of flowers were in April/May. Fruits were observed only in 1 or 2 years from June to February.

Ternstroemiaceae

3. *Adinandra lasiopetala*, Choisy—(S. Heenkolamihiriya)

Distribution :—Six trees at Pattipola.

An evergreen species with a gradual renewal of leaf. Flowers were observed at all times of the year. Fruits were recorded mainly during March/June.

4. *Gordonia zeylanica*, Wright—(S. Mihiriya)

Distribution :—Seventeen trees at Sita Eliya and Pattipola.

An evergreen species. The pinkish new leaf was recorded throughout the year. It was quite conspicuous on the tree for about 3 months each year. Flowers were observed mainly from April to July and Fruits from May to August, but have been recorded also at other times of the year. The individual tree was in flower in about 5 to 6 of the 7 years while fruiting was less frequent and took place in about 3 to 4 of the 7 years.

5. *Ternstroemia japonica*, Thunb.—(S. Ratatiya)

Distribution :—Four trees at Sita Eliya.

An evergreen species in which the pinkish young leaves were recorded throughout the year. The individual tree occasionally put on new leaf for about 6 months in the year either continuously or in 2 or 3 bursts.

Flowers were observed from April to July in 3 out of 10 years. Fruits were never observed in the 4 trees at Sita Eliya. Four trees under observation at Mahakudugala from 1943 to 1946 flowered in July/September while fruits were recorded from November to January every year.

Tilliaceae

6. *Elaeocarpus glandulifer*, Mast. (S. Malweralu)

Distribution :—Seven trees at Pattipola and Sita Eliya.

An evergreen species with a pronounced shedding of leaf, the time of which varies from year to year. The reflush of pinkish young leaf was observed at all times of the year. Flowering and fruiting were recorded at all times of the year.

7. *Elaeocarpus montanus*, Thw.—(S. Galweralu)

Distribution :—Five trees at Pattipola.

An evergreen species. Young leaf was conspicuous from January to March but also observed at all times of the year. Flowering was recorded in every month of the year but mainly from May to September. Fruits were observed from January to May.

Sabiaceae8. *Meliosma arnottiana*, Walp—(S. Walbilen)

Distribution :—Five trees at Sita Eliya.

A deciduous species. It shed its leaves during October/December and was bare for about a month. Reflush was conspicuous during January/March.

Flowers were observed from April to July and fruits from August to November. Flowering took place every year on a cycle of about 11 to 13 months. Flowering usually started at the end of reflush.

Myrtaceae9. *Syzygium assimile*, Thw.—(S. Waljambu)

Distribution :—Nine trees at Sita Eliya and Pattipola.

An evergreen species in which leaf-fall took place at all times of the year. The pink young leaves were prominent about November/March. Individual trees were observed to flush twice in some years in November/March and again about June/August.

Flowers were observed mainly from April to August and fruits from October to December. The individual tree flowered in about 6 out of 10 years on a cycle of about 11 to 13 months.

Cornaceae10. *Mastixia tetrandra*, Clarke—(S. Matawara)

Distribution—Thirteen trees at Sita Eliya and Pattipola.

An evergreen species. Leaf shedding was observed for about 2 months in the year from November to April but occasionally also from June to August.

Flowers were observed at all times of the year but mainly during March/May and September/November. Fruits were observed at all times of the year mainly from October to December.

Lauraceae11. *Neolitsea involucrata*, Lamk.—(S. Kuduawula)

Distribution :—Thirteen trees at Pattipola and Sita Eliya.

An evergreen species. It put on new leaf mainly during November/March.

Flowering was recorded at all times of the year. Most observations were in May, June and July. Fruits were observed from October to March, mainly during December, January and February. The individual tree flowered in about 5 to 6 of the 10 years while fruiting took place in about 4 to 5 years.

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THE TAXONOMY OF THE LORANTHACEAE OF CEYLON*

W. G. Weeraratna.

Historical Note

In the first edition of the "Species Plantarum" in 1753, Linnaeus distinguished three genera, *Scurrula*, *Loranthus* and *Viscum*, which are now considered under Loranthaceae. Since then several taxonomists including Korthals, Engler and Van Tieghem have drawn up various classifications. The merits and demerits of these classifications are discussed by Danser (1929, 1931), who proposed a new system of classification of the Loranthaceae. Danser's system differs from other classifications by the distinction of a larger number of genera. In the Loranthoideae, Danser (1931) has separated the tribe Elytrantheae from the Lorantheae due to its plurilocular ovary. On the basis of the structure of the inflorescence, Danser (1941) has also prepared a new arrangement for the Viscoideae.

Trimen (1895) recognised four genera in the Loranthaceae in Ceylon:—*Loranthus*, *Viscum*, *Notothixos* and *Ginalloa*. He distinguished 17 species of *Loranthus*, 6 species of *Viscum*, 1 *Notothixos* and 1 *Ginalloa*.

According to the system adopted by Danser (1929), the 17 species of the genus *Loranthus* as distinguished by Trimen (1895) have been split up into 7 genera:—*Barathranthus*, *Dendrophthoe*, *Elytranthe*, *Helixanthera*, *Scurrula*, *Taxillus* and *Telypanthus*. Of the 6 species of *Viscum* referred to by Trimen, *Viscum japonicum* had been named *Korthalsella opuntia* earlier by Van Tieghem.

Present Investigation

During the present investigation 465 specimens of the Loranthaceae were collected throughout Ceylon, of which 165 specimens were brought to Oxford along with pickled material for further study. These have been compared with type specimens at the Herbarium Peradeniya (Ceylon), the British Museum and Kew Herbarium. A few specimens were earlier identified with the assistance of Dr. Kostermann at the Herbarium Bogoriense, Indonesia. The taxonomic problems which remain after these studies are briefly mentioned below:—

In the Viscoideae the following species of *Viscum* are recorded by Trimen:—*Viscum orientale*, *V. monoicum*, *V. ramosissimum*, *V. articulatum* and *V. capitellatum*.

Both Danser (1941) and Rao (1957) refer to the occurrence of *Viscum hyneanum* in Ceylon. Danser records its occurrence in Jaffna and Point de Galle. *Viscum hyneanum* closely resembles *Viscum orientale* and *Viscum monoicum*, but the young fruits of *Viscum hyneanum* are distinctly different, being attenuate at both ends and being warty when young. The writer has collected *Viscum hyneanum* in the Dry Zone chiefly on *Chloroxylon swietenia*. A few specimens were also collected at Kottawa in the low wet country on *Gomphia* sp. Some of these specimens sent to Bogor have been identified as *Viscum hyneanum* and a subsequent check at Kew has confirmed this.

In the leafless Viscoideae with distinctly flattened internodes, Trimen (1895) has recorded only *Viscum articulatum*. Danser (1941) has separated

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Viscum articulatum from *Viscum nepalense* on the basis of the breadth of the internodes and size and shape of fruit. Types with internodes up to 5 m.m. breadth have been classified as *Viscum articulatum*. These have white or greenish white globose fruits, up to 3 m.m. in diameter. Those with internodes from 5-10 m.m. have been classified as *Viscum nepalense* by Danser. These have darker coloured fruits. Rao (1957) is, however, not in agreement with Danser on this separation. He concludes that both *Viscum articulatum* and *Viscum nepalense* are one and the same.

Specimen Thw. Enum. 136 from Ceylon, in the Kew Herbarium, on which Trimen has recognised *Viscum articulatum* was re-labelled *Viscum nepalense* Sprengel in 1941 by Danser.

Of several specimen resembling *Viscum articulatum* collected by the writer throughout the Dry Zone of Ceylon, a few had exceptionally wide internodes. Specimens collected near Chavakachcheri have significantly wider internodes than those collected at Trincomalie and Anuradhapura, and have been identified at Bogor as *Viscum nepalense*. They were also found to agree closely with specimen Thw. Enum. 136 labelled by Danser as *Viscum nepalense*.

Both Danser (1941) and Rao (1957) have regarded *Viscum articulatum* var. *flexuosum* (Gamble) Danser, as a variety restricted to the Malayan Peninsula. It has very narrow internodes and small fruits. Specimens collected on *Scolopia* sp. at Hakgalla in the Montane Zone agree with this type when compared at Kew. It is proposed to collect more fresh material with better flowers and fruits to confirm its naming.

Some of the writer's specimens of the Loranchoideae (Weeraratna 39, 46, 49, 53, 56) sent to Bogor herbarium have been identified as *Amvema* sp. This genus whilst abundant in the Phillipine Islands, extends to Australia, New Caledonia and the Malay Peninsula, but has not been recorded for India and Ceylon. *Amvema* is characterised by an inflorescence which is an umbel of triads. It may be reduced to a simple umbel or to a sessile simple few flowered umbel. Having studied this at Kew, it appears that the writer's specimens identified as *Amvema* at Bogor are really *Dendrophthoe neelgherrensis*. In *Dendrophthoe* the flowers are not in triads, and are single in the inflorescence. No finality could be reached with comparison of types at Kew due to insufficiency of flowering material in these specimens. The leaves of *Dendrophthoe neelgherrensis* and some *Amvema* are quite similar with indistinct nervation. Some of the species collected, however, had extremely long runners attached to the host, resembling a climber, which according to Danser is a feature of *Amvema*. It is proposed to make more collections of this species to pursue its study.

The only two species of *Scurrula* recorded by Trimen for Ceylon are *Scurrula cordifolia* and *Scurrula parasitica*. During the course of collections, several types of *Scurrula* were collected, a few of which did not agree with the description for the two above species. Some of the specimens have been identified at Bogor as *Scurrula fusca* and *Scurrula atropurpurea*. No finality could be reached on their identification at Kew due to insufficient material. It is proposed to collect more of these types.

The field characters, distribution and common host plants of the Ceylon Loranaceae as determined by the writer is given in Appendix I. A revised classification for the Loranaceae of Ceylon combining the writer's observations with the works of Danser (1929, 1931) and Trimen (1895) is given below. Rao's (1957) modifications of Danser's arrangement of the genus *Viscum* have also been followed in this classification.

Revised Key to the Loranthaceae of Ceylon

- 1a Flowers hermaphrodite, conspicuous. Perianth double composed of a calyx and corolla.

Sub-family LORANTHOIDEAE

- 2a Ovary 2-more celled in very young stage (Embryo sacs penetrating into the basal part of the style only). Cotyledons spreading during germination.

Tribe ELYTRANTHEAE. Dans.

Flowers single in the inflorescence. Inflorescence a spike, flowers inserted in hollows of the axis. Corolla sympetalous, three bracts (1 bract and 2 bracteoles)

1. ELYTRANTHE. Blume

- 3a Corolla tube over 1 inch—(Found generally in hill country)

E. parasitica

- 3b Corolla tube under $\frac{1}{2}$ inch—(Found generally in low wet country)

E. capitellata

- 2b Ovary one celled from the very beginning (Embryo sacs at last penetrating up to the upper part of the style)

Tribe LORANTHEAE, Engl.

Cotyledons hidden in the distinct endosperm during germination.

Sub-tribe HYPHEATINAE. Dans.

- 3a Flowers in simple, 3 flowered or 2 flowered cymes. (Triads or Dyads) which are united into large inflorescences.

Inflorescence an umbel of triads often reduced to a simple umbel or to a sessile simple few flowered umbel.

2. AMYEMA Van Tiegh.

- 3b Flowers not in triads, single in the inflorescence.

- 4a Corolla choripetalous.

- 5a Inflorescence a raceme or spike.

Anthers linear.

3. HELIXANTHERA. Lour.

- 6a Leaves opposite, oblong falcate, 3-5 parallel veins, flowers on pedicels.

H. ensifolia

- 6b Leaves alternate, flowers sessile.

H. Hookeriana

- 5b Inflorescence a sessile head without involucre.

4. BARATHRANTHUS Miq.

6a Leaves over 3 inches. Petals $\frac{1}{2}$ -inch—

B. nodiflorus

6b Leaves under 1 inch. Petals $\frac{1}{4}$ inch.

B. mabaeoides

4a Corolla sympetalous.

5a Flowers in racemes or spikes or more or less crowded to heads, but in latter case regular.

6a Ovary and fruit not or only slightly attenuate towards the base. Filaments and anthers normal. Leaves opposite or scattered. Flowers 5-4 merous. Infl. a spike or raceme. Flowers regular or slightly zygomorphic.

5. *DENDROPTHOE*. Mart.

7a Calyx limb obviously toothed. Fl. in racemes. Leaves rotundate, coriaceous, 3-nerved at base.

D. suborbicularis.

7b Calyx limb truncate, or nearly so.

8a Corolla tube under 1 inch. Veins indistinct.

D. neelgherrensis

8b Corolla tube over 1 inch. Veins distinct except in *D. ligulatus*.

9a Flowers in racemes.

10a Leaves fleshy, oblong-linear. Veins indistinct. Flowers yellow.

D. ligulatus

10b Leaves large ovate or oval. Fl. red or greenish white.

D. falcata.

9b Flowers in fascicles. Large leaf scars on branches.

D. lonchophylla.

6b Ovary and fruit strongly attenuate towards the base. Corolla 4 merous, zygomorphous, much deeper slit at one side.

6. *SCURRULA*. Linn.

7a Leaves oval, not cordate at base. Shape variable. Young parts rusty tomentose.

S. parasitica.

7b Leaves rotundate. Cordate at base. Entire plant covered with white tomentum.

S. cordifolia.

5b Flowers in umbels, or these if few flowered, contracted to heads, or even reduced to a single sessile flower.

6a Corolla quite regular, at most curvate. Flowers sessile or nearly so in a head with an involucre of many bracts.

7. TOLYPANTHUS. Bl.

Leaves large, upper surface light green, lower pale; flowers in clusters in old wood.

T. Gardneri

6b Corolla distinctly zygomorphous. Much more deeply slit at one side. Corolla lobes reflexed, not twisted. Stamens straight. Inflorescence an umbel or a head-like umbel, rarely diminished to one flower.

8. TAXILLUS Van. Tiegh.

7a Calyx limb truncate or nearly so. Leaves small, glabrous, often in fascicles.

T. cuneatus

7b Calyx limb obviously toothed.

8a Fl. in clusters. Leaves rufous tomentose beneath.

T. tomentosus.

8b Fl. in racemes. Leaves glabrous and spathulate oval.

T. sclerophyllus.

1b Fl. always unisexual, inconspicuous. Perianth simple, calyx-like.

sub-family VISCOIDEAE.

2a Anthers 2 celled.

tribe PHORADENDRAE Engl.

3a Fl. in spikes of decussate sessile 3-flowered simple cymes, of which the middle fl. is female and the lateral fls. are male.

Anthers free.

sub-tribe GINALLOINAE Engl.

9. GINALLOA.

Leaves 1-3 ins., liner spathulate, tapering to base, rounded at apex, obscurely 3-nerved.

G. spathulifolia

3b Fl. at the nodes, originally in simple 3-flowered cymes, afterwards in 3 series. Simple articulate hairs between the flowers instead of bracts. Anthers cohering.

sub-tribe KORTHALSELLINAE. Engl.

10. KORTHALSELLA.

Leaves absent, joints flattened, fl. very small, petals persistent.

K. opuntia

2b Anthers many celled, each opening with a pore.

tribe VISCEAE. Engl.

11. NOTOTHIXOS.

- 3a Anthers not sessile, not adnate to the perigone, transversely chambered.

Leaves small, oval or rotundate, glabrous above, finely and densely woolly beneath.

N. floccosus.

- 3b Anthers sessile, wholly or partly adnate to the perigone, irregularly chambered. Fl. in simple cymes or in larger inflorescences, glabrous.

12. VISCUM.

- 4a No adventitious flowers in the cymes. Flowers in usually 1-5 flowered spikes with terminal fl. which, if female, usually with a bracteal cup of its own. Monoecious, leafless or leaves scaly and very indistinct.

- 5a Flowering stems with distinctly flattened internodes.

- 6a Internodes of varying breadth up to about 5 m.m., broadening gradually from base to top, decussate but twisted near the base to appear as in one plane, much longitudinally grooved. Fruit globose, up to 3 m.m. in diameter, white or greenish white.

V. articulatum.

- 6b Internodes 5-10 m.m. broad. Fruit darker coloured than in *V. articulatum*. Fr. globose or oblong in the unripe stage.

V. nepalense.

- 5b Flowering stems with distinctly round internodes, often terete or grooved. Fruit sub globose, small.

V. ramosissimum.

- 4b Inflorescence enlarged by the development of adventitious flowers.

- 5a Middle flower of the cyme female. Leafy.

- 6a Leaves mostly ovate with obtuse or rounded apex, fruits mostly ovoid, contracted at apex, gland-dotted but not warty.

V. orientale.

- 6b Leaves mostly ovate with obtuse or acute apex, unripe fruits oblong, attenuate at both ends, warty, nearly smooth when ripened, sepals usually persistent.

V. heyneanum.

- 6c Leaves lanceolate, slightly falcate with acute or somewhat acuminate apex, fruits oblong, somewhat truncate, never attenuate or contracted at apex, smooth.

V. monoicum.

- 5b Middle fl. of cyme male. Leaf present or absent. When present leaf small, roundish-obovate, with obtuse apex, always curved upwards, peduncles of cymes prominent.

V. capitellatum.

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APPENDIX I

Field Characters, Distribution and Common Host Plants
of the Loranthaceae of Ceylon**Barathranthus mabaeoides** (Trim.) Dans :

Field characters :—Parasite heavily branched ; young parts furfuraceous ; leaves small, veins obscure ; flowers in fascicles, sessile.

Distribution :—Rare. Restricted to parts of Matale District.

Localities :—Matale, Wattagama.

Weeraratna 201, 203.*

Host plants :—*Mangifera indica*.

Barathranthus nodiflorus (Thw.) V. Tiegh. :

Field characters :—Branches slender and compressed ; young parts furfuraceous. Leaves about 3 inches, bright green ; flowers sessile and crowded in clusters.

Distribution :—Rare. Restricted to parts of the Wet Zone in Galle District.

Localities :—Udugama, Hiniduma.

Weeraratna 205, 206, 209.

Host plants :—*Eugenia* sp. *Bombax malabaricum*.

Dendrophthoe falcata. (Linn. F.) Ettingsh :

Field characters :—Large shrub ; leaves large, midrib prominent, sometimes purple beneath ; leaf petiolate or sessile and amplexicaul ; fl. large and tube has a range of colours :—dark red, pink, orange, light purple or greenish white. Lobes generally green.

Distribution :—Very widely distributed, covering the whole Island. There appear to be several varieties. The varieties with dark red flowers and very coriaceous leaves are found in the drier tracts.

Localities :—Throughout Ceylon.

Host plants :—Occurs on a wide variety of hosts.

(a) Heavily attacked :—*Acacia melanoxylon*, *Artocarpus integrifolia*, *Bombax malabaricum*, *Casuarina equisetifolia*, *Citrus acida*, *Citrus aurantium*, *Citrus grandis*, *Ceiba pentandra*, *Grevillea robusta*, *Hevea brasiliensis*, *Tectona grandis*, *Mangifera indica*.

(b) Moderately attacked :—*Eugenia jambolana*, *Eugenia javanica*, *Eugenia malaccensis*, *Melia composita*, *Albizia odoratissima*, *Ficus* sp.

Weeraratna 3, 6, 11, 26, 50, 165.

Dendrophthoe ligulata (Thw.) V. Tiegh. :

Field characters :—Leaves fleshy, oblong linear, veins inconspicuous ; flower tube lemon yellow.

Distribution :—Dry and arid areas in Jaffna, Mannar and Puttalam Districts in the north-west of the Island.

* Numbered collections made by the Author.

Localities :—Jaffna, Elephant Pass, Puttalam, Mannar, Kalpitiya.
Weeraratna 13, 21.

Host plants :—*Salvadora persica*, *Tamarix gallica*.

Dendrophthoe lonchophylla (Thw.) Dans :

Field characters :—Large leaf scars on stout branches ; leaves with prominent veins beneath ; fl. in fascicles ; fruit large, ovoid, red when ripe.

Distribution :—Very rare, Wet Zone, parts of Colombo District.

Localities :—Waga.

Weeraratna 215.

Host plant :—*Mangifera indica*.

Dendrophthoe neelgherrensis (W. & A.) V. Tiegh. :

Field characters :—Leaves large, opposite, almost sessile, pale green, veins inconspicuous ; flowers on short pedicles on umbellate racemes, corolla tube less than an inch ; fruit large, orange when ripe.

Distribution :—Moist hilly areas. Also in moist low country, Colombo, Ratnapura and Badulla Districts.

Localities :—Colombo, Homagama, Ratnapura, Haputale, Badulla, Kuliyaipitiya.
Weeraratna 9, 39, 46, 52, 56.

Host plants :—*Mangifera indica*, *Eucalyptus globulus*, *Anacardium occidentale*, *Grevillea robusta*, *Nerium* sp., *Psidium guajava*.

Dendrophthoe suborbicularis (Thw.) Dans. :

Field characters :—Branches stout ; young parts finely tomentose ; leaves rotundate or rounded at apex, very coriaceous, 3 nerved at base ; corolla tube inflated ; fruit capped with cal-segments, ovate oblong.

Distribution :—Montane zone, Nuwara Eliya District.

Localities :—Nuwara Eliya, Horton Plains, Pidurutalagala, Hakgalla.
Weeraratna 45, 47.

Host plants :—Very common on *Rhododendron arboreum*, *Widdringtonia whytei*.

Elytranthe capitellata (W. & A.) Engl. :

Field characters :—Large shrub ; branches slender and pendant ; midrib of leaf sometimes purple ; flower tube light pink with lobes often green.

Distribution :—Few places in Wet Zone in Galle and Ratnapura Districts.

Localities :—Mapalagama, Kananke, Kottawa, Labugama.

Weeraratna 32, 38a, 68.

Host plants :—*Artocarpus integrifolia*, *Mangifera indica*, *Semecarpus* sp.

Elytranthe parasitica (Linn.) Dans. :

Field characters :—Large bushy shrub ; flowers larger than in *E. capitellata* ; corolla tube pink, lobes green.

Distribution :—Montane zone, Very common at Nuwara Eliya District.
Lower limit of distribution appears to be Kandy.

Localities :—Nuwara Eliya, Hakgalla, Maturata, Ragalla, Badulla.

Weeraratna 48, 163.

Host plants :—*Acacia melanoxylon*, *Glochidion zeylanicum*.

Ginalloa spathulifolia (Oliv.)

Field characters :—Leaves linear, spathulate ; flowers sessile.

Distribution :—Moist regions in Colombo and Ratnapura Districts.

Localities :—Waga, Labugama, Karawita.

Weeraratna 130.

Host plants :—*Mangifera indica*, *Artocarpus integrifolia*.

Helixanthera ensifolia (Hhw.) Dans. :

Field characters :—Leaves opposite, falcate, 3-5 parallel veins.
 Distribution :—Moist low country, Sabaragamuwa district. Rare.
 Localities :—Ratnapura, Karawita.
 Host plants :—*Bombax malabaricum*.
 Weeraratna 240.

Helixanthera Hookeriana W. & A.) Dans. :

Field characters :—Young leaves rufous-scurfy ; mature leaves glabrous and coriaceous, twisted ; flowers in axillary spikes.
 Distributions :—Recorded by me only in the Batticaloa and Polonnaruwa districts. It has not been seen in the Montane zone (although reported by Trimen).
 Localities :—Vakaneri, Polonnaruwa, Manampitiya.
 Weeraratna 57, 127.
 Host plants :—*Walsura piscidia*.

Korthalsella opuntia (Thunberg). Merril.

Field characters : Small, short flattened joints, fleshy, leaves absent.
 Distribution :—Montane zone at altitudes over 6,000 ft. (approx.) in Nuwara Eliya district.
 Localities :—Horton Plains, Pidurutalagala.
 Weeraratna 88, 120, 130.
 Host plants :—*Symplocos* sp., *Eurya* sp.

Notothixos floccosus (Oliv.):

Field characters :—Young parts woolly ; leaves small, oval, glabrous above, woolly beneath. Fruit ovoid, creamish white.
 Distribution :—Ratnapura district, and parts of Hiniduma Korale in Galle district.
 Localities :—Potgulkanda.
 Weeraratna 34, 35, 89.
 Host plants :—*Palaquium* sp.

Scurrula cordifolia (Wall.) G. Don :

Field characters :—White tomentum covers the whole plant ; leaves rotundate.
 Distribution :—North-Central and drier parts of North-Western Province.
 Localities :—Nochiyagama, Anuradhapura, Mihintale, Padeniya.
 Weeraratna 17, 18.
 Host plants :—*Grewia polygama*, *Moringa pterygosperma* *Scurrula parasitica* (Linn. :)

Field characters :—Leaf variable, young parts rusty-tomentose, upper surface of leaf almost glabrous, lower surface pubescent ; corolla tube inflated, curved, lobes reflexed ; fruit club shaped.

Distribution :—Common in the Dry zone. Also found in the Intermediate zone and rarely in the wet country.

Localities :—Puttalam, Anuradhapura, Trincomalie, Kurunegala, Yakkatuwa, Waga.
 Weeraratna 1.

Host plants :—*Pterospermum suberifolium*, *Eucalyptus globulus*, *Neolitsea* sp., *Calatropis gigantea*, *Randia* sp., *Bridelia retusa*.

Taxillus cuneatus (Roth.) Dans. :

Field characters. Leaves small and in fascicles, almost sessile, cuneate obovate ; Corolla tube gibbous at base.

Distribution :—Common throughout the Dry zone, chiefly North-Central and Northern provinces. Also recorded at Peradeniya.

Localities :—Anuradhapura, Trincomalie, Mankulam, Vavuniya, Galgamuwa, Peradeniya.

Weeraratna 2, 19, 25.

Host plants :—*Hemicyclea sepiaria*, *Limonia* sp., *Aegle marmalos*, *Diplospora dalzellii*, *Manilkara hexandra*.

Taxillus sclerophyllus (Thw.) Dans. :

Field characters :—Leaves spatulate-oval, tapering at base, stiff. Margin of leaf often red.

Distribution :—Montane zone above 6,000 ft., Nuwara Eliya district.

Localities :—Hakgalla, Nuwara Eliya, Horton Plains, Haputale, Kandapola.

Weeraratna 40.

Host plants :—Abundant on *Rhododendron arboreum*.

Taxillus tomentosus (Roth.) V. Tiegh. :

Field characters :—Young plants rusty tomentose ; leaves green above, densely brown tomentose beneath, veins prominent ; corolla densely woolly.

Distribution :—Abundant in the lower hills of the Montane zone. Rarely ascends above 6,500 ft., Nuwara Eliya and Badulla districts.

Localities :—Haldummulla, Welimada, Kinigama, Hakgalla, Kandapola.

Weeraratna 44, 72.

Host plants :—Abundant on *Emblica officinalis* and *Neolitsea involucrata* :—Also found on *Citrus* sp., *Trema orientalis*, *Bridelia moonii*.

Tolypanthus Gardneri (Thw.) V. Tiegh.

Field characters :—Leaves large, upper surface light green, lower surface pale. Flowers sessile in clusters in old wood, bracts forming a prominent involucre.

Distribution :—Moist low country in Colombo district. Rare.

Localities :—Labugama.

Weeraratna 86, 87.

Host plants. (not identified).

Viscum articulatum (Burm.) :

Field characters :—Leaves absent. Stem flattened. Internodes broadening gradually from base to top, twisted at the base, longitudinally grooved. Fruit globose, light yellow when mature.

Distribution :—Mostly in the Dry zone, particularly at Trincomalie. Extends to the drier parts of the Intermediate zone.

Localities :—Trincomalie, Batticaloa, Pallai, Anuradhapura, Galgamuwa.

Weeraratna 5.

Host plants :—*Cassia fistula*, *Cassia marginata*.

Viscum articulatum Burm. var **flexuosum** (Gamb.) Danser :

Field characters :—Resembles *Viscum articulatum* but the internodes are very narrow and the fruits small. My specimens (Weeraratna 67,136) agrees with Rao's (1957) description of this species.

Distribution :—Found only at Hakgalla in the Montane zone, Nuwara Eliya district.

Weeraratna 67, 136.

Host plants. *Scolopia* sp.

***Viscum capitellatum* (Sm. in Rees, Cyclop.)**

Field characters :—Young plants generally have leaves which are shed when old. Leaves when present curled upwards. Internodes terete, sometimes grooved. Fruits ovate.

Distribution :—Occurs in all climatic zones in Ceylon although sporadically distributed. Has been found only on *Dendrophthoe falcata*. Wherever *Dendrophthoe* occurs in epidemic form, *Viscum capitellatum* is always found, as at Haldummulla and Mitrigala.

Weeraratna 4, 26, 36, 54, 123.

Localities :—Kinigama, Haldummulla, Labugama, Waga, Mitrigala, Puttalam, Batticaloa, Pallai, Kitulgala, Kandy, Koslanda.

Host plant :—*Dendrophthoe falcata*.

***Viscum heyneanum* (A. P. de Candolle)**

Field characters :—Leaves opposite, shape variable, generally roundish ovate, margin crisp, slightly coriaceous; fruits oblong, attenuate towards both ends particularly when young; fruit warty when young.

Distribution :—Generally Dry zone, occasionally in the Low Wet country.

Weeraratna 8, 10, 27, 145, 158.

Localities : Mankulam, Anuradhapura, Batticaloa, Puttalam, Kottawa.

Host plants :—Generally on *Chloroxylon swietenia*, also found on *Gomphia angustifolia*.

***Viscum monoicum* (Roxb.) :**

Field characters :—Leaves opposite, elliptic, usually falcate, apex acuminate; fruits usually oblong, rounded at base, truncate at apex.

Distribution :—Generally in the Intermediate zone and also Uva.

Localities :—Gokarella, Ella.

Weeraratna 14.

Host plants. (not recorded).

***Viscum nepalense* (Sprengel)**

Field characters :—Resembles *Viscum articulatum* but the internodes are broader. Fruits darker coloured.

Distribution :—Near Chavakachcheri in the Northern province and near Koslanda in Uva province. Rare.

Weeraratna 12.

Host plants :—*Cassia fistula*.

***Viscum orientale* (Willd.)**

Field characters :—Leaves opposite, mostly ovate or obovate, margin entire; fruit round and contracted at apex.

Distribution :—Mostly in the Dry Zone.

Localities :—Mullaitivu, Jaffna, Anuradhapura.

Weeraratna 16, 23.

Host plants :—Mostly *Thespesia populnea*.

***Viscum Ramosissimum* (Wall.) :**

Field characters :—Stem terete, sometimes round and grooved, much branched; leaves absent.

Distribution :—Montane zone, Nuwara Eliya district. Rare.

Localities :—Hakgalla, Ragalla.

Weeraratna 268.

Host plant :—*Rhododendron arboreum*.

RESEARCH NOTES

FUNGI CAUSING ROOT DISEASE OF FOREST TREES IN CEYLON

A. L. Bertus

VERY little is known regarding the root diseases of our forest trees. A great many of these diseases are due to parasitic fungi which attack the roots of the living tree causing die-back, wilt, &c., in the aerial portion, and, unless checked, ultimately result in the death of the tree. Unfavourable growth conditions such as a too high or too low moisture content of the soil can also cause the death of roots, thereby reducing the vigour of the tree and permitting fungi, which are only weakly parasitic or saprophytic and incapable of attacking vigorously growing roots, to enter the dead roots and progress into the trunk causing decay of the heartwood of the butt without killing the tree. A good many of the hollow trees found in our forests may have been caused this way.

In a natural forest, due to the wide variety of species present, and to a certain amount of selectivity regarding hosts of the fungi, root disease does not cause an appreciable loss of timber, but in plantations, restricted to one or a few species, diseases such as root rots could assume dangerous proportions. This is particularly so where the species are grown on sites to which they are not completely adapted. The importance attached to the control of root-disease fungi in tea and rubber plantations, where they could cause extensive damage, is proof of this.

A good many of the root disease fungi recorded to date are common to many forest trees, e.g., *Fomes noxius*, the cause of brown root disease, *Rhizoctonia bataticola*, *Ganoderma lucidum*, &c. This feature is an added danger, as once the fungus is established in a forest or plantation it can proceed from tree to tree regardless of species and soon be spread out in a wide area.

The following list was prepared mainly to serve as a guide to the fungi recorded on forest trees both naturally found in Ceylon and introduced from abroad. It is possible that the list includes some fungi which are not normally parasitic and may be of little importance, but of necessity have to be included to make the list as comprehensive as possible.

ACACIA DECURRENS. Willd.

Armillaria mellea (Fr.) Quel.—Root rot.

Ganoderma applanatum (Pers. ex Fr.) Pat.

Poria albobrunnea, Petch.

ALBIZZIA MOLUCCANA, Miq.

Botryodiplodia theobromae, Pat.

Fomes noxius, Corner.—Brown root disease.

Ganoderma lucidum (Leyss. ex Fr.) Karst.

Poria hypolateritia, (Berk.) Cooke.

Rhizoctonia bataticola (Taub.) Butl.

Ustulina deusta (Fr.) Petrak.

ARECA CATECHU, L. S. Puwak ; T. Kamukai.

Ganoderma lucidum (Leyss. ex Fr.) Karst.

Rhizoctonia bataticola (Taub.) Butl.

Ustulina deusta (Fr.) Petrak.

ARTOCARPUS ALTILIS (Park.) Forst. S. Rata-del ; T. Erapilakai.

Sphaerostilbe repens, B. & Br.

ARTOCARPUS HETEROPHYLLUS, Lam. S. Kos ; T. Pila.

Fomes lignosus (Klotz.) Bres.

Fomes noxius, Corner—Brown root disease.

Rhizoctonia bataticola, (Taub.) Butl.

Rosellinia bunodes (B. & Br.) Sacc.

ARTOCARPUS NOBILIS, Thw. S. Bedi-del.

Fomes noxius, Corner—Brown root disease.

BARRINGTONIA ASIATICA (L.) Kurz. S. Mudilla.

Rhizoctonia bataticola (Taub.) Butl.

BORASSUS FLABELLIFER, L. S. Tal ; T. Panai.

Rhizoctonia bataticola (Taub.) Butl.

CANANGA ODORATA (Lam.) Hook.f.& Thomas. S. Wana-sapu.

Fomes lignosus (Klotz.) Bres.

CASUARINA EQUISETIFOLIA, L. S. Kasa.

Ganoderma lucidum. (Leyss. ex Fr.) Karst.

Poria hypolateritia, (Berk.) Cooke.

Trichosporium vesiculosum, Butl.—Root and stem disease.

CEIBA PENTANDRA (L.) Gaertn. S. Imbul, Pulun-imbul ; T. Kappu.

Fomes noxius, Corner—Brown root disease.

CROTON LACCIFER, L. S. Keppetiya, Gas-keppetiya ; T. Teppadi.

Poria hypolateritia, (Berk.) Cooke.

CUPRESSUS MACROCARPA, Hartn. Monterey Cypress.

Rhizoctonia bataticola (Taub.) Butl.

DELONIX REGIA (Boj.) Rafin. S. Diya-ratmal.

Fomes floccosus, Bres.

Fomes noxius, Corner—Brown root disease.

Ganoderma applanatum (Pers. ex Fr.) Pat.

Ganoderma lucidum (Leyss. ex Fr.) Karst.

Sphaerostilbe repens, B. & Br.

DIOSPYROS EBENUM, Koen. S. Kaluwara, T. Karunkali.

Ustulina deusta (Fr.) Petrak.

ERYTHRINA LITHOSPERMA, Miq.

Fomes lignosus (Klotz.) Bres.

Fomes noxius, Corner—Brown root disease.

Poria hypobrunnea, Petch—Red root disease.

Rhizoctonia bataticola (Taub.) Butl.

Ustulina deusta (Fr.) Petrak.

EUCALYPTUS MACULATA, Hk. Spotted gum.

Ganoderma lucidum (Leyss. ex Fr.) Karst.

FISCUS RELIGIOSA, L. S. Bo ; T. Arachu.

Fomes noxius, Corner—Brown root disease.

- GREVILLEA ROBUSTA, A. Cunn. Silky Oak.
Botryodiplodia theobromae, Pat.
Fomes noxius, Corner—Brown root disease.
Poria hypolateritia, (Berk.) Cooke.
Rhizoctonia bataticola (Taub.) Butl.
Rosellinia arcuata, Petch.
Ustulina deusta (Fr.) Petrak.
- MANGIFERA INDICA, L. S. Amba; T. Maanga.
Ganoderma lucidum (Leyss ex. Fr.) Karst.
- MELIA DUBIA, Car. S. Lunumidella; T. Malaivempu.
Ustulina deusta (Fr.) Petrak.
- MEMECYLON GRANDE, Retz. S. Dodan-wenna.
Rhizoctonia bataticola (Taub.) Butl.
- NEOLITSEA CASSIA (L.) Kosterman. S. Dawul-kurundu, Kudu-dawulu.
Rhizoctonia bataticola (Taub.) Butl.
- OCHROMA LAGOPUS, Sw. Balsa.
Rhizoctonia bataticola (Taub.) Butl.
- PLEIOSPERMUM ALATUM (Wight and Arn.) Swingle. S. Tumpat kurundu.
Ganoderma lucidum (Leyss. ex Fr.) Karst.
- SALMALIA MALABARICA (DC) Schott & Endl. S. Katu-imbul; T. Puruthi.
Fomes floccosus, Bres.
Fomes noxius, Corner—Brown root disease.
- SANTALUM ALBUM L. S. Sudu-handun; T. Srigandum.
Rhizoctonia bataticola, (Taub.) Butl.
- SPONDIAS PINNATA, Kurz. S. Embarella, T. Ampallai.
Fomes noxius, Corner—Brown root disease.
- SWIETENIA MACROPHYLLA, King. Honduras mahogany.
Fomes noxius, Corner—Brown root disease.
- SYMPLOCOS FURCATA, Brand.
Rosellinia arcuata, Petch.
- TAMARINDUS INDICA, L. S. Siyambala; T. Puli.
Ustulina deusta (Fr.) Petrak.
- THESPIA POPULNEA (L.) Soland. ex. Corr. S. Suriya; T. Kavarachu.
Fomes noxius, Corner—Brown root disease.
- VITEX PINNATA, L. S. Milla; T. Maila.
Fomes noxius, Corner—Brown root disease.

REFERENCES

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2. PETCH, T. and BISBY, G. R. (1950) The fungi of Ceylon
Peradeniya Manual No. VI. Ceylon Govt. Press.

FORESTRY FIELD TRAINING SCHOOL—2ND SESSIONS

PRIZE GIVING AND DISTRIBUTION OF CERTIFICATES

THE first official prize giving of the Forest Field Training School was held on Friday, the 11th December, 1959, in the School Hall at Monkey Bridge at about 10.30 a.m.

Due to the unavoidable absence of Mr. J. L. E. Fernando, C.C.S., Mr. R. A. de Rosayro, Senior Assistant Conservator of Forests, presided over the function and distributed the certificates and prizes. In his Presidential Address he outlined the past history of this institution and the events that led to making Monkey Bridge as the present Headquarters of the Forestry Field Training School. For this, he said, the Department owed a deep debt of gratitude to the present Government Agent, Trincomalee, and the Divisional Forest Officer, North-Central Division, through whose efforts and initiative, this had become possible.

He also dealt at some length on the present course of training which had been brought to a successful completion. He complimented the staff and trainees for what had been achieved and he hoped that those who had achieved a high standard would be considered for early promotion to the higher grades of service.

The Principal thanked the Senior Assistant Conservator of Forests and the other forest officers who had accepted the invitation to be present at the function at much inconvenience to themselves. He also thanked the staff, both past and present and the trainees for their ready assistance and co-operation, which had in a great way been responsible for the success of the present sessions. He regretted very much that the Conservator of Forests has not been able to be present. He concluded by wishing all the trainees the best of luck and success in their future.

Mssrs. H. W. K. Weeraratne and A. Kandiah proposed and seconded a vote of thanks to the chair and to the other guests present.

The proceedings were brought to a close by planting basket plants of *Eucalyptus camaldulensis* by the Senior Assistant Conservator of Forests, the Additional Divisional Forest Officer, North-Central Division, and a few others in commemoration of the event.

Award of Certificates

HONOURS CERTIFICATE : AVERAGE 75% OF THE TOTAL MARKS AND OVER

	Marks obtained		Average	
1. Mr. K. Vythilingam	..	1852	..	81
2. Mr. S. D. E. Vincent	..	1757	..	76
3. Mr. K. D. Dharmasena	..	1717	..	75

PASS CERTIFICATE : AVERAGE BELOW 75% OF THE TOTAL MARKS AND ABOVE 40%

4. Mr. M. T. Sirisena	..	1681	..	73
5. Mr. P. Alagiyawanna	..	1652	..	72
6. Mr. S. Sangarapillai	..	1586	..	69
7. Mr. C. Benedict	..	1567	..	68
8. Mr. C. G. de Silva	..	1543	..	67

		<i>Marks obtained</i>	<i>Average</i>
9. G. S. Perera ..	..	1522	.. 66
10. Mr. T. Van Sanden ..	..	1495	.. 65
11. Mr. V. K. Pathmanathan ..	..	1478	.. 64
12. Mr. K. A. J. Dias ..	..	1458	.. 63
13. Mr. P. A. Jinadasa ..	..	1443	.. 63
14. Mr. H. W. K. Weeraratne ..	..	1437	.. 63
15. Mr. B. Michaelpillai ..	..	1423	.. 62
16. Mr. W. M. K. Banda ..	..	1393	.. 61
17. Mr. M. K. Sellathurai ..	..	1378	.. 60
18. Mr. G. S. Weerasekere ..	..	1375	.. 60
19. Mr. A. Kandiah ..	..	1368	.. 59
20. Mr. C. Lucas Fernando ..	..	1351	.. 59
21. Mr. R. Wickramasinghe ..	..	1345	.. 59
22. Mr. P. A. E. de Silva ..	..	1331	.. 58
23. Mr. A. W. Amunugama ..	..	1320	.. 57
24. Mr. G. D. Gunaratnam ..	..	1231	.. 54

PRIZES

1. Conservator's Prize presented by J. L. E. Fernando, Esq., C.C.S., Conservator of Forests, for the trainee scoring the highest aggregate awarded to Mr. K. Vythilingam.
2. The J. A. de Silva Prize presented by J. A. de Silva, Esq., Warden, Wild Life Department, for Mensuration, Management and Working Plans, awarded to Mr. K. Vythilingam.
3. The Senior Assistant Conservator of Forests (I)'s Prize presented by R. A. de Rosayro, Esq., S.A.C.F. (I) for Silviculture, awarded to Mr. K. D. Dharmasena.
4. The Senior Assistant Conservator of Forests (II)'s Prize presented by E. C. Tamby Raja, Esq., S.A.C.F. (II) for Utilization, Surveying and Engineering awarded to Mr. M. T. Sirisena.
5. The Senior Assistant Conservator of Forests (III)'s Prize presented by M. Namasivayam, Esq., S.A.C.F. (III) for Range Administration, Law and Forest Protection, awarded to Mr. P. Alagiyawanna.
6. The Past Principals' Prize presented by W. G. Weeraratne, Esq., A. E. K. Tissaveerasinghe, Esq., and S. H. Bagot, Esq., for Botany awarded to Mr. S. D. E. Vincent.

NATURE NOTES

RAIN FROM TREES

R. A. de Rosayro.

ONE is familiar with the phenomenon of "rain from trees" which occurs in forests throughout the Tropics. In Ceylon it is experienced principally in the Dry Zone. This form of precipitation is generally associated with heavy dew-fall and has been referred to scientifically as "occult precipitation". It has practically been taken for granted that dew-fall contributes appreciably to the total rainfall and especially in times of drought, can be the principal factor contributing towards the establishment and maintenance of forest vegetation.

Recently, however, there has been considerable attention focussed on this phenomenon of "rain from trees". In several issues of the "Malayan Forester" within the past 2 years, an interesting series of letters have expressed different opinions, especially in the case of individual trees, chiefly the Meranti Batu (*Shorea dasyphylla*) which is a large emergent tree of the rain forest in the Malayan Peninsula. A peculiar feature appears to be that the rain from under such trees was found to be prolific, almost as if it was in the form of a natural shower of rain. Several interesting theories have been suggested to account for such a phenomenon, but no clear and definite solution seems to have yet been reached. The suggestion that Cicadas were probably instrumental, has been suggested by a number of writers but several authorities do not agree that such large quantities of water can be exuded in the form of rain from these creatures. The opinion generally held is that the exudation is due to natural causes, namely, the suction pressure of an enormous root system which causes the transpiring surface of the crown to exude large quantities of water under conditions of excessive humidity.

More recently, however, other authorities have by their own personal observation, lent more force to the theory that the Cicada is probably responsible for it in some instances. For instance Swabey writing on an African experience states that under the well-known Rain tree (*Samanea saman*), it did actually rain in the form of a continuous fall of fine droplets, a phenomenon which is well-known also in this country. His African assistant suggested with characteristic directness that "some small ting dere for up make piss sah". On climbing the tree, large clouds of Cicadas rose from it and instantly the rain ceased. Swabey's examination of the bark of one of the branches with the aid of a powerful lens showed that minute punctures had been made by the probosces of these sucking insects and suggests that the suction exerted by their mouth-parts caused the excess water to be given out in the form of "rain".

Audy has suggested that other insects of the family *Cercopidae* which include the group of froghoppers or cuckoo-spit insects, which infest trees in large numbers are responsible for the phenomena of "weeping trees" which makes such copious exudation that the drops have been compared to a shower of rain. He states that in Ceylon, the larvae of *Machaerota guttigera* constructs tubes fixed to the twigs of the tulip tree (*Thespesia populnea*) and from these tubes, water is exuded drop by drop.

The recent experience of the writer in Ceylon is interesting in that it provides confirmation of at least one reason for this phenomenon. In inspecting a teak plantation near Mankulam in the Northern Province in May last year, at about 7.30 in the morning, the phenomenon of rain from trees was not confined to just one of the trees, but practically amounted to a *light drizzle* in the entire plantation. His attention was drawn by the Forest Ranger Mr. Sebamalai to that fact that under certain trees especially of the understory, the floor of dead leaves was completely wet as though it had rained heavily in the night. Finding that this was not so, the party observed that the entire plantation was thick with swarms of Cicadas creating a terrific din almost making conversation impossible. Closer observation of the smaller trees showed that the Cicadas on the branches were responsible for producing a copious shower of rain. These insects are especially clearly visible on the branches against the light background of the bark of the "vel vel" (*Acacia leucophloea*) trees. From time to time showers of "rain" are shot out from the abdomens of these insects in the form of fine jets thrown horizontally from their bodies which are projected to a distance of almost two feet. This was continuous and practically at all times while the insects fed on the branches on the trees. Beeson in his classic work the "Ecology and Control of Forest Insects

in India and the Neighbouring Countries" published in 1941 by the Government of India, states quite explicitly that the "adult Cicada sucks sap from the slender shoots and twigs and longer soft bark stems and branches up to about 8 inches in girth. When feeding, the beak is held at right angles to the head, the thorax is raised and the abdomen is pressed close against the stem; the stylets penetrate about one third their length through a minute puncture. In this position the Cicada feeds for hours ejecting the fluid excreta in a jet which pours into a fine spray".

There is no doubt whatsoever, that this phenomenon in the tropics is very largely due to the activities of insects, especially the family "Cicadidae" which in Ceylon at least are known by all foresters to be prolific in almost all forests. It is distinctly probable, therefore, that much of this so-called "occult precipitation" which has been previously attributed to heavy dew-fall is largely produced by the Cicada. The personal observations of the writer and his party should clinch this issue.

REVIEW

AGRICULTURE AND ECOLOGY IN AFRICA—A STUDY OF ACTUAL AND POTENTIAL DEVELOPMENT SOUTH OF THE SAHARA, BY JOHN PHILLIPS. PUBLISHED BY FABER AND FABER, LONDON. Pps 424 WITH ONE MAP PRICE : 63 sh.

“Mother Africa is a grand old lady : we may guide her, persuade her—and even seduce her—but we cannot drive her. We must learn to know more of her home life and economy, her ecology.”

THIS quotation from a verbal remark of Field Marshall Smuts followed by a Foreword in similar strain by the Honourable Kwame Nkrumah, Prime Minister of Ghana, is a pointer to the tone, idealism and the profound thought that characterises Professor Phillips' monumental work.

Professor Phillips has long been recognised as an exponent of the science of Ecology. His series of articles on Succession, Development and Climax published in the *Journal of Ecology* in 1934 and 1935 are masterpieces of ecological polemics, postulating, analysing and synthesizing the existing concepts of ecological thought with clarity and precision. The same sure touch, clear thought and profound knowledge runs through the wide field which comprises this book.

The book is divided into four parts. The first part, Book One, outlines the scope and basis of approach, which is essentially ecological. In fact, the ecological approach is stressed throughout the book drawing upon examples of the failure of grandiose schemes—such as the now well-known groundnut scheme in Tanganyika—where because of the lack of proper and careful planning, an all too hastily conceived enterprise was doomed to failure from the start. As Professor Phillips puts it in a foot-note on page 34 “with its original aims and time schedule and its ecological setting no power on earth could have led the undertaking to success.” Then follows an outline of the Climax and Bioclimatic Regions which is elaborated in subsequent chapters. It is in the classification of Vegetation and Bioclimatic Regions, that the reviewer finds himself unable to subscribe to the expression of these in a concise form by combinations of letters signifying the various factors of the habitat and the constituents of the forest Panclimax (Panclimax = world grouping of climax vegetational types). This combination of letters, such as “HSFESL”—“Humid-humid-subhumid forest but an outlier, Cx (i.e. climax) with much SV” (i.e. secondary vegetation)—or again, “MSAWS” (mild sub-arid wooded savanna), is extremely confusing and necessitates constant reference to the key as these combinations are numerous and cannot easily be kept in mind. This is perhaps, unfortunate, as the treatment of each type in Book Two and Three is so complete and up-to-date that very little purpose seems to have been achieved in adopting these abbreviated forms—brevity at the expense of a clarity! Further confusion is introduced by the breaking up of the climatic factors expressed in a similar combination of simple letters, eg. exc = excessive, vvsl = very, very slight (for annual rainfall) fl = fairly long, vsl = very slight (for the number of wet and dry months, etc.). All these combinations are introduced in the specific tables for each vegetational type described in Books Two and Three.

Professor Phillips mentions in passing Thornthwaite's (1948) recent classification of climates and Carter's (1954) series of maps based on this method, comparing his approach with these classifications. The recent Vegetation Map of Africa published by the Oxford University Press (1959) with introductory notes by Keay is also mentioned. Within the limits imposed by the small scale (1 : 20,000,000) and consequent approximation of boundaries of Bioclimatic Regions, Phillips' map (opposite page 412) corresponds fairly well with the Vegetation Map of Africa drawn up by a number of well-known authorities. But his map suffers in comparison by the inclusion of too many sub-units of vegetation and the resultant minor inaccuracies in their limits. As against only 32 in the former which has the added merit of a larger scale (1 : 10,000,000) and an excellent combination and range of colours, Phillips' map comprises 45 units of vegetation and a narrower range of colours. His terminology is also somewhat confused and too elaborate, differing in this respect from the more universally accepted and simpler terminology adopted by the team of experts. The latter chapters in Book One deal with the

background of the problems of agricultural, forestry and related developments in Africa and stress the inherent difficulties of the soil and animal populations in the complex of factors militating against such developments.

Book Two deals with the Forest Panclimaxes. It outlines the distribution of forest and the major climatic factors controlling the forest climax. Subsequent chapters deal specifically with each forest type, followed by chapters on climate, soils and agricultural development in relation to the latter. This section contains a wealth of information and embodies material from the most recent literature on the subject. They are modern and far-reaching in their scope and treatment. The final chapter of *Book Two* which is a survey entitled "A Summary of Challenge and Promise" indicates the basis of future development, especially the necessity of a firm policy of forest reservation and the careful management of forests.

Book Three deals with the Wooded Savanna and allied Bioclimatic Regions ranging from sub-humid Wooded Savanna to the desert types and sub-tropical "Cape Macchia". Despite the inherent difficulties of compassing this wide and most important range of vegetation peculiar to Africa, Phillips' survey of this type is comprehensive and masterly in its treatment. The chapters dealing with the soils of the Wooded Savanna include all the latest information deriving from the Russian School and goes on to examine the agricultural potential of the soils. Milne's (1938) concept of the *Catena* which has been found to have almost universal application to tropical soils has, however, not received sufficient consideration. The final chapter of *Book Three* contains an excellent summary of each type and the potentialities for agricultural development.

Book Four deals with the influence and interactions of man and his domestic animals on the habitat. The inherent ills, the diseases which plague man and livestock in Africa are dealt with concisely and effectively. The lack of adequate and reliable water supplies and communications, the existence of a low or marginal economy in agriculture and the factors contributing to this state are examined on the one hand; the corresponding features of the existing high potential in mineral wealth and agriculture are presented on the other—"the paradox of plenty and poverty" so typical of most of the Tropics. The reasons for these economic problems are analysed in a study of trade and production, the unsatisfactory systems of land tenure and labour and finally the present development and potential according to the historical development of the countries under different colonial administrations. The "piece de resistance" of this book is the chapter which examines and compares 3 typical large scale development projects, the first the Gezira Scheme in the former Anglo-Egyptian Sudan, the Groundnut Scheme referred to earlier and the Volta River Project in Ghana. All phases of these 3 schemes are examined, their ecological background, objectives, history and implementation. The success of the Gezira Scheme, the failure of the Groundnut Scheme and the careful preparatory planning of the Volta Project are compared in the light of each of these factors. In essence, this chapter brings out the *fundamental* need for careful and co-ordinated planning with proper research and pilot schemes to obtain as complete as possible an ecological understanding, in the broader sense, of all the factors involved. The moral clearly drawn is to "hasten slowly". The objectives and approach to future schemes are then outlined and sound, timely advice is given to those responsible for future agricultural policy and planning. The final chapter of "General Conclusions and Broad Recommendations" synthesizes Phillips' plans for the future development of Africa in a spirit of realism and confidence.

Truly this is a great book, to be read, re-read and digested by ecologists, agriculturists and administrators alike, especially those who have the interests of the great African Continent at heart.

R. A. de Rosayro.

Appropriate Technology Services

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