Rainforest in Ceylon

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II—RAIN-FOREST IN CEYLON. JOHN R. BAKER (Department of Zoology and Comparative Anatomy, Oxford).

The south-west part of Ceylon receives both monsoons and has no really dry season, though the rainfall rises to maxima twice a year. The natural vegetation at low and medium altitudes in this area is tropical rain-forest, but there have been extensive clearings for cultivation and for the most part only small patches of the original forest remain. One rather large patch has, however, survived. This is the Sinharaja Forest, which is the subject of the present paper. I have recently given a general description (2) of the geography, climate and natural history of this forest, but the botany was only briefly mentioned. Some photographs were, however, published, which might be of interest to readers of this paper.

Schimper (11) does no more than mention that rain-forest exists in south-west Ceylon and that plank-buttresses on the trees are very common. Campbell (4) says that little forest remains in this area, and that such as remains is not particularly luxuriant. Guenther (6) made several short visits to patches of rain-forest in the south-west of Ceylon, though not to the Sinharaja itself; and he has left an interesting account of what he saw. The forest is mentioned by name by Willis (13) and Charawanamuttu (5), and Lewis (9) records a number of plants as occurring in it.

The Sinharaja Forest is situated south of Ratnapura and about 12 miles away at its nearest point. It is about 26 miles long and has an area of some 90 square miles. It extends from less than 300 feet to 3,838 feet above sea-level. It presents the characteristic features of a virgin tropical rain-forest. A list of the fifty commonest species of higher plants, away from paths, streams and clearings, is given in the Appendix. The straightness of the stems of the trees is a striking feature almost everywhere. Branches are only given off towards the tops, and the vertical pillar-like stems give the impression of the interior of a cathedral, which has struck observers of rain-forest in other parts of the world. One may estimate the height of the forest as a whole at about 115 feet. One tree was chosen as representing the average, and this was measured trigonometrically. The highest leaves were found to be 119 feet above the ground. When the forest is viewed from a distance, however, huge giants may be seen towering above this: these are probably mostly *Doona congestiflora, Dipterocarpus hispidus* and *D. zeylanicus*. One may distinguish these giants from the ordinary large trees such as the one measured, and also from small trees such as *Agrostistachys longifolia*; but there are not regular canopies, one below another, such as have been described in other rain-forests. Many of the trees have plank-buttress roots, but very high buttresses are not abundant.

In order to find which are the most abundant of the larger trees, a square half-acre was marked off at a medium elevation (1900 feet), and every tree was counted whose stem had a circumference of four feet or more at four feet above the ground. There were 25 such trees, namely the following :—eight specimens of *Durio zeylanicus* ; two specimens of each of the following :—*Myristica dactyloides, Calophyllum Calaba, Doona congestiflora, Palaquium grande,* and " Alaheraliya " ; one specimen of each of the following :—*Calophyllum Soulattri, Mesua Thwaitesii, Mangifera zeylanica, Semecarpus subpeltata, Anisophyllea cinnamomoides, Diospyros quaesita,* and " Yakahalu." The *Guttiferae* and *Dipterocarpaceae* are the families with the greatest number of common species in the forest, though in the area in which the count was made only one large Dipterocarp was present. The helicopter-like fruits usual in this family would only be able to serve their purpose in distribution in a species which projects above the general level of a forest. *Durio zeylanicus,* with its great prickly durian-like, but inedible fruit, is abundant everywhere. *Diospyros quaesita,* the calamander, is common ; but the beautifully figured and valuable heart-wood is only present in a small proportion of specimens.

In general, the various species of trees are mixed up together, but occasionally one species predominates almost to the exclusion of others. Thus there is a large group of *Mesua Thwaitesii* near the river Elewalaganga, south of the village of Pitakele. This species, common everywhere, is the local iron-wood.

Woody lianas (*Dalbergia* sp., *Chilocarpus* sp., *Calamus* spp. and others) are common, but not so common as in some rain-forests ; indeed, there is a certain restraint about the vegetation, contrasting with the wild luxuriance of, for instance, that of the northern New Hebrides. When the wind blows hard above the forest and sways the tree-tops, it is curious to see the lianas moving about near the ground among the immobile bases of the trees. There is no profusion of epiphytic growth on the stems of the trees, at any rate near the ground, and only a moderate growth of creepers (chiefly " Panampeti," *Freycinetia,* and *Pothos scandens,* the latter being remarkable for its flattened petioles).

The undergrowth is scanty, so that with two men going ahead with large knives one may proceed in any direction at about one mile per hour, unless prevented by the steepness of the ground. The poverty of the undergrowth is no doubt mostly due to the density of the leaf-canopy above ; though soil conditions may play a part. Kurz (8) says of the tropical rain-forest of Burma that shrubby vegetation " often disappears entirely in the depth of the dark interior." In the Sinharaja the undergrowth is to an extraordinary extent simply a nursery for the trees, but the young specimens are not present in the same proportions as their elders. Young trees of *Dipterocarpus zeylanicus* are particularly abundant, together with *Mesua Thwaitesii, Durio zeylanicus,* and the thatching-

leaf tree, *Agrostistachys longifolia*. The young trees are as lacking in lateral growth as their elders. A typical young *Dipterocarpus zeylanicus* was carefully measured, to serve as an example. The stem was unbranched and 10 feet 11 inches high. There were only nine leaves, and these were all large and were borne on the uppermost six inches of the stem. The stem was only one inch in diameter at the ground and $\frac{9}{16}$ inch at four feet. Such curiously-shaped young trees intensify the vertical effect of the whole forest. Many of the young trees produce new leaves which are red and droop vertically downwards. These are adaptations to avoid the ill-effects of brilliant illumination on growing tissues, and are no doubt useful when new leaves are being formed at the tops of the big trees; but in the gloom below the canopy the character must be useless. I did not notice red or drooping young leaves on any forest plant except on those species whose subsequent growth would bring them into brilliant illumination. The young leaflets of the rattans (*Calamus*), which are also reddish, stick vertically upwards instead of drooping.

The really common undergrowth plants, other than young trees, are very few. Young rattans, before the growth of any stem, are abundant. The commonest plants which live all their life in the undergrowth are the ferns *Polystichum carvifolium* and *Cyathea sinuata*; the wild cardamom (*Elettaria Cardamomum*) and another Zingiberaceous plant called "Wal-niya"; and the bush *Apama siliquosa*. The latter is the only common bush of the forest, for this species departs from the general character of nearly all the plants in presenting a much-branched stem. The ground was largely covered at the time of my visit with the big leaves of *Dipterocarpus zeylanicus*, which had fallen some months before. Fallen timber is quite extraordinarily abundant, and impedes passage through the forest more than the undergrowth does. Polyporeae grow on the fallen timber, but I never saw a toadstool (Agaricineae) except in one situation: nearly every patch of elephant's dung has one or more, always apparently of the same species.

Fig. 1 illustrates the forest which I have described. It is very difficult to take a photograph which will give an accurate impression of a rain-forest. If one searches the literature, one finds that nearly all the photographs are of the edge of the forest, where it abuts on a river or clearing, or at least where a stream or path passes through it. If one studies such a place, one finds that the vegetation is almost completely different from that of the forest as a whole, owing to the much greater illumination. The photographs therefore represent only a minute fraction of the whole. I have tried to avoid this by placing my camera in the untouched forest, away from any path, stream or clearing. The difficulties of photography under such conditions are very great and technically good results cannot be obtained, but the object is to some extent represented.

The description I have given applies particularly to a medium elevation, namely about 1700–2000 feet. At lower elevations there

is no striking difference, but the following trees become noticeably commoner below 1000 feet :—*Trichadenia zeylanica, Homalium zeylanicum, Dipterocarpus zeylanicus* and *Vateria acuminata*. There is perhaps a slightly greater development of buttress-roots and lianas. At high elevations, e.g., at the summit of Wanduragala (3028 feet) and at 3400 feet on Rupahinkanda, the differences are more marked. The trees are smaller and more branched. *Wormia triquetra, Calophyllum Calaba* and species of *Eugenia* become abundant, and the fallen leaves of the first-named replace those of *Dipterocarpus zeylanicus*. *Doona congestiflora* remains abundant and is the largest tree at this elevation also. The less complete leaf-canopy gives more illumination beneath, and there is correspondingly more undergrowth. Bamboo forms an important part of it in places, and young specimens of *Agrostistachys* no longer abound. Dicotyledonous lianas do not occur, at any rate in any considerable numbers, though both thick and thin rattans persist and help to give a tropical impression.

According to the natives, the characteristically deciduous trees of the forest are *Dipterocarpus zeylanicus, D. hispidus, Doona nervosa, Stemonoporus Wightii,* and *Canarium zeylanicum*. During February or thereabouts these are commonly without leaves. February is the month in which the rainfall tends to be at a minimum. It will be noticed that four of the five deciduous trees mentioned above are Dipterocarps. In this there is agreement with the tropical rain-forest of Burma, of which Kurz (8) says, " The lofty trees towering above the dense forest mass are chiefly leaf-shedders " ; and he instances several Dipterocarps. Since none of the deciduous trees is particularly abundant in the Sinharaja, the forest is evergreen ; and indeed it would be a very extraordinary thing if it were not so, in such a remarkably unvarying climate. The trees of the forest as a whole are said by the natives to shoot forth their young leaves (often reddish) mostly about February and March. Flowering is said to be seasonal, most of the trees producing flowers about May–June, particularly about the time of the " wesak " full moon (May). The natives deny that any of the kinds of forest trees produces flowers and fruits throughout the year. *Doona nervosa* is said to flower and fruit only once in seven years, all individuals at the same time : the last occasion was about 1932. The fruits of most of the trees are said to ripen about the time of the harvesting of the " yala " rice-crop (August–September). This was borne out by myself, for during August I saw fruits of the following species on the trees or freshly dropped to the ground :—*Trichadenia zeylanica, Wormia triquetra, Dillenia retusa, Garcinia echinocarpa, Dipterocarpus zeylanicus, Doona congestiflora, Vateria acuminata, Elaeocarpus subvillosus, Durio zeylanicus, Kokoona zeylanica, Palaquium grande,* and " Alaheraliya."

I collected wood specimens of some of the trees for the study of growth rings, and my brother, Mr. S. J. Baker, has kindly prepared

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Fig. 1. The Interior of the Sinharaja Forest, near Hapugoda.

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these for examination. In one species, *Anisophyllea cinnamomoides*, the medullary rays are so well developed as to obscure the concentric rings. In my specimens of *Mesua Thwaitesii* definite rings are not visible, and they are not well marked in *Dipterocarpus zeylanicus*. This is perhaps rather remarkable in a deciduous species. They are rather better developed in *Myristica dactyloides* and (?) *Vitex altissima*. In the other species studied (*Garcinia echinocarpa*, *Doona nervosa*, *D. congestiflora*, *Durio zeylanicus*, *Semecarpus subpeltata* and "Alaheraliya") they are as distinct as in ordinary Dicotyledonous trees of temperate regions, despite the small seasonal changes in climate. There is no certainty, however, that the rings are annual. In both species of *Doona* and also in "Alaheraliya" there is a tendency for the dark rings to be approximated in pairs. Since there are two hot wet periods in the year, alternating with two slightly cooler and noticeably less wet ones, it is tempting to suppose that a pair of dark rings is formed annually. *Durio zeylanicus* has the sharpest dark rings, and in this species they are curiously arranged. Many of the dark rings seen in transverse section spread out on one side of the stem in such a way as to enclose a crescentic region of paler wood. This shows that rapid growth of wood has occurred on one side of the stem at a time when it was not occurring on the other side.

Seasonal phenomena in the cultivated plants of the neighbourhood of the Sinharaja may be considered next. Breadfruit is plentiful in July and August, and a little is available in May. The main season for this food is not at the corresponding period of the year in the New Hebrides, in the Southern Hemisphere. Yams (*Dioscorea fasciculata* or "kukul-ala") are only cultivated on a small scale, and are planted and dug at any time of year, without reference to the season. This is in marked contrast to the New Hebrides, where the utmost care is taken always to plant at a definite season (Baker and Baker, 3). Cuttings of the sweet potato are put in twice a year, after the sowing of rice, and the tuberous roots are dug four months later. Two crops of ordinary or swamp rice are grown annually, as is usual in Ceylon. The sowing of the "yala" crop is finished by the Sinhalese New Year on 12th April. Harvesting takes place in August and September. This agrees with the general Ceylon practice, as given by Macmillan (10). The "maha" crop is sown in October–November, three months later than elsewhere, and harvested in February–March. Hill-rice, which grows on the hillside without the necessity for terracing and irrigation, is planted about 13th March, i.e., 30 days before the Sinhalese New Year, and is harvested about the time of the yala crop of swamp-rice. The kitul-palm, *Caryota urens*, flowers at all seasons of the year. The areca palm (*Areca Catechu*), unlike the kitul, is strongly seasonal. In the least wet month, February, some of the leaves fall and the flowers appear. The fruits are small in August and fully ripe by October.

Other plants commonly cultivated in the neighbourhood are Hevea rubber, manioc, tea, coconut, taro, and kurakkan.

I now turn to by far the most striking phenomenon presented by the forest as a whole. This is the shape of the leaves. Nearly every plant has the tip of the leaf or leaflet drawn out into a point. The common Monocotyledons of the forest mostly have such very narrow leaves that further narrowing to a special tip is not easily recognized, but in the Dicotyledons it is most obvious. Of the 41 Dicotyledons that are the commonest in the forest (apart from the vicinity of streams and paths), no fewer than 37 have the tips drawn out, and these 37 belong to more than 20 families. The phenomenon is common to the trees, to the bush *Apama siliquosa*, and to the lianas and creepers. (There is no very common Dicotyledonous undergrowth-plant.) The only exceptions among the common plants are *Wormia triquetra*, *Dillenia retusa*, *Calophyllum Calaba* and *Kokoona zeylanica*. The leaves and leaflets of the Dicotyledons are represented in Fig. 2. It might be thought that I had specially chosen those with pointed tips, but this is emphatically not so. The figure simply shows the leaves of those species which I regard as the most abundant at middle elevations in the forest.

Pointed tips to leaves are characteristic of plants of wet regions, and especially of tropical rain-forests, but I doubt whether any rain-forest can show the phenomenon more markedly than the Sinharaja. Attention was called to the subject by Jungner (7), who was struck by the prevalence of drawn-out tips to leaves (" Stachelspitzen ") in the plants of the rain-forest of the Cameroon region of West Africa. He concluded that the function of the pointed tip was to hasten the run-off of water from the leaf, and thus help to prevent insects and lower plants from attacking them. He noticed that leaves whose points have been broken off are much parasitized. He remarked that those Cameroon species which are not provided with the " Stachelspitze " have usually some other means (*e.g.*, poisonous sap) of protecting their leaves from parasitism. Stahl (12) made an elaborate study of the subject in West Java. He used the term " Träufelspitze " to indicate his conviction that the purpose of the drawn-out tip is to facilitate the run-off of water from the upper surface of the leaf. He timed the period required for the drying of a wetted leaf before and after the cutting off of the point, and noted large differences. He considered that the rapid run-off of water presents three advantages in addition to that stressed by Jungner. He pointed out that less mechanical strain is put upon the plant if the leaves are not weighted down by water ; that the water is directed straight towards the roots, instead of being dispersed or evaporated ; and that transpiration is aided by the reduction of the humidity of the air in the neighbourhood of the leaves. In the Sinharaja one notices that when it rains, one is not much protected by the canopy above, although it appears so dense. No doubt the " Träufelspitzen " are the cause.

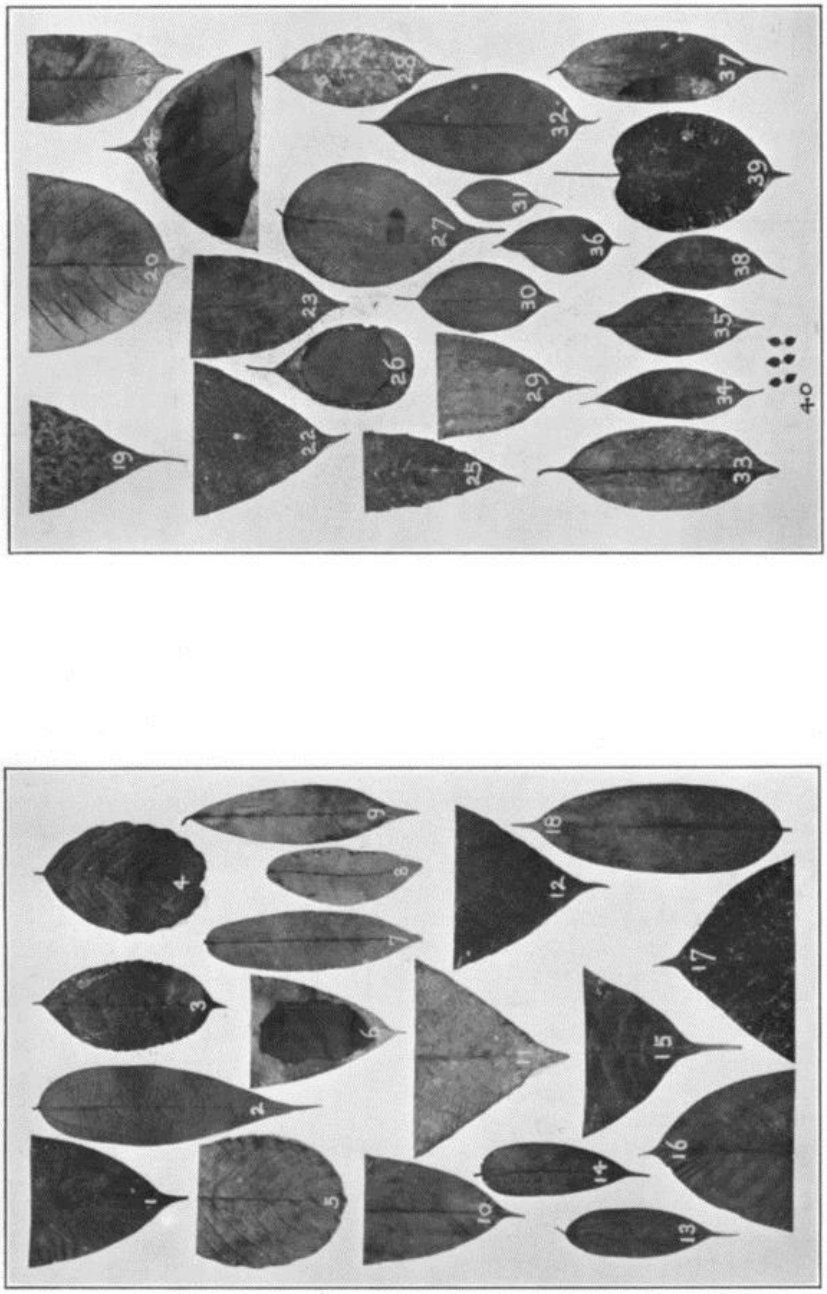

Fig. 2. The leaves and leaflets of the forty commonest Dicotyledons of the Sinharaja Forest, illustrating the prevalence of drip-points. The bases of the larger leaves have been omitted to save space. For names of the species see Appendix, p. 16.

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As is usual in tropical rain-forests, many of the trees have very large leaves (e.g., *Dipterocarpus hispidus*, *Vateria acuminata*, *Canarium zeylanicum*, and *Semecarpus subpeltata*).

I wish to thank Messrs. A. H. G. Alston, A. W. Exell, W. R. Philipson and T. B. Worthington for much help in the identification of the plants. The scientific names are mostly those used by Alston (1). Mr. A. B. Lushington and Mr. W. M. McNeill kindly gave me valuable advice.

Summary.

(1) The Sinharaja Forest, situated in the wet (south-west) part of Ceylon, is the only considerable area of virgin tropical rain-forest in the island. It covers about 90 square miles.

(2) It would appear that despite the relatively small climatic changes during the year, the flowering and fruiting is largely seasonal, and some of the largest trees are deciduous.

(3) Drip-points to leaves or leaflets are present in the great majority of the plants.

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APPENDIX.

List of the fifty flowering plants and ferns (excluding epiphytes) of the Sinharaja Forest, judged to be the commonest at medium altitudes, away from paths, streams and clearings. The numbers in the second column correspond with those in Fig. 2. The Sinhalese names are those used by the natives of the locality, who in some cases use a name for a plant differing from that used by the natives of other parts of Ceylon (e.g., Katamoda), and in other cases use the same name for a different plant (e.g., Na).

Family.	*No.*	*Species.*	*Local Sinhalese Name.*	*Habit.*
DICOTYLEDONS—				
Myristicaceae ...	1	*Myristica dactyloides* ...	Malaboda ...	Tree.
Aristolochiaceae	2	*Apama siliquosa*	Kepun-kiriya ...	Bush.
Flacourtiaceae ...	3	*Homalium zeylanicum* ...	Liyan	Tree.
Dilleniaceae ...	4	*Wormia triquetra*	Supara ...	Tree.
	5	*Dillenia retusa*	Godapara ...	Tree (small).
Guttiferae ...	6	*Garcinia echinocarpa* ...	Madol	Tree.
	7	*Calophyllum Soulattri* ...	Domba-kina ...	Tree.
	8	*Calophyllum Calaba* ...	Gutu-kina ...	Tree (small).
	9	*Calophyllum bracteatum* ...	Walu-kina ...	Tree.
	10	*Mesua Thwaitesii*	Na	Tree.
Dipterocarpaceae	11	*Dipterocarpus hispidus* ...	Buhora ...	Tree (very large).
	12	*Dipterocarpus zeylanicus* ...	Hora	Tree (very large).
	13	*Doona nervosa*	Hin-beraliya ...	Tree (very large).
	14	*Doona congestiflora*	Tinniya ...	Tree (very large).
	15	*Vateria acuminata*	Hal	Tree (very large).
	16	*Stemonoporus Wightii* ...	Maha-beraliya	Tree.
Tiliaceae	17	*Elaeocarpus subvillosus* ...	Gal-weralu ...	Tree (small).
Malvaceae ...	18	*Durio zeylanicus*	Katamoda ...	Tree.
Sterculiaceae ...	19	*Sterculia Balanghas* ...	Nava	Tree (small).
Euphorbiaceae ...	20	*Agrostistachys longifolia* ...	Beru	Tree (small).
	21	*Agrostistachys coriacea* ...	Hin-beru ...	Tree (small).
Burseraceae ...	22	*Canarium zeylanicum* ...	Dik-kekuna ...	Tree (very large).
Anacardiaceae ...	23	*Mangifera zeylanica* ...	Etamba ...	Tree.
	24	*Semecarpus subpeltata* ...	Maha-badulla	Tree.
Sapindaceae ...	25	*Pometia eximia*	Na-imbul ...	Tree.
Celastraceae ...	26	*Kokoona zeylanica*	Kokun ...	Tree.
Leguminosae ...	27	*Dalbergia sp.* (?)	Bambara-wel ...	Woody liana.
Rhizophoraceae ...	28	*Carallia calycina*	Ubberiya ...	Tree (very large).
	29	*Anisophyllea cinnamomoides*	Welipiyenna ...	Tree.
Combretaceae ...	30	*Terminalia parviflora* ...	Hampalanda ...	Tree (small).
Myrtaceae ...	31	*Eugenia phyllyraeoides* ...	Pinibaru ...	Tree (small).
Sapotaceae ...	32	*Palaquium grande*	Kiri-himbiliya	Tree.
Ebenaceae ...	33	*Diospyros quaesita*	Kalumederiya	Tree.
Apocynaceae ...	34	*Chilocarpus sp.* (?)	Kiri-wel ...	Woody liana.
Verbenaceae ...	35	*Vitex altissima* (?)	Milla	Tree.
Unidentified ...	36	—	Alaheraliya ...	Tree.
	37	—	Yakahalu ...	Tree.
	38	—	Kirindi-wel ...	Woody liana.
	39	—	Panu-wel ...	Woody liana.
	40, 41.	—	Hin- & wal-panampeti.	Creepers.
MONOCOTYLEDONS—				
Pandanaceae ...	42	*Freycinetia pycnophylla* ...	Viya-keyiya ...	Creeper.
Palmaceae ...	43, 44, 45.	*Calamus* spp. ...	We-, kukulu- & thambutu-wel.	Lianas.
Araceae	46	*Pothos scandens*	—	Creeper.
Zingiberaceae ...	47	—	Wal-hiya ...	Undergrowth plant.
	48	*Elettaria Cardomomum* ...	—	Undergrowth plant.
FERNS—				
Filicaceae ...	49	*Polystichum carvifolium* ...	Wal-miyena ...	Undergrowth plant.
Cyatheaceae ...	50	*Cyathea sinuata*	—	Undergrowth plant.