The Limestone Hill Flora of Malaya I

by

S. C. CHIN

University of Malaya, Kuala Lumpur

Malaysia

CONTENTS

Abstract

Limestone habitats, chiefly karst towers, in the Malayan Peninsula, support a rich flora of about 1216 species of vascular plants, in 582 genera and 124 families. Phanerogam families total 119, representing 61.6% of the total number of phanerogam families recorded for the whole Malayan flora; only 72 families are not represented on limestone, and these are mostly aquatics or small rare groups. Specific endemism among the limestone plants is 21.4% (261 species), and of these 10.7% (130 species) are found only on limestone. There are 335 species "characteristic" of the limestone flora, and 254 of these (20.8%) are restricted to limestone.

The limestone vegetation is described and classified into "types" and secondary vegetation and succession is discussed. Pioneer species on limestone include those found on other disturbed terrestrial habitats in Malaya. Some plants found on limestone are found elsewhere in Malaya only at significantly higher elevations. A discussion of the geological origin and distribution of the Malayan limestone areas is also included.

Preface and Acknowledgements

This publication is based on the dissertation accepted for the Master of Science Degree in 1973 by the School of Biological Sciences, University of Malaya. I am grateful to Professor van Steenis, external examiner, for his critical comments and helpful suggestions.

My work was supervised by Dr. B. C. Stone who introduced me to this topic, provided an unfailing source of guidance, and who also permitted me free access to his most remarkable collection of botanical literature which has been an inspiring and invaluable source of reference. I am also grateful for his encouragement to publish this work.

The Department of Botany, University of Singapore allowed me the use of their herbarium and Dr. H. Keng helped with the identification of several Labiatae. He also generously provided me with the records of the collection made by the UNESCO 1962 limestone expedition to Ulu Kelantan. These consisted of a map, several note books and a set of duplicate labels to the collection.

The Director of the Botanic Gardens, Singapore, gave me permission to work and the staff helped me in the herbarium on several occasions.

Dr. T. C. Whitmore and subsequently Dr. Francis Ng allowed me to use freely the facilities of the herbarium at the Forest Research Institute, Kepong, and manuscripts of their 'Tree Flora of Malaya', vol. 2 then in press. Dr. Whitmore also helped with the identification of some Garcinias, Euphorbiaceae and Palms; Dr. Ng with some Ebenaceae and other members of the staff with some general collections.

Dr. K. U. Kramer of the State University, Utrecht, Netherlands, identified several fern specimens and Dr. T. Shimizu of Shinshu University, Japan, provided literature and helped with the identification of a specimen of *Impatiens*.

With Dr. P. R. Wycherley, formerly of the Rubber Research Institute, Kuala Lumpur, I had interesting discussions and he also introduced me to the Johore limestone.

Mr. W. Swinson, Project Manager for the South East Johore Project, then engaged in a Master Plan Study of South East and Central Johore for the Government of Malaysia and State Government of Johore and his staff provided maps, transport, guides and equipment for two trips into the Gunong Sumalayang limestone outcrops in Johore. Mr. Swinson also provided unpublished data on the locality.

Dato Haji Wan Hassan bin Abdul Halim, the State Forest Officer of Johore gave permission to enter and botanize in the Johore limestone area.

Incik Mahmud bin Sidek and Incik Badaruddin, field investigator and herbarium assistant respectively, assisted in several excursions. Friends, particularly J. Boey, provided help and interesting company on numerous trips to the limestone.

To all these helpful persons I express my most grateful thanks.

I must also state my appreciation for the comments of Dr Chang Kiaw Lan, editor.

Most of this work was carried out during the tenure of a tutorship in the School of Biological Sciences, Universiti Malaya.

SECTION 1 — General

1. INTRODUCTION

Background to the flora

The limestone landscape in Malaya is very distinctive. Typically the hills are tower-like, rising from the surrounding scenery, with sheer rock walls and often jagged summits. These 'tower karst' formations occur as isolated crags or are grouped together into small massifs — all products of erosion of calcareous rock. Erosion too is responsible for the presence of caves that often characterize limestone hills. These caves have, since prehistoric times, often been used as human dwellings, and as much as the vegetation on the hills provide clues to the history and evolution of the Malayan flora, provide evidence for an insight into prehistoric Malayan culture.

Most of the past work on the Malayan limestone concerned the geology, origin and age of the rock, e.g. Scrivenor (1931), Paton (1961, 1964), Gobbett (1965) and Hutchison (1963, 1968). Other investigators have concerned themselves with cave archaeology, e.g. Evans (1920), Tweedie (1940) and Peacock (1965), or cave ecology and fauna, e.g. Bullock (1963, 1965), Dunn (1965), McClure (1965) and Tweedie (1947).

The only separate work on the flora is that of Henderson (1939). This contains an introduction giving the collecting localities, with notes on the vegetation and the characteristics of the flora. The localities are introduced state by state; the chief hills are named and the major collectors mentioned. There is however, no map of the distribution of the hills mentioned. The vegetation is described; there is a division of the hills into two main groups, the 'wet' and 'dry' hills. The frequency of the occurrence of the plant families (restricted to the spermatophytes) is briefly summarized.

A total of about 745 species is recorded from the limestone by Henderson. The species are presented in a check-list with short distributional notes; the arrangement of the families follows Ridley (1922-25), while the genera and species are arranged in alphabetical order. Of the 745 species recorded about 195 (26%) in the Peninsula are known only from limestone. The species endemic and confined to the limestone number about 130.

Apart from this study, species distribution on limestone is sometimes mentioned in floristic or monographic works on the local flora. Thus this well known habitat is, botanically, relatively unworked.

The history of botanical exploration on the Malayan limestone hills began in August 1880 when Kunstler, collector for Sir George King, made a collecting trip to the Gopeng limestone in Perak (the exact locality is unknown). Other early collectors (before 1900) include Curtis, Fox, Kelsall, Ridley and Wooldridge. Up to the present day more than 60 collectors have left their mark on this history. Their efforts have accumulated about 4,500 numbers (an estimate based on my having seen about 4000 numbers and assuming that I have not seen about 10% of the total); of this the writer contributed 1550 numbers.

The total area of limestone in Malaya, considering the average height to be 243.8 m (800 ft), is about 260 sq. km. (an estimate based on Scrivenor, in Burkill, 1935). Therefore per unit area the limestone may seem to have been very intensively botanised, with about 1962 numbers per 100 sq. km. (compared with the average of 175 numbers per sq. km. for the whole of Malaya, Steenis-Kruseman, 1973). These figures are, however, deceptive and misleading when the richness of the limestone flora is taken into account. The total number of collections from the Malay Peninsula is about 232,000 (a rough estimate based on Steenis-Kruseman, 1973) and the total species present in Malaya is estimated to be between 8000–8500 (Keng, 1970). This total number of species is an estimation only and is more than the number of species presently known. Thus this shows that on the

average, each species is represented by 26–29 numbers. On the other hand, 1216 species are recorded from the limestone (present study) which are represented by about 4500 numbers, thus giving an average of about 4 numbers per species. Even if only the characteristic species (with affinities for the limestone habitat) were considered (they number 335 and the total numbers collected would also drop far below 4500) and the total numbers collected be retained at 4500, the average number of specimens per species will be 13, which is still low.

Besides low total numbers collected with respect to the extremely rich flora, many of the limestone species have a very local distribution which intensifies the problem of insufficient collection. Though most of the limestone localities have been visited by botanists, the total number of hills actually climbed and collected on is only about 50, and the number of islands (in Langkawi) visited is about 25 (the writer has visited 25 hills and 12 islands, some repeatedly). There are no estimates of the total number of limestone hills in Malaya, but they probably number well over 200, and Langkawi consists of 99 islands (though not all are limestone, a large percentage are). Thus we have a situation where many hills, islands and localities have been repeatedly visited while others have not been botanised at all. The "popular" localities include Bukit Takun, Gunong Rapat, Gua Musang, Pulau Dayang Bunting (around the lake), Pulau Jerkom and Pulau Timun. However, this is not to say that these relatively frequently visited spots are sufficiently botanised. For instance, recently I discovered a clump of *Oncosperma horridum* on the summit of Gua Batu (which rates high on the list of popular localities), a species which has not been recorded on the limestone before. Considering that Gua Batu is less than 2.59 sq. km (1 sq. mile), in area, this clearly shows that the many rugged faces of a limestone hill can conceal even the most conspicuous plant.

Therefore in relation to its rich flora, extremely varied habitat and the fact of uneven local exploration, the limestone vegetation is probably the least botanised, and hence botanically known, of all the vegetation types in Malaya.

The collectors who have contributed to our knowledge of the limestone flora are listed below with a brief mention of collection dates and localities.

Collectors

Allen, B.E.G.M. Dec. 15th. 1950; Gunong Keriang (Kedah), a specimen of *Chirita viola* Ridl. 1958–1960; widely in Perak, visited Gunong Idong, Gunong Kanthan, Rotan Segar. Almost 100 numbers.

Allen, E.F. May 1946; collected on 'Kinta limestone'. April 1955–Jan. 1957; collected on several occasions from Gua Batu and Bukit Takun in Selangor.

Alphonso, A.G. & A. Samsuri. Nov.–Dec. 1960; several numbers from Langkawi (Pulau Bumbon Besar and Bumbon Kechil).

Batten Pooll, A.H. A poorly labelled *Dendrocalamus elegans* (Ridl.) Holtt. from the Langkawi limestone.

Best, G.A. Oct. 29th–Nov. 3rd, 1929; miscellaneous, about 80 numbers from Gunong Baling, Kedah.

Boey, H.Y. July 1970 — Sept 1971; collected from Bukit Takun on four occasions and once from Bukit Anak Takun, Selangor. August 1971; collected from Gua Musang, Gua Batu Boh, Batu Neng and Batu Tapah (all in Kelantan) and Gua Layang, Pahang. November 1971; visited Langkawi and collected from a number of limestone islands. About 350 numbers in all.

Burkill, I.H. 1916–1920; collected from Gua Batu, Selangor and around Ipoh, Perak. Sometimes with Haniff.

Burtt, B.L. & Woods, P.J.B.; Langkawi, at Sungei Kisap and Pulau Dayang Bunting; Perlis at Bukit Chupeng and Bukit Bintang; Perak, around Ipoh. About 146 numbers in all.

Carr, C.E. 1928–1930; visited Kota Glanggi, Gunong Senyum, Gua Tipus and Tembeling in Pahang. Collected mainly orchids; some ferns also.

Chan, Y.C. July 1970; collected from around Lenggong, Perak. Several assorted numbers.

Chew, W.L. April–May 1957; collected on Bukit Hantu, Bukit Kalong, Gunong Baling and around Dayang Bunting, Langkawi; all in Kedah. In the same period also visited Bukit Manek and Kaki Bukit in Perlis.

Cockburn, P.F. June 10th 1968; some specimens from Batu Biwa in Trengganu.

Corner, E.J.H. Nov. 16th–25th, 1929 (with Henderson); collected on Bukit Lagi, Perlis. 1936–1937; visited Ipoh and Bukit Takun. Nov. 13th-22nd 1941 (sometimes with Nauen); collected from all over Langkawi, resulting in some 200 numbers. 25th Nov. 1941 (with Nauen); collected on Gunong Baling, Kedah.

Curtis, C. 1888–1902; visited Langkawi (Kedah), Gua Batu in Selangor, Kinta district, around Ipoh and Sungei Siput in Perak. Most of the specimens are very poorly labelled.

Durant, C.L. Oct. 30th 1940; a specimen of *Maxburretia rupicola* (Ridl.) Fur. from Bukit Takun (Selangor).

Dransfield, J. July 31st 1968; several orchids from Bukit Anak Takun (Selangor).

Enoch, I. Sept. 25th 1954; a specimen of *Impatiens mirabilis* Hk.f. from Pahang.

Evans, G.B. Early 1966; Ipoh Temple limestone (Perak) and Bukit Takun (Selangor); several ferns.

Everett, B. July 1970; collected from around Lenggong, Perak. Eighteen numbers.

Fox, W. 1899-1904; several plants from Langkawi (Kedah) and around Ipoh (Perak).

Furtado, C.X. June 4th 1937; several palms and two aroids from Gunong Baling, Kedah.

Haniff, Mohamed. 1900–1921; collected occasionally from limestone, visited Bukit Wang, Gunong Keriang and Langkawi (Kedah), and Gunong Pondok (Perak). After 1918 usually with Nur. *See also* Burkill.

Hashim, Ja'afar. Collected a *Wikstroemia indica* (L.) C.A. Mey from Langkawi.

Henderson, M.R. 1923–1935; visited most of the limestone localities. Langkawi, usually on both sides of Selat Panchor (straits), and around Pulau Dayang Bunting. Gua Lambok, Gua Musang, Gua Panjang and Gua Teja (Kelantan). Bukit Cheras, Bukit Chintamani, Bukit Serdam, Gua Tipus, Gunong Senyum and Kota Glanggi (Pahang). Gua Lanno, Gunong Pondok, Ipoh, Lenggong and Pulai (Perak). Besih Hangat, Bukit Chupeng, Bukit Lagi, Bukit Wang Tangga and Tebing Tinggi (Perlis). More than 700 numbers.

Holttum, R.E. Oct. 3rd 1922; Gua Batu, Selangor, several ferns. Aug. 22nd-26th 1925; Langkawi, around Pulau Dayang Bunting and Pulau Timun. About 25 numbers.

Johnson, A. Nov. 17th 1968; several ferns from Gua Batu, Selangor.

Kadim, Tassim. Aug. 13th 1959 (with Allen, B.E.G.M.); several numbers from Gunong Tempurong, Perak.

Kassim, Rajab, Aug. 17th 1962; several numbers from Gua Batu, Selangor.

Kelsall, H. Jan. 1891; several plants from Gua Batu, Selangor; all poorly labelled.

Keng, H. Sept. 25th 1954; at Kuala Trengganu, several ferns. Mar. 28th 1962 (with Mrs. Keng); a specimen of *Monophyllaea horsfieldii* R. Br. Nov. 3rd–7th. 1968; Langkawi islands (sometimes with others); some assorted specimens.

Kerr, A.F.G. June 20th 1932; Langkawi, around Kuah; several numbers.

Kiah, Hj.M.S. April 11th-May 9th 1938; collected on Gunong Baling, Kedah and Kaki Bukit, Perlis. More than 150 numbers.

King, Sir G. *See under* Kunstler.

Kunstler, H.H. (collector for Sir G. King, as King's collector) 1880–1885; collected around Gopeng and Larut, also visited Gunong Pondok (all in Perak). Almost 100 numbers.

Loh, H.S. July 1970; Gua Peningat, Pahang. Recorded 101 numbers. This is the first known occasion that this outcrop (at 713 m the tallest in Malaya) has been climbed. February 1972; visited Gua Musang, Kelantan. Sixteen numbers.

Mahmud, S. 1970–1971; Bukit Anak Takun (Selangor), and Ipoh (Perak). Several numbers *See also* Samsuri.

Mat Sani, W. Jan. 1939; a specimen of *Cymbogon calcicola* Hubb. from Gunong Baling, Kedah.

Merton, L.F.H. Dec. 22nd 1960; Gua Batu, Selangor; several numbers.

Mills, G.R. April 16th 1925 (with Henderson); Gunong Lanno, Perak; several specimens.

Nauen, J.C. Nov. 13th–17th 1941; Gunong Baling and Langkawi, both in Kedah. About 20 numbers. *See also* Corner.

Ng, F.S.P. Oct. 1966–Feb. 1968; Gunong Mesah, Gunong Rapat, Gunong Tempurong and other hills around Ipoh (all in Perak). Gua Batu and Bukit Takun in Selangor and Gua Musang in Kelantan. More than 150 numbers.

Nur, Mohamed. 1931–1937; Bukit Sagu, Pahang and Bukit Takun and Gua Batu, Selangor. *See also* Haniff. About 160 numbers.

Ogata, K. Feb. 14th–15th, 1968; Gunong Gajah and Gunong Tempurong in Perak. Some assorted specimens.

Phang, C.I. Sept. 15th 1960; several ferns from Bukit Anak Takun, Selangor.

Poore, M.E.D. Sept. 12th 1960 & July 16th 1961; visited Gua Batu, Selangor. Several numbers.

Reid, J. Jan. 29th 1950; three numbers from Bukit Takun, Selangor.

Ridley, H.N. 1896–1897; visited Kuala Dipang (Perak) and Gua Batu, Selangor 1898–1920; visited Gua Batu about five times, also Gunong Keriang, Kedah and Bukit Lagi, Perlis. About 150 numbers.

Samat, A. 1961–1969; visited Langkawi (Kedah), Bukit Anak Takun and Bukit Takun (Selangor). Mainly ferns; about 15 numbers.

Samsuri, A. Mar. 8th–14th, 1971 (with Mahmud); collected in Perak, around Gopeng, on Gua Putri, Gunong Pondok, Gunong Rapat, around Ipoh, and in Tambun district. About 120 numbers.

Shimizu, T. Oct.–Nov. 1967 (with Stone); visited Gua Musang (Kelantan) and Bukit Takun (Selangor). Some ferns.

Sinclair, J. 1958–1962; visited hills around Ipoh (Perak) and Gua Batu (Selangor). About 30 numbers.

Singh, Hardial. Jan. 23rd 1966; visited Gua Batu (Selangor). Several numbers.

Smith, G. One *Chirita caliginosa* Cl. from Perak Cave Temple.

Smith, J.W. July 19th 1956; one *Vitex siamica* Will. from Gunong Baling, Kedah.

Soepadmo, E. Sept. 1968; one *Carallia brachiata* (Lour.) Merr. from Ipoh, Perak.

Spare, G.H. Oct. 1st 1939; Gunong Pondok, Perak. Several numbers.

Start, A. Jan. 23rd 1972; one *Mucuna biplicata* Teysm. et Binn. from Bukit Anak Takun, Selangor.

Stone, B.C. 1965–1972; visited Langkawi (many of the islands), Kedah, Gua Musang (Kelantan), Gunong Pulai (Perak), Bukit Anak Takun, Bukit Takun and Gua Batu (Selangor). Chintamani (Pahang). About 450 numbers.

Students (University of Malaya 1967) May 1967; some numbers from Langkawi (Kedah).

Symington, C.F. 1934–1938; visited Langkawi (Kedah) and Bukit Takun. About a dozen numbers.

Teruya, Z. Jan. 20th 1929; one *Monophyllaea horsfieldii* R. Br. from Gua Batu, Selangor.

Tomlinson, P.B. Sept. 1955; one *Monophyllaea hirticalyx* pr. from Ipoh Perak.

Turnau, E.A. Aug. 5th 1962; two numbers from Langkawi, Kedah.

UNESCO 1962 July 27th-Aug. 13th, 1962; visited the Kelantan limestone around Gua Musang and Bertam, collected on Batu Bayan, Batu Hayan, Batu Ner, Batu Pinta, Gua Batu Boh, Gua Musang, Gua Serai, Gua Seri and Gua Panjang. About 700 numbers. Led by Dr. H. Keng.

Whitmore, T.C. 1966–1970; visited Langkawi (Kedah), Gua Batu Boh, Gua Musang, Kuala Jenera, Sungei Nenggiri (Kelantan), and Bukit Anak Takun, Bukit Takun, and Gua Batu (Selangor). About 120 numbers.

Wong, Y.K. May 13th 1962; a *Maxburretia rupicola* (Ridl.) Furt. from Bukit Takun, Selangor.

Wooldridge, T.A. June 1896; a *Dracaena curtisii* Ridl. from Langkawi (Kedah).

Wray, L. 1894; two specimens from Perak limestone; labels mutilated, one undated.

Wyatt-Smith, J. June 11th 1960; one *Salacia grandiflora* Kurz. from Gua Batu, Selangor.

Wycherley, P.R. Dec. 28th 1969 (with Stone); Gua Batu, Selangor. Some assorted specimens.

For the purpose of this study most of the limestone areas in Malaya were visited and numerous hills explored and botanised. About 1550 numbers were collected.

The plants treated include the terrestrial as well as the epiphytic members. Included also are species from hill bases where the soil is definitely of limestone origin; this is usually a rusty-red loam and very distinctive. Characteristically there are numerous boulders strewn about. Admittedly it is often difficult to decide what does or does not constitute the limestone vegetation. Certainly the vegetation at hill bases (with limestone derived soil) is different from that on hill tops, but equally it also differs from that of the surrounding lowland forest. This hill base

vegetation has arisen as a result of the interaction between the presence of the hill and the surrounding forest. Accordingly I have included the species found here in this treatment.

In the case of plants from the small outcrops recently discovered in Johore (Rajah, 1970) great care was exercised to see that only those actually growing on the rocks were recorded. This is because the outcrops here are very limited and low, from boulder size protrusions to several of about 20 m tall and as broad. Most of the cracks and crevices are filled with soil derived from the surrounding sandstone formation. (This publication also records the first botanical exploration on the Johore limestone.)

All specimens from 'near the base of hill', or from 'hill bases' as recorded on the labels of herbarium sheets are excluded unless the labels also specify that the particular plant was from limestone rock or soil.

In order to obtain as complete a record as possible of the limestone flora, every sheet in the herbaria at the Singapore Botanic Gardens, the University of Singapore and the University of Malaya was scrutinized. A start was also made at the herbarium of the Forest Research Institute but as the search was not showing success it was stopped. Practically all the old and most of the new limestone records there (at Kepong) are duplicated in the Singapore Botanic Gardens herbarium. Subsequently the examination of specimens at Kepong was restricted to the known limestone genera and to recent (post 1960) records from limestone districts (with the help of collector's field notes).

Many labels are unclear and to decide whether a specimen was recorded from limestone or not is not always straightforward. Sometimes the town, village or district bears the same name as the limestone hill (or vice versa), e.g. Baling, Gua Batu and Gua Musang. Specimens in such cases were excluded unless the record states explicitly that it was from the hill.

By searching the herbaria and literature I have managed, I think, to include all the species (possibly with few exceptions) so far recorded from the Malayan limestone.

Purpose and Scope

This work attempts to present a comprehensive account of all pteridophytes (true ferns only) and spermatophytes ever found growing on limestone hills and sites in the Malayan Peninsula. Included also are the non-indigenous species (introduced, inadvertently or otherwise) which have become naturalized and now form part of the wild-growing population.

Sect. 1 discusses the geology, origin and distribution of the limestone hills, the vegetation, phytogeography and size of the flora, and affinities of the floristic components to limestone.

Sect. 2 the flora proper, starts with the Pteridophytes (true ferns only), going on to the Gymnosperms and ending with the Angiosperms (Dictoyledons and Monocotyledons). Under these four main groups, the families are arranged in alphabetical order and thereunder the genera and species. Dichotomous keys leading to the identification of almost all the species are included. For the exceptionally large groups, the Pteridophytes, Euphorbiaceae, Orchidaceae and Rubiaceae, an introductory key with leads to the main key is provided.

Every species is provided with its approved name and the original place of publication. Synonyms, if any, especially those published in major works relevant to the local flora, are cited. References are also made to publications on the local flora, and reference to Henderson (1939) is cited for every species included in his work.

The names of *characteristic species* (those that come under my 'affinity' grouping I and II in ch. 5) are printed in ***bold face*** type. In addition, brief notes on the distribution, and frequency on the Malayan limestone are often included for these species.

All literature cited in the discussion are listed in full in the bibliography at the end of this work.

Specimens are cited only in special cases, such as rarity, or doubtful locality, or in relation to certain taxonomic problems. However, full lists of specimens are to be found in the dissertation paper, and this may be consulted in the Library of the University of Malaya or in the University Herbarium, Kuala Lumpur.

Lastly Bryophyte collections were made during this study but are not included here because of the difficulty in obtaining identifications. A further study of this group would be desirable.

2. *GEOLOGY, ORIGIN AND DISTRIBUTION OF THE LIMESTONE HILLS.*

Geology

Most of the limestone hills in Malaya rise from flat or undulating plains. They form conspicuous and often spectacular hills up to 2342 ft. (713 m.), (Gua Peningat, Pahang), often with sheer, vertical or overhanging cliffs.

They range in age from Ordovician to Triassic. The estimation of age has been a difficult problem since are recrystallised, unfossiliferous (Hutchison, 1968), and as all studied samples are recrystallised, thermoluminescence cannot be used to differentiate limestone stratigraphically in Malaya (Hutchison, 1968). Up to as late as the 1950's anything calcareous in Malaya has been assumed to be carboniferous and was ascribed to the calcareous formation. Since then many studies have been made, providing a more accurate picture of the age of our limestone, e.g. Paton (1961), Ingham and Bradford (1960), Gobbett (1965a), Hutchison (1968) and Suntharalingam (1968), but the ages of many still remain indicated by only a very rough estimation.

The Kedah/Perlis(including Langkawi) limestone areas are mainly Ordovician-Silurian. The Selangor limestone appears to be confined to the Silurian (Gobbett, 1964), and the recently discovered Johore limestone is Permian (Rajah, 1970). Most of the others are Permian (Paton, 1961), but further studies will probably show a variation in age from the Silurian to Permian (as is the Selangor limestone Paton included under Permian). However no hill has been found to be Triassic which so far is limited to small lenticular beds in Pahang (Paton, 1961).

It is generally thought that the older limestone gives rise to more or less continuous ranges of hills without marked vertical cliffs whereas on the other hand the younger limestone produces more isolated hills with high, vertical or even overhanging cliffs (Paton, 1961). This weathered-look is shown by the Kedah/ Perlis (including Langkawi) limestone of Ordovician-Silurian age. This generalisation was made before the Selangor limestone was known to be Silurian, and now no longer holds. This is because the latter shows marked cliff development (except for Bukit Anak Takun). Thus it would seem that the age of the actual limestone rock itself has little bearing on the development of the hills, and there is no difference in form between hills from Permian and Ordovician-Silurian rock.

Our limestones are generally very pure. Most are white, pale grey or slightly yellowish; some are dark grey to almost black because of carbonaceous or argillaceous impurity. Rarely it is red because of hematite inclusion or by iron staining. Hutchison (1968), who analysed 182 very random samples chemically (which therefore should give a rough indication of the true nature of the Malayan limestone) recorded that most of them have about 2.5% insoluble residue with an arithmetic mean of about 4.4% insoluble residue. He further notes that 81% of his samples are limstone ($CaCO_3$) and 19% dolomite ($CaMg(CO_3)_2$).

Origin

Originally sedimentary, the Malayan limestone is, as mentioned earlier, recrystallised. It is thus in fact marble. This happened when peninsular Malaya underwent an orogeny (an episode of mountain-building during which the rocks, including the Malaysian limestone were compressed, folded and heated) in the Triassic period (about 200 million years ago). Towards the end of the Triassic orogeny the rocks were uplifted into hills and mountains. The botanical stage was set, since then most of the Malayan limestone was never submerged again, and they were ready to receive their first plant. However it is not certain how long it took before the limestone topography as we know came into being.

Various theories have been put forward to explain the existence of the limestone in the form of spectacular karst-tower hills. These are reviewed by Paton (1964), and include block faulting, sub-aerial erosion, folding, marine erosion and plastic flow. The most plausible explanation seems to be simple sub-aerial denudation modified in certain cases by marine erosion.

The theory of sub-aerial erosion takes into account the high solubility of calcium carbonate compared to the majority of the silicates, of which most of all other rocks are composed. This is an important point, for any theory seeking to explain why the limestone hills are in the form they are must also explain why formations of other rocks are not existing in the form the limestone hills are. Weathering of silicate rocks produces more or less rounded topography; on limestone deep channels are often cut.

Streams and swamps at the bases of limestone (assuming that they were once well-jointed and continuous) are highly effective in eroding it. The pH of swamp and stream water in low-lying areas is commonly as low as 3.5 (Paton, 1964). This acidic water gradually erodes the rock, forming channels; floors and walls are enlarged, and from above, downward erosion cuts deep channels that eventually reach the base. The underground channels continue to expand laterally, finally resulting in the collapse of the roofs, producing steep-sided and isolated hills.

The initial stages of erosion by water are evident in the form of grooves or nips, characteristic of many coastal limestone areas in Langkawi and at the bases of hills on the mainland. Some grooves on hills in the Kinta and Kedah/Perlis area are marine in origin, formed in the post-glacial periods (post Pleistocene) when the sea level, at least 50 ft. higher than now (Scrivenor, 1949; Walker, 1956), flooded the plains.

Distribution

Until recently, all the known limestone outcrops were from north of Kuala Lumpur. However in 1965-66, officials of the Geological Survey of Malaysia discovered limestone outcrops in Johore while carrying out geological mapping of that area (Rajah, 1970). The outcrops are in an area 500 by 1200 m on the south-eastern slope of Gunong Sumalayang at an elevation of 250 to 400 m. There are about 30 outcrops here varying in size from boulders 1–2 m across to the largest about 20 m tall and as wide.

Elsewhere in Malaya the limestone hills are in their most spectacular and prolific development in south-west Kelantan and north-west Pahang, in the Kinta valley from Kampar northwards to Ipoh, Tambun and Tanjong Rambutan, and in north-west Perlis.

Hills are also found around Alor Star, Kedah, elsewhere in Pahang, near Kuala Lumpur, Selangor and rarely in Trengganu. They are very prominent in the Langkawi group of islands off the extreme north-west coast of Malaya. Not all the islands are limestone, and some are limestone only in part, but generally limestone is abundant, especially in the eastern and southern aspects of Langkawi. This is the only coastal limestone in Malaya.

The distribution of the Malayan limestone hills is shown in Maps 1, 2 & 3. All the hills botanised are included in the maps except some of the smaller hills which are not named even in regional 1 inch to 1 mile maps. It has also not been possible to include all existing outcrops, but all the limestone localities are represented and most of the popuarly and less popularly known have been included.

3. *VEGETATION*

The limestone vegetation forms a characteristic and easily recognised forest type in Malaya. It is a distinct Edaphic Climax Formation (Symington, 1943). In fact, Corner (1960) considered the limestone forest as one of the three constituent forest types (the other two being the lowland and the mountain forest).

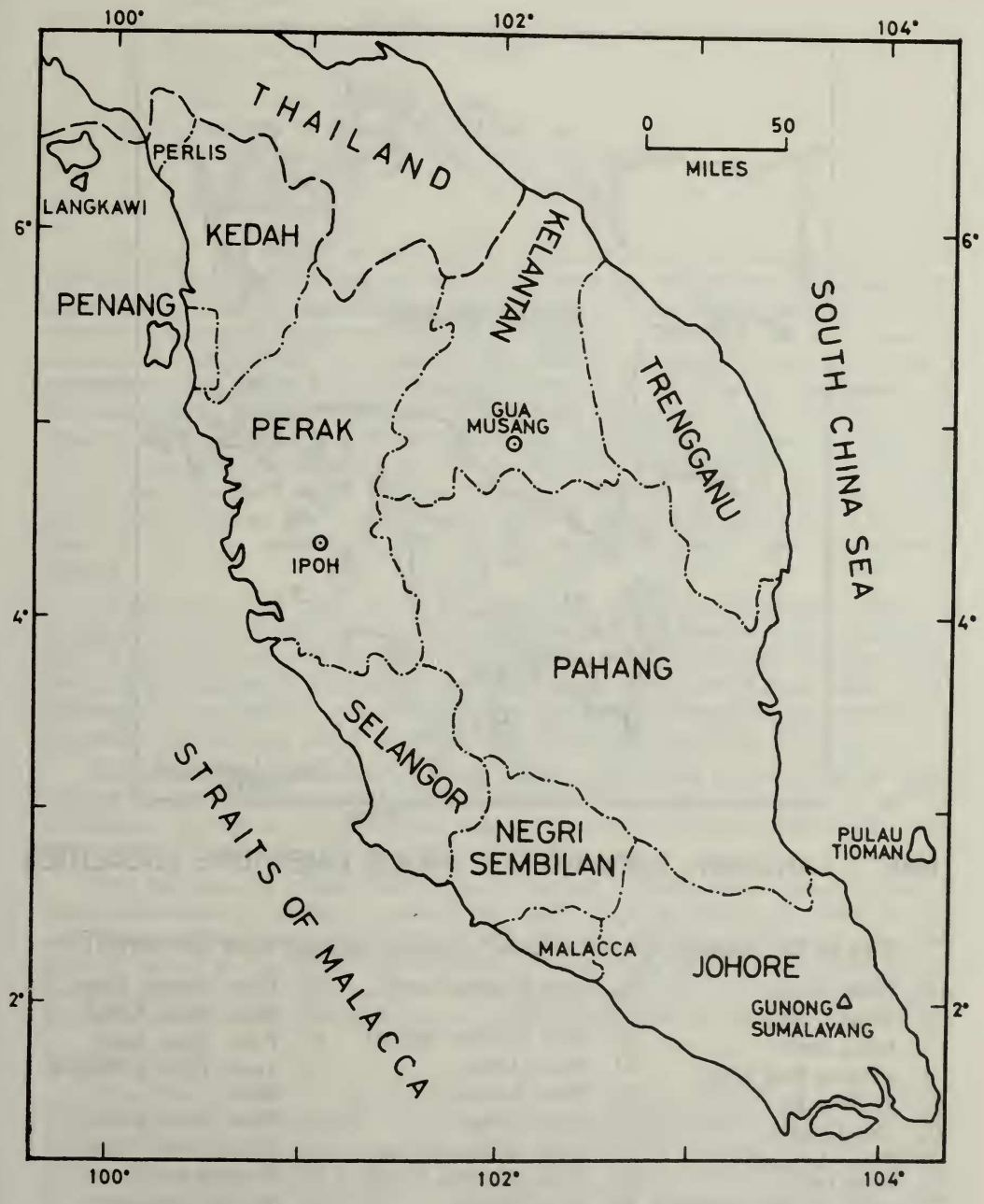
The vegetation supports an extremely diverse and rich flora which is a reflection of the diversity of the habitat. Henderson (1939) classified the Malayan limestone hills into three broad groups, viz.:

1. Very dry hills with little soil and much exposed rock. Trees usually rather stunted; mosses and herbaceous plants scarce.
2. Wet hills often with gullies filled with rich soil. Trees fair-sized and not stunted; mosses and herbaceous plants present.
3. Soil-rich hills, well covered with soil (usually a stiff red clay), little rock exposed. Trees tall; mosses and herbaceous plants few.

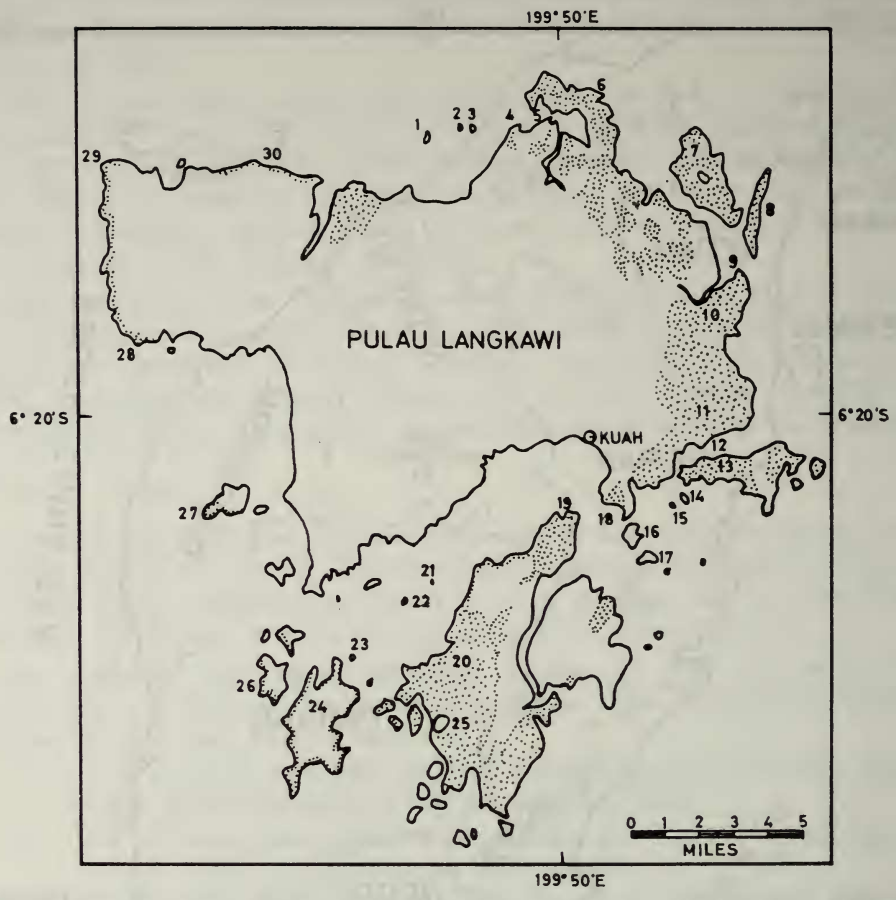
This is in effect, as Henderson further discussed, dividing the limestone hills into two general categories, 'dry hills' (1) and 'wet hills' (2 and 3). This classification however does not do justice in summing up the diverse limestone habitat. 'Dry hills' often have sheltered gullies with soil supporting fair-sized trees, mosses and herbaceous plants. Similarly 'wet hills' often have exposed rocky ridges with stunted vegetation.

Anderson (1965) subdivides the Sarawak limestone habitat into eight groups, viz.: 1. Alluvial soils at the base of hills. 2. Base of hills and ravines between hills. 3. Slopes of hills 4. Cliffs. 5. Scree slopes on hills. 6. Summits of hills at low altitudes. 7. Submontane limestone. 8. Secondary vegetation on hills.

In Malaya there are no submontane limestone hills and this classification does not seem to effectively describe the Malayan limestone habitat. Thus another classification is proposed. This is, like the other schemes, only provisional and there is a great deal of overlap between the subdivisions. This subdivision of the habitat takes into account the geology and topography of the hill, the physiognomy of the vegetation and the floristic composition. Succession is also considered and disturbed or secondary vegetation is therefore made a subdivision.



MAP 1. MALAYA IN GENERAL



MAP 2. LANGKAWI, SHOWING THE MAJOR LIMESTONE LOCALITIES

Key to the numbers (in a clockwise direction starting from the north).

1. Pulau Dangli
2. Pulau Gasing
3. Pulau Pasir
4. Tanjong Batu Kulat
5. Tanjong Ru
6. Gua Cherita
7. Pulau Langgun (with lake)
8. Pulau Tanjong Dendang
9. Tanjong Dagu
10. Tanjong Dagu Forest Reserve
11. Selat Panchor Forest Reserve
12. Selat Panchor (straits)
13. Pulau Timun
14. Pulau Lading
15. Pulau Chupak
16. Pulau Bumbon Besar
17. Pulau Bumbon Kechil
18. Telok Sambar
19. Tanjong Tirai
20. Pulau Dayang Bunting
21. Pulau Jerkom Kechil
22. Pulau Jerkom Besar
23. Pulau Singa Kechil
24. Pulau Singa Besar
25. Tasek Dayang Bunting (lake)
26. Pulau Beras Basah
27. Pulau Rebak Besar
28. Tanjong Belua
29. Tanjong Chinchin
30. Tanjong Tok Manap

The subdivisions are:

1. Base of hills
2. Talus slopes
3. Hill slopes to about 60° steepness
4. Gullies and valleys
5. Cliffs and near-vertical slopes
6. Summits with considerable soil cover
7. Summits with none or very little soil cover
8. Coastal limestone
9. Disturbed areas

Although the nature of the habitat necessitates a classification taking into account all the characteristics present to separate the subdivisions effectively, this classification is more physiognomic than floristic in kind. The physiognomy of the vegetation is in turn dependent on the topography of the hill, the abundance or scarcity of soil, moisture and shelter. The floristic composition however varies a great deal from hill to hill and although it would be possible to subdivide a hill floristically, this pattern of floristic distribution would not hold for other hills. Species characterising a dry rocky summit like Bukit Takun (*Buxus malayana* and *Wikstroemia androsaemifolia*) are not found on a similarly dry and rocky part of, for example, Batu Neng. *Sycopsis dunnii* is common on Bukit Serdam summit (with thin soil) but on Gunong Rapat summit (also with thin soil) a common plant is *Murraya paniculata*, and *Sycopsis dunnii* is absent, and the converse applies.

Floristically also, the limestone north of Alor Star, including those in Langkawi, mainland Kedah and Perlis differs from that further south. They form part of the Thai flora which begins north of Alor Star, in Kedah (Ridley, 1911) or north of the mouth of Kedah river which is near Alor Star (Kloss, 1922). (This difference in the floristic composition is due mainly to the regular dry season from December to February which is confined to the extreme north of Malaya).

However in this classification, the Langkawi limestone is treated in the same manner as the rest and not as a distinct floristic entity. This is in order to provide a coherent picture of the Malayan limestone in which floristic composition is one of the criteria used and not *the* deciding factor.

The examples of plants cited in the following discussion are representative of the subdivisions of limestone habitats in which they are found. However a considerable number of such examples do not have rigid habitat preferences and may also be found in the other subdivisions. Though they are representative of the various subdivisions they are not necessarily found on all hills with similar habitats; in fact many species form very local populations on one or several hills.

1. Base of hills

The bases of hills are usually covered by a mixture of alluvial soil not derived from the limestone but from the surrounding geological formation and also soil derived from weathering of the hills. The vegetation here varies with the locality of the hill and probably with the nature of the derived alluvial soil (from the surrounding geological formation). Protected valleys (wangs) may occur; these are surrounded, often entirely, by abrupt limestone walls. The floor is usually the typical Terra Rossa soil. Such areas are often cultivated (as in the hills around Ipoh).

The vegetation is generally tall and closed, with the crowns of the plants touching or overlapping. Typical species include *Villebrunea sylvatica, Gmelina asiatica, G. villosa, Dendrocnide stimulans, Diospyros cauliflora, Mallotus philippensis, Melanolepis multiglandulosa, Orophea hirsuta* and *Pisonia umbellifera.* Some climbers are also found e.g.; *Iodes cirrhosa* and *Mucuna biplicata.*

Sometimes where water drips down from steep rocky slopes or from overhanging cliffs, a distinct herb community develops. Species include *Alocasia lowii*, *Chirita caliginosa* (which is also found on dry situations) *Epithema saxatile* and *Monophyllaea horsfieldii*. Bryophytes are usually luxuriant.

2. Talus slopes

At and near the base of many hills are accumulations of boulders, organic matter and general debris from the hill. Rocks from this scree have evidently fallen from the hill. Often the bases of hills surrounding amphitheatres or wangs have talus slopes at their bases. These are probably remnants of the roofs of large caverns that have suffered a cave-in. The vegetation here is tall and closed, physiognomically not unlike that on cliff bases (Gp. 1.). The composition is however somewhat different; and perhaps the distinguishing character is the herb and shrub vegetation characteristing such a shady, rocky terrain. The trees and shrubs include *Atalantia roxburghiana* (peculiar to Bukit Takun), *Cleidion javanicum*, *Morinda elliptica*, *Streblus ilicifolius* and *Trivalvaria macrophylla*. The herbs include *Heterogonium pinnatum*, *H. alderwereltii*, *Impatiens* spp. (I. *mirabilis* dominates the scenery on Pulau Langgun, Langkawi, north of the lake), *Pilea* and *Procris*.

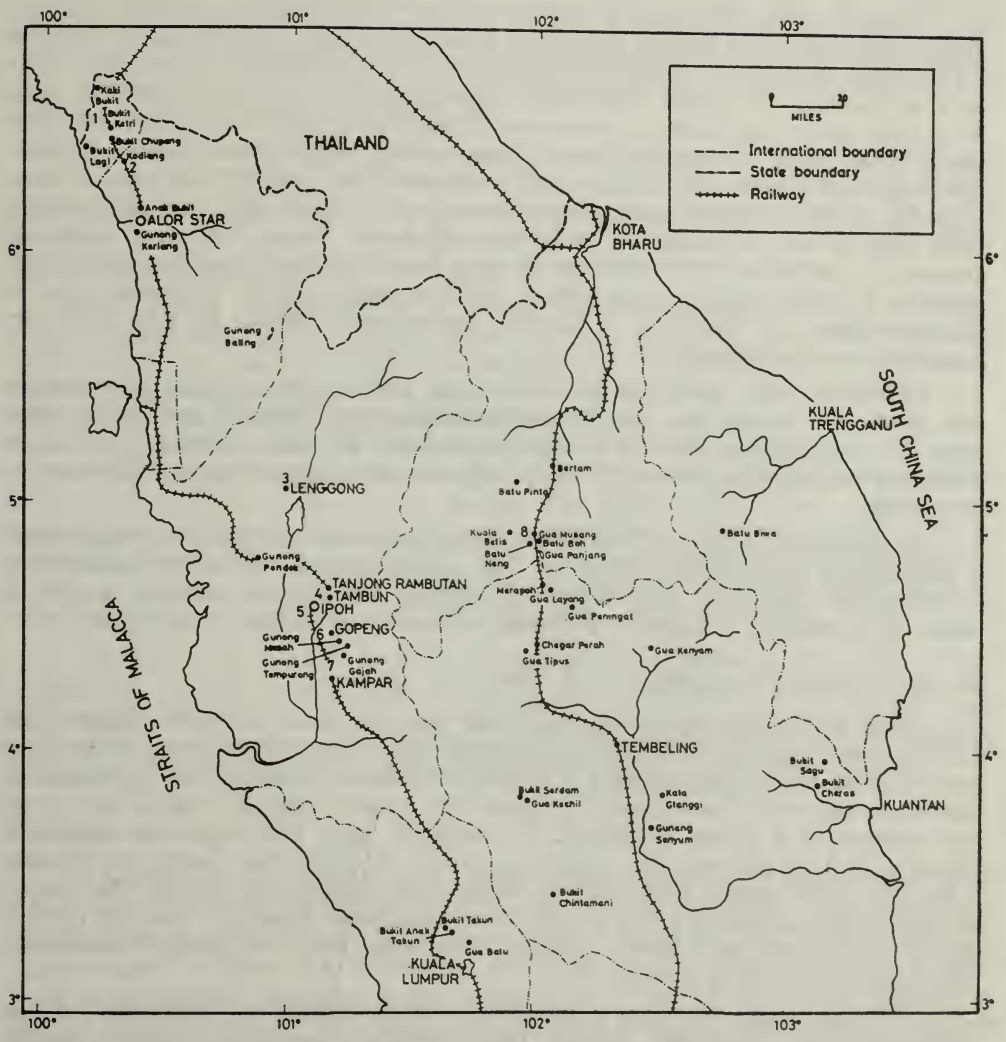
3. Hill slopes to about 60° steep

These more gentle slopes are nearly always covered with soil and support a dense, close vegetation 5–10 m or more tall. The soil may be thin or to about 1 m deep at places, and boulders are usually present emerging from the soil. Ground vegetation is usually spares and is often associated with the boulder outcrops. These include *Antrophyum parvulum* (on rocks), *Ophiorrhiza*, *Piper*, and in the more sheltered niches *Gymnostachyum decurrens* and *Scutellaria discolor*. The trees and shrubs include *Cladogynus orientalis*, *Croton cascarilloides*, *Mallotus dispar*, *Microdesmis casearifolia*, *Orophea cuneiformis*, *Polyalthia brunneifolia*, *Saraca declinata*, *S. thaipingensis* and *Rinorea bengalensis*. On Gua Kechil, Raub, the rare tree *Diospyros adenophora* is fairly common.

4. Gullies and valleys

These are often the most sheltered spots on hills. This group includes pot-holes, depressions, gullies, valleys, ravines and other concavities which may be narrow and small or broad and extensive, extending between two peaks on the same hill. The ground is usually deep or shallow soil with a covering of litter and other organic debris. The vegetation is fairly dense, 5–10 m tall with occasional emergents, and physiognomically not unlike that on soil-covered slopes and talus slopes. The floristic composition varies somewhat and its location and topography is usually distinctive. (Sometimes however gullies and valleys may emerge into hill slopes.) Gullies may even be present on the so-called 'dry hills' (the most outstanding example is Bukit Takun), harbouring mosses and delicate herbaceous plants like *Corybas mucronatus* and *Goodyera hispida*. The ground vegetation is usually quite sparse, no doubt because of the closed canopy. Bryophytes are common and herbs like *Epithema saxatile* and *Monophyllaea* are usually associated with boulder outcrops.

The trees and shrubs include *Agrostistachys gaudichaudii*, *Canthium didymum*, *Fagraea curtisii*, *Randia densiflora*, *Sauropus suberosus* and *Sterculia rubiginosa*. Climbers like *Connarus* and *Lasiobema* are found and the palms present include *Arenga westerhoutii* (also from talus slopes), *A. hookeriana* and *Iguanura polymorpha*.



MAP 3. MALAYA (EXCLUDING LANGKAWI) SHOWING THE MAJOR LIMESTONE OUTCROPS

Key to the numbers indicating position of outcrops.

1. Bukit Besih Hangat
   Bukit Wang Tangga
   Tebing Tinggi
2. KODIANG — including Batu Hantu
   Batu Kalong
3. LENGGONG — including Batu Tukang
   Gua Badak
   Gua Pipit
   Gua Putri
4. TAMBUN — including Gunong Ginting
   Rotan Segar
5. IPOH — including Perak Cave Temple
6. GOPENG — including Gunong Lanno
   Gunong Rapat
7. Kuala Dipang
   Sungei Siput
8. GUA MUSANG — including Batu Machang
   Batu Papan
   Batu Tapah
   Gua Serai

5. Cliffs and near-vertical slopes

Vertical cliffs, overhanging cliffs and near vertical slopes present a unique habitat and support a distinct vegetation which depends on the degree of exposure of the cliffs, presence or absence of soil pockets and availability of moisture. This is a very easily recognised subdivision topographically and the vegetation varies from very sparse and open (or sometimes absent) to a fairly dense herb and scrub cover. This denser vegetation cover is found along ledges where there is accumulated soil and debris and in other soil pockets. Where there is seepage or water dripping down a characteristic vegetation develops along this line of moisture. This may be on overhangs or clefts on cliff faces. If on clefts this vegetation decends to the base of the cliff and is very similar to that described under subdivision 1 (where water is available). This includes *Chirita, Epithema saxatile, Monophyllaea* and the fern *Adiantum malesianum* (which is also from dry localities) and bryophytes.

Cliff faces with no cracks or crevices do not support any macro-vegetation, but those with cracks and crevices which invariably collect soil and other debris support a distinctive flora. The species include the very characteristic *Boea, Paraboea* and *Chirita. Boea* spp. especially are often very prominent high up on cliff faces.

Near vertical slopes and cliffs with ledges and other soil pockets often support a herbaceous or scrubby vegetation. The species include *Canscora pentanthera, Cymbopogon calcicola, Callicarpa angustifolia, Cheilanthes farinosa* (only on Bukit Chintamani), *Jasminum, Pyrrosia stigmosa* and *Zizyphus oenoplia.*

6. Summits with considerable soil cover.

Most hill summits are covered with soil (at least in part). Some have considerable to extensive rock outcrops with sparse vegetation (these rocky spots are included under subdivision 7.) In places scattered boulders and pot-holes are common; generally the topography is uneven to very rugged. Ridges with some soil supporting a closed vegetation are included here. The vegetation is usually scrubby, 2–7 m tall and the canopy is closed. In places the plants are spindly. Generally these shrubs and trees are fairly well spaced, and though the canopy is closed there usually is a rich ground flora. Occasional emergent trees are present, eg; *Mangifera* sp. on Gunong Pondok, *Madhuca ridleyi* on Bukit Serdam and *Garcinia murdochii* on Gua Kechil.

The trees (they are usually somewhat stunted, though not extremely so) and shrubs include *Cleistanthus gracilis, Decaspermum fruticosum, Dehaasia curtisii, Eriobotrya bengalensis, Erythroxylum cuneatum, Eugenia pendens, Garcinia minutiflora, Mallotus brevipetiolatus, Mallotus miquelianus, Murraya paniculata, Neolitsea zeylanica* and *Sycopsis dunnii* (especially on Bukit Serdam). The pandan, *Pandanus irregularis* is common and conspicuous on ridges on Batu Neng. Climbers and scramblers are usually scarce and include *Maytenus curtisii* and *Lygodium polystachyum.*

The ground vegetation is fairly rich in bryophytes especially in the more sheltered spots on rocks and at the basal parts of tree trunks. The herbs include the lycopod, *Lycopodium squarrosum;* ferns are common and in places from the dominant ground cover; they include *Asplenium adiantoides, A. macrophyllum, Loxogramme avenia, Photinopteris speciosa, Phymatodes scolopendria* and *Pyrrosia stigmosa.* Ground orchids are equally common and include *Agrostophyllum bicuspidatum* (which may also be a low epiphyte), *Coelogyne asperata* (which on parts of Batu Neng and Batu Tapah forms almost pure mats), *Dendrobium luxurians, Eria rigida* and *Renanthera histrionica.* Epiphytes are usually not conspicuous though occasionally they are found; these include orchids, e.g. *Appendicula torta* and *Bulbophyllum apodum* and ferns, e.g. *Pyrrosia.*

7. Summits with no or very little soil cover

Most hills have some exposed rocky parts, while a very few have extensive rocky summits. Soil is scanty and found in little hollows, cracks and clefts in the rock but is never completely absent. Even extensively rocky summits have gullies and valleys where soil and litter are accumulated and the vegetation supported is different (included under subdivision 4.)

The vegetation on these rocky summits is sparse and open but fair-sized trees rooted in clefts and hollows are present. Most are, however, stunted and gnarled though occasionally large ones occur. An example are the figs, the roots of which ramify all over the rocks, into every crack and crevice and often extending for many meters over cliff faces in an intermeshed network.

Bukit Takun in Selangor is the classic example of a hill with an extensive rocky summit, but other examples occur, e.g. in Langkawi. The plants on these hills include some herbs usually from soil pockets and from amongst the surface roots of trees where some debris have accumulated. These include *Adenia nicobarica, Amorphophallus* spp., *Arisaema fimbriatum, A. roxburghii, Boea* spp., *Chirita* spp. and *Dichanthium mucronulatum.* It is interesting to note that of these, *Adenia nicobarica, Amorphophallus* spp. and *Arisaema* spp. have fleshy tubers which often grow into cracks and crevices. The possession of tubers could be an advantage under such dry and exposed conditions. Climbers present include *Dischidia hirsuta, Morinda umbellata* and *Secamone micrantha,* and the pandan, *Pandanus alticola* (commonly an epiphyte outside the limestone field) which is often present growing from rocks (it is abundant on Bukit Takun).

The trees and shrubs present include *Buxus malayana, Diospyros ferrea* (commonly on hills around Gua Musang), *Ficus calcicola, Glycosmis calcicola, Memecylon laevigatum, Pistacia malayana, Planchonella obovata, Podocarpus polystachyus, Tarenna curtisii, Terminalia triptera* (only Langkawi), *Vaccinium littoreum* (only on Bukit Takun and Anak Takun), and *Vitex siamica.*

8. Coastal limestone

In Malaya this only occurs in Langkawi where part of the coast of the main island and many of the smaller islands are entirely limestone. Hills and islets which descend gradually to the sea are often fringed on the seaward edge by narrow sandy beaches (non-limestone, and derived from other geological formations as weathered limestone produce hardly any 'sand') on which develops a typical strand vegetation. It is these low limestone areas that are mostly influenced by the sea and are invaded by some species from the strand vegetation. Hills with tall abrupt cliffs do not show any littoral influence. However, it must be remembered that many species from the Langkawi limestone are not found on limestone further south on the mainland, but this is due to the northerly position of Langkawi principally, and not due to littoral influence (which is coincidental and at the most contributary). These species include *Bombax anceps, Cycas siamensis, Colona merguensis, Euphorbia antiquorum, Grewia viminea, Hopea ferrea, Pentacme siamensis, Sterculia lancaviensis* and *Vatica cinerea.*

The coastal limestone therefore is restricted to that part of the limestone in close proximity to the sea, and this is usually near sea-level. The seaward edge is fringed with sand which supports a typical Indo-Malaysian littoral vegetation (sensu Schimper, 1903). The vegetation on this limestone is sparse to dense, short or tall, depending on the availability of soil and the topography; but littoral species are present. The species include some herbaceous members like *Davallia solida, Humata pectinata, Eurycles sylvestris* and *Tacca leontopetaloides.* Trees and shrubs include *Barringtonia asiatica, Caesalpinia crista, Guettarda speciosa,*

Heritiera littoralis, Pandanus odoratissimus, Peltophorum pterocarpum, Thespesia populnea and *Xylocarpus granatum*. Together with the species mentioned above this makes up a distinctive coastal limestone vegetation (probably distinctive even if there were other coastal limestone areas further south).

9. Disturbed areas

Disturbed areas usually occur on the summits, lower slopes and bases of hills. These disturbances could have been brought about by a number of causes, viz:

(i) Fire, occurring naturally or artificially, e.g. Bukit Takun in August 1970 and Gua Musang in mid-1969.

(ii) Mining and quarrying activities. This is seen on a large number of hills in all the major limestone districts.

(iii) Agriculture, affecting only hill bases, e.g. some hills around Ipoh and in limited spots on many other hills.

(iv) Erection of communication transmitters and trignometrical stations, e.g. on Gunong Lanno, G. Layang-Layang and G. Tasek, also on other hills.

(v) Frequent trampling by visitors, e.g. on Bukit Takun and Gua Musang.

Whatever the cause, disturbances result in the partial or complete destruction of the original vegetation. It is interesting to note that *Cratoxylum maingayi, Podocarpus polystachyus* and *Radermachera lobbii* survived the 1969 fire on Gua Musang that destroyed all the other vegetation affected. *Cratoxylum* and *Podocarpus* probably survived because they were the largest trees there and consequently had thick bark. Several plants of *Radermachera* (they were slender and probably not more than 4 m tall) were burnt almost to the ground. By August 1971 the sucker-shoots sent out were already 2 m tall and flowering.

Though the complete development from sere to high forest has never been observed, a composite and representative picture (at least of the initial stages) can be formed by observation of a number of hills. One of the earliest colonisers is the moss *Bryum coronatum* Schwaegr. which was abundant on Gua Musang in August 1970 and also in August 1971 on burnt earth and on rocks. This moss is followed (or accompanied) by a large number of ubiquitous weeds, truly opportunistic and very adaptable and probably completely indifferent to the limestone influence. The species include *Chrysopogon aciculatus, Colocasia gigantea* (prominent on Gua Musang), *Eleusine indica, Erechtites valerianifolia, Eupatorium odoratum, Macaranga tanarius, Muntingia calabura* (prominent on the quarried slopes of Bukit Chintamani), *Nephrolepis biserrata, Neyraudia reynaudiana* (conspicuously gracing the summit of Gua Musang in 1971), *Paspalum conjugatum, Pityrogramma calomelanos, Pteridium caudatum* var. *yarrabense, Pteris vittata, Rhynchelytrum repens* and *Solanum ferox*. Limestone elements present at this early stage include *Boea* spp., *Chirita* spp. and *Schizaea inopinata*.

Trees like *Macaranga tanarius* and *Trema* spp. are probably quite persistent, though the latter stages of this succession have not been observed. Presumably seedlings of other limestone elements get established and eventually from the dominant vegetation once again, shading out the colonisers.

4. PHYTOGEOGRAPHY AND SIZE OF THE FLORA

The total number of species recorded for the limestone flora is 1216 distributed in 582 genera and 124 families (This includes the true ferns, Gymnosperms and Angiosperms). The introduced elements (as weeds and escapes from cultivation) number 39 species or 3.2% of the total flora.

The breakdown of the flora is as follows:

		Genera	*Species*	*Dubious Records*
PTERIDOPHYTES				
Adiantaceae		8	16	—
Dennstaedtiaceae		17	45	—
Grammitidaceae		1	2	—
Hymenophyllaceae		1	4	—
Polypodiaceae		11	21	—
Schizaeaceae		2	3	—
Thelypteridaceae		3	6	—
TOTAL	7	43	97	—
	=	=	=	=
GYMNOSPERMS				
Araucariaceae		1	1	—
Cycadaceae		1	2	—
Gnetaceae		1	2	—
Podocarpaceae		1	2	—
TOTAL	4	4	7	—
	=	=	=	=
ANGIOSPERMS				
DICOTYLEDONS				
Acanthaceae		16	32	—
Amaranthaceae		2	2	1
Anacardiaceae		8	9	1
Annonaceae		19	39	—
Apocynaceae		10	17	—
Aquifoliaceae		1	1	—
Araliaceae		3	9	—
Aristolochiaceae		—	—	1
Asclepiadaceae		9	23	—
Balanophoraceae		1	1	—
Balsaminaceae		1	8	—
Begoniaceae		1	8	—
Bignoniaceae		1	1	—
Bombacaceae		2	2	—
Boraginaceae		2	3	—
Burseraceae		3	5	—
Buxaceae		1	3	—
Caprifoliaceae		1	2	—
Capparidaceae		1	1	—
Cardiopteridaceae		1	1	—
Celastraceae		6	10	—
Chloranthaceae		1	1	—
Combretaceae		3	5	—
Compositae		7	9	—
Connaraceae		2	3	—
Convolvulaceae		4	5	—
Cucurbitaceae		6	6	—
Datiscaceae		1	1	—
Dilleniaceae		3	3	—
Dipterocarpaceae		8	12	—
Ebenaceae		1	17	—
Elaeocarpaceae		1	1	—

Dicotyledons (*cont.*)				
Ericaceae		2	2	—
Erythroxylaceae		1	1	—
Flacourtiaceae		37	81	—
Fagaceae		1	2	—
Eacourtiaceae		5	12	1
Gentianaceae		3	3	—
Gesneriaceae		11	39	—
Guttiferae		4	11	—
Hamamelidaceae		2	2	—
Hernandiaceae		1	1	—
Hypericaceae		1	1	—
Icacinaceae		2	3	—
Labiatae		8	13	—
Lauraceae		8	13	—
Lecythidaceae		1	3	—
Leguminosae		10	31	3
Lentibulariaceae		1	1	—
Loganiaceae		3	8	1
Loranthaceae		4	5	—
Lythraceae		1	1	—
Malvaceae		4	4	—
Melastomaceae		8	18	1
Meliaceae		6	8	—
Menispermaceae		6	6	—
Monimiaceae		1	1	—
Moraceae		3	29	—
Myristicaceae		2	5	—
Myrsihaceae		4	21	—
Myrtaceae		4	9	—
Nepenthaceae		1	1	—
Nyctaginaceae		2	3	—
Ochnaceae		1	1	—
Oleaceae		3	11	—
Onagraceae		1	1	—
Oxalidaceae		1	1	—
Passifloraceae		2	2	—
Piperaceae		3	14	—
Pittosporaceae		1	1	—
Polygalaceae		3	5	—
Polygonaceae		1	1	—
Primulaceae		1	1	—
Ranunculaceae		1	2	—
Rhamnaceae		4	5	—
Rhizophoraceae		1	1	—
Rosaceae		2	2	—
Rubiaceae		27	66	—
Rutaceae		8	14	1
Santalaceae		1	1	—
Sapindaceae		4	4	—
Sapotaceae		6	8	—
Scrophulariaceae		3	4	—
Solanaceae		2	6	—
Staphyleaceae		1	1	—
Sterculiaceae		8	13	—
Thymelaeaceae		1	3	—
Tiliaceae		4	7	—
Ulmaceae		2	3	—
Urticaceae		9	12	—
Verbenaceae		8	14	—
Violaceae		1	4	—
Vitaceae		6	19	1
TOTAL	93	389	805	11

MONOCOTYLEDONS				
Agavaceae		1	7	—
Alismataceae		—	—	1
Amaryllidaceae		2	2	—
Araceae		19	43	1
Burmanniaceae		2	3	—
Commelinaceae		4	7	1
Cyperaceae		4	13	—
Dioscoreaceae		1	10	—
Flagellariaceae		1	1	—
Gramineae		26	32	1
Hypoxidaceae		1	1	1
Liliaceae		4	5	—
Lowiaceae		1	1	—
Marantaceae		2	2	—
Musaceae		1	1	—
Orchidaceae		52	136	—
Palmae		12	18	—
Pandanaceae		1	6	—
Stemonaceae		1	1	—
Taccaceae		1	1	—
Triuridaceae		1	1	—
Zingiberaceae		9	16	—
TOTAL	22	146	307	5
GRAND TOTAL	126	582	1216	16

The total number of families presented here include Aristolochiaceae and Alismataceae which have only been dubiously recorded. Thus the number of families actually recorded from the limestone is 124. The total number of plants recorded from limestone is 1216 and excluding the ferns this give a total of 1119 species of spermatophytes. Keng (1970) estimated that between 8000-8500 species of spermatophytes occur in the Malay Peninsula. Thus the total number of species of spermatophytes on the limestone is between 13.0–13.9% of the total number of species found in the Peninsula.

Henderson (1939) compared the number of species on limestone and the area of limestone with the total number of species in Malaya and the total area of Malaya. Based on Scrivenor, in Burkill (1935), Henderson concluded that the total area of limestone, which is about 260 sq. km. (100 sq. miles), is 0.2–3% of the total area of the Peninsula. The total number of species from limestone recognised then was 745 which was about 8–9% of the total number of flowering plants (then known) in the Peninsula. These figures seem to indicate a much richer flora per unit area on the limestone than on the other formations. The present figure of 13.0–13.9% would suggest an even richer flora.

This method of comparison assumes that there is a direct relationship between the number of species and the area of land, and that the number of species increases linearly with the increase in land area. This seems incorrect. For instance, Gua Batu supports about 170 species of plants. This is 14.5% of the total number recorded from limestone. It has an area of only about 2.59 sq. km. (1 sq. mile), which is 1% of the total area of limestone in Malaya. It would appear that Gua Batu were floristically 14.5 times richer than the other limestone hills.

To obtain a correct picture, only the 'minimal area' of a community should be used in comparison with the 'minimal area' of another community. This concept of 'minimal area' (Braun-Blanquet, 1932; Poore, 1955) has been defined

as the smallest area which can contain an adequate representation of an association. However, the 'minimal area' for both the limestone and the lowland forest in Malaya have not been worked out. One alternative, therefore, is to select an area with the same or about the same area as the limestone and whose flora has been worked out. This flora could be used to compare the limestone flora with.

The flora of Penang island which is about 285 sq. km. (110 sq. mi.) in area has been worked out by Curtis (1894). His list of flowering plants total 1805 species. Similarly the flora of Singapore (Ridley, 1900) which is about 582 sq. km. (225 sq. mi.) included 1952 species. The two floras give an idea of the richness of the Malayan flora but as far as a comparison with the limestone flora go, they do not give an accurate picture. The limestone flora is from an edaphic climax formation whereas areas like Singapore and Penang support (originally) a climatic climax formation which includes a number of other climaxes, e.g.; mangrove swamp forest, beach forest, hill dipterocarp forest (in Penang), *Adinandra* forest (in Singapore), riparian fringes and seasonal swamp forest (at least in Singapore) apart from the lowland dipterocarp forest.

The other alternative therefore is to compare a "minimal area" of the limestone flora with the "minimal area" of the flora of another edaphic climax formation. This comparison will probably give the most accurate picture of the relative size and richness of the limestone flora. Unfortunately no flora of any other edaphic climax in Malaya has been worked out that could be conviniently used.

However, Anderson (1963) published an account of the past swamp forest of Sarawak and Brunei, which under the present circumstances should be the most relevant to compare the limestone flora with. The coastal and deltaic peat swamps cover a total of 15644 sq. km. (6040 sq. mi.) of Sarawak and Brunei. The total number of flowering plants recorded in Anderson's list is 393 species. Thus in comparison even the vastness of the Sarawak and Brunei peat swamps have not support a flora as rich as that on the Malayan limestone. The limestone vegetation of Sarawak (surface area much less than the peat swamp) is also exceptionally rich in plant species. A preliminary report on the Sarawak limestone (Anderson, 1965) records over 600 species, and this number is bound to increase as more limestone areas are explored.

Thus one can conclude that the limestone flora of Malaya (and Sarawak) is extremely rich in species, intrinsically and also relatively, in comparison with the peat swamp flora of Sarawak and Brunei, and most probably with floras of other edaphic climaxes.

The total number of families recorded from limestone is 124; of these 117 are families of spermatophytes. The total number of families of flowering plants recorded from Malaya (both native and introduced) is 188 (figure obtained by totalling the list in Keng, 1969). The delimitation of families in this study is the same as in Keng except for Icacinaceae, which is split into Cardiopteridaceae and Icacinaceae, and Tiliaceae which has been treated as Elaeocarpaceae and Tiliaceae. With the addition of these two families the total number of plant families in Malaya becomes 190; the total recorded from limestone amounts to 61.6% of this.

This rich flora differs from that of the rest of Malaya only in degree and not in kind (Henderson 1939). No one family or group of families predominates or is confined to the limestone except for two small families represented by very few species in Malaya, Buxaceae (three species) and Primulaceae (one species). The representation of a family on the limestone also more or less reflects the size of the family as represented in Malaya. Table 1 shows the twelve largest families in Malaya (from Keng, 1969) which is based on Ridley, 1925, with the total genera and species from limestone compared beside them.

TABLE 1. GENERA AND SPECIES IN THE TWELVE LARGEST (SPECIESWISE) FAMILIES IN MALAYA AND THEIR OCCURRENCE ON LIMESTONE

Families	Genera		Species	
	Malaya	Limestone	Malaya	Limestone
Orchidaceae	104	52	669	136
Rubiaceae	67	27	368	66
Euphorbiaceae	71	37	343	81
Leguminosae	66	19	266	31
Gramineae	83	26	205	32
Annonaceae	30	19	184	39
Palmae	30	12	181	18
Melastomaceae	25	8	174	18
Lauraceae	16	8	174	13
Acanthaceae	36	16	168	32
Gesneriaceae	21	11	161	39
Zingiberaceae	20	9	157	16
Averages: Ratio	2 :	1	6 :	1

On limestone, Orchidaceae still tops the list but there are proportionally more members of the Euphorbiaceae than Rubiaceae. The limestone seems a little poor in Leguminosae, Palmae, Melastomaceae, Lauraceae and Zingiberaceae though the other families are more or less proportionally represented. The reasons for this difference may be various and not conjectured as knowledge on the requirements of these plants is almost non-existent.

The families recorded from Malaya but not represented on the limestone are:

GYMNOSPERMS

Pinaceae

Dicotyledons

Aceraceae
Actinidiaceae
Aizoaceae
Ancistrocladaceae
Basellaceae
Bixaceae
Cactaceae
Campanulaceae
Caricaceae
Caryophyllaceae
Casuarinaceae
Chenopodiaceae
Clethraceae
Cornaceae
Crassulaceae
Cruciferae
Cunoniaceae
Daphniphyllaceae
Dichapetalaceae
Droseraceae
Elaeagnaceae
Epacridaceae
Gonystylaceae
Goodeniaceae
Hydrophyllaceae
Illiciaceae
Juglandaceae
Linaceae
Magnoliaceae
Malpighiaceae
Monotropaceae
Moringaceae
Myricaceae
Nymphaeaceae
Olacaceae
Opiliaceae
Orobanchaceae
Pedaliaceae
Plantaginaceae
Plumbaginaceae
Portulacaceae
Proteaceae
Rafflesiaceae
Sabiaceae
Salicaceae
Saxifragaceae
Schisandraceae
Simaroubaceae
Stylidiaceae
Styraceae
Symplocaceae
Theaceae
Turneraceae
Umbelliferae

Monocotyledons

Bromeliaceae
Butomaceae
Cannaceae
Eriocaulaceae
Hydrocharitaceae
Iridaceae
Juncaceae
Lemnaceae
Najadaceae
Philydraceae
Pontamogetonaceae
Pontederiaceae
Restionaceae
Smilacaceae
Typhaceae
Xyridaceae

These 71 families can be divided into six groups.

1. Aquatic or marsh plants. These are represented by 12 families, and include most of the monocots. They are, Nymphaeaceae, Stylidiaceae, Butomaceae, Eriocaulaceae, Hydrocharitaceae, Lemnaceae, Najadaceae, Philydraceae, Pontamogetonaceae, Pontederiaceae, Restionaceae, and Typhaceae.

2. Parasitic plants. These are represented by two families, Orobanchaceae and Rafflesiaceae.

3. Coastal plants. Represented by three families, Casuarinaceae, Goodeniaceae and Portulacaceae. Aizoaceae also has a coastal member in *Sesuvium*, while the remaining two genera in Malaya are not very common herbs.

4. Weeds or plants in cultivation. These are represented by 17 families, Pinaceae, Basellaceae, Bixaceae, Caricaceae, Caryophyllaceae, Cactaceae, Chenopodiaceae, Crassulaceae, Cruciferae, Moringaceae, Pedaliaceae, Plantaginaceae, Plumbaginaceae, Salicaceae, Turneraceae, Bromeliaceae and Iridaceae.

5. Very rare plants. In many cases these families are represented by a solitary species in Malaya. There are 15 such families. They are, Aceraceae, Ancistrocladaceae, Clethraceae, Cunoniaceae, Daphniphyllaceae, Droseraceae, Elaeagnaceae, Epacridaceae, Hydrophyllaceae, Illiciaceae, Magnoliaceae, Monotropaceae, Myricaceae, Cannaceae and Juncaceae.

6. Others. These remaining 23 families are often small and uncommon. They are Actinidiaceae, Aizoaceae, Campanulaceae, Cornaceae, Dichapetalaceae, Gonystylaceae, Juglandaceae, Linaceae, Malpighiaceae, Olacaceae, Opiliaceae, Proteaceae, Sabiaceae, Saxifragaceae, Schisandraceae, Simaroubaceae, Styracaceae, Symplocaceae, Theaceae, Umbelliferae, Smilacaceae and Xyridaceae.

It is unlikely that members of group 1 will ever be found on limestone, but it is probable that members of group 2 are present on limestone. Members of group 3 could conceivably be present on coastal limestone barring any physiological antagonism to limestone. When more limestone areas are disturbed by man, some, particularly the weed members of group 4 will probably be recorded. Members group 5 which are very rare plants will, even if they are recorded on limestone, also be very rare. New records for limestone from families not yet represented will therefore most likely be from group 6, but there will not be many species, for most of these families are small. The greatest number of new records will probably be from families already represented on the limestone.

Phytogeography

The 1216 species recorded from the limestone can be grouped according to their geographical distribution into a number of classes, viz:

PANTROPIC: Species occurring throughout the tropical regions of the world.

PALEOTROPIC: Species occurring in the tropics of the Old World, from Africa and India through Malesia and to the Pacific.

INDO-MALESIAN: Species disturbed in mainland Asia as well as in Malesia; including India to the Himalayas, Burma, S. China, Indochina, Thailand, Malesia and southwards to Australia and the Pacific Islands.

ASIATIC: Species only in mainland Asia, sometimes only from Thailand.

MALESIAN: Species occurring in Malesia, including Malaysia, Indonesia, Philippines, New Guinea and sometimes to Australia and the Pacific.

ENDEMIC: Species occurring only in Malaya. These are subdivided into

(a) Species restricted to limestone in Malaya.

(b) Species not restricted to limestone in Malaya.

The result of this analysis is shown in Table 2.

TABLE 2. GEOGRAPHICAL DISTRIBUTION OF THE SPECIES
NUMBER OF SPECIES

	Pteridophytes	Gymnosperms	Angiosperms	Total	%
PANTROPIC	6	—	14	20	1.7
PALEOTROPIC	8	—	27	35	2.9
INDO-MALESIAN	40	4	315	359	29.6
ASIATIC (Asia mainland)	5	1	228	234	19.0
MALESIAN	32	1	225	257	21.2
ENDEMIC (total)	5	—	266	272	22.5
(a. restricted to limestone	2	—	127	129	10.7)
(b. not restricted to limestone	3	—	139	143	11.8)
WEEDS AND ESCAPES	1	—	38	39	3.2

From the table it can be seen that the pantropic element is negligible; this is because most species of this group are weeds (plants that occur in cultivated habitats as undesirables, also in lawns and other open places and often as members of secondary vegetation) and have been included under that group. The widely distributed paleotropic element is also small. There is no predominance of either the Asiatic or Malesian element, both being equally represented except for the ferns. The weeds and escapes are noticably few in number; this is probably because there are few areas on the limestone that support a secondary vegetation. However, this is not to say that the limestone hills have been free from interference, but, that when the limestone hills are disturbed it usually means that the habitat itself is bodily removed as for instance in mining and quarrying.

Krasan (1882) and Steenis (1934) suggested that on limestone mountains plants might be able to descend abnormally low. Although there are no really high limestone mountains in Malaya this tendency can be seen. Here the mountain massif has many peaks rising to over 1500 m, with Gunong Tahan rising to 2187 m. Plants known from 800–2000 m (very rarely from lower elevation, if ever) have been found on low elevation (usually less than 300 m) on the limestone and not elsewhere.

The species recorded include *Antrophyum semicostatum, Leptochilus decurrens, Vittaria angustifolia, Alyxia angustifolia, Alyxia pumila, Corybas, mucronatus, Distylium stellare, Liparis compressa, Paphiopedilum lowii, Schefflera elegans, Sciaphila asterias, Scycopsis dunnii* and *Toxocarpus curtisii.*

5. *AFFINITIES OF THE FLORISTIC COMPONENTS TO LIMESTONE*

The component species of the Malayan limestone can be arranged in the following four groups:

I. EXCLUSIVES: These are species which, in Malaya, are restricted to the limestone and include, (a) Species endemic to Malaya. (b) Species not endemic to Malaya.

II. PREFERENTS: Species with a preference for the limestone field, appearing in both fields (limestone and non-limestone) but more abundantly in the limestone field.

III. INDIFFERENTS: Species with no affinity for either field, appearing in both fields without exhibiting any difference in abundance between them. This group includes most epiphytes and plants of secondary vegetation.

IV. STRANGERS: Species appearing accidentally on the limestone field; frequently collected from the non-limestone field but only rarely from the limestone field.

The criterion of fidelity (Brown-Blanquet, 1932) is used in constructing this grouping, fidelity being indicative of the degree with which a species is restricted to a particular kind of community (in this case the limestone community).

The fidelity of each species and thus the allocation to the various groups is based solely on field work. Species under groups I and II are termed the characteristic species.

Rarely collected species which have been recorded both from limestone and non-limestone fields are included under group III (indifferents) instead of under group IV (strangers). This is because the limestone areas are probably the least botanised of all the vegetation types in Malaya and chances are that rare species already recorded from limestone are more likely to turn up from it again rather than from the other vegetation types.

Weeds and plants escaped from cultivation usually fit into groups III (indifferents) or IV (strangers). However, here they are listed separately.

The true and intrinsic reasons for a plant to be on the limestone field could also be used to classify the floristic components. Any of the plants found on limestone could be:

(a) Calciphilous (chalk-loving) in the true physiological sense (Jackson, 1928). They may be obligate calciphiles, in which case the limestone field is a prerequisite for growth and survival, or non-obligate. The non-obligates have a physiological need or affinity for limestone but are able to survive without the limestone field.

A large number of species in my group I (exclusives) are probably obligate calciphiles while some (those that are non-endemic which are also found away from the limestone outside Malaya) are probably non-obligate calciphiles. These non-obligate calciphiles will also include a large number of species from my group II (preferents).

(b) Indifferents; species that are able to tolerate or are unaffected, physiologically, by the limestone habitat; as in my group III.

(c) Calcifugal (shunning chalk) in the true physiological sense (Jackson, (1928). Obligate calcifuges cannot tolerate the limestone field whereas the non-obligate calcifuges may often appear as strangers on the limestone field when the other criteria of space, competition and moisture are favourable. The non-obligates include at least some of my group IV.

However, this classification can only be effected by experimental work.

The species list of the different groups follows and are summed up in Table 3.

I. EXCLUSIVES

PTERIDOPHYTES

Adiantum zollingeri
Antrophyum parvulum
Cheilanthes farinosa
*Doryopteris allenae
Doryopteris ludens
Drynaria bonii
Heterogonium alderwereltii
Heterogonium pinnatum
Lygodium polystachyum
Nephrolepis dicksonioides
*Polystichum lindsaeifolium
Pyrrosia stigmosa
Schizaea inopinata
Tectaria amplifolia
Tectaria devexa

GYMNOSPERMS

Cycas siamensis

ANGIOSPERMS

DICOTYLEDONS

Actephila excelsa
Aeschynanthus longicaulis
*Amaracarpus saxicola
Andrographis tenuiflora
*Aporuellia sumatrensis var. ridleyi
*Adisia biflora
*Ardisia langkawiensis
*Ardisia meziana
Argostemma diversifolium
*Barleria siamensis var. glabrescens
Begonia curtisii
*Begonia foxworthyi
*Begonia ignorata
*Begonia kingiana
*Begonia nurii
*Begonia phoeniogramma
Boea acutifolia
*Boea brachycarpa
*Boea caerulescens
*Boea divaricata
*Boea lanata
*Boea minutiflora
*Boea paniculata
*Boea parviflora
*Boea suffruticosa
Boea treubii
*Boea verticillata
Boerhavia chinensis
*Buxus holttumiana
*Buxus malayana
*Buxus rupicola
*Callicarpa angustifolia
*Canarium perlisanum
Canscora pentanthera
*Canthium aciculatum
Capparis diffusa
Celtis philippensis
*Chirita caliginosa
Chirita hamosa
Chirita involucrata
Chirita lacunosa
*Chirita rupestris
*Chirita sericea
*Cleistanthus parvifolius
Cnesmone laevis
*Cnesmone subpeltata
Colona javanica
Cynoctonum mitreola
Dendronide sinuata
Dichiloboea speciosa

*Endemic to Malaya.

Dicotyledons (cont.)

*Dicliptera rosea
Dimocarpus longan ssp. longan var. longan
Diospyros daemona
*Diospyros holttumii
Diospyros retrofracta
Diospyros transitoria
Diospyros undulata
*Dischidia tomentella
*Drypetes nervosa
*Embelia calcarea
Euphorbia antiquorum
Excoecaria oppositifolia
*Fagraea calcarea
Ficus calcicola
Garuga floribunda
Glossocarya mollis
*Glycosmis calcicola
*Glycosmis calcicola var. kelantanica
Glyptopetalum zeylanicum
*Gongylosperma lanuginosum
Goniothalamus subevenius
Grewia viminea
Gymnanthera insularum
*Gymnostachyum robinsonii
Heritiera pterospermoides
*Homalium kunstleri
Homalium undulatum
*Hoya occlusa
Hydnocarpus ilicifolia
*Impatiens crytoneura
Impatiens marosepala
Impatiens mirabilis
Impatiens opinata
*Impatiens ridleyi
Impatiens scortechinii
*Impatiens tipusensis
Impatiens vaughanii
*Isonandra perakensis var. kelantanensis
*Isonandra perakensis var. perakensis
*Jasminum cordatum
*Jasminum curtisii
*Jasminum sp. A aff. trinerve
*Jasminum sp. B
*Justicia microcarpa
*Justicia robinsonii
*Justicia rupestris
*Justicia subalternans
Justicia valida
*Kopsia griffithii var. paucinervia
*Lagerstroemia langkawiensis
*Lasiobema flavum
Leptopus australis
Leucas mollissima
Ligustrum confusum
Lysimachia peduncularis
*Madhuca calcicola
*Mallotus bracteatus
Mallotus brevipetiolatus
Mallotus cuneatus
Maytenus curtisii
*Melodinus perakensis
Microphium pubescens
*Miliusa parviflora
*Millettia pterocarpa
Monophyllaea glabra
*Monophyllaea hirticalyx
Oldenlandia rosettifolia
*Ophiorrhiza fruticosa
Ophiorrhiza kunstleri
*Ophiorrhiza longerepens
Ornithoboea flexuosa
Orophea cuneiformis
*Orophea hirsuta
Orophea polycarpa
*Osmanthus scortechinii
*Paraboea bakeri
*Paraboea bettiana
*Paraboea ferruginea
*Paraboea laxa
*Paraboea vulpina
Parishia rosea
*Pavetta pauciflora
Pentacme siamensis
Pentaspadon curtisii
Peperomia dindigulensis
Peperomia portulacoides
*Peperomia sp. A.
*Phanera decumbens
Phyllanthus columnaris
Phyllanthus ridleyanus
*Pilea fruticosa
*Piper collinum
Pisonia aculeata
Pisonia umbellifera
*Pistacia malayana
*Plectranthus kunstleri
Polygala cardiocarpa
Polygala malesiana
Polygala triphylla
*Polytrema cupreum
*Popowia velutina
*Rungia minutiflora
Sageretia thea
Sapium insigne
*Sauropus calcareus
Sauropus macranthus
Sauropus suberosus
*Schefflera subracemosa
Scleropyrum wallichianum
*Scolopia steenisiana
Semecarpus glomerulata
Solanum biflorum
*Sonerila elliptica
Sonerila tenera
*Stenothyrsus ridleyi
Stephania venosa
Sterculia angustifolia
Sterculia lancaviensis
*Strobilanthes pachyphyllus
Tarenna angustifolia
*Tarenna calcarea
Tarenna curtisii
Tetrameles nudiflora
Timonius atropurpureus
*Toxocarpus pauciflorus
Trigonostemon verticillatus
*Tylophora calcicola
Vernonia curtisii
*Vernonia rupicola
Vitex siamica
*Vitis scortechinii
Wikstroemia androsaemifolia
*Zanonia clarkei
*Zizyphus pernettyoides

MONOCOTYLEDONS

*Aglaonema costatum
Amorphophallus carnosus
Amorphophallus haematospadix
Arisaema fimbriatum
Arthraxon prionodes
Asparagus racemosus
*Boesenbergia curtisii
*Calamus balingensis
Calanthe rubens
Calanthe vestita
*Carex malaccensis
Carex speciosa
*Corymborchis brevistylis
Cymbopogon calcicola
*Dendrobium langkawiense
Dendrocalamus dumosus
*Dendrocalamus elegans
Dichanthium annulatum
*Dichanthium mucronulatum
Dracaena curtisii
Dracaena yuccaefolia
Eulalia quadrinervis
Eulophia keithii
*Fimbristylis calcicola
*Fimbristylis malayana
*Fimbristylis trichophylla
*Globba albiflora var. aurea
Goodyera hispida
Habenaria carnea
*Habenaria kingii
Hapaline brownii
*Isachne langkawiensis
Kaempferia elegans
Kaempferia pulchra
*Liberbaileya gracilis
*Malaxis reniloba
*Malleola undulata
*Maxburretia rupicola
*Oberonia calcicola
Oberonia caudata
*Oberonia transversiloba
*Pandanus calcicola
*Pandanus irregularis
*Pandanus piniformis
Paphiopedilum niveum
Pollia subumbellata
Pomatocalpa naevatum
Pomatocalpa setulense
*Pothos lorispatha
*Pteroceras tanyphyllum
*Raphidophora kunstleri
Sarcanthus termissus
Spathoglottis hardingiana
*Stachyphrynium cylindricum
*Thelasis succosa
Trichoglottis winkleri var. minor
*Typhonium filiforme
*Typhonium fultum

*Endemic to Malaya.

II. PREFERENTS

PTERODOPHYTES

Adiantum malesianum
Adiantum soboliferum
Asplenium adiantoides
Asplenium squamulatum
Cyclopeltis crenata
Hemionitis arifolia
Pteridrys syrmatica
*Pteris longipinnula var. b
Pyrrosia penangiana

GYMNOSPERMS

ANGIOSPERMS

DICOTYLEDONS

*Argostemma inaequilaterum
Argostemma pictum
Berrya cordifolia
Chirita viola
Cladogynos orientalis
Cleistanthus gracilis
*Cleistanthus kingii
Colona merguensis
Croton cascarilloides
Cymaria dichotoma
*Debregeasia squamata
Deeringia polysperma
*Dehaasia curtisii
Desmodium rugosum
*Drypetes oxyodonta
Epithema saxatile
Fagraea carnosa
Fagraea curtisii
Ficus curtipes
Garcinia minutiflora
Gomphostemma crinitum
Hedyotis coronaria
*Heterostemma piperifolium
Hopea ferrea
*Hoya citrina
Illigera pulchra
*Ixora clerodendron
Jasminum wrayi
*Justicia henicophylla
Lasiobema curtisii
*Lasiobema strychnoideum
*Leea saxatilis
Litsea glutinosa
*Madhuca ridleyi
Mallotus dispar
Mallotus miquelianus
Memecylon laevigatum
*Miliusa amplexicaulis
Monophyllaea horsfieldii
Murraya paniculata
*Orophea maculata
*Paraboea capitata
*Peperomia kotana
*Phyllanthus filicifolius
Procris pedunculata
Rinorea bengalensis
Sauropus villosus
Sumbaviopsis albicans
Terminalia triptera
Trigonostemon viridissimus
Vitis discolor
Wikstroemia indica
Zizyphus oenoplia

MONOCOTYLEDONS

Abdominea minimiflora
Amomum testaceum
Apluda mutica
Appendicula torta
Arachnis flos-aeris
Bulbophyllum fenestratum
*Bulbophyllum flammuliferum
Bulbophyllum lilacinum
Dendrobium salaccense
Dioscorea calcicola
Dracaena congesta
*Dracaena graminifolia
*Globba fasciata
Habenaria reflexa
Pholidota pallida
*Pothos macrocephalus
*Sarcanthus rugulosus
Trichoglottis retusa
Uncifera tenuicaulis

III. INDIFFERENTS

PTERIDOPHYTES

Adiantum stenochlamys
Asplenium macrophyllum
Asplenium pellucidum
Asplenium salignum
Davallia denticulata
Davallia solida
Drynaria quercifolia
Drynaria rigidula
Humata pectinata
Loxogramme avenia
Loxogramme scolopendrina
Nephrolepis falcata
Photinopteris speciosa
Phymatodes nigrescens
Phymatodes papillosum
Phymatodes scolopendria
Pityrogramma calomelanos
Pteridium aquilinum var. wightianum
Pteridium caudatum var. yarrabense
Pteris ensiformis
Pteris tripartita
Pteris vittata
Pyrrosia adnascens
Pyrrosia varia
Tectaria variolosum
Thelypteris immersa
Trichomanes bipunctatum

GYMNOSPERMS

Cycas rumphii
Podocarpus polstachyus

ANGIOSPERMS

DICOTYLEDONS

Actephila ovalis
Adenia nicobarica
Aeschynanthus parvifolia
*Aglaia argentea
Aglaia odoratissima
Aglaia splendens
Agrostistachys gaudichaudii
Allophylus cobbe var. glaber
Allophylus cobbe var. villosus
Alyxia selangorica
Antidesma japonicum
*Ardisia fulva
*Ardisia kunstleri
Ardisia lancelolata
Ardisia oxyphylla
*Ardisia solanacea var. elata
*Ardisia vaughani
Argyreia maingayi
Argyreia mollis
*Artabotrys grandifolius
Atalantia monophylla
*Atalantia roxburghiana
Becheria parviflora
*Begonia debilis
Begonia guttata
*Beilschmiedia lumutensis
Bombax anceps
Bridelia ovata
Bridelia tomentosa
Callicarpa lanata
Canthium didymum
Carallia brachiata
Casearia capitellata
Cassia timoriensis
Cinnamomum iners
Clausena excavata
*Cleidion javanicum
Cleistanthus decurrens
*Cleistanthus glaucus
*Cleistanthus macrophyllus
Clerodendron penduliflorum
Clerodendron serratum
Clidemia hirta
Combretum porterianum
Congea vestita
Connarus sp.
Cordia griffithii
Cordia obliqua
Cratoxylum maingayi
Cyclea laxiflora
*Dalbergia kunstleri
Dalbergia phyllanthoides
Dalbergia scortechinii

*Endemic to Malaya.

Dicotyledons (cont.)

Decaspermum fruticosum
*Dehaasia longipedicellata
Dendrocnide stimulans
Desmos cochinchinensis
Desmos dasymaschalus var. wallichii
Desmos dunalii
*Diospyros adenophora
Diospyros buxifolia
Diospyros cauliflora
*Diospyros ellipsoidea
Diospyros ferrea
Diospyros frutescens
Diospyros toposiodes
Dischidia benghalensis
Dischidia hirsuta
*Dischidia scortechinii
Ehretia timorensis
*Elatostema curtisii
Elatostema latifolium
*Enicosanthum congregatum
Eriobotrya bengalensis
Erismanthus obliquus
*Ervatamia peduncularis
Erythroxylum cuneatum
*Eugenia pendens
*Eugenia porphyranthera
Euonymus cochinchinensis
Fagraea blumei
Ficus binnendykii
Ficus deltoidea
Ficus elastica
Ficus hispida
Ficus microcarpa
Ficus sagittata
Ficus subulata
Ficus sundaica
Ficus superba var. japonica
Ficus tinctoria ssp. gibbosa
Ficus virens var. glabella
Ficus villosa
Garcinia murdochii
Garcinia nigrolineata
*Garcinia opaca
Geophila repens
Glochidion rubrum
Glycosmis puberula
Glycosmis rupestris
*Glycomis sapindoides
Glytopetalum quadrangulare
Gomphia serrata
Gomphostemma javanicum
Gomphostemma microcalyx
*Goniothalamus fulvus
Grewia acuminata
*Gymnostachyum decurrens
*Gymnostachyum diversifolium
Hedyotis tenelliflora
Hedyotis verticillata
Helicteres angustifolia
Helicteres hirsuta
Helixanthera axillaris
Helixanthera pulchra
Hemigraphis ridleyi
Heritiera littoralis
Holarrhena curtisii
Homalanthus populneus
Homalium dasyanthum
Hoya coronaria
Hoya latifolia
*Hoya maingayi
Hoya parviflora
Hoya ridleyi
Hydnocarpus wrayi
Iodes cirrhosa
Iodes ovalis
Ipomoea illustris
Ixora nigricans var. ovalis
Ixora pendula
Ixora umbellatta var. multibracteata
Jacquemontia paniculata
Jasminum adenophyllum
Jasminum insularum
*Justicia pectinella
*Justicia ptychostoma
*Justicia subcymosa
*Justicia uber
Knema globularia
Knema laurina
Kopsia pauciflora
Laportea interrupta
Leea aequata
Leea rubra
Leea sambucina
Leptonychia glabra
Ligustrum robustum
Litsea norohae
Loeseneriella pauciflora
Macaranga tanarius
Macrosolen cochinchinensis
*Maesa pahangiana
Malaisia scandens
Mallotus wrayi
Mammea brevipes
Marsdenia tinctoria
*Medinilla scortechinii
Meiogyne virgata
Melochia umbellata
*Melodinus orientalis
Melothria affinis
*Memecylon dichotomum
Memecylon edule
Memecylon floribundum
*Memecylon kunstleri
Memecylon pauciflorum
*Memecylon wallichii
Microdesmis casearifolia
Micromelum minutum
Milusa longipes
Mimusops elengi
Momordica subangulata
Morinda elliptica
Morinda umbellata
Mucuna biplicata
Mycetia malayana
Myrsine porteriana
Naravelia dasyoneura
Neolitsea zeylanica
Oldenlandia ovatifolia
Oldenlandia pterita
Ophiorrhiza discolor
Ophiorrhiza hispidula
*Ophiorrhiza pallidula
Ophiorrhiza remotiflora
Orophea enterocarpa
Orthosiphon aristatus
Oxymitra biglandulosa
Pachycentria constricta
Paederia tomentosa
Paramignya scandens
Paranephelium macrophyllum
Payena lucida
Petunga hirta
Phanera glauca
Phyllanthus oxyphyllus
Phyllanthus pulcher
Phyllanthus sikkimensis
*Piper mucronatum
*Piper scortechinii
Piper umbellatum
Planchonella obovata
*Plethiandra sessiliflora
Pogonanthera pulverulenta
Poikilospermum suaveolens
*Polyalthia brunneifolia
*Polyalthia lateritia
Polytrema uber
*Prema rubens
Prismatomeris malayana
Pseuderanthemum crenulatum
Pseuderanthemum graciliflorum
Pseuduvaria macrophylla
Pseuduvaria setosa
Psychotria angulata
*Psychotria cantleyi
Psychotria montana
Psychotria rhinocerotis
Pterolobium densiflorum
Pterospermum jackianum
Pterospermum pectiniforme
*Quisqualis parvifolia
Radermachera lobbii
Randia densiflora
Rauwolfia reflexa
*Richeriella malayana
Rinorea horneri
Rostellaria procumbens
*Rubus angulosus
Ruellia repens
*Rhus perakensis
Salacia grandiflora
Salacia korthalsiana
Salacia macrophylla
Salomonia ciliata
Saraca declinata
Saraca thaipingensis
Secamone micrantha
Schefflera junghuhniana
*Schefflera musangensis
Schefflera subulata
Schefflera tomentosa
Schefflera venolusa
Scolopia spinosa
Scurrula ferruginea
Scutellaria discolor var. discolor

*Endemic to Malaya.

Dicotyledons (cont.)

Sida javensis
Stauranthera grandifolia
Stelechocarpus cauliflorus
Sterculia rubiginosa
Streblus asper
Streblus ilicifolius
Streblus taxoides
*Strobilanthes leucopogon
Strychnos axillaris
*Tarenna pulchra
*Tarenna ridleyi
Terminalia calamansanai
*Toxocarpus curtisi
Treina tomentosa
Trigonostemon aurantiacus
Trichosanthes tricuspidata
*Trigonostemon villosus
*Tristania subauriculata
Trivalvaria macrophylla
Turpinia ovalifolia
Tylophora perakensis
Tylophora tenuis
Vaccinium littoreum
Vatica cinerea
Ventilago gladiata
Ventilago oblongifolia
Villebrunea sylvatica
Viscum orientale
Vitis furcata
Vitis glaberrima
Vitis hastata
*Vitis kunstleri
*Vitis mollissima
Vitis pyrrhodasys
Vitis repens
*Vitis wrayi
Wrightia dubia
Wrightia laevis

MONOCOTYLEDONS

*Adenoncos major
Adenoncos parviflora
Adenoncos sumatrana
Aglaonema oblongifolium
Agrostophyllum bicuspidatum
Alocasia denudata
Alocasia lowii
Amorphophallus prainii
Amorphophallus variabilis
Amydrium humile
Anadendrum marginatum
*Arenga hookeriana
*Arenga westerhoutii
Arisaema roxburghii
Borassodendron machadonis
Bulbophyllum apodum
Bulbophyllum concinnum
Bulbophyllum membranaceum
Burmannia championii
Burmannia lutescens
Calamus concinnus
Calamus siamensis var. malaianus
Calanthe ceciliae
Calanthe triplicata
Camarotis apiculata
Carex breviscapa
Caryota mitis
Catimbium speciosum
Centhotheca lappacea
Ceratostylis pendula
Chlorophytum orchidastrum
Chrysopogon fulvus
Chrysopogon orientalis
Coelogyne asperata
*Coelogyne pallens
Coelogyne pandurata
Colocasia gigantea
Corybas mucronatus
Corymborchis veratrifolia
Cymbidium finlaysonianum
Dendrobium aloifolium
Dendrobium spurium
Dichanthium caricosum
Dioscorea bulbifera
Dioscorea esculenta
Dioscorea filiformis
Dioscorea glabra
Dioscorea prazeri
Dracaena angustifolia
*Dracaena nutans
Ephemerantha luxurians
Epipremnum giganteum
Eria leptocarpa
Eria pulchella
Fimbristylis fusca
Fimbristylis fuscoides
*Forrestia monosperma
Hanguana malayana
*Homalomena deltoidea
*Iguanura polymorpha
Lasia aculeata
Liparis caespitosa
Liparis gibbosa
Malaxis calophylla
Malleola dentifera
Microsaccus ampullaceus
Microsaccus brevifolius
Microsaccus javensis
Neyraudia reynaudiana
*Oberonia flava
Oplismenus compositus
*Pandanus alticola
*Peliosanthes lurida
Phalaenopsis cornu-cervi
Phalaenopsis decumbens
Phreatia secunda
Podochilus lucescens
Podochilus microphyllus
Pogonatherum paniceum
Pollia sumatrana
Polystachya flavescens
Pomatocalpa spicatum
Pothos scandens
Pteroceras ciliatum
Pteroceras hirsutum
Renanthera histrionica
Rhychelytrum repens
Sarcanthus sacculatus
Sarcanthus scortechinii
Sarcanthus subulatus
Schismatoglottis calyptrata
*Schismatoglottis mutata
*Sciaphila asterias
Scindapsus hederaceus
Scindapsus perakensis
Scleria lithosperma
Stemona tuberosa
Thelasis micrantha
Thelasis triptera
*Tupistra grandis
Vandopsis gigantea

IV. STRANGERS

PTERIDOPHYTES

Abacopteris urophylla
Antrophyum callifolium
Antrophyum semicostatum
Arcypteris irregularis
Asplenium phyllitidis
Asplenium unilaterale
Athyrium cordifolium
Athyrium esculentum
Athyrium montanum
Athyrium pinnatum
*Athyrium prescottianum
Blechnum finlaysonianum
Crypsinus enervis
Ctenopteris alata
Ctenopteris moultoni
Cyclosorus extensus
Cyclosorus interruptus
Cyclosorus megaphyllus
Cyclosorus unitus
Drynaria sparsisora
Humata heterophylla
Lemmaphyllum accedens
Lepisorus longifolius
Leptochilus decurrens
Lindsaya lucida
Lygodium flexuosum
Microlepia speluncae
Microsorium musifolium
Microsorium punctatum

*Endemic to Malaya.

Pteridophytes (cont.)

Nephrolepis biserrata
Nephrolepis hirsutula
Nephrolepis radicans
Oleandra undulata
Pteris mertensioides
*Pteris scabripes
Pyrrosia floccigera
Taenitis blechnoides
Tectaria barberi
Tectaria griffithii
Tectaria macronta
Trichomanes christii
Trichomanes humile
Trichomanes motleyi
Vittaria angustifolia
Vittaria elongata var. angustifolia

GYMNOSPERMS

Agathis dammara
Gnetum cuspidatum
Gnetum gnemon var. tenerum
Podocarpus neriifolius

ANGIOSPERMS

DICOTYLEDONS

Acrotrema costatum
Adenosma capitatum
Aeschynanthus radicans
Agelaea borneensis
Alchornea rugosa
Alsomitra pubigera
Alstonia scholaris
*Alyxia angustifolia
*Alyxia pumila
Anaxagorea javanica
Antidesma montanum
Antidesma tomentosum
*Aporosa stellifera
Aralidium pinnatifidum
Ardisia andamanica
Ardisia crenata
Ardisia colorata var. complanata
Ardisia pendula
*Ardisia playtyclada
Ardisia ridleyi
*Ardisia tahanica
Ardisia villosa
Azadirachta excelsa
Baccaurea lanceolata
Balanophora fungosa
Barleria prionitis
Barringtonia asiatica
*Barringtonia fusiformis
Barringtonia macrostachya
Bauhinia acuminata
*Beilschmiedia pahangensis
Biophytum adiantoides
Blumeodendron kurzii
Brassaiopsis polyacantha
Breynia vitis-idaea
Bridelia stipularis
Buchanania sessilifolia
Caesalpinia crista
Calophyllum curtisii
Cananga odorata
Canarium pilosum
Canarium pseudodecumanum
Capparis pubiflora
Cardiopteris javanica
Casearia grewiaefolia
Centranthera hispida
Chloranthus elatior
Chukrassia tabularis
Citrus macroptera
Claoxylon longifolium
Cleistanthus hirsutulus
Cleistanthus polyphyllus
Clerodendron paniculatum
Cnesmone javanica
Coffea canephora
*Coffea malayana
Coleus scutellarioides
Colubrina asiatica
Combretum latifolium
Connarus semidecandrus
Cotylelobium malayanum
Croton argyratus
Croton erythrostachys
Croton laevifolius
Cryptocarya griffithiana
Curanga amara
Cynometra malaccensis
*Cyrtandra cupulata
*Cyrtandra lanceolata
*Dacryodes kingii
Dehassia microcarpa
Derris elliptica
Derris thyrsiflora
Desmodium umbellatum
Dillenia indica
Diospyros hermaphroditica
Diospyros malayana
Diospyros pilosanthera
Diospyros rigida
Diospyros wallichii
Diploclisia glaucescens
Dipterocarpus oblongifolius
Dischidia rafflesiana
Distylium stellare
Dryobalanops aromatica
Dryobalanops oblongifolia
Dysoxylum arborescens
Elaeocarpus pedunculatus
Endospermum diadenum
Erythrina variegata
Eugenia chlorantha
Eugenia claviflora
Eugenia spicata
Euonymus javanicus
Exacum tetragonum
Fagraea auriculata
Fagraea ceilanica
Ficus annulata
Ficus botryocarpa
Ficus montana
Ficus oligodon
Ficus parietalis
Ficus racemosa
Ficus scortechinii
Ficus semicordata
Ficus stricta
Ficus trichocarpa var. obtusa
Firmiana malayana
Garcinia cowa
*Garcinia eugeniaefolia
Garcinia merguensis
*Garcinia montana
Glochidion obscurum
Glochidion perakense
Glycosmis chlorosperma
Gmelina asiatica
Gmelina villosa
Gomphandra quadrifida var. quadrifida
Gomphostemma curtisii
Goniothalamus scortechinii
Goniothalmus uvarioides
Grewia paniculata
Guettarda speciosa
Gymnopetalum cochinchinense
Hedyotis congesta
Homonoia riparia
Hopea dryobalanoides
Horsfieldia tomentosa
*Hoya revoluta
Hunteria zeylanica
Hydnocarpus castanea
Hydnocarpus woodii
Hydnophytum formicarum
Hygrophila angustifolia
Hypserpa cuspidata
*Ilex maingayi
Ixora brunonis
Ixora congesta
Ixora grandifolia
Ixora lobbii var. stenophylla
Ixora nigricans
*Ixora scortechinii
Jasminum bifarium
Justicia vasculosa
Kibara chartacea
Knema cinerea var. patentinervia
Knema cinerea var. rubens
Knoxia corymbosa
Koiledepas longifolium
*Kopsia macrophylla
Lantana camara var. aculeata
Lasianthus stipularis
Lepistemon binectariferum
Leucaena leucocephala
Leucas zeylanica
*Lindera concinna
Lithocarpus elegans
Lithocarpus urceolaris
Litsea polyantha
Ludwigia hyssopifolia
Luvunga eleutherandra
Maesa striata
Mallotus eriocarpus
*Mallotus griffithianus
Mallotus oblongifolius
Mallotus peltatus
Mallotus philippensis
Mallotus repandus

*Endemic to Malaya.

Dicotyledons (cont.)

Medinilla crassifolia var. hasseltii
Melaleuca cajuputi
Melanolepis multiglandulosa
Melastoma polyanthum
*Memecylon acuminatum
Memecylon oleaefolium
Mesua ferrea
Millettia hemsleyana
Millettia sericea
*Mitrephora maingayi
Moghania strobilifera
Naravelia laurifolia
Nauclea junghuhnii
Neesia synandra
Neonauclea calycina
Nepenthes sp.
Ophiorrhiza communis
Palaquium obovatum
Palaquium ottolanderi
Parameria polyneura
Parashorea lucida
Pavetta indica
Pavetta naucleiflora
Peltophorum pterocarpum
Phanera integrifolia
Phoebe lanceolata
Piper boehmeriaefolium
Piper caninum
*Piper porphyrophyllum
Piper retrofractum
Pittosporum ferrugineum
Polyalthia cauliflora var. beccarii
Polyalthia cinnamomea
*Polyalthia hypogaea
Polyalthia motleyana var. glabrescens
Polyalthia rumphii
Polyalthia stenopetala
Polygonum chinense
Premna pyramidata
Psychotria rostrata
Psychotria sarmentosa
Psychotria viridiflora
Pterygota alata
Pterisanthes coriacea
Rauvolfia perakensis
Reissantia indica
Rhododendron longiflorum var. longiflorum
Rhynchoglossum obliquum
Rinorea anguifera
Rinorea macrophylla
Sageraea elliptica
Sauropus brevipes
*Schefflera elegans
Shorea guiso
Shorea leprosula
Shorea ovalis
Solanum decemdentatum
Spondias dulcis
Stauranthera umbrosa
Streblus laxiflorus
Tamarindus indica
*Tarenna appressa
Tetracera scandens
Thespesia populnea
Thunbergia fragans var. javanica
Tinomiscium petiolare
Tinospora crispa
Trema orientalis
Tristania merguensis
*Turraea breviflora
Urophyllum corymbosum
Urophyllum glabrum
Utricularia minutissima
Uvaria cordata
Uvaria javana
Viburnum sambucinum
Vitex pubescens
Vitis lanceolaria
Vitis martinelli
Vitis novemfolia
Vitis peduncularis
Wikstroemia polyantha
Xanthophyllum glaucum
*Xerospermum wallichii
Xylocarpus granatum
Xylopia malayana
Zippelia begoniaefolia

MONOCOTYLEDONS

Acampe longifolia
*Achasma macrocheilos
Achasma megalocheilos
Achasma triorgyale
Aerides odoratum
Agrostophyllum hasseltii
Agrostophyllum majus
*Amomum biflorum
*Anadendrum latifolium
Anadendrum montanum
Aneilema nudiflorum
Appendicula anceps
Appendicula cornuta
Appendicula undulata
Areca triandra
Arenga pinnata
Ascochilopsis myosurus
Bulbophyllum pulchellum
Bulbophyllum sessile
*Calamus ornatus var. horridus
Carex perakensis
Coelogyne rochussenii
*Corymborchis rhytidocarpa
Costus globosus
Costus speciosus
Crinum defixum
*Cryptocoryne affinis
*Cryptocoryne minima
*Cryptocoryne purpurea
Curculigo latifolia
Cymbidium dayanum
Cyperus trialatus
Cyrtosperma lasioides
Dendrobium acerosum
Dendrobium excavatum
Dendrobium farmeri
Dendrobium indivisum
Dendrobium leonis
Dendrobium planibulbe
Dendrobium pumilum
Dendrobium secundum
Dendrobium subulatum
*Dendrobium tetrodon
Dioscorea hispida
Dioscorea polyclades
Dioscorea prainiana
Dioscorea pyrifolia
Dipodium pictum
Donax grandis
*Dracaena porteri
Ephemerantha fimbriata
Epipremnopsis media
Eria citrina
Eria leiophylla
Eria nutans
Eria pannea
Eria vestita
Eurycles sylvestris
Geodorum citrinum
Globba patens
Gymnosiphon aphyllus
Hippeophylum scortechinii
Homalomena griffithii
Homalomena humilis
Homalomena rubra
Iguanura geonomaeformis
Ischaemum indicum
Ischaemum timorense
Leptaspis urceolata
*Licuala modesta
Liparis compressa
Livistona saribus
Malaxis latifolia
Malaxis micrantha
Musa malaccensis
Oberonia anceps
Oberonia dissitiflora
Oberonia spathulata
Onchosperma horridum
*Orchidantha longiflora
Pandanus odoratissimus
Pandanus recurvatus
Panicum sarmentosum
Paphiopedilum lowii
Paspalum conjugatum
Peliosanthes violacea
*Phaeomeria maingayi
Plectocomia griffithii
Poaephyllum pauciflorum
Podochilus tenuis
Pollia sorzogonensis
Pollia thyrsiflora
Polytrias amaura
Pomatocalpa kunstleri
Pomatocalpa latifolium
*Pothos latifolius

*Endemic to Malaya.

Monocotyledons (cont.)

Raphidophora beccarii
Raphidophora korthalsii
*Raphidophora maingayi
Renanthera elongata
Sarcanthus machadonis
Schoenorchis micrantha
Scindapsus scortechinii
Scleria purpurascens
Setaria palmifolia
Staurochilus fasciatus
Stenotaphrum helferi
Tacca leontopetaloides
Taeniopyllum culciferum
Taeniophyllum filiforme
Taeniophyllum obtusum
Thecostete alata
Thelasis carinata
Thrixspermum album
Thrixspermum amplexicaulis
Thysanolaena maxima
Trichoglottis misera
Tropidia curculigoides
*Zingiber spectabile

WEEDS AND ESCAPES

PTERIDOPHYTES

Adiantum tenerum

GYMNOSPERMS

—

ANGIOSPERMS

DICOTYLEDONS

Abutilon indicum ssp. indicum
Acalypha lanceolata
Ageratum conyzoides
Aleurites moluccana
Bidens pilosa
Boehmeria nivea
Cyathula prostrata
Erechtites valerianifolia
Eupatorium odoratum
Euphorbia hirta
Flacourtia jangomas
Hyptis rhomboidea
Hyptis suaveolens
Mikania cordata
Mimosa pudica
Muntingia calabura
Murraya koenigii
Passiflora foetida var. hispida
Physalis minima
Pilea microphylla
Piper nigrum
Scoparia dulcis
Solanum ferox
Solanum nigrum
Solanum torvum
Spondias pinnata
Tridax procumbens
Urena lobata
Vernonia cinerea

MONOCOTYLEDONS

Axonopus compressus
Chrysopogon aciculatus
Coix lacryma-jobi
Colocasia antiquorum
Cyperus kyllingia
Digitaria violascens
Eleusine indica
Imperata cylindrica var. major
Rhoeo spathacea

TABLE 3. AFFINITIES OF THE FLORISTIC COMPONENTS
NUMBER OF SPECIES

	Pterido-phytes	Gymno-sperms	Dicoty-ledons	Monocoty-ledons	Total	%
EXCLUSIVES	15	1	182	62	257	21.1
PREFERENTS	9	—	53	19	81	6.6
INDIFFERENTS	27	2	285	104	415	34.1
STRANGERS	45	3	257	131	424	34.9
WEEDS AND ESCAPES	1	—	29	9	39	3.2

The species known in Malaya only from limestone (exclusives, which includes endemic and non-endemics) total 257. This is an increase of 62 over Henderson's (1939) figure of 195. However the percentage which is 21.1% of the present total is less than Henderson's figure of 26% of his total. This is because of the even greater increase in the overall total (from 745 to 1216) of the species recorded from the limestone. The total number of species endemic and restricted to the limestone remains unchanged with no new additions. Henderson recorded about 130 species, the present figure is exactly 129 species.

The characteristic species of the limestone which are the exclusives and preferents number 338. This is 27.7% of the total flora. The indifferents and strangers are represented by 839 species (69.0% of the total flora), forming the bulk of the flora. The weeds and escapes are poorly represented by only 39 species (3.2% of the total flora).

SECTION II — The Flora

PTERIDOPHYTES

INTRODUCTORY KEY TO THE FERNS

The numbers on the right hand side refer to the numbers in the main key with which one should continue.

1. Fronds of two distinct forms; nest and foliage ..... 2. *Drynaria* spp.
1. Fronds not as above.
    2. Filmy ferns; laminar part of fronds one cell thick ....6. *Trichomanes* spp.
    2. Not filmy ferns; fronds thicker, usually several cells thick.
        3. Fronds twining ..... 11. *Lygodium* spp.
        3. Fronds not twining.
            4. Fronds simple, erect, grass-like ..... 12. *Schizaea inopinata*
            4. Fronds not as above.
                5. Fronds simple, entire or lobed.
                    6. Fronds entire.
                        7. Base of fronds cordate or sagittate, stipitate. ..... 16 *Athyrium cordifolium, Hemionitis arifolia, Doryopteris* spp.
                        7. Base of fronds simple, if cordate then sessile.
                            8. Stipe articulated ..... 19. *Oleandra undulata*
                            8. Stipe if present, not articulated.
                                9. Sori marginal or sub-marginal .... 20. *Vittaria* spp.
                                9. Sori not marginal or sub-marginal.
                                    10. Sori indusiate ..... 23. *Humata heterophylla, Asplenium* spp. (some)
                                    10. Sori non-indusiate.
                                        11. Sori acrostichoid ..... 26.
                                        11. Sori not acrostichoid.
                                            12. Sori elongate along veins .... 28. *Loxogramme* spp., *Antrophyum* spp.
                                            12. Sori not elongate.
                                                13. Frond pubescent with stellate hairs ..... 3. *Pyrosia* spp.
                                                13. Frond not so pubescent ..... 39. *Lemmaphyllum accedens, Lepisorus longifolius, Microsorium* spp. *Cryptsinus enervis.*

6. Fronds lobed to more than half way to rachis.
    14. Sori only at the end of lobes ..... 43. *Ctenopteris alata*
    14. Sori differently arranged.
        15. Sori indusiate ..... 45. *Humata pectinata, Doryopteris* spp.
        15. Sori non-indusiate ..... 47. *Polypodium papillosum, Phymatodes* spp.

5. Fronds compound, pinnate or more divided.
    16. Undersurface of fronds chalky-white ..... 50. *Cheilanthes farinosa, Pityrogramma calomelanos*
    16. Not so.
        17. Sori acrostichoid or sub-acrostichoid ..... 52. *Photinopteris speciosa, Heterogonium* spp.
        17. Sori differently arranged.
            18. Sori marginal or sub-marginal, elongate ... 55. *Lindsaya lucida, Pteridium* spp., *Pteris* spp.
            18. Sori not marginal or sub-marginal, if marginal or sub-marginal, then not elongate.
                19. Sori marginal or sub-marginal.
                    20. Sori on reflexed marginal flaps ..... 65. *Adiantum* spp.
                    20. Sori otherwise.
                        21. Fronds simply pinnate ..... 70. *Ctenopteris moultoni, Nephrolepis* spp. (some)
                        21. Fronds more divided ..... 73.
                19. Sori not marginal or sub-marginal.
                    22. Sori elongate ..... 75. *Taenitis blechnoides, Blechnum finlaysonianum, Athyrium* spp., *Asplenium* spp. (some)
                    22. Sori rounded.
                        23. Sori indusiate.
                            24. Fronds pinnate or bipinnatifid ..... 86. *Polystichum lindsaefolium, Pteridrys syrmatica, Cyclopeltis crenata, Nephrolepis* spp. (some), *Thelypteris immersa, Cyclosorus* spp.
                            24. Fronds bipinnate or more amply divided ..... 95. *Tectaria* spp., *Microlepia speluncae*
                        23. Sori non-indusiate ..... 101. *Abacopteris urophylla, Acrypteris irregularis*

FERNS — MAIN KEY

1. Fronds of two distinct forms, nest and foliage leaves 2
   Fronds not differentiated into nest and foliage leaves 5

2. Nest leaves lobed 2 cm or more deep 3
   Nest leaves not or only very shallowly scalloped ..... *Drynaria bonii*

3. Foliage leaves pinnate; pinnae stalked ..... *Drynaria rigidula*
   Foliage leaves lobed 4

4. Rhizome covered by short appressed scales. Sori in two irregular rows ..... *Drynaria sparsisora*
   Rhizome covered by long, semi-erect scales. Sori in two regular rows ..... *Drynaria quercifolia*

5. Sori enclosed by the hollow base of indusium. Sporangia on an elongate receptacle. Filmy ferns 6
   Sori different. Not filmy ferns 10

6. Rhizome erect; fronds tufted ..... *Trichomanes obscurum*
   Rhizome creeping; fronds borne at intervals 7

7. Fronds simple, orbicular to broadly ovate ..... *Trichomanes motleyi*
   Fronds pinnate or more dissected 8

8. Fronds with false veins 9
   Fronds with no false veins ..... *Trichomanes humile*

9. Soral-lips of two triangular lobes ..... *Trichomanes bipunctatum*
   Soral-lips not lobed, trumpet-like ..... *Trichomanes christii*

10. Fronds twining, long climbing 11
    Fronds different 12

11. Sterile leaflets regularly lobed; plant of forest shade ..... *Lygodium polystachyum*
    Sterile leaflets not lobed or only the basal leaflets lobed; usually in partly open places ..... *Lygodium flexuosum*

12. Fronds simple, erect, narrow and grass-like ..... *Schizaea inopinata*
    Fronds different 13

13. Fronds simple, entire or lobed 14
    Fronds compound, pinnate or more divided 49

14. Fronds entire or almost entire, base cordate, sagittate, or simple 15
    Fronds lobed, usually to more than half-way to rachis 43

15. Frond base cordate or sagittate, stalked 16
    Frond base not cordate or sagittate, or if appearing cordate then sessile 19

16. Fronds broadly lanceolate ..... *Athrium cordifolium*
    Fronds ovate 17

17. Stipes grooved on the adaxial side; sori superficial ... *Hemionitis arifolia*
Stipes not grooved; sori sub-marginal 18

18. Hydathodes present as a series of sub-marginal white spots; marginal veins mostly free ..... *Doryopteris ludens*
Hydathodes absent; marginal veins mostly jointed ... *Doryopteris allenae*

19. Stipes articulated at a point between the rhizome and blade .....
..... *Oleandra undulata*
Stipes not articulated 20

20. Sori marginal or sub-marginal 21
Sori not marginal or sub-marginal 22

21. Fronds sessile, 20 by 0.2 – 0.3 cm ..... *Vittaria angustifolia.*
Fronds stipitate, to 90 by 0.5 cm ..... *Vittaria elongata* var *angustifolia*

22. Sori indusiate 23
Sori non-indusiate 26

23. Rhizome long creeping; fronds dimorphic ..... *Humata heterophylla*
Rhizome short, erect; fronds not dimorphic 24

24. Fronds simple 25
Fronds pinnate ..... *Asplenium salignum*

25. Veins of fronds united in a sub-marginal vein ..... *Asplenium phyllitidis*
Veins of frond all free ..... *Asplenium squamulatum*

26. Sori acrostichoid or sub-acrostichoid ..... *Leptochilus decurrens*
Sori not acrostichoid or sub-acrostichoid 27

27. Sori elongate along veins 28
Sori not elongate along veins 32

28. Sori obique to the midrib, in roughly parallel rows 29
Sori along many veins, forming a network 30

29. Midrib raised on the lower surface, almost flat above .....
..... *Loxogramme scolopendrina*
Midrib raised on the upper surface, almost flat below .....
..... *Loxogramme avenia*

30. Paraphyses in sori club-shaped 31
Paraphyses in sori thread-like ..... *Antrophyum callifolium*

31. Stipes to 10 cm; fronds to 30 by 10 cm ..... *Antrophyum semicostatum*
Stipes not distinct; fronds smaller, to 15 by 2 cm .....
..... *Antrophyum parvulum*

32. Fronds densely or sparsely covered by stellate hairs, more on the lower surface 33
Fronds not covered by stellate hairs 39

33. Sterile fronds much longer than broad 34
Sterile fronds orbicular to broadly ovate ..... *Pyrrosia nummularifolia*

34. Sori in a single row on either side of the midrib, to about 0.5 cm across ..... *Pyrrosia angustata*
Sori arranged differently, smaller 35

35. Fronds dimorphic; sterile shorter and sometimes wider 36
Fronds not dimorphic; sterile about the same size and shape 37

36. Sterile fronds 1 – 1.5 cm wide; fronds when dried, the margins involuted the upper surface becoming concave; scales of rhizome not closely appressed ..... *Pyrrosia adnascens*
Sterile fronds 2 – 3.5 cm wide; fronds when dried, the margins revoluted, the upper surface becoming convex; scales of rhizome not closely appressed ..... *Pyrrosia varia*

37. Lower surface of frond densely brown-stellate pubescent ..... *Pyrrosia stigmosa*
Lower surface sparsely pubescent, not brown 38

38. Fronds about 1.8 cm wide; sori on the apical half or whole of frond; no clear margin at the edge ..... *Pyrrosia floccigera*
Fronds 3 – 6 cm wide; sori on the apical third of frond; with a clear margin to 1 cm wide at the edge ..... *Pyrrosia penangiana*

39. Sori in two rows, one on either side of the midrib 40
Sori scattered all over the surface 41

40. Fertile part of frond narrowed; frond less than 15 cm long ..... *Lemmaphyllum accedens*
Fertile part of frond not narrowed; frond to over 30 cm long ..... *Lepisorus longifolius*

41. Fronds stipitate 42
Fronds sessile, widening abruptly from the base ..... *Microsorium musifolium*

42. Stipes 1 cm or less; fronds widening very gradually from the base ..... *Microsorium punctatum*
Stipes 5 cm or more; fronds with broad bases ..... *Crypsinus enervis*

43. Sori only at the ends of the lobes of frond; usually 2 – 5 on each lobe ..... *Ctenopteris alata*
Sori differently arranged 44

44. Sori indusiate 45
Sori non-indusiate 47

45. Sori continuous along margins of fronds 46
Sori not so; in two rows, one on either side of midrib ..... *Humata pectinata*

46. Hydathodes present as a series of submarginal white spots; marginal veins mostly free ..... *Doryopteris ludens*
Hydathodes not present; marginal veins mostly joined ..... *Doryopteris allenae*

47. Veins anastomosing. Rhizome stout, to over 1 cm diameter 48
Veins all free, forked once. Rhizome slender, 0.2 – 0.3 cm diameter ..... *Polypodium papillosum*

48. Fronds with 1 – 4 pairs of lobes; sometimes simple ..... *Phymatodes scolopendria*
Fronds with 7 – 10 pairs of lobes; never simple ..... *Phymatodes nigrescens*

49. Underside of fronds completely or partially covered by chalky-white power 50
Underside of fronds not chalky-white 51

50. Fronds to 20 cm long, often less; sporangia near the margin of frond ..... *Cheilanthes farinosa*
Fronds much larger, 30–60 cm long; sporangia scattered all over the undersurface of frond ..... *Pityrogramma calomelanos*

51. Sori acrostichoid or sub-acrostichoid, on the apical part of frond or on a special fertile frond 52
Sori not acrostichoid or sub-acrostichoid 54

52. Pinnae entire ..... *Photinopteris speciosa*
Pinnae lobed 53

53. Sori indusiate ..... *Heterogonium alderwereltii*
Sori exindusiate ..... *Heterogonium pinnatum*

54. Sori marginal or submarginal, continuous in a short or long band 55
Sori not marginal or submarginal, if marginal or submarginal, rounded or short, not banded 63

55. Sori short banded, uniting the end of several veins ..... *Lindsaya lucida*
Sori continuous. 56

56. Fronds tripinnate or quadripinnatifid; of long continued growth 57
Fronds pinnate or tripinnatifid or rarely tripartite; not of long continuous growth 58

57. Ultimate segments widely spaced, connected by a wing decurrent from the preceeding segment ..... *Pteridium caudatum* var. *yarrabense*
Ultimate segments close together, not connected by a wing ..... *Pteridium aquilinum* var. *wightianum*

58. Pinnae all simple, entire ..... *Pteris vittata*
Pinnae lobed or branched 59

59. Fronds dimorphic in mode of branching; sterile, with deeply lobed pinnae; fertile, with only the basal pinnae having a single basiscopic lobe ..... *Pteris ensiformis*
Fronds not dimorphic 60

60. Pinnae, margin entire or serrulate ..... *Pteris scabripes*
Pinnae, deeply lobed. 61

61. Fronds tripartite, basal pinnae almost as large as the terminal one .....
..... *Pteris tripartita*
Fronds not tripartite 62

62. Fronds less than 50 cm long; lowest vein in each pinnae lobe 3–4 times forked ..... *Pteris mertensioides*

63. Sori marginal or submarginal 64
Sori not marginal or submarginal 74

64. Sori on small reflexed marginal flaps 65
Sori otherwise 69

65. Fronds simply pinnate 66
Fronds tripinnate or more divided 68

66. Stipes, rachises and stalks of pinnae winged ..... *Adiantum soboliferum*
Stipes, rachises and stalks of pinnae not winged 67

67. Rachis and pinnae hairy; indusial flaps almost circular .....
..... *Adiantum malesianum*
Rachis hairy on the upper surface only; pinnae glabrous; indusial flaps broader than long ..... *Adiantum zollingeri*

68. Fronds tripinnate, basal angle of leaflet usually more than a right-angle
..... *Adiantum stenochlamys*
Fronds quadripinnate or more divided, basal angle of leaflet usually less than a right-angle ..... *Adiantum tenerum*

69. Fronds simply pinnate 70
Fronds tripinnatifid or more divided 73

70. Sori indusiate; fronds 50 cm or more 71
Sori non-indusiate; fronds 10-20 cm .....
..... *Ctenopteris moultoni, Nephrolepis radicans*

71. Apex of pinnae rounded ..... *Nephrolepis radicans*
Apex of pinnae pointed 72

72. Pinnae about 5 cm long, strongly falcate ..... *Nephrolepis falcata*
Pinnae about 8 cm long, weakly falcate ..... *Nephrolepis hirsutula*

73. Fronds tripinnatifid or tripinnate, no false veins; sori longer than broad
..... *Davallia solida*
Fronds quadripinnate or more divided, false veins present; sori about as wide as long ..... *Davallia denticulata*

74. Sori elongate 75
Sori rounded 84

75. Sori in a longitudinal band halfway between the margin and costa .....
..... *Taenitis blechnoides*
Sori different 76

76. Sori elongate along and on either side of the midrib ..... *Blechnum finlaysonianum*
Sori not elongate along the midrib 77

77. Sori, on one or both sides of vein; transverse section of the upper part of stipe shows vascular strand with two arms (easily seen in fresh material) 78
Sori, all on one side of vein; transverse section of the upper part of stipe shows vascular strand with four arms 81

78. Fronds simply pinnate; pinnae entire or lobed 79
Fronds more amply divided. Large plant, stipe and frond to 2 m long ..... *Athyrium esculentum*

79. Rhizome scales entire 80
Rhizome scales toothed ..... *Athyrium pinnatum*

80. Lateral veins of pinnae forked once, basiscopic veinlet simple or forked ..... *Athyrium montanum*
Lateral veins of pinnae in pinnate groups, each with 3-4 pairs of veinlets ..... *Athyrium prescottianum*

81. Rhizome slender, creeping; fronds at interval ..... *Asplenium unilaterale*
Rhizome stout, short creeping; fronds tufted 82

82. Lower pinnae gradually reduced ..... *Asplenium pellucidum*
Lower pinnae not reduced 83

83. Pinnae to 7 by 2 cm ..... *Asplenium adiantoides*
Pinnae to 15 by 4.5 cm ..... *Asplenium macrophyllum*

84. Sori indusiate; indusia sometimes deciduous 85
Sori non-indusiate 101

85. Fronds pinnate or at most bipinnatifid 86
Fronds bipinnate or more amply divided 95

86. Fronds to 3.5 cm wide ..... *Polystichum lindsaeifolium*
Fronds broader 87

87. A tooth is present in the sinus between lobes ..... *Pteridrys syrmatica*
No tooth in sinuses 88

88. Sori in three irregular rows on either side of the midrib ..... *Cyclopeltis crenata*
Sori not so arranged 89

89. Sori arranged on either side of the costa 90
Sori arranged on either side of the costule 91

90. Sori on marginal lobes ..... *Nephrolepis dicksonioides*
Sori not on marginal lobes ..... *Nephrolepis biserrata*

91. Veins of the adjacent lobes of pinnae fused to form an excurrent vein in the sinus. If this is not distinct then lobes only two-third to the costae 92
Veins of the adjacent lobes of pinnae not fused, at the most meeting at the sinus. Lobes almost to the costae ..... *Thelypteris immersa*

92. Sori confined to the lobes of the pinnae, not on the lower veins 93
Sori not confined to the lobes of the pinnae, also on the lower veins 94

93. Pinnae mostly lobed two-third to the costa. Lowest pair of pinnae not reduced ..... *Cyclosorus extensus*
Pinnae lobed one-quarter to one-third to the costa. Lowest pair of pinnae often reduced to auricles ..... *Cyclosorus interruptus*

94. Pinnae to 1 cm wide; costae densely pubescent beneath ..... *Cyclosorus unitus*
Pinnae to 3 cm wide; costae minutely pubescent below ..... *Cyclosorus megaphyllus*

95. Basiscopic lobe of the lowest pair of pinnae enlarged 96
Not so. Fronds deeply dissected 100

96. All sori on anastomosing veins ..... *Tectaria amplifolia*
All or nearly all sori on free veins 97

97. Fronds glabrous on the upper surface, or with some hairs near the sinuses 98
Frond pubescent on the upper surface 99

98. Scales thin, pale brown. Fertile frond contracted ..... *Tectaria variolosa*
Scales stiff, dark purple-brown. Fertile frond not contracted ..... *Tectaria griffithii*

99. Veins anastomosing in the costal and costular areoles only (forming a single row of areoles on either side of the costae and costules) ..... *Tectaria devexa*
Veins more amply divided ..... *Tectaria macrodonta*

100. Under-surface of lamina glabrous, glabrecent or rarely pubescent ..... *Microlepia speluncae*
Under-surface of lamina densely pubescent ..... *Microlepia speluncae* var. *villosissima*

101. Pinnae not lobed, at most crenate or toothed only ..... *Abacopteris urophylla*
Pinnae deeply lobed, often pinnate at the base; basiscopic lobe of lowest pinnae enlarged ..... *Arcypteris irregularis*

Adiantaceae

Adiantum malesianum Ghatak, Bull. Bot. Surv. Ind. 5 : 73. 1963; Holtt., Fl. Mal. 2 : 638. 1966.

A. caudatum L., Mant. (1771) 308; Holtt., l.c. 599.

Distributed in N.E. India, S. China, Thailand, Indo-China, Sumatra, Sarawak and Philippines. Common on limestone in Malaya but also found on other rock types. A fern of moderately shaded places.

Adiantum soboliferum Wall. apud Hk., Spec. Fil. 2 : 13. 1851; Holtt., Fl. Mal. 2 : 598. 1966.

Distributed throughout the Old World tropics. In Malaya recorded only from the north and usually on limestone.

Adiantum stenochalamys Bak., Ann Bot. 5 : 29. 1891; Holtt., Fl. Mal. 2 : 602. 1966.

A. opacum Copel., Phil. J. Sc. 1, Suppl. 255, t. 3. 1906.

In Malaya, nearly always found on rocks near the sea. Found inland only on rocks along the Tahan river and on limestone along Sungei Betis in Kelantan.

Adiantum tenerum Sw., in Hk. et Bk., Syn. Fil. (1868) 124; v.A.v.R., Mal. Ferns (1908) 330.

A tropical American species now widely cultivated in tropical, subtropical or even temperate countries. Recorded on limestone as escapes from cultivation; on shady hill slopes.

Adiantum zollingeri Mett. ex Kuhn, Ann. Mus. Bot. Lugd. Bat. 4 : 280. 1869; Holtt., Fl. Mal. 2 : 638. 1966.

A. caudatum L. var. *subglabrum* Holtt., l.c. 600.

Distributed in Ceylon, S. India, Thailand and Indochina. In Malaya recorded only from limestone in Kedah and Perlis.

Antrophyum callifolium Bl., Enum. Pl. Jav. (1828) 111; Holtt., Fl. Mal. 2 : 605. 1966.

A common forest fern, epiphytic or on rocks. Recorded from limestone in South Kelantan and Central Pahang.

Antrophyum parvulum Bl. Enum. Pl. Jav. (1828) 110; Holtt., Fl. Mal. 2 : 605. 1966.

Distributed in Java. In Malaya this species is widely distributed and common on limestone, on rocks; with only one record as an epiphyte (Henderson 1939). It has been recorded from limestone in the south in Johore and apparently absent from the vast tract of forest separating the Johore from the northern limestone. It has been collected away from limestone only twice, both on Penang Hill.

Antrophyum semicostatum Bl., Enum. Pl. Jav. (1828) 110; Holtt., Fl. Mal. 2 : 605. 1966.

An epiphytic fern of mountain forest. Recorded from low elevation on limestone probably as epiphytes in Kelantan. Resembles *A. callifolium* but distinguished by the club-shaped paraphyses.

Cheilanthes farinosa (Forsk.) KLf., Enum. Fil. (1824) 202; Holtt., Fl. Mal. 2 : 592. 1966.

Pteris farinosa Frosk., Fl. Aegypt. Arab. (1775) 187.

Aleuritopteris farinosa Fée, Gen. Fil. (1850–52) 153.

Distributed in most tropical and temperate regions with two records from Malaya, both from limestone. One was from Bukit Baling in Kedah and the other from Bukit Chintamani in Pahang the Chintamani specimen was growing in rock crevices from vertical cliffs.

Doryopteris ludens (Wall.) J. Sm., Hist. Fil. (1875) 289; Holtt., Fl. Mal. 2 : 594. 1966.

Pteris ludens Wall. apud Hk., Spec. Fil. 2 : 210. 1858.

Distributed from N. India and S. China southwards through Malesia. Restricted to limestone in Malaya and all collections except two are from Kedah and Perlis; the exceptions are from Gua Batu, Selangor and Batu Kurau, Perak.

Doryopteris allenae Tryon, Contr. Gray Herb. 91 : 91, 97. 1962; Holtt., Fl. Mal. 2 : 638. 1966.

This species is similar to *D. ludens* in appearance. It differs however in having the rhizome short creeping rather than long creeping, the marginal veins in the sterile lamina mostly jointed rather than free and in not having any hydathodes on the upper surface of the fronds.

Endemic to limestone in Malaya, recorded from Perak and Selangor. Usually in shaded localities from rock crevices.

Hemionitis arifolia (Burm.) Moore, Ind. Fil. (1859) 114; Holtt., Fl. Mal. 2 : 596. 1966.

Asplenium arifolium Burm., Fl. Ind. (1768) 213.

Distributed in Ceylon, India, Burma, Indochina, Malesia and the Philippines. In Malaya only from the north, nearly always from limestone.

Pityrogramma calomelanos (L.) Link, Handb. Gew. 3 : 20. 1833; Holtt., Fl. Mal. 2 : 593. 1966.

Acrostichum calomelanos Linn., Sp. Pl. (1753) 1072.

Pantropic, originating in tropical America. Common in Malaya, from the lowlands to 1,300 m. Frequently one of the early colonisers of open ground. Recorded once from the base of limestone.

Taenitis blechnoides (Willd.) Sw., Syn. Fil. (1806) 24, 220; Bedd., Handb. 410, t. 242; Holtt., Fl. Mal. 2 : 586. 1966.

Pteris blechnoides Willd., Phytogr. (1794) 13.

Vittaria angustifolia Bl., Ennum. Pl. Jav. (1828) 199; Holtt., Fl. Mal. 2 : 610. 1966.

Distributed throughout Malesia. In Malaya, Sumatra, Borneo and Java this is a mountain epiphyte at 600–1800 m. On limestone in Malaya this has been collected as a low epiphyte from 20–300 m; recorded from Kedah, Kelantan and Perlis; uncommon.

Vittaria elongata Sw., Syn. Fil. (1806) 302; Holtt., Fl. Mal. 2 : 614. 1966. var. *angustifolia* Holtt., in l.c.

This variety is endemic to Malaya and found only in the North-west and on Pulau Tioman in the South-east. It is both an epiphyte and rock plant and recorded from only one limestone locality as an epiphyte. The typical variety is a common lowland and mountain epiphyte with a paleotropical distribution.

Dennstaedtiaceae

Arcypteris irregularis (Pr.) Holtt., Reinw. 1 : 193. 1951; Fl. Mal. 2 : 538. 1966.

Polypodium irregulare Pr., Rel. Haenk. 1 : 25. 1825.

A common forest species in Malaya. Recorded once from the small limestone outcrop in deep forest in Johore.

Asplenium adiantoides (L.) C. Chr., Ind. Fil. 1905; Holtt., Fl. Mal. 2 : 431. 1966.

Trichomanes adiantoides L., Sp. Pl. (1753) 1098.

Distributed in Burma, Thailand and southwards to Malesia, Australia and Polynesia. Also in Madagascar.

Resembles *A. macrophyllum* Sw. but generally smaller. Intermediates occur but the extreme forms are very different. More field work and cultivation of this species will help to clarify the growth form of this species. Presently they are best kept apart.

This is a fern of rocky places and nearly always from limestone. It is very common on scrubby summits of some hills around Gua Musang in Kelantan.

Asplenium macrophyllum Sw., Schrad. Journ. 1800/2 : 52. 1801; Holtt., Fl. Mal. 2 : 431. 1966.

Found in most parts of Malaya on rocks and as epiphytes. It is common on coastal areas in the east coast and on limestone in Selangor.

Asplenium pellucidum Lam., Encyl. 2 : 305. 1786; Holtt., Fl. Mal. 2 : 428. 1966.

Common in Malaya from the lowlands to the hills, on rocks or as epiphytes; often on limestone.

Asplenium phyllitidis Don, Prodr. Fl. Nep. (1825) 7; Holtt., Fl. Mal. 2 : 420. 1966.

Common in Malaya, usually epiphytic. Recorded from limestone in Kelantan.

Asplenium salignum Bl., Enum. Pl. Jav. (1828) 175; Holtt., Fl. Mal. 2 : 421. 1966.

A. filiceps Copel., Philip. J. Sc. 5c : 285. 1910.

Common in Malaya, usually as an epiphyte, on the lowands, hills and mountains. Fairly common on limestone under partial shade as a low epiphyte or on rocks.

Asplenium squamulatum Bl., Enum. Pl. Jav. (1828) 174; Holtt., Fl. Mal. 2 : 426. 1966.

Distributed throughout Malesia. Recorded in Malaya from Pahang, Kelantan and Selangor, usually on limestone.

Asplenium unilaterale Lam., Encys. 2 : 305. 1786; Holtt., Fl. Mal. 2 : 438. 1966.

Widely distributed in Malaya, on rocks in moist shady places. Uncommon on limestone.

Athyrium cordifolium (Bl.) Copel., Philip. J. Sc. 3c : 300. 1908; Holtt., Fl. Mal. 2 : 548. 1966.

Diplazium cordifolium Bl., Enum. Pl. Jav. (1828) 190.

Common in lowland and mountain forest in Malaya. Recorded only once from limestone.

Athyrium esculentum (Retz.) Copel., Philip. J. Sc. 3c : 295. 1908; Holtt., Fl. Mal. 2 : 562. 1966.

Hemionitis esculenta Retz., Obs. Bot. (1791) 38.

Common in wet places in the lowlands of Malaya. Recorded once from limestone at the base of hill.

Athyrium montanum (v.A.v.R.) Holtt., Fl. Mal. 2 : 555. 1966.

Diplazium montanum v.A.v.R., Bull. Jard. Bot. Ser. II, 28 : 19. 1918.

Common in Malaya in lowland and hill forest. Recorded from limestone in Johore only.

Athyrium pinnatum (Blanco) Copel., Philip. J. Sc. 3c : 297. 1908; Holtt., Fl. Mal. 2 : 560. 1966.

Allantodia pinnata Blanco, Fl. Filip. Ed. 2 (1845) 571.

Widespread in Malaya with one record from limestone.

Athyrium prescottianum (Wall.) Holtt., Fl. Mal. 2 : 557. 1966.

Asplenium prescottianum Wall., Cat. (1829) 235 (nom. nud.)

Endemic, an uncommon species. Recorded once as an epiphyte from limestone.

Blechnum finlaysonianum Hk. et Grev., Ic. Fil. (1831) t. 225; Holtt., Fl. Mal. 2 : 445. 1966.

A common species in lowland and hill forest, once recorded from limestone.

Cyclopeltis crenata (Fée) C. Chr., Ind. Fil. Suppl. 3 : 64. 1934; Holtt., Fl. Mal. 2 : 527. 1966.

Hemicardion crenatum Fée, Gen. Fil. (1852) 283, t. 22A.

Distributed in Burma, S. China and western Malesia. This is a plant of rocky places, usually but not always from limestone, in Malaya. Widely collected from limestone, in part shade.

Davallia denticulata (Burm.) Mett., in Kuhn., Fil. Deck. (1867) 27; Holtt., Fl. Mal. 2 : 359. 1966.

A common rock plant and epiphyte; recorded a number of times from limestone.

Davallia solida (Frost.) Sw., Schrad. Journ. 1800/2 : 87. 1801; Holtt., Fl. Mal. 2 : 360. 1966.

Trichomanes solidum Forst., Prodr. (1786) 86.

A common coastal epiphyte and rock plant in Malaya. Uncommon inland. Recorded only once on limestone; this was from a large local population on the summit of Batu Tapah, growing in part shade on rocks and as a low epiphyte. It is probably not uncommon on limestone, on such dry, rocky, scrubby summits.

Heterogonium alderwereltii Holtt., Sarawak Mus. J. 5 : 163. 1949, Fl. Mal. 2 : 522. 1966.

Pleocnemia membranifolia p.p. quoad Bedd., Handb. Suppl. (1892) 48.

Plant like that of *H. pinnatum*. The typical specimen however has larger sterile fronds with 4–7 pairs of pinnae. The sori is not acrostichoid but is either distinct or elongate along veins. The indusia is distinct though less prominent in mature sori.

Distributed in Sumatra. Restricted to limestone in Malaya (except for a specimen from Patani, Kedah); not as common as *H. pinnatum*.

For notes see under *H. pinnatum*.

Heterogonium pinnatum (Copel.) Holtt., Sarawak. Mus. J. 5 : 163. 1949, Fl. Mal. 2 : 524. 1966.

Stenosemia pinnata Copel., Phil. J. Sc. 1, Suppl. 2 : 48. 1892.

Pleocnemia membranifolia p.p. quoad Bedd. Handb. Suppl. (1892) 48.

Distributed in Sumatra, Borneo and the Philippines. Restricted to limestone in Malaya, and the commonest fern on limestone.

Typically this fern is distinguished from *H. alderwereltii* Holtt. mainly by the absence of indusia and the sterile fronds having only one instead of four to seven pairs of free lateral pinnae. *H. alderwereltii* has distinct sori or extended sori along the veins while typical *H. pinnatum* has acrostichoid sori, and if atypical, the sori extend along veins but still without indusia.

However, there is great variation in the morphology of these two species, thus delimited. There are *H. pinnatum* plants with up to 7 pairs of free pinnae (in the sterile fronds) and which have, in the fertile fronds, an acrostichoid condition in which the sori are non-indusiate. The sterile lamina with up to 7 pairs of free pinnae would seem to belong to *H. alderwereltii* while the acrostichoid non-indusiate sori would seem to belong to *H. pinnatum*. Apart from the extreme forms of *H. pinnatum* in which the sterile fronds have normally one pair of free pinnae, the form and size of the sterile fronds are insufficient characters to separate these two species.

There are identical plants in which the sori are distinct or elongate sub-marginally. In some instances they are indusiate and in others they are not. Once these two species are kept distinct, one can say that the non-indusiate plants would be abnormal *H. pinnatum* (the normal plants have acrostichoid sori). However, this argument would be equally valid if one says that the non-indusiate condition is found on abnormal *H. alderwereltii* which have lost their indusia. In both indusiate and non-indusiate forms there often exists a condition in which sori are found on fronds with the size and form of a sterile frond. These sori are either very distinct on vein endings or often form submarginal bands.

This range of variation can be found in a single population such as that on the base of Bukit Takun, Selangor, growing on limestone and organic debris. Only the extreme forms would seem to keep these two species apart and I suspect (as Beddome thought) they are variations of one species. This is as much as I can conclude from field observations; experimental culture from spores is required.

Besides these variations there are indusiate as well as non-indusiate forms which are free veined, a character now found in *H. sagenoides* (Mett.) Holtt. Also, the form in which the fertile fronds have a broad lamina and distinct sori encroaches on one of the characters of the remaining species of Heterogonium found in Malaya, *H. saxicolum* (Bl.) Holtt. Other characters, however, seem to keep *H. pinnatum* and *H. alderwereltii* distinct from these latter two species. The former two are also different in being exclusively limestone plants in Malaya with an exception of one specimen of *H. alderwereltii* collected from Patani, Kedah.

In the light of recent collections, the taxonomic status of this complex of *Heterogonium* needs looking into, especially the limestone-inhabiting groups.

For convenience, the two species are retained here, often distinguished only by the presence or absence of an indusium. *H. pinnatum* is the more commonly collected species, appearing on most limestone outcrops except in the extreme north and Kelantan. Both are found in shady, rocky places and most luxuriently in situations with humus accumulation.

It is interesting to note that *H. pinnatum* has been collected from the very small and isolated Johore limestone, forming a link with the more southern Sarawak populations.

Humata heterophylla (Sm.) Desv., Prodr. (1825) 323; Holtt., Fl. Mal. 2 : 366. 1966.
Davillia heterophylla Sm., Mem. Ac. Turin. 5 : 415. 1793.

A widely distributed species in Malaya usually in exposed places, on rocks or as epiphytes. Recorded on limestone from Kelantan.

Humata pectinata (Sm.) Desv., Prodr. (1827) 323; Alston, Phil. J. Sc. 50 : 175 1933; Holtt., Fl. Mal. 2 : 369. 1966.

Davallia pectinata Sm., Mem. Ac. Turin. 5 : 415. 1793.

Distributed from Sumatra to New Guinea, usually on coastal rocks and trees. Inland collections in Malaya are restricted to limestone, growing as low epiphytes or on rocks in shade or part shade. Abundant on the rocky, scrubby summit of Batu Tapah.

Lindsaya lucida Bl., Enum. Pl. Jav. (1828) 216; Holtt., Gard. Bull. S.S. 9 : 131. 1937, Fl. Mal. 2 : 328. 1966.

L. lobbiana Hk. Sp. Fil. 1 : 205. 1848; C. Chr., Gard. Bull. S.S, 4 : 396, 1929; Holtt., Gard. Bull. S.S. 5 : 61. 1930.

In Malaya, a streamside plant of low country, widespread. Recorded once from the base of a limestone hill growing on limestone boulders by a stream.

Microlepia speluncae (L.) Moore, var. *villossima* C. Chr., Gard. Bull. S.S. 4 : 399. 1929; Holtt., Fl. Mal. 2 : 314. 1966.

Nephrolepis biserrata (Sw.) Schott, Gen. Fil. (1834) t. 3; Holtt., Fl. Mal. 2 : 380. 1966.

Aspidium biserratum Sw., Schrad. Jour. 1800/2 : 32. 1801.

A very common fern of open or partly shaded places. Recorded once from limestone (on Gua Musang) as a secondary element about a year and a half after fire destroyed the original vegetation.

Nephrolepis dicksonioides Chr., Verh. Nat. Ges. Basel 11 : 241. 1895; Holtt., Fl. Mal. 2 : 376. 1966.

Distributed in Celebes, Borneo and New Guinea. In Malaya it is restricted to limestone, on exposed or partly exposed situations. Common on many hills and often forming dense thickets.

Nephrolepis falcata (Cav.) C.Chr., Dansk. Bot. Ark. 9 : 15. 1937; Holtt., Fl. Mal. 2 : 381. 1966.

Tectaria falcata Cav., Descr. (1802) 250.

N. barbata Copel., in Holtt., Gard. Bull. S.S. 9 : 132. 1937.

A common fern on rocky places and as epiphytes. Sometimes on limestone.

Nephrolepis hirsutula (Forst.) Pr., Tent. Pterid. (1836) 79; Holtt., Fl. Mal. 2 : 382. 1966.

Polypodium hirsutulum Forst., Prodr. (1786) 81.

Common in Malaya in open places. Recorded once from the disturbed base of limestone in secondary scrub vegetation.

Nephrolepis radicans (Burm.) Kuhn, Ann. Lugd. Bat. 4 : 285. 1869; Holtt., Fl. Mal. 2 : 381. 1966.

Polypodium radicans Burm., Fl. Ind. (1768) 233, t. 66.

Oleandra undulata (Willd.) Ching, Lingnan Sc. Jour. 12: 565. 1933; Holtt., Fl. Mal. 2 : 384. 1966.

Polypodium undulatum Willd., Sp. Pl. 5 : 155. 1810.

A mountain fern, common in Malaya above 1000 m., often on acid peat and humus. An unlikely species to be found on limestone. However, one specimen (Kadim K491) positively of this, is labelled as from Gunong Tempurong, in forest

at 250 – 550 m. The main range of mountains which rises abruptly to over 650 m just over a mile to the east of the Gunong Tempurong massive could provide the source for the spread of this species. The plant was probably growing on an accumulation of humus over the limestone.

Polystichum lindsaeifolium Ridl., J. Mal. Br. R. As. Soc. 4 : 61 1926; C. Chr., Gard. Bull. S.S. 4 : 393. 1929; Holtt., Fl. Mal. 2 : 489. 1966.

Endemic to limestone in Selangor, Pahang, Kelantan and Perak, uncommon.

Pteridium aquilinum (L.) Kuhn, *var. wightianum* (Ag.) Tryon, Rhodora 43 : 1-70. 1941; Holtt., Fl. Mal. 2 : 634. 1966.

Pteris aquilina L., Sp. Pl. (1753) 1075.

Pteridium aquilinum (L.) Kuhn, in Holtt., l.c. 389.

Recorded from limestone as a secondary element.

Pteridium caudatum (L.) Maxon var. *yarrabense* Domin, in Tryon, Rhodora 43 : 63. 1941; Holtt., Fl. Mal. 2 : 634. 1966.

Pteris esculenta Forst., Pl. Escul. (1786) 74.

Pteridium esculentum (Forst.) Nakai, Bot. Mag. Tokyo 39 : 109. 1925; Holtt., l.c. 390.

Recorded on limestone as an element of secondary vegetation.

Pteridrys syrmatica (Willd.) C. Chr. et Ching, Bull. Fan Mem. Inst. Bot. 5 : 131. 1934; Holtt., Fl. Mal. 2 : 530. 1966.

Aspidium syrmaticum Willd., Sp. Pl. 5 : 277. 1810.

Distributed in Ceylon, Thailand, Indochina and Malesia to the Philippines. In Malaya, this fern is found mainly in the north and nearly always from limestone. It is a rock fern of shady places.

Pteris ensiformis Burm., Fl. Ind. (1768) 230. Holtt., Fl., 2 : 399. 1966.
Sometimes on limestone.

Pteris longipinnula Wall., Cat. (1829) 108; Holtt., Fl. Mal. 2 : 404. 1966. var. *b*, in Holtt., l.c. 405.

This variety is endemic to Malaya and chiefly from limestone, though not exclusively so. The typical variety is distributed from India to China and southwards throughout Malesia. It differs from the typical variety by the narrower pinnae and by the presence of the branched basal pair of pinnae.

Pteris mertensioides Willd., Sp. Pl. 5 : 394. 1810; Holtt., Fl. 2 : 404. 1966.

Pteris scabripes Wall. apud Hook., Sp. Fil. 2 : 165. 1858; Holtt., Fl. Mal. 2 : 399. 1966.

Endemic, usually on rocks by streams, also in lowland forest and rarely on limestone, not a common species.

Pteris tripartita Sw., Sshrad. Jour. 1800/2 : 67. 1801; Holtt., Fl. Mal. 2 : 408 1966.

P. marginata Bory, Voy. 2 : 192. 1804.

Pteris vittata L., Sp. Pl. (1753) 1074; Holtt., Fl. Mal. 2 : 396. 1966.

Not uncommon on disturbed localities on limestone, by quarry edges and on disturbed summits.

Tectaria amplifolia (v.A.v.R) C. Chr., Ind. Fil. Suppl. 3 : 176. 1934; Holtt., Fl. Mal. 2 : 515. 1966.

Aspidium amplifolium v.A.v.R., Bull. Jard. Bot. Buit. Ser. II, 11 : 2. 1913.

Distributed in Sumatra. Common on and restricted to limestone in Malaya. Apparently unknown from the extreme North-west. A plant of shady places.

Tectaria barberi (Hk.) Copel., Philip. J. Sc. 2c : 414. 1907; Holtt., Fl. Mal. 2 : 508. 1966.

Polypodium barberi Hk., Sp. Fil. 5 : 100. 1864.

Tectaria devexa (Kze) Copel., Philip. J. Sc. 2c : 415. 1907; Holtt., Fl. Mal. 2 : 505. 1966.

Aspidium devexum Kze, Bot. Zeit. (1848) 259.

A. membranaceum Hk., Sp. Fil. 5 : 105. 1864.

Distributed in Ceylon, Thailand and S. China. Restricted to limestone in Malaya, widely distributed and fairly common.

Tectaria griffithii (Bak.) C.Chr., Ind. Fil. (1867) 300; Holtt., Fl. Mal. 2 : 636 1966.

Nephrodium griffithii Bak., Syn. Fil. (1867) 300.

Tectaria multicaudata Ching, Sinensia 2 : 20. 1931; Holtt., F. Mal. 2 : 507. 1966.

T. malayense Christ, Philip. J. Sc. 2c : 187. 1907.

Tectaria macrodonta (Fee) C. Chr., Ind. Fil. Suppl. 3 : 181. 1934; Holtt., Fl. Mal. 2 : 505. 1966.

Sagenia macrodonta Fée, Gen. Fil. (1852) 313 t. 24.

A number of specimens collected from north Malaya are doubtfully identified as this species. One of these is from limestone. They are smaller than the typical form of this species which are represented in India. They resemble *T. variolosa* but the fronds are hairy on both surfaces and hardly dimorphic, and the sori are not all on free veins.

Tectaria variolosa (Wall.) C. Chr., Contr. U.S. Nat. Herb. 26 : 289. 1931; Holtt., Fl. Mal. 2 : 506. 1966.

Aspidium variolosum Wall., Hook., Spec. Fil. 4 : 51. 1862.

Grammitidaceae

Ctenopteris alata (Bl.) Holtt., Fl. Mal. 2 : 232. 1966.

Davallia alata Bl., Enum. Pl. Jav. (1828) 230.

Prosaptia alata Christ, Ann. Buit. II, 5 : 127. 1905.

Ctenopteris moultoni (Copel.) C. Chr. et Tard. Not. Syst. 8 : 181. 1939; Holtt., Fl. Mal. 2 : 229. 1966.

Polypodium moultoni Copel., Philip. J. Sc. 10c : 149. 1915.

Hymenophyllaceae

Trichomanes bipunctatum Poir., in Lamk., Encyl. 8 : 69. 1808; Holtt., Fl. Mal. 2 : 99. 1966.

Crepidomanes bipunctatum Copel., Phil. J. Sc. 67 : 59. 1938.

The only common species of this family (except in the very north) on limestone.

Trichomanes christii Copel., Phil. J. Sc. 1. Suppl. 251. 1906, ibid., 51 : 185. 1933; Holtt., Fl. Mal. 2 : 100. 1966.

Crepidomanes christii Copel., Phil. J. Sc. 67 : 60. 1938.

Trichomanes humile Forst., Prodr., (1786) 84. Copel., Phil. J. Sc. 51 : 164. 1933; Holtt., Fl. Mal. 2 : 98. 1966.

Crepidopteris humilis Copel., Phil. J. Sc. 67 : 58. 1938.

Trichomanes motleyi Bosch, Ned. Kruidk. Arch. 5 : 145. 1861; Copel., Phil. J. Sc. 51 : 201. 1933; Holtt., Fl. Mal. 2 : 92. 1966.

Polypodiaceae

Crypsinus enervis (Cav.) Copel., Gen. Fil. (1947) 207; Holtt., Fl. Mal. 2 : 199. 1966.

Polypodium enervis Cav., Descr. (1802) 245.

Drynaria bonii Christ., Not. Syst. 1 : 186. 1910; Tardieu-Blot et Christ., Fl. Gen. Indochine 7 : 515. 1941.

Rhizome creeping. Nest leaves small, ovate, base cordate-sagittate, margin entire scalloped or shallowly lobed, 5–10 by 3.5–6.5 cm. Foliage leaves with stipes 8–20 cm long, narrowly winged; lamina deeply lobed, 20–45 by 12–20 cm. Lobes 3–7 pairs, 8–20 by 2–4 cm, base decurrent along the rachis. Sori non-indusiate and small, scattered on the lower surface of frond.

Distributed in S. China, Indochina and Thailand. A new record (Chin 1764) for Malaya. Common as low epiphytes and on rocks in Pulau Langgun, Langkawi on the northern side of the island.

Characterised by the small unlobed nest leaves and the dissection of the foliage leaves. The old rhizome which is fleshy and flattened grows up to 3 by 1.5 cm.

Drynaria quercifolia (L.) J. Sm., J. Bot. 3 : 398. 1841; Holtt., Fl. Mal. 2 : 182. 1966.

Polypodium quercifolium Linn., Sp. Pl. (1753) 1087.

Drynaria rigidula (Sw.) Bedd., Ferns Brit. Ind. (1869) t. 314; Holtt., Fl. Mal. 2 : 183. 1966.

Polypodium rigidulum Sw., Schrad. J. 1800/2 : 26. 1801.

A common epiphyte in the northern half of Malaya; it is not found in the south. It is not uncommon on limestone in Langkawi and has been recorded as far south as Bukit Takun in Selangor. This forms the southernmost record for this species in Malaya. On limestone it has been recorded as epiphytes as well as on rocks.

Drynaria sparsisora (Desv.) Moore, Ind. Fil. (1862) 348; Holtt., Fl. Mal. 2 : 183. 1966.

Polypodium sparsisorum Desv., Berl. Mag. 5 : 315. 1811.

Lemmaphyllum accedens (Bl.) Donk. Reinw. 2 : 409. 1954; Holtt., Fl. Mal. 2 : 152. 1966.

Polypodium accedens Bl., Enum. Pl. Jav. (1828) 121.

Weatherbya accedens Copel., Gen. Fil. (1947) 191.

Lepisorus longifolius (Bl.) Holtt., Fl. Mal. 2 : 151. 1966.

Grammitis longifolia Bl., Enum. Pl. Jav. (1828) 119.

Paragramma longifolia Moore, Copel., Gen. Fil. (1947) 190.

Leptochilus decurrens Bl., Enum. Pl. Jav. (1828) 206; Holtt., Fl. Mal. 2 : 164 1966.

Acrostichum variabile Hook, Sp. Fil. 5 : 277. 1864.

Loxogramme avenia (Bl.) Presl., Tent. Pterid. (1836) 215; Holtt., Fl. Mal. 2 : 167. 1966.

Grammitis avenia Bl., Enum. Pl. Jav. (1828) 117.

Loxogramme blumeana Presl., Tent. Pterid. (1836) 215.

Not common on limestone, but recently found to be abundant on the rocky, one-layered scrub forest on the summit of Gua Batu Boh, near Gua Musang, Kelantan; on rocks and as low epiphytes.

Loxogramme scolopendrina (Bory) Presl., Tent. Pterid. (1836) 215; Holtt., Fl. Mal. 2 : 168. 1966.

Grammitis scolopendrina Bory, Dup. Voy. (1829) 257.

Fairly common on limestone and widely distributed.

Microsorium musifolium (Bl.) Ching, Bull. Fan Mem. Inst. 4 : 295. 1933; Holtt., Fl. Mal. 2 : 176. 1966.

Polypodium musifolium Bl., Enum. Pl. Jav. (1828) 134.

Microsorium punctatum (L.) Copel., Univ. Cal. Publ. Bot. 16 : 111. 1929; Holtt., Fl. Mal. 2 : 179. 1966.

Acrostichum punctatum Linn., Sp. Pl. Ed. 2. (1763) 1524.

Photinopteris speciosa (BL.) Presl., Epim. Bot. (1849) 264; Holtt., Fl. Mal. 2 : 187. 1966.

Lomaria speciosa Bl., Enum. Pl. Jav. (1828) 202.

Photinopteris rigida Bedd., Fl. Brit. Ind. (1867) t. 211.

Phymatodes nigrescens (Bl.) J. Sm., Ferns Br. & For. (1866) 94; Holtt., Fl. Mal. 2 : 193. 1966.

Polypodium nigrescens Pl., Enum. Pl. Jav. (1828) 126.

Phymatodes scolopendria (Burm.) Ching, Contr. Inst. Bot. Nat. Acad. Peip. 2 : 63. 1933; Holtt., Fl. Mal. 2 : 191. 1966.

Polypodium scolopendria Burm., Fl. Ind. (1769) 232.

P. phymatodes Linn., Mant. (1771) 306.

Recorded a number of times from limestone, abundant on Batu Tapah. Kelantan, on the scrubby summit growing over boulders and as low epiphytes.

Polypodium papillosum Bl., Enum. Pl. Jav. (1828) 131; Holtt., Fl. Mal. 2 : 203. 1966.

Pyrrosia adnascens (Sw.) Ching, Bull. Chin. Bot. Soc. 1 : 45. 1935; Holtt., Fl. Mal. 2 : 144. 1966.

Polypodium adnascens Sw., Syn. Fil. (1806) 25.

Common in the lowlands of Malaya, epiphytic and on rocks; also common on limestone and widely collected.

Pyrrosia floccigera (Bl.) Ching, Bull. Chin. Bot. Soc. 1 : 71. 1935; Holtt., Fl. Mal. 2 : 147. 1966.

Niphobolus flocciger Bl., Enum. Pl. Jav. (1828) 107.

Fairly common in Malaya, usually from 300–1300 m, in partly shaded areas, epiphytic. Recorded once from limestone at less than 100 m elevation (UNESCO 1962, 216, from Gua Batu Boh, Kelantan).

Pyrrosia penangiana (Hook.) Holtt., Fl. Mal. 2 : 146. 1966.

Niphobolus penangianus Hook., Ic. Pl. (1840) t. 203.

Distributed in Sumatra. Recorded from the northern half of Malaya, usually on limestone; on rocks or as epiphytes.

Pyrrosia stigmosa (Sw.) Ching, Bull. Chin. Bot. Soc. 1 : 67. 1935; Holtt., Fl. Mal. 2 : 148. 1966.

Polypodium stigmosum Sw., Schrad. Jour. 1800/2 : 21. 1801.

Distributed in North India and Indochina and from Sumatra to New Guinea. Restricted to limestone in Malaya, on rocks and epiphytic; it has been reported as an epiphyte on Rain trees near Gua Batu, Selangor.

Pyrrosia varia (Kaulf.) Farwell, Am. Midl. Nat. 12 : 302. 1931; Holtt., Fl. Mal. 2 : 146. 1966.

Niphobolus varius Kaulf., Enum. Fil. (1824) 125.

A widely distributed species, also common on limestone.

Schizaeaceae

Lygodium flexuosum (L.) Sw., Schrad. Jour. 1800/2 : 106. 1801; Holtt., Fl. Mal. 2 : 57. 1966.

Ophioglossum flexuosum Linn., Sp. Pl. (1753) 1063.

Lygodium polystachyum Wall. ex Moore, Gard. Chron. (1859) 671; Holtt., Fl. Mal. 2 : 56. 1966.

Distributed in Burma and Thailand. Uncommon and apart from specimens from Penang Hill (granite), this species is restricted to limestone in Malaya. Recorded from Perak, Kelantan, Langkawi and Pahang, usually in shady forest.

Schizaea inopinata Selling, Sevensk Bot. Tidskr. 40 : 274. 1946; Holtt., Fl. Mal. 2 : 52. 1966.

Distributed in Sumatra and Philippines. In Malaya, this species is restricted to limestone in Kelantan, Pahang and Selangor, not uncommon. It resembles the common *S. digitata* (L.) Sw. and is frequently mistaken for it. *S. inopinata* is however characterized by having the sporangia in two instead of four rows.

Thelypteridaceae

Abacopteris urophylla (Wall.) Ching, Bull. Fan Mem. Inst. Bot. 8 : 251. 1938; Holtt., Fl. Mal. 2 : 296 1966.

Polypodium urophyllum Wall., in Hook., Sp. Fil. 5 : 9. 1863.

Cyclosorus extensus (Bl.) Ching, Bull. Fan Mem. Inst. Bot. 8 : 182. 7938; Holtt., Fl. Mal. 2 : 264. 1966.

Aspidium extensum Bl., Enum. Pl. Jav. (1828) 156.

Cyclosorus interruptus (Willd.) Ching, Bull. Fan Mem. Inst. Bot. 8 : 184. 1938; Holtt., Fl. Mal. 2 : 262. 1966.

Pteris interrupta Willd., Phytogr. 1 : 13. 1794.

Cyclosorus megaphyllus (Mett.) Ching, Bull. Fan Mem. Inst. Bot. 8 : 225. 1938; Holtt., Fl. Mal. 2 : 268. 1966.

Aspidium megaphyllum Mett., Ann. Mus. Lugd. Bat. 1 : 233. 1864.

Cyclosorus unitus (L.) Ching, Bull. Fan Mem. Inst. Bot. 8 : 192. 1938; Holtt., Fl. Mal. 2 : 260. 1966.

Polypodium unitum L., Syst. Nat. ed. 10, 2 : 1326. 1759.

Thelypteris immersa (Bl.) Ching, Bull. Fan Mem. Inst. Bot. 6 : 306. 1936; Holtt., Fl. 2 : 243. 1966.

Aspidium immersum Bl., Enum. (1828) 156.

GYMNOSPERMS

Araucariaceae

Agathis dammara (Lambert) L. G. Rich., Comm. Bot. Conif. Cycad. (1826) 83; Keng, Tree Fl. Mal. 1 : 41. 1972.

A. loranthifolia Salisb. in Ridl., Flora 5 : 278. 1925.

A. alba (Lam.) Jeff. in Burk., Dict. I : 62. 1935. Corner, Ways. Trees I : 715. 1940.

Usually found on the hills; once recorded (Loh FRI 17201) for limestone at 600–700 m at Gua Peringat, Pahang. This was growing in deep soil in a gully.

Cycadaceae

Leaves with petioles about 100 cm long, leaflets 0.7–0.9 cm wide. Male cone about 20 cm long ..... *Cycas siamensis*
Leaves with petioles about 200 cm long, leaflets 1.3–2.0 cm wide. Male cone about 35 cm long ..... *Cycas rumphii*

Cycas rumphii Miq., Bull. Sc. Phys. Neerl. 839, 45; Hk. f., F.B.I. 5 : 657; Ridl., Fl. 5 : 284. 1925.

Cycas siamensis Miq., Bot Zeit. (1863) 334; Hk. f., F.B.I. 5 : 657; Ridl. Fl. 5 : 285. 1925.

Distributed in Burma and Thailand; in Malaya, restricted to limestone, and common on Langkawi islands.

Gnetaceae

A shrub or small tree, to 3 m tall; flowers not embedded in thick hair masses. ..... *Gnetum gnemon* var. *tenerum*
A liana, more than 10 m long; flowers embedded in thick hair masses. ..... *Gnetum cuspidatum*

Gnetum cuspidatum Bl., Rumphia 4 : 5. 1848; Henders., J. Mal. Br. As. Soc. 17 : 87. 1939; Markgraf, Fl. Mal. I, 4 : 343. 1951.

G. penangense Ridl., Fl. 5 : 276. 1925.

Gnetum gnemon Linn., Mant. 1 : 125. 1767; Markgraf, Bull. Jard. Bot. Btzg III, (10) : 436. 1930; Ridl. Fl. 5:273. 1925; Markgraf, Fl. Mal. I, 4 : 340. 1951.

var. *tenerum* Markgraf, Fl. Mal. I, 4 : 341. 1951.

Podocarpaceae

Male cones 3–5 together. Leaves 2.5–10 by 0.5–1 cm ..... *Podocarpus polystachyus*
Male cones solitary or sometimes 2–3 together. Leaves usually larger, 5.5–20 by 0.7–1.5 cm ..... *Podocarpus neriifolius*

Podocarpus polystachyus R. Br. [in Mirb., Mem. Mus. Hist. nat. Paris 13:47. 1825 nom. nud.] ex Endl., syn. Conif. (1847) 215. Ridl., Fl. 5 : 282. 1925; Keng, Tree Fl. Mal. 1 : 53: 1972.

Usually coastal except on limestone hills where it is very widely distributed and common.

Podocarpus neriifolius D. Don, in Lambert, Desc. Gen. Pinus 1 : 21. 1824; Ridl., Fl. 5 : 281. 1825; Keng, Tree Fl. Mal. 1 : 51. 1972.

Usually on hill and mountain forest, rarely below 300 m. Recorded on limestone from Gua Batu Selangor. (Ng FRI. 1634).