

## **GRAMMITIDACEAE (PTERIDOPHYTA) OF MOUNT JAYA, NEW GUINEA AND OTHER MONTANE MALESIAN LOCALITIES**

**B.S. PARRIS**

Fern Research Foundation, 21 James Kemp Place, Kerikeri, Bay of Islands, New Zealand 0470 (Email: bsparris@igrin.co.nz)

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### **ABSTRACT**

Mount Jaya (5000 m) in Papua (Indonesian New Guinea) is the highest mountain in Malesia and 56 species of Grammitidaceae are known from it. They are listed, together with their altitude ranges, habitat types and geographic distribution. Comparisons are made with Grammitidaceae of Murkele Ridge in Seram, Moluccas, Indonesia (3000 m, 55 species), Mount Kinabalu in Sabah, East Malaysia, Borneo (4100 m, 76 species) and Gunung Mulu, Sarawak, East Malaysia, Borneo (2400 m, 43 species). A Malesia-wide core of 23 grammitid species is identified.

### **INTRODUCTION**

The limestone massif of Mount Jaya (c. 5000 m) in Papua (Indonesian New Guinea) is the highest peak in Southeast Asia. It is the only peak in the region high enough to support glaciers and has long been a magnet for biologists. Previous names for the mountain are Mount Carstenz and Punjak Sukarno. The Royal Botanic Gardens, Kew, has organised five botanical expeditions to the mountain during 1998 to 2000, during which many collections were made along an altitudinal transect on the southern side. A detailed description of the alpine flora of Mount Jaya (above 3000 m) is in preparation at the Royal Botanic Gardens, Kew (Johns *et al.* in prep.). While writing up the treatment of Grammitidaceae for this account, all relevant material collected on Mount Jaya was identified, not just that from high altitudes, and included specimens gathered by Kloss on the Wollaston expedition on the mountain during 1912-1913 and those collected by Miller in 1991 and 1992. Although nearly all of the available material has been collected from only the southern side of the mountain, it is of sufficient interest to document here in the following terms: 1) how many species?, 2) what are they?, 3) what are their altitude ranges?, 4) what vegetation types are they found in?, 5) where else do they occur?

Comprehensive collections of pteridophytes from specific localities are rare in Malesia, because many botanical collectors have specialised in gathering only flowering plants and have tended to overlook the smaller and more obscure species of pteridophytes, including most Grammitidaceae. There are only three other localities in Malesia where the fern flora, including Grammitidaceae, has been relatively well-collected over a wide altitudinal range: Mount Kinabalu Park in Sabah, East Malaysia, Borneo, Gunung Mulu National Park in Sarawak, East Malaysia and Murkele Ridge in Seram, Moluccas, Indonesia. More than 40 species are known from each of these localities and they provide a useful comparison with Mount Jaya. The following questions are relevant: 1) how much do the floras of the three areas have in common

with Mount Jaya?, 2) is there a distinct East Malesian element present on Mount Jaya and Murkele Ridge?, 3) is there a distinct West Malesian element on Mount Kinabalu and Gunung Mulu?, 4) is there a Malesia-wide group of species of predictable occurrence?, 5) do other pteridophytes show the same geographical distribution patterns and do they also have Malesia-wide species of predictable occurrence?

Map 1 shows the location of Mount Jaya, Murkele Ridge, Mount Kinabalu and Gunung Mulu.

**Map 1.** Malesia.



Most species of Grammitidaceae are epiphytes on trunks and branches of a variety of trees and shrubs, or on the trunks of *Cyathea* in alpine communities, often associated with bryophytes, and a few species, particularly those of subalpine habitats, are lithophytes.

**Mount Jaya**

56 species of Grammitidaceae are known from Mount Jaya. They are listed, together with their altitude range, vegetation types and distribution, in Table 1.

Tropical lowland rainforests are generally poor in members of Grammitidaceae, which are far more numerous above the average daily lower limits of cloud. On Mount Jaya only five (9%) species occur in lowland rainforest, which contains the tree genera *Chisocheton*, *Ficus*, *Myristica*, *Octomeles*, *Pometia* and *Vatica*, with undergrowth of ferns including tree ferns, *Arthropteris* and *Marattia*, and Gesneriaceae. All five species are also found in heath forest. Heath forest, the other lowland forest habitat on Mount Jaya, supports a surprisingly large number of species, 16 (29%). It occupies old Pleistocene outwash terraces at the foot of the mountain (R.J. Johns pers. comm.) and includes the trees *Alstonia spectabilis* R. Br., *Calophyllum*, *Casuarina*, *Dacrydium*, *Metrosideros* and *Vatica*, together with *Nepenthes*, *Davallia*, *Lecanopteris*, Hymenophyllaceae and Polypodiaceae. Two of the four Mount Jaya endemics, *Ctenopteris hymenophylloides* (also in lowland rainforest) and *Grammitis velutina*, occur here, together with two other species (*Ctenopteris nutans*, *Grammitis scabristipes*) disjunct from much higher altitudes in midmontane forest, upper montane

**Table 1.** Grammitidaceae of Mount Jaya.

<b>Species</b>	<b>Altitude</b>	<b>Vegetation</b>	<b>Distribution</b>
1. <i>Acrosorus schlechteri</i> (H.Christ) H.Christ	1700 m	LMF	New Guinea endemic
2. <i>Calymmodon clavifer</i> (Hook.) T.Moore	1200-2300 m	LMF MMF	Sumatra to New Guinea
3. <i>C. cucullatus</i> (Nees & Blume) C.Presl	2300-3500 m	MMF SA	Pen. Malaysia to Solomon Is.
4. <i>C. fragilis</i> Copel.	3800 m	SA	New Guinea endemic
5. <i>C. mniodes</i> Copel.	1800 m	MMF	Moluccas, New Guinea
6. <i>C. ramifer</i> Copel.	3600 m	SA	New Guinea endemic
7. <i>Chrysogrammitis musgraviana</i> (Baker) Parris	2500-2700 m	MMF UMF	SE Asia, Malesia to Vanuatu
8. <i>Ctenopteris bipinnatifida</i> (Baker) Copel.	2600-3600 m	UMF SA	New Guinea endemic
9. <i>C. blechnoides</i> (Grev.) W.H.Wagner & Grether	200-800 m	HF LF	S. India to Society Is.
10. <i>C. denticulata</i> (Blume) C.Chr. & Tardieu	1500-2300 m	LMF MMF	Indochina to New Guinea
11. <i>C. fusca</i> Copel.	3300-3800 m	SA	New Guinea endemic
12. <i>C. hymenophylloides</i> Parris	200-500 m	HF LF	Mount Jaya endemic
13. <i>C. millefolia</i> (Blume) Copel.	2000-2600 m	MMF	Sumatra to New Guinea
14. <i>C. nutans</i> (Blume) J.Sm.	500-3600 m	HF MMF SA	Pen. Malaysia to New Guinea
15. <i>C. serrata</i> Parris ined.	200-600 m	HF	Sulawesi to New Guinea
16. <i>C. subsecundodissecta</i> (Zoll.) Copel.	2200-2400 m	MMF	Java to New Caledonia
17. <i>C. subulatipinna</i> (Alderw.) Copel.	3200 m	SA	New Guinea endemic
18. <i>Grammitis archboldii</i> (C.Chr) Copel.	1800-2800 m	MMF UMF	New Guinea endemic

19. <i>G. ceratocarpa</i> Copel.	3500 m	SA	New Guinea endemic
20. <i>G. clavata</i> Parris	2400 m	MMF	Mount Jaya endemic
21. <i>G. debilifolia</i> Copel.	3600 m	SA	New Guinea endemic
22. <i>G. dolichosora</i> (Copel.) Copel.	500-600 m	HF LF	Borneo to New Guinea
23. <i>G. frigida</i> (Ridl.) Copel.	2300-4200 m	MMF SA	New Guinea endemic
24. <i>G. hispida</i> Copel.	2500 m	MMF	New Guinea endemic
25. <i>G. interrupta</i> (Baker) Copel.	2600 m	UMF	New Guinea endemic
26. <i>G. intromissa</i> (H.Christ) Parris	1800-3800 m	MMF SA	SE Asia to New Guinea
27. <i>G. knutsfordiana</i> (Baker) Copel.	800-2300 m	LMF MMF	Peninsular Malaysia to Fiji
28. <i>G. locellata</i> (Baker) Copel.	3500-3800 m	SA	Sumatra to New Guinea
29. <i>G. loculosa</i> (Alderw.) Copel.	500-2500 m	HF LMF MMF	New Guinea endemic
30. <i>G. meijer-dreesii</i> Copel.	3900 m	SA	New Guinea endemic
31. <i>G. ornatissima</i> (Rosenst.) Copel.	1900 m	MMF	Sumatra to New Guinea
32. <i>G. padangensis</i> (Baker) Copel.	2600-3900 m	MMF UMF SA	Sumatra to New Guinea
33. <i>G. papuensis</i> (Alderw.) Parris	800-2300 m	LMF MMF	Mount Jaya endemic
34. <i>G. pleurogrammoides</i> (Rosenst.) Copel.	600 m	HF	Moluccas to Solomon Is.
35. <i>G. scabristipes</i> (Baker) Copel.	400-3800 m	HF MMF SA	Sumatra to Vanuatu
36. <i>G. sumatrana</i> (Baker) Copel.	1700-2600 m	MMF UMF	Sumatra to New Guinea
37. <i>G. velutina</i> Parris	200-400 m	HF	Mount Jaya endemic
38. <i>Prosaptia burbridgei</i> (Baker) Parris	200 m	HF	Borneo to New Guinea
39. <i>P. circumvallata</i> (Rosenst.) Parris	2000-3400 m	MMF SA	New Guinea endemic
40. <i>P. contigua</i> (G.Forst.) C.Presl	1800-2300 m	MMF	S India to Marquesas Is.

41. <i>P. davalliacea</i> (F.Muell. & Baker) Copel.	3400-3700 m	SA	Pen. Malaysia to New Guinea
42. <i>P. obliquata</i> (Blume) Mett.	800 m	LMF	S India to New Guinea
43. <i>P. papillata</i> Parris ined.	800 m	LMF	New Guinea endemic
44. <i>P. pensilis</i> (Ridl.) Parris	1800 m	MMF	New Guinea endemic
45. <i>P. venulosa</i> (Blume ex Kunze) M.G.Price	2400 m	MMF	Java to New Guinea
46. <i>Scleroglossum juncifolium</i> Copel.	2700 m	UMF	New Guinea, Solomon Is.
47. <i>S. pusillum</i> (Blume) Alderw.	600 m	HF	Thailand to Solomon Is.
48. <i>S. sulcatum</i> (Kuhn) Alderw.	600 m	HF	Sri Lanka to Marquesas
49. <i>Themelium allocotum</i> (Alderw.) Parris	2300-3400 m	MMF SA	New Guinea endemic
50. <i>T. fasciatum</i> (Blume) Parris	200 m	HF LF	Sumatra to New Guinea
51. <i>T. graminifolium</i> (Copel.) Parris	2600 m	UMF	New Guinea endemic
52. <i>T. yoderi</i> (Copel.) Parris	1200-2400 m	LMF MMF	Philippines to Solomon Is.
53. <i>Xiphopteris govidjoaensis</i> (Brause) Copel.	500-600 m	HF LF	Pen. Malaysia to New Guinea
54. <i>X. pseudospiralis</i> (Alderw.) Parris	2400-2600 m	MMF UMF	New Guinea endemic
55. <i>X. setulifera</i> (Alderw.) Parris	500-600 m	HF	Pen. Malaysia to New Guinea
56. <i>X. subpinnatifida</i> (Blume) Copel.	1800-3600 m	MMF SA	Pen. Malaysia to New Guinea

HF, heath forest (200-600 m). LF, lowland rainforest (200-500 m). LMF, lower montane forest (800-1700 m). MMF, midmontane forest (1800-2800m). UMF, upper montane forest (2600-2700 m). SA, subalpine communities (3300-4200 m).

Note: altitude range 2800-3500 m not collected by Kew botanists because of precipitous nature of terrain along transect.

forest and subalpine communities. *Ctenopteris serrata*, *Grammitis pleurogrammoides*, *Prosaptia burbridgei*, *Scleroglossum pusillum*, *S. sulcatum* and *Xiphopteris setulifera* are known only from heath forest on Mount Jaya, but occur in other communities elsewhere in New Guinea and further afield in Malesia. The formation may exist elsewhere in New Guinea, but apparently no members of Grammitidaceae have been collected from it. Heath forest, also called kerangas, is known from Peninsular Malaysia, Borneo, and elsewhere in Malesia. It develops at low altitudes on very poor or thin soils over rock or in areas of impeded drainage and is characterised by straight, pole-like small to medium sized trees and an understorey including pitcher plants (*Nepenthes*). Usually it contains very few, if any, species of Grammitidaceae.

Apart from heath forest, the most species-rich habitats on Mount Jaya are midmontane forest (28, 50%), and subalpine communities, with 19 species (21%). Lower montane and upper montane forests are less rich, each with 9 species (16%). Lower montane forest contains the fern *Selliguea* (no other information concerning the vegetation of lower montane forest is available on the specimen labels). The midmontane forest is dominated by *Nothofagus*; *Casuarina*, *Dacrydium*, *Fagraea*, Loranthaceae, *Macaranga*, *Papuacedrus*, *Rhododendron* and *Timonius* are also present together with the sedge *Mapania*, the ferns *Asplenium*, *Belvisia*, *Cyathea*, *Elaphoglossum* and *Loxogramme*, and shrubby Urticaceae. *Grammitis clavata* is the only Mount Jaya endemic in midmontane forest. Only eight species are restricted to midmontane forest, with another eight extending downward to lower montane forest and sometimes further, to heath forest and lowland rainforest, and 13 extending upwards to upper montane forest and sometimes to the subalpine communities. Upper montane forest is dominated by *Papuacedrus papuana* (F. Muell.) Li and *Podocarpus brassii* Pilg., with *Dicksonia*, *Drimys*, *Elaeocarpus*, *Nepenthes*, *Rapanea*, *Rhododendron*, *Sloanea* and *Utricularia*. *Grammitis interrupta*, *Scleroglossum juncifolium* and *Themelium graminifolium* are restricted to upper montane forest on Mount Jaya, but occur in other vegetation types elsewhere. Another five species occur in midmontane forest as well as upper montane forest, and two, *Ctenopteris bipinnatifida* and *Grammitis padangensis*, extend to the subalpine zone. The subalpine grasslands are dominated by *Cyathea* tree ferns, while the subalpine shrubland contains *Cyathea*, *Coprosma*, *Drimys*, *Rhododendron* and *Vaccinium*, and the subalpine forest contains *Dacrycarpus compactus* (Wassch.) de Laub. and *Podocarpus*. Nine species are restricted to subalpine habitats: *Calymmodon fragilis*, *C. ramifer*, *Ctenopteris fusca*, *C. subulatipinna*, *Grammitis ceratocarpa*, *G. debilifolia*, *G. locellata*, *G. meijer-dreesii* and *Prosaptia davalliacea*. With the exception of *G. locellata* and *P. davalliacea*, all are New Guinea endemics. While the nine species all occur on Mount Jaya at altitudes higher than that of the nearest subalpine site to New Guinea, Murkele Ridge (3000 m) in Seram, the two species that are widespread through Malesia, *G. locellata* and *P. davalliacea*, occur at lower altitudes on Murkele Ridge.

Several species found on Mount Jaya are infrequently collected and are known from very few localities. They include medium to high altitude Papua endemics known elsewhere only from Lake Habbema - *Grammitis hispida*, *Themelium allocotum*, Mount Trikora - *Ctenopteris fusca*, *G. meijer-dreesii*, and/or Mount Doorman, *C. subulatipinna*, *T. allocotum*, and Mount Goliath and Hellwig Mounts - *Xiphopteris pseudospiralis*. *Xiphopteris govidjoensis* (syn. *X. exilis* Parris) is known from two other localities, Gunung Belumut in Peninsular Malaysia and Govidjoa in Papua New Guinea.

Four species (7%) are endemic to Mount Jaya; *Ctenopteris hymenophylloides*, *Grammitis clavata*, *G. papuensis* and *G. velutina*. Surprisingly, none occurs in the subalpine communities, as might be expected when considering that several other mountains in New Guinea have high altitude endemics, e. g. *Grammitis dictymioides* Copel., *G. habbemensis* Copel., *Xiphopteris antipodalis* Copel. (all Lake Habbema), *G. reptans* Parris (Mount Trikora), *G. montana* Parris, *G. trogophylla* Copel. (both Mount Sarawaket), *G. murrayana* (C.Chr.) Copel. (Wharton Range) and *G. salticola* Parris (Mount Giluwe) (Parris, 1983).

A number of other high altitude New Guinea species found on Mount Trikora and/or Lake Habbema, and elsewhere in Papua New Guinea, may be expected on Mount Jaya, including *Ctenopteris pendens* (Rosenst.) Copel., *C. whartoniana* (C.Chr.) Copel. and *Grammitis tomaculosa* Parris.

New Guinea endemic species are important on Mount Jaya, comprising 36% (20 species) of the total. While they occur in all of the vegetation types they are best represented in the high altitude subalpine communities, where they form 20% (11 species) of the total number of species. The largest number of species, 24 (43%) are Malesia-wide in the sense that they occur in both West Malesia and East Malesia, on both sides of Zollinger's line (see later) between Borneo and Sulawesi, sometimes extending into Thailand, Indochina and Taiwan to the north-west and into Melanesia (Solomon Islands, Vanuatu, New Caledonia and Fiji) to the south-east. A small group of species (4, 7%) is very wide-ranging, from South India to the Society Islands (*Ctenopteris blechnoides*), South India to the Marquesas Islands (*Prosaptia contigua*), Sri Lanka to the Marquesas Islands (*Scleroglossum sulcatum*) and from South India to New Guinea (*P. obliquata*). These four species are amongst the most common and widespread members of Grammitidaceae in the Asia-Malesia-Pacific region. Another four (7%) species are restricted to East Malesia; *Ctenopteris serrata* ranges from Sulawesi to New Guinea, *Calymmodon mniodes* is in the Moluccas and New Guinea, *Grammitis pleurogrammoides* extends from the Moluccas to the Solomon Islands and *Scleroglossum juncifolium* occurs in New Guinea and the Solomon Islands.

The grammitid flora of Mount Jaya inevitably invites comparison with that of Mount Kinabalu (4100 m) in Sabah, Borneo, East Malaysia, the highest peak between the Himalayas and Papua, and the two other areas sufficiently well-known to permit comparison of their grammitid floras: the Murkele Ridge, a limestone massif including Gunung Binaiya (3000 m) in Seram, Moluccas, Indonesia, and Gunung Mulu National Park (including Gunung Mulu, sandstone, 2400 m and Gunung Api, limestone, 1700 m) in Sarawak, Borneo, East Malaysia. It is useful to examine the composition of these montane grammitid floras with respect to Zollinger's line, which divides West Malesia, comprising Peninsular Malaysia, Sumatra, Java, Borneo, the Philippines and the Lesser Sunda Islands, from East Malesia, consisting of Sulawesi, the Moluccas and New Guinea, and separated by the Makassar Strait between Borneo and Sulawesi. Wallace's line is similar, but includes Bali, the westernmost of the Lesser Sunda Islands, in West Malesia, and the remaining Lesser Sunda Islands in East Malesia. As the Lesser Sunda Islands are considered a discrete botanical region, Zollinger's line is preferred to Wallace's line. Mount Kinabalu and Gunung Mulu National Park (subsequently referred to as Gunung Mulu) are in West Malesia, while Murkele Ridge and Mount Jaya are in East Malesia. Both Mount Kinabalu and Murkele Ridge have subalpine areas above the treeline, but Gunung Mulu is forested to its summit.

The Moluccas have been of biogeographical interest ever since Wallace (1869)

suggested that the region has been constantly receiving immigrants from New Guinea. Kato (1989a) also points out that the affinity of the fern flora of Seram at species level is with New Guinea to the east rather than with Sulawesi to the west. Parris (1993) notes that the endemic pteridophytes of Seram are derived on the whole from wide-ranging taxa or those from East Malesia, and that Seram is the end of the line for numerous species moving east from West Malesia and moving west from New Guinea. Grammitidaceae of Seram collected by the Japanese-Indonesian expeditions of 1983, 1985 and 1986 (but not those collected by Parris in 1987) have been listed (Kato & Parris, 1992), the pteridophyte flora of Mount Kinabalu has been documented (Parris *et al.*, 1992), and a checklist of pteridophytes of Gunung Mulu National Park has been compiled (Parris, unpublished). Numerous changes have been made to the taxonomy of Grammitidaceae in Seram and on Mount Kinabalu since the publications of Kato & Parris (1992) and Parris *et al.* (1992).

### **Murkele Ridge**

55 species of Grammitidaceae are known from Murkele Ridge. They are listed, together with their altitude range, vegetation types and distribution, in Table 2.

It is useful to compare the grammitid floras of Mount Jaya and Murkele Ridge, the two East Malesian localities, which have very similar numbers of species, 56 in the former and 55 in the latter. 25 species are shared between the two, and nine of these are restricted to East Malesia. The remaining 16 are more widespread, occurring in East and West Malesia and sometimes beyond. Only *Ctenopteris serrata* extends throughout East Malesia from Sulawesi to New Guinea, so a well-defined widespread East Malesian endemic element is lacking in Grammitidaceae. Only one species, *Acrosorus friderici-et-pauli*, reaches its eastern limit of distribution on Murkele Ridge in Seram, but eight others, *Calymmodon mniodes*, *Ctenopteris whartoniana*, *Grammitis ahenobarba*, *G. collina*, *G. parva*, *G. pseudolocellata*, *G. subfasciata* and *Prosaptia engleriana*, reach their western limit in Seram, either on Murkele Ridge or slightly further to the north-west on Gunung Kobipoto (*G. collina*) or Gunung Roihelu (*G. parva*). They amply demonstrate Wallace's point (1869) that the Moluccas receive immigrants from New Guinea. In addition, some of the Murkele Ridge endemic species have obvious vicariants in New Guinea, e. g. *Ctenopteris themelioides* with *C. bipinnatifida*, and *Themelium pseudallicotum* with *T. allicotum*. The similarity in species numbers between Mount Jaya and the much lower Murkele Ridge is surprising, and the reasons for it are not obvious.

Comparisons between Murkele Ridge and the two West Malesian localities, Mount Kinabalu and Gunung Mulu, are interesting. 33 species are shared with Mount Kinabalu, more than are shared with Mount Jaya. They include seven widespread species collected on Gunung Mulu and known from New Guinea that are absent from Mount Jaya: *Calymmodon gracilis*, *C. pectinatus*, *C. reconditus*, *Ctenopteris brevivenosa*, *Grammitis adspersa*, *G. impressa*, *G. reinwardtii*. All are expected on Mount Jaya. 19 species are shared with Gunung Mulu and, with the exception of *Calymmodon conduplicatus*, all are also known from Mount Kinabalu.

31 species (56%) on Murkele Ridge are found in both East and West Malesia and another 5 (9%) extend well beyond Malesia, while 9 species (16%) occur in East Malesia and another 9 (16%) are endemic to Murkele Ridge. The amount of local endemism is much higher than on Mount Jaya, which has only four endemics. One might expect local endemism at high altitudes on Murkele Ridge, the highest part of the



**Table 2.** Grammitidaceae of Murkele Ridge.

<b>Species</b>	<b>Altitude</b>	<b>Vegetation</b>	<b>Distribution</b>
1. <i>Acrosorus friderici-et-pauli</i> (H.Christ) Copel.	1300-2000 m	LMF	SE Asia to Moluccas
2. <i>A. vallatus</i> Parris ined.	1700 m	LMF	Murkele Ridge endemic
3. <i>Calymmodon binaiyensis</i> Parris ined.	2800 m	SA	Murkele Ridge endemic
4. <i>C. clavifer</i> (Hook.) T.Moore	1700-2000 m	LMF	Sumatra to New Guinea
5. <i>C. conduplicatus</i> (Brause) Copel.	1200-2500 m	LMF UMF	Borneo to New Guinea
6. <i>C. cucullatus</i> (Nees & Blume) C.Presl	1800-2800 m	LMF UMF SA	Pen. Malaysia to Solomon Is.
7. <i>C. gracilis</i> (Fée) Copel.	1800 m	LMF	SE Asia to New Guinea
8. <i>C. mniodes</i> Copel.	1800 m	LMF	Moluccas, New Guinea
9. <i>C. pectinatus</i> Parris ined.	1600-1800 m	LMF	Java to New Guinea
10. <i>C. reconditus</i> Parris ined.	2500 m	UMF	Borneo to New Guinea
11. <i>Chrysogrammitis musgraviana</i> (Baker) Parris	1200-2000 m	LMF	SE Asia, Malesia to Vanuatu
12. <i>Ctenopteris blechnoides</i> (Grev.) W.H.Wagner & Grether	500-1300 m	LF LMFS.	India to Society Is.
13. <i>C. brevivenosa</i> (Alderw.) Holttum	2400 m	UMF	Thailand to Vanuatu
14. <i>C. denticulata</i> (Blume) C.Chr. & Tardieu	1200 m	LMF	Indochina to New Guinea
15. <i>C. millefolia</i> (Blume) Copel.	1800-2000 m	LMF	Sumatra to New Guinea
16. <i>C. nutans</i> (Blume) J.Sm.	1800-2900 m	LMF UMF	Pen. Malaysia to New Guinea
17. <i>C. seramensis</i> Parris ined.	1600 m	LMF	Murkele Ridge endemic
18. <i>C. serrata</i> Parris ined.	600-2000 m	LMF	Sulawesi to New Guinea

19. <i>C. subsecundodissecta</i> (Zoll.) Copel.	1300 m	LMF	Java to New Caledonia
20. <i>C. themelioides</i> Parris ined.	2000-2800 m	LMF UMF SA	Murkele Ridge endemic
21. <i>C. whartoniana</i> (C.Chr.) Copel.	2900 m	SA	Moluccas, New Guinea
22. <i>Grammitis adspersa</i> (Blume) Blume	1600 m	LMF	SE Asia to Fiji
23. <i>G. ahenobarba</i> Parris	1600 m	LMF	Moluccas, New Guinea
24. <i>G. caespitosa</i> Blume	2100 m	LMF	Sumatra to New Guinea
25. <i>G. collina</i> Parris	1400 m	LMF	Moluccas, New Guinea
26. <i>G. dolichosora</i> (Copel.) Copel.	800-2000 m	LMF	Borneo to New Guinea
27. <i>G. impressa</i> Copel.	1300 m	LMF	Sumatra to New Guinea
28. <i>G. intromissa</i> (H.Christ) Parris	1600-2000 m	LMF	Taiwan to New Guinea
29. <i>G. kanikehensis</i> Parris ined.	600 m	LMF	Murkele Ridge endemic
30. <i>G. knutsfordiana</i> (Baker) Copel.	2000 m	LMF	Peninsular Malaysia to Fiji
31. <i>G. locellata</i> (Baker) Copel.	2800-2900 m	SA	Sumatra to New Guinea
32. <i>G. manuselensis</i> Parris ined.	600 m	LMF	Murkele Ridge endemic
33. <i>G. mollis</i> Parris ined.	1700 m	LMF	Borneo to Moluccas
34. <i>G. padangensis</i> (Baker) Copel.	1800-2000 m	LMF	Sumatra to New Guinea
35. <i>G. parva</i> (Brause) Copel.	1800-2900 m	LMF UMF SA	Moluccas, New Guinea
36. <i>G. pseudolocellata</i> Parris	2900 m	SA	Moluccas, New Guinea
37. <i>G. reinwardtii</i> Blume	700-2000 m	LMF	Sri Lanka to Solomon Is.
38. <i>G. scabristipes</i> (Baker) Copel.	2200-2900 m	UMF SA	Sumatra to Vanuatu
39. <i>G. subfasciata</i> (Rosenst.) Copel .	1400-1900 m	LMF	Moluccas, New Guinea
40. <i>G. sumatrana</i> (Baker) Copel.	1300-2000 m	LMF	Sumatra to New Guinea

41. <i>G. tehoruensis</i> M.Kato & Parris	1300 m	LMF	Murkele Ridge endemic
42. <i>Prosaptia contigua</i> (G.Forst.) C.Presl	700-2000 m	LMF	S India to Marquesas Is.
43. <i>P. davalliacea</i> (F.Muell. & Baker) Copel.	2800-2900 m	SA	Pen. Malaysia to New Guinea
44. <i>P. engleriana</i> (Brause) Copel.	600-800 m	LMF	Moluccas, New Guinea
45. <i>P. obliquata</i> (Blume) Mett.	600-2000 m	LMF	S India to New Guinea
46. <i>P. seramensis</i> Parris ined.	1800-2000 m	LMF	Murkele Ridge endemic
47. <i>P. subglabra</i> (M.Kato & Parris) Parris	1300-1600 m	LMF	Moluccas endemic
48. <i>P. venulosa</i> (Blume ex Kunze) M.G.Price	2100 m	LMF	Java to New Guinea
49. <i>Scleroglossum pusillum</i> (Blume) Alderw.	1000-1300 m	LMF	Thailand to Solomon Is.
50. <i>S. sulcatum</i> (Kuhn) Alderw.	1000-1300 m	LMF	Sri Lanka to Marquesas
51. <i>Themelium pseudalocotum</i> Parris ined.	1300 m	LMF	Murkele Ridge endemic
52. <i>T. taxodioides</i> (Baker) Parris	2200 m	UMF	Borneo to New Guinea
53. <i>T. yoderi</i> (Copel.) Parris	1800-2000 m	LMF	Philippines to Solomon Is.
54. <i>Xiphopteris setulifera</i> (Alderw.) Parris	900-1000 m	LMF	Pen. Malaysia to New Guinea
55. <i>X. subpinnatifida</i> (Blume) Copel.	1800 m	LMF	Pen. Malaysia to New Guinea

LF, lowland forest (600 m). LMF, lower montane forest (600-2100 m). UMF, upper montane forest (2100-2500 m). SA, subalpine communities (2400-3000 m).

Moluccas and the only part of the region to be above the tree line, but only *Calymmodon binaiyensis* is restricted to subalpine habitats. *Ctenopteris themelioides* ranges from lower montane forest to subalpine habitats while the other local endemics are all found in lower montane forest. Only one species, *Prosaptia subglabra*, is endemic to the Moluccas.

### Mount Kinabalu

76 species of Grammitidaceae are known from Mount Kinabalu. They are listed, together with their altitude range, vegetation types and distribution, in Table 3.

Mount Kinabalu and Mount Jaya make an interesting contrast. The former has far more species of Grammitidaceae, 76, than the latter, with 56. Mount Kinabalu has a long history of botanical collecting, however, over more than a century, which may explain its species richness in part (Parris *et al.*, 1992). It should be noted, however, that nine species have not been collected on the mountain in the last 60 years (Parris, 2001) and may well be locally extinct. 23 species occur on both mountains; all of them, except *Themelium fasciatum*, are also found on Murkele Ridge, and 10 of them are also found on Gunung Mulu. Mount Kinabalu has nine endemic species of Grammitidaceae (16%), more than double the number found on Mount Jaya. As with Murkele Ridge, one might expect the endemic species to be associated with the high altitude vegetation communities above the tree line, but only *Grammitis kinabaluensis* extends above the tree line, and it also occurs in lower montane and mid-montane forest. *Grammitis graniticola*, *G. muscicola* and *G. nubicola* are restricted to upper montane forest, while *Calymmodon innominatus* and *Grammitis ramicola* are found only in lower montane forest and *Calymmodon kinabaluensis*, *Grammitis havilandii* and *G. ultramaficola* occur in both lower montane and upper montane forest. 44 species (58%) are Malesian-wide, a higher number and percentage than for either Mount Jaya or Murkele Ridge. Another eight species (11%) extend well beyond Malesia. 10 species are restricted to West Malesia, six of which are also found on Gunung Mulu. The West Malesian *Ctenopteris fuscata* occurs at high altitudes on Mount Kinabalu (3000-3800 m) and is not found on Gunung Mulu (2400 m), but *Grammitis congener* (1100-2500 m) and *Themelium curtisii* (1400-2400 m) are absent from Gunung Mulu, but may be expected. *Xiphopteris nudicarpa* occurs on ultramafic rocks on Mount Kinabalu and on Palawan Island in the Philippines. Ultramafic rocks, and *X. nudicarpa*, are absent from Gunung Mulu. Five species are endemic to Borneo and all are shared with Gunung Mulu.

### Gunung Mulu

43 species of Grammitidaceae are known from Gunung Mulu. They are listed, together with their altitude range, vegetation types and distribution, in Table 4.

Gunung Mulu is lower than Mount Jaya, Murkele Ridge and Mount Kinabalu, and lacks vegetation communities above the tree line. It has no endemic species, and 36 of its 43 species are also found on Mount Kinabalu. 22 species (51%) are Malesian-wide and five (12%) range well beyond Malesia. The nine West Malesian species (21%) all occur on Mount Kinabalu. Seven species are endemic to Borneo; five also occur on Mount Kinabalu, but *Scleroglossum crassifolium* and *Themelium sarawakense* are not known there.

In Table 5 the geographic distribution of Grammitidaceae on Mount Jaya, Murkele Ridge, Mount Kinabalu and Gunung Mulu is summarised.

**Table 3.** Grammitidaceae of Mount Kinabalu.

<b>Species</b>	<b>Altitude</b>	<b>Vegetation</b>	<b>Distribution</b>
1. <i>Acrosorus friderici-et-pauli</i> (H.Christ) Copel.	1500-1900 m	LMF	SE Asia to Moluccas
2. <i>A. streptophyllus</i> (Baker) Copel.	800-1900 m	HF LMF	Thailand to Philippines
3. <i>Calymmodon atrichus</i> Copel.	1800-3400 m	LMF UMF	Borneo to New Guinea
4. <i>C. borneensis</i> Parris ined.	1500-3000 m	LMF UMF	Borneo endemic
5. <i>C. clavifer</i> (Hook.) T.Moore	1500-2600 m	LMF	Sumatra to New Guinea
6. <i>C. cucullatus</i> (Nees & Blume) C.Presl	2200-3000 m	LMF UMF	Pen. Malaysia to Solomon Is.
7. <i>C. gracilis</i> (Fée) Copel.	1200-3000 m	LMF UMF	SE Asia to New Guinea
8. <i>C. hygrosopicus</i> Copel.	1400-2100 m	LMF	Java to New Guinea
9. <i>C. innominatus</i> Parris ined.	2400 m	LMF	Mount Kinabalu endemic
10. <i>C. kinabaluensis</i> Parris ined.	1500-2800 m	LMF UMF	Mount Kinabalu endemic
11. <i>C. luerssenianus</i> (Domin) Copel.	1500-2400 m	LMF	SE Asia to Solomon Is.
12. <i>C. muscoides</i> (Copel.) Copel.	1500 m	LMF	Java to Philippines
13. <i>C. pectinatus</i> Parris ined.	1500-2500 m	LMF	Java to New Guinea
14. <i>C. reconditus</i> Parris ined.	1500-3100 m	LMF UMF	Borneo to New Guinea
15. <i>Chrysogrammitis glandulosa</i> (J.Sm.) Parris	1500 m	LMF	Sri Lanka to Philippines
16. <i>C. musgraviana</i> (Baker) Parris	1400-2100 m	LMF	SE Asia to Vanuatu
17. <i>Ctenopteris blechnoides</i> (Grev.) W.H.Wagner & Grether	800-1000 m	HF	S. India to Society Is.
18. <i>C. brevivenosa</i> (Alderw.) Holttum	1400-3000 m	LMF UMF	Thailand to Vanuatu
19. <i>C. denticulata</i> (Blume) C.Chr. & Tardieu	1200-1800 m	LMF	Indochina to New Guinea
20. <i>C. fuscata</i> (Blume) Kunze	3000-3800 m	UMF SA	Thailand to Philippines
21. <i>C. inconspicua</i> (Blume) Copel.	1700 m	LMF	Pen. Malaysia to Philippines
22. <i>C. millefolia</i> (Blume) Copel.	1800 m	LMF	Sumatra to New Guinea
23. <i>C. minuta</i> (Blume) Holttum	1400 m	LMF	Pen. Malaysia to Philippines
24. <i>C. mollicoma</i> (Nees & Blume) Kunze	1500-2900 m	LMF UMF	SE Asia to New Guinea
25. <i>C. nutans</i> (Blume) J.Sm.	2600-3800 m	UMF SA	Pen. Malaysia to New Guinea

26. <i>C. repandula</i> (Mett.) C.Chr. & Tardieu	2700 m	UMF	Sri Lanka to Solomon Is.
27. <i>C. subminuta</i> (Alderw.) Holttum	1400-2000 m	LMF	Sumatra to Borneo
28. <i>C. subsecundodissecta</i> (Zoll.) Copel.	1700-2400 m	LMF	Java to New Caledonia
29. <i>Grammitis adspersa</i> (Blume) Blume	1500 m	LMF	SE Asia to Fiji
30. <i>G. bongoensis</i> (Copel.) Copel.	1500-1800 m	LMF	Borneo endemic
31. <i>G. caespitosa</i> Blume	1800 m	LMF	Sumatra to New Guinea
32. <i>G. clemensiae</i> (Copel.) Parris	3400-4000 m	UMF SA	Borneo to New Guinea
33. <i>G. congener</i> Blume	1100-2500 m	LMF	SE Asia to Philippines
34. <i>G. dolichosora</i> (Copel.) Copel.	1100-3000 m	LMF UMF	Borneo to New Guinea
35. <i>G. friderici-et-pauli</i> (H.Christ) Copel.	2000-2700 m	LMF UMF	Borneo, Sulawesi
36. <i>G. graniticola</i> Parris ined.	3300-3400 m	UMF	Mount Kinabalu endemic
37. <i>G. havilandii</i> (Baker) Copel.	1500-3200 m	LMF UMF	Mount Kinabalu endemic
38. <i>G. holttumii</i> Copel.	1700-2900 m	LMF UMF	Pen. Malaysia to Sulawesi
39. <i>G. impressa</i> Copel.	1200 m	LMF	Sumatra to New Guinea
40. <i>G. intromissa</i> (H.Christ) Parris	1400-2400 m	LMF	Taiwan to New Guinea
41. <i>G. jagoriana</i> (Mett. ex Kuhn) Tagawa	1400-2600 m	LMF UMF	SE Asia to Solomon Is.
42. <i>G. kinabaluensis</i> (Copel.) Copel.	1800-4000 m	LMF UMF SA	Mount Kinabalu endemic
43. <i>G. knutsfordiana</i> (Baker) Copel.	1500-2700 m	LMF UMF	Peninsular Malaysia to Fiji
44. <i>G. locellata</i> (Baker) Copel.	3200-3700 m	UMF SA	Sumatra to New Guinea
45. <i>G. mollis</i> Parris ined.	1400-1500 m	LMF	Borneo to Moluccas
46. <i>G. muscicola</i> Parris ined.	3400 m	UMF	Mount Kinabalu endemic
47. <i>G. nubicola</i> Parris ined.	3000-3200 m	UMF	Mount Kinabalu endemic
48. <i>G. oblanceolata</i> (Baker) Copel.	1200 m	LMF	Sumatra to Solomon Is.
49. <i>G. padangensis</i> (Baker) Copel.	3400 m	UMF	Sumatra to New Guinea
50. <i>G. pilosiuscula</i> Blume	1600-2500 m	LMF	Sumatra to Philippines
51. <i>G. ramicola</i> Parris ined.	1500-2600 m	LMF	Mount Kinabalu endemic
52. <i>G. reinwardtii</i> Blume	1100-1800 m	LMF	Sri Lanka to Solomon Is.
53. <i>G. reinwardtioides</i> Copel.	1200-2300 m	LMF	Borneo endemic

54. <i>G. scabristipes</i> (Baker) Copel.	1800-3000 m	LMF UMF	Sumatra to Vanuatu
55. <i>G. sumatrana</i> (Baker) Copel.	1500-3000 m	LMF UMF	Sumatra to New Guinea
56. <i>G. ultramaficola</i> Parris ined.	2400-3000 m	LMF UMF	Mount Kinabalu endemic
57. <i>Prosaptia alata</i> (Blume) H.Christ	800 m	HF	S India to Samoa
58. <i>P. barathrophylla</i> (Baker) M.G.Price	1200-1500 m	LMF	SE Asia to Philippines
59. <i>P. borneensis</i> Parris ined.	2100 m	LMF	Borneo endemic
60. <i>P. celebica</i> (Blume) Tagawa & K.Iwats.	1500-2100 m	LMF	Thailand to New Guinea
61. <i>P. contigua</i> (G.Forst.) C.Presl	1200-2900 m	LMF UMF	S India to Marquesas Is.
62. <i>P. davalliacea</i> (F.Muell. & Baker) Copel.	2900-3800 m	UMF SA	Pen. Malaysia to New Guinea
63. <i>P. multicaudata</i> (Copel.) Parris	1500-2100 m	LMF	Borneo to New Guinea
64. <i>P. obliquata</i> (Blume) Mett.	1500-1800 m	LMF	S India to New Guinea
65. <i>P. venulosa</i> (Blume ex Kunze) M.G.Price	2500-2900 m	LMF UMF	Java to New Guinea
66. <i>Scleroglossum debile</i> (Kuhn) Alderw.	1800-2600 m	UMF	Pen. Malaysia to New Guinea
67. <i>S. gracillimum</i> Parris ined.	1000 m	HF	Borneo endemic
68. <i>S. pusillum</i> (Blume) Alderw.	1500-3200 m	LMF UMF	Thailand to Solomon Is.
69. <i>S. sulcatum</i> (Kuhn) Alderw.	1500-3000 m	LMF UMF	Sri Lanka to Marquesas
70. <i>Themelium curtisii</i> (Baker) Parris	1400-2400 m	LMF	Sumatra, Borneo
71. <i>T. fasciatum</i> (Blume) Parris	2700-3400 m	UMF	Sumatra to New Guinea
72. <i>T. halconense</i> (Copel.) Parris	2100 m	LMF	Borneo, Philippines
73. <i>T. taxodioides</i> (Baker) Parris	2300-3000 m	LMF UMF	Borneo to New Guinea
74. <i>X. hieronymusii</i> (C.Chr.) Holttum	1200-1700 m	LMF	Thailand to Borneo
75. <i>X. nudicarpa</i> (Zamora & Co) Parris	2700-2900 m	UMF	Borneo, Philippines
76. <i>X. subpinnatifida</i> (Blume) Copel.	1500-2200 m	LMF	Pen. Malaysia to New Guinea

HF, hill forest (800-1200m). LMF, lower montane forest (1200-2600m). UMF, upper montane forest (2600-3500m). SA, subalpine communities (3500-3800m).

**Table 4.** Grammitidaceae of Gunung Mulu.

<b>Species</b>	<b>Altitude</b>	<b>Vegetation</b>	<b>Distribution</b>
1. <i>Acrosorus friderici-et-pauli</i> (H.Christ) Copel	1200-1800 m	LMF	SE Asia to Moluccas
2. <i>A. streptophyllus</i> (Baker) Copel.	1500-1800 m	LMF	Thailand to Philippines
3. <i>Calymmodon borneensis</i> Parris ined	1400-1700 m	LMF	Borneo endemic
4. <i>C. conduplicatus</i> (Brause) Copel.	1800 m	LMF	Borneo to New Guinea
5. <i>C. cucullatus</i> (Nees & Blume) C.Presl	1900 m	UMF	Pen. Malaysia to Solomon Is.
6. <i>C. gracilis</i> (Fée) Copel.	900-2000 m	LMF UMF	SE Asia to New Guinea
7. <i>C. luerssenianus</i> (Domin) Copel	1700-1800 m	LMF	SE Asia to Solomon Is.
8. <i>C. pectinatus</i> Parris ined.	1200-1800 m	LMF	Java to New Guinea
9. <i>C. reconditus</i> Parris ined.	2000-2300 m	UMF	Borneo to New Guinea
10. <i>Chrysogrammitis musgraviana</i> (Baker) Parris	1200-1800 m	LMF	SE Asia to Vanuatu
11. <i>Ctenopteris blechnoides</i> (Grev.) W.H.Wagner & Grether	200-1200 m	LF LMFS.	India to Society Is.
12. <i>C. brevivinosa</i> (Alderw.) Holttum	1300-2000 m	LMF UMF	Thailand to Vanuatu
13. <i>C. brooksiae</i> (Alderw.) Parris	400 m	LF	Sumatra, Borneo
14. <i>C. mollicoma</i> (Nees & Blume) Kunze	2100-2300 m	UMF	SE Asia to New Guinea
15. <i>C. nutans</i> (Blume) J.Sm.	2300 m	UMF	Pen. Malaysia to New Guinea
16. <i>C. subminuta</i> (Alderw.) Holttum	1700 m	LMF	Sumatra to Borneo
17. <i>Grammitis adspersa</i> (Blume) Blume	1000-1800 m	LMF	SE Asia to Fiji
18. <i>G. bongoensis</i> (Copel.) Copel.	900-1500 m	LMF	Borneo endemic
19. <i>G. friderici-et-pauli</i> (H.Christ) Copel.	1700 m	LMF	Borneo, Sulawesi
20. <i>G. impressa</i> Copel.	1200 m	LMF	Sumatra to New Guinea
21. <i>G. jagoriana</i> (Mett. ex Kuhn) Tagawa	1600 m	LMF	SE Asia to Solomon Is.



22. <i>G. knutsfordiana</i> (Baker) Copel.	2000 m	UMF	Peninsular Malaysia to Fiji
23. <i>G. oblanceolata</i> (Baker) Copel.	1000-1200 m	LMF	Sumatra to Solomon Is.
24. <i>G. padangensis</i> (Baker) Copel.	2300 m	UMF	Sumatra to New Guinea
25. <i>G. pilosiuscula</i> Blume	2000 m	UMF	Sumatra to Philippines
26. <i>G. reinwardtii</i> Blume	1700 m	LMF	Sri Lanka to Solomon Is.
27. <i>G. reinwardtioides</i> Copel.	1400-2000 m	LMF UMF	Borneo endemic
28. <i>G. setosa</i> Blume	1800-2000 m	LMF UMF	Sumatra to Sulawesi
29. <i>G. sumatrana</i> (Baker) Copel.	2000 m	UMF	Sumatra to New Guinea
30. <i>G. vittariifolia</i> (C.Chr.) Parris	200 m	LF	Pen. Malaysia to Borneo
31. <i>Prosaptia alata</i> (Blume) H.Christ	100-1200 m	LF LMF	S India to Samoa
32. <i>P. barathrophylla</i> (Baker) M.G.Price	600-800 m	LF LMF	SE Asia to Philippines
33. <i>P. borneensis</i> Parris ined.	2300 m	UMF	Borneo endemic
34. <i>P. celebica</i> (Blume) Tagawa & K.Iwats.	1800-2200 m	LMF UMF	Thailand to New Guinea
35. <i>P. contigua</i> (G.Forst.) C.Presl	500-1800 m	LF LMF	S India to Marquesas Is.
36. <i>Scleroglossum crassifolium</i> (Baker) C.Chr.	900-1600 m	LMF	Borneo endemic
37. <i>S. gracillimum</i> Parris ined.	1000-1200 m	LMF	Borneo endemic
38. <i>S. pusillum</i> (Blume) Alderw.	1600-2400 m	LMF UMF	Thailand to Solomon Is.
39. <i>S. sulcatum</i> (Kuhn) Alderw.	200-1800 m	LF LMF	Sri Lanka to Marquesas
40. <i>Themelium halconense</i> (Copel.) Parris	1800 m	LMF	Borneo, Philippines
41. <i>T. sarawakense</i> (Parris) Parris	1500 m	LMF	Borneo endemic
42. <i>Xiphopteris alternidens</i> (Ces.) Copel.	600 m	LF	Pen. Malaysia to Borneo
43. <i>X. hieronymusii</i> (C.Chr.) Holttum	400-1800 m	LF LMF	Thailand to Borneo

LF, lowland rainforest (100-800m). LMF, lower montane forest (800-1900m). UMF, upper montane forest (1600-2300m).

**Table 5.** Geographic Distribution of Grammitidaceae of Mount Jaya, Murkele Ridge, Mount Kinabalu and Gunung Mulu

<b>Geographic distribution</b>	<b>Species no. and percentage of total species</b>			
	<b>Mount Jaya</b>	<b>Murkele Ridge</b>	<b>Mt Kinabalu</b>	<b>Gunung Mulu</b>
1. Widespread beyond Malesia, to Polynesia and/or Sri Lanka	4, 70%	5, 90%	8, 11%	5, 12%
2. Malesia-wide or slightly beyond, or at least across Zollinger's line	24, 43%	31, 56%	44, 58%	22, 51%
3. E Malesia (MJ, MR) or W Malesia (MK, GM)	4, 70%	9, 16%	10, 13%	9, 21%
4. Country endemic	20, 36%	1, 20%	5, 70%	7, 16%
5. Locality endemic	4, 70%	9, 16%	9, 12%	0, 00%
Species total	56	55	76	43

### DISCUSSION

Compared with Murkele Ridge, Mount Kinabalu and Gunung Mulu, Mount Jaya has many more country endemics. This reflects the explosive speciation of Grammitidaceae in New Guinea (together with many other groups of plants) and their distribution along the central ranges of the island. The wide distribution of species along the central ranges of New Guinea is probably also an explanation for the low number of endemic species compared with Mount Kinabalu and Murkele Ridge. While Mount Jaya is the highest peak in a series of high altitude peaks on the ranges that form the backbone of New Guinea, Murkele Ridge and Mount Kinabalu are isolated from other areas at high altitudes. Mount Jaya and Gunung Mulu have fewer species that are widespread in Malesia and beyond than do Murkele Ridge and Mount Kinabalu. Gunung Mulu, being relatively low altitude, does not have the array of habitats or even comparable areas of the same habitats as do the higher Murkele Ridge and Mount Kinabalu. The reason for Mount Jaya having fewer of the widespread species is less obvious. In the discussion of Murkele Ridge (see above), seven widespread species are mentioned that are absent from Mount Jaya, but present in New Guinea and thus to be expected. Another two species that occur on Mount Kinabalu and are disjunct with Papua New Guinea are also expected on Mount Jaya. They are *Calymmodon atrichus* and *Grammitis clemensiae*.

There is a group of 10 grammitid species that have been collected on all of the four montane Malesian localities documented here: they are *Calymmodon cucullatus*, *Chrysogrammitis musgraviana*, *Ctenopteris blechnoides*, *C. nutans*, *Grammitis knutsfordiana*, *G. padangensis*, *G. sumatrana*, *Prosaptia contigua*, *Scleroglossum pusillum* and *S. sulcatum*. Two other widespread high altitude subalpine species are not found on Gunung Mulu (2400 m alt.) because it is too low: *Grammitis locellata* (2800-3800 m) and *Prosaptia davalliacea* (2800-3800 m). Another group of species, *Calymmodon clavifer*, *Ctenopteris denticulata*, *C. millefolia*, *C. subsecundodissecta*, *Grammitis dolichosora*, *G. intromissa*, *G. scabristipes*, *Prosaptia obliquata*, *P. venulosa* and *Xiphopteris subpinnatifida* occur on Mount Jaya, Murkele Ridge and Mount Kinabalu within the altitudinal range of Gunung Mulu and may be expected there. The widespread *Grammitis reinwardtii* is absent from Mount Jaya, but occurs in the other three localities. The species that are absent from Gunung Mulu and from Mount Jaya, together with the 10 listed above, form a core of 23 grammitid species that are widespread and common throughout Malesia. Examination of herbarium collections during preparation of the account of Grammitidaceae for Flora Malesiana has provided much detailed data on species distribution that has been collated for over 500 localities. The core group of 23 grammitid species is well-represented in the following localities, each of which has 20 or more species of Grammitidaceae. The altitude range over which Grammitidaceae have been collected and the number of species currently known is given for each locality. Peninsular Malaysia: Cameron Highlands, 1400-2000 m, 23 species; Gunung Tahan, 600-2200 m, 21 species; Sumatra, Gunung Kerinci, 300-3800 m, 22 species; Java, Gunung Gede, 1200-3000 m, 39 species; Sulawesi, Mount Roroka Timbu, 1200-2400 m, 25 species; Philippines, Mount Apo, 1000-3000 m, 25 species; Papua, Mount Trikora, 2800-4200 m, 36 species, Idenberg River, 700-2200 m, 22 species; Papua New Guinea, Aseki, 1300-1800 m, 20 species, Ekuti Range at Watut-Aseki Divide, 2000-2100 m, 22 species, Mount Giluwe, 2100-4100 m, 38 species, Mount Hagen, 2400-4000 m, 34 species, Rawlinson Range, 1500-4000 m, 33 species, Saruwaged Range, 1200-4000 m, 40 species, Star Mountains, 1400-4000 m, 24 species, Mount Suckling, 400-3700 m, 20 species, Mount Wilhelm, 2700-4500 m, 26

species.

The identification of pteridophytes below the subalpine and alpine areas of Mount Jaya is not yet complete (R.J. Johns pers. comm.), so a complete evaluation of the relationships of the pteridophyte flora is not yet possible. Ridley (1916) records a number of pteridophytes from Mount Jaya, however, and this is sufficient to establish that there is a core of widespread pteridophytes in families other than Grammitidaceae that are also present on Mount Kinabalu (Parris *et al.*, 1992), Murkele Ridge (Parris, 1993) and Gunung Mulu (Parris, unpublished). They include *Asplenium tenerum* G. Forst., *Diplazium cordifolium* Blume, *Lindsaea rigida* J. Sm. (Kato, 1992), *Lycopodiella cernua* (L.) Pic. Serm., *Ophioglossum pendulum* L. (Kato, 1989b), *Selliguea enervis* (Cav.) Ching and *Trichomanes pallidum* Blume.

### CONCLUSIONS

Mount Jaya has some unique features compared with the other Malesian mountains considered here: the presence of a rich grammitid flora in the heath forests between 200 and 600 m alt. is unexpected, and there is a good representation of widespread New Guinea endemic Grammitidaceae. The absence of high altitude endemics in the family is surprising, given that several other high New Guinea mountains have one or more endemic species. Mount Jaya is much less species-rich than Mount Kinabalu, and this may be explained at least in part by the much longer history of collecting on the latter and the paucity of collections from the largely inaccessible upper montane forest of the former. Compared with Mount Jaya, the Murkele Ridge, 2000 m lower, supports a rich flora of Grammitidaceae, but the reason for this is not evident.

Zollinger's line does not present an insuperable barrier to the distribution of Grammitidaceae, as 59 (45 %) of the 130 species listed in Tables 1 to 4 occur on both sides of it.

The concept of a core Malesian-wide pteridophyte flora present in all suitable areas has not been suggested previously, but there is ample evidence for it in 23 species of Grammitidaceae and numerous species in other pteridophyte families.

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### REFERENCES

- JOHNS, R.J. *et al.* in prep. A guide to the subalpine and alpine flora of Mount Jaya, New Guinea. Royal Botanic Garden, Kew.
- KATO, M. 1989a. The fern flora of Seram. In: BAAS, P., KALKMAN, K. & GEESINK, R. (Eds) *The Plant Diversity of Malesia*, pp. 225-234. Kluwer, Dordrecht.
- KATO, M. 1989b. Taxonomic Studies of Pteridophytes of Ambon and Seram (Moluccas) Collected by Indonesian- Japanese Botanical Expeditions. III. Eusporangiate and Some Lower Leptosporangiate Families. *Acta Phytotax. Geobot.* 40: 77-92.
- KATO, M. 1992. Taxonomic Studies of Pteridophytes of Ambon and Seram (Moluccas) Collected by Indonesian-Japanese Botanical Expeditions. IX. Woodsiaceae, Lindsaeaceae, and Adiantaceae. *J. Fac. Sci. Univ. Tokyo Sec. III*, 15: 135-152.

- KATO, M. & PARRIS, B.S. 1992. Taxonomic Studies of Pteridophytes of Ambon and Seram (Moluccas) Collected by Indonesian-Japanese Botanical Expeditions. VII. Grammitidaceae. J. Fac. Sci. Univ. Tokyo Sec. III, 15: 111-133.
- PARRIS, B.S. 1983. A taxonomic revision of the genus *Grammitis* Swartz (Grammitidaceae: Filicales) in New Guinea. *Blumea* 29: 13-222.
- PARRIS, B.S. 1993. Studies on the Phytogeography and Altitudinal Zonation of the Pteridophyte Flora of Seram. In: EDWARDS, I.D., MACDONALD, A.A. & PROCTOR, J. (Eds) *Natural History of Seram, Maluku, Indonesia*, pp. 75-89. Intercept, Andover.
- PARRIS, B.S. 2001. Taxonomy of Malesian Grammitidaceae in relation to ecology and phytogeography. In SAW, L.G., CHUA, L.S.L. & KHOO, K.C. (Eds) *Taxonomy, the Cornerstone of Biodiversity*, pp 155-160. Forest Research Institute Malaysia, Kuala Lumpur.
- PARRIS, B.S. unpublished. A Checklist of Pteridophytes from Gunung Mulu National Park.
- PARRIS, B.S., BEAMAN, R.S. & BEAMAN, J.H. 1992. *The Plants of Mount Kinabalu. 1. Ferns and Fern Allies*. Royal Botanic Gardens, Kew.
- RIDLEY, H.N. 1916. Report on the botany of the Wollaston Expedition to Dutch New Guinea. *Trans. Linn. Soc. London (Bot.)* 2, 9: 1-269.
- WALLACE, A.R. 1869. *The Malay Archipelago*. Macmillan, London.