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CONTENTS

Page

MAIN ARTICLES

SHORT NOTES

ECOLOGICAL NOTES

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ERRATUM in Fern Gaz.11:201 (1976): Amend caption to read:

> . . . (d, fertile frond;) e, scale from rhizome x 25; f, scale from stipe x 50; g, scale from sterile lamina x 50.

NOTES ON SOME MASCARENE SPECIES OF ELAPHOGLOSSUM (LOMARIOPSIDOIDEAE SENSU HOLTTUM)

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ABSTRACT

The preparation of an account of the fern genus *Elaphoglossum* in the Mascarene area has brought to light certain problems. This article deals with the taxonomy of *Elaphoglossum lanatum,* the leptotypification and taxonomy of *E. lepervanchii* and the leptotypification of *E. sieberi.*

INTRODUCTION

The preparation of an account of the fern genus *Elaphoglossum* for the forthcoming "Flore des Mascareignes" has brought to light certain problems which are dealt with in the following notes. Abbreviations used herein are in accordance with those found in the "Index Herbariorum" ed. 5, with the exception of REU, which is used as an abbreviation for the "Herbier du Centre d'Enseignment Supérieur Scientifique (Ile de la Réunion)".

THE TAXONOMY OF ELAPHOGLOSSUM LANATUM

Elaphoglossum lanatum (Bojer ex Baker) Lorence, *comb. & stat. nov.*

Basionym: *Acrostichum viscosum* Sw. var. *lanatum* Bojer ex Baker, Fl. Maurit. & Seych.: 512 (1877).
Holotype: Mauritius, *Bojer* s.n., "Acrostichum lanatum nob. Hab. in rupibus, et ad rivulorum ripas in ins. Mauritii au quart. *Moka,* juxta Bois Chéri" (four left-hand collections, excluding two right-hand fertile fronds, Herb. Hook. K!).

Elaphoglossum lanatum was originally collected in Mauritius by Bojer who considered it to be a new and distinct species, a fact which he noted on several of his gatherings. The plant was subsequently described by Baker (1877) and treated as a variety of *Acrostichum viscosum* Sw., for which he gives *A. salicifolium* Willd. ex Kaulf. as a synomym.

The latter species, *A. salicifolium,* was transferred to the genus *Elaphoglossum* by Hieronymus as a variety of *E. viscosum.* More recently Schelpe (1969) has considered it to be a subspecies of *E. petiolatum* (Sw.) Urban *E. petiolatum* ssp. *salicifolium* occurs in Africa and the adjacent islands, and, according to Schelpe, forms "a reasonably distinct segregate of a world-wide *E. petiolatum* complex with small, variously shaped laminar species". Furthermore, it is a strictly free-veined species, bears scattered acicular, substellate laminar scales and occurs as an epiphyte on trees and rotting logs.

On the other hand, *Acrostichum viscosum* var. *lanatum* has not, to my knowledge, been transferred to the genus *Elaphoglossum* to which it belongs. Although it shows certain affinities with *E. petiolatum* ssp. *salicifolium,* the following differences are sufficient for it to merit specific status. It is unique in being the only Mauritian *Elaphoglossum* that is rupicolous and grows exclusively on vertical river banks and cliff faces composed of decaying lava, a fact noted by Bojer on his type specimen ("in rupibus et ad rivulorum ripas"). Apparently endemic to Mauritius, it is a viable species forming large but localized colonies, and there is also evidence that it hybridises with other species of the genus. It possesses arachnoid laminar scales with long, more or less tangled cilia (fig. 1g) which are quite dense and matted on young fronds (fig. 1b), thus imparting a characteristic lanate appearance not found in *E. petiolatum* ssp. *salicifolium.* Finally, in *E. lanatum* a certain percentage of the veins reunite into simple intramarginal arcs, the rest being free. This trait is quite variable, some specimens being predominantly free-veined, others not. Both the extremes and the intermediates may, in fact, occur on the same plant as they do in Bojer's type specimen.

Material Studied

MAURITIUS. *Bojer* s.n., Bois Chéri (K-holo); *Bojer* s.n., ex ins. Mauritii (K); *Bojer* s.n., Bourbon, *pro parte* (K, mixed collection, origin probably Mauritius); *Anon.* in MAU 16849 (MAU); Mare Longue Plateau, *Lorence* in MAU 15014 (MAU, P); ibid., *Lorence* in MAU 15243 (MAU, K, P. REU); Cascade 500 pieds, *Lorence* in MAU 15241 (MAU); Tamarin Falls Reservoir, *Lorence* in MAU 15823C (MAU); Black River Gorges, *Lorence* in MAU 15533 (MAU, REU); Le Pouce Mt., *Lorence* 21.1 in MAU 16280 (MAU); Perrier Nature Reserve, *Lorence* 17.2 in MAU 15830 (MAU); Bel Ombre forest, *Lorence* 1406A in MAU 17542 (MAU).

THE LECTOTYPIFICATION AND TAXONOMY OF ELAPHOGLOSSUM LEPERVANCHII

Elaphoglossum lepervanchii (Fée) Moore, Ind. Fil.: 11 (1857); Tard. in Notul. Syst. 15 (4): 428, pl. 2, fig. 8–11 (1959). Type: Réunion, *collector?* (Herb. Bory no. 27, 14 right-hand specimen, P-lecto!)

Acrostichum lepervanchii Fée, Mém. Fam. Foug. 2: 37, pl. 9, fig. 1 (1845).
Acrostichum conforme sensu Bojer, Hort. Maurit.: 412 (1837); sensu Baker, Fl. Maurit. & Seych.: 511 (1877); sensu Cordemoy, Fl. Reun.: 93 (1895), *non* Sw.
Acrostichum ovalifolium Bojer, Hort. Maurit.: 414 (1837), *nom. nud.* Type: Mauritius, *Bojer* s.n. (K!)
Acrostichum didynameum Fée, Mém. Fam. Foug. 2: 37, pl. 16, fig. 2 (1845). Type: Réunion, *Lepervanche-Mézière* s.n. (Herb. Bory no. 27, 13–P!).
Elaphoglossum didynameum (Fée) Moore, Ind. Fil.: 8 (1857); Tard. in Humbert, Fl. Mad. 5^{e} Fam. 2: 26, pl. 11, fig. 1–2 (excluding pl. 11, fig.3)4) (1960) *pro parte; synon. nov.*
Acrostichum latifolium sensu Baker, Fl. Maurit. & Seych.: 511 (1877) *non* Sw.
Acrostichum curtisii Baker in Ann. Bot. 5: 489 (1891). Type: Madagascar, *Curtis* 121 (K!).
Acrostichum borbonicum Baker in Ann. Sot. 5: 491 (1891). Type: Réunion (Bourbon), *Balfour* 27 (K!).
Elaphoglossum borbonicum (Baker) C.Chr., Ind. Fil.: 303 (1905).
Elaphoglossum curtisii (Baker) C.Chr., Ind. Fil.: 305 (1905); Dansk. Bot. Ark. 7: 165 (1932); Tard. in Humbert, Fl. Mad. 5^{e} Fam. 2: 36, pl. 11, fig. 5–6 (1960); *synon. nov.*
Elaphoglossum latifolium sensu C.Chr. in Trans. Linn. Soc., ser. 2, Bot. 7: 420 (1912), *non* (Sw.) J.Sm.
Elaphoglossum conforme sensu C.Chr. in Trans. Linn. Soc. ser. 2, Bot. 7: 420 (1912), sensu Tard. in Humbert, Fl. Mad. 5^{e} Fam. 2: 35 (1960) *pro parte, non* (Sw.) Schott.
Elaphoglossum angustatum sensu Tard. in Humbert, Fl. Mad. 5^{e} Fam. 2: 38, (including pl. 10, fig. 1–3) (1960) *pro parte, non* (Schrad.) Hieron.

Elaphoglossum lepervanchii (Fée) Moore is an extremely polymorphic species and there is evidence to suggest that this variability, as expressed primarily in size and shape of lamina and stipe: 1 lamina length, is to a large degree a function of age and response to environmental factors. *Elaphoglossum lepervanchii* and *E. didynameum* were both described concurrently under the genus *Acrostichum* by Fée (1845). It is accordingly decided to retain the epithet *lepervanchii* because Fée's type and description are most representative of the species as a whole.

The holotype specimen of *E. lepervanchii* (Réunion, *Lepervanche-Mézière* 1834, in herb. Bory) was not located at the Muséum National d'Histoire Naturelle, Paris in 1972, nor was it found during a further search in 1975 (Badré, pers, comm.). As a result, the specimen figured by Fée (op. cit.: 37, pl. 9, fig. 1) that is, Réunion *collector?* (Herb. Bory no. 27, 14 P) and bearing in his manuscript the annotation "Acrostichum lepervanchii, F. mém, sur les acrostich.

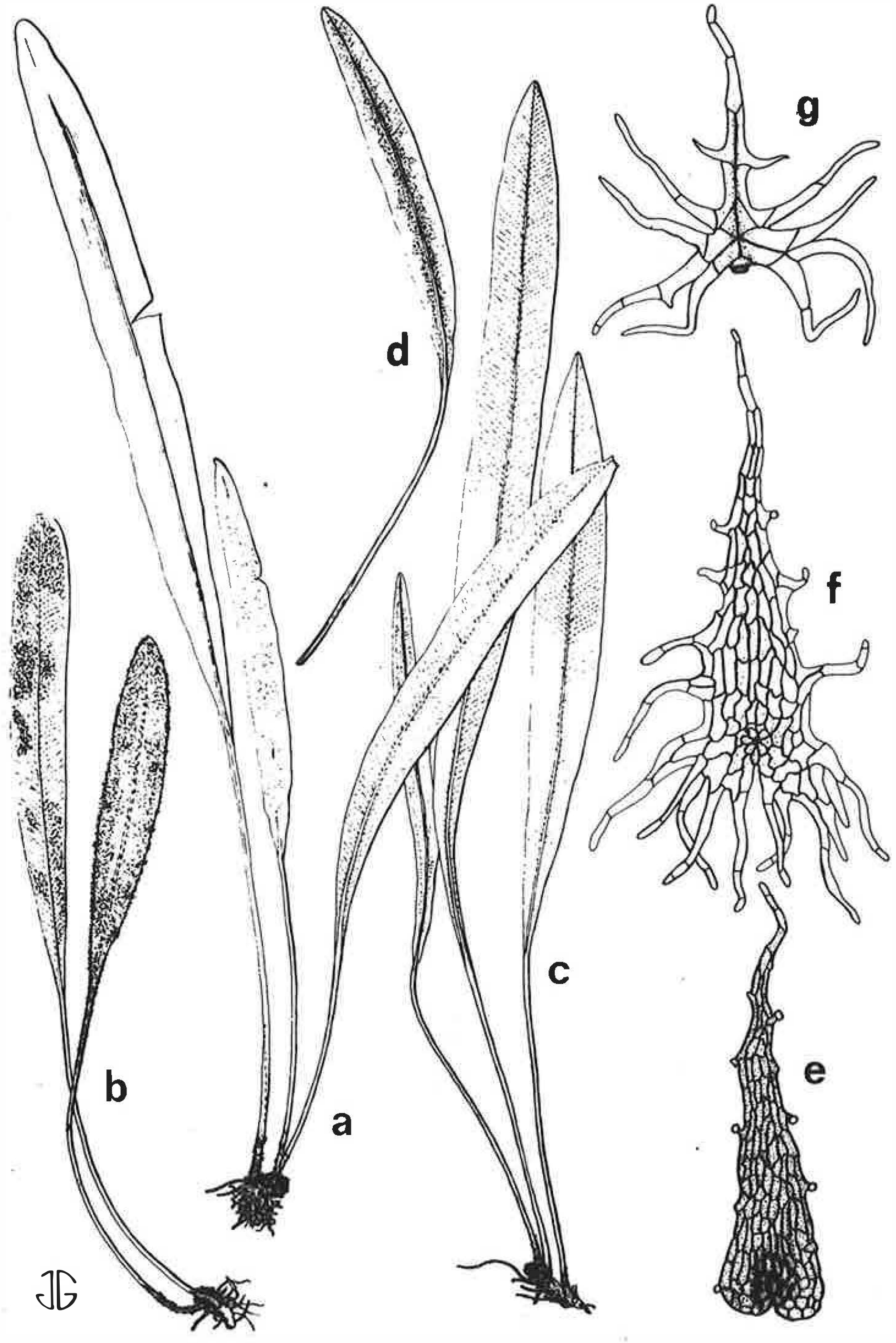

FIGURE 1: *Elaphoglossum lanatum* (*Bojer* s.n. "Bois Chéri", holotype): a, c, fertile plants; b, sterile plant showing densely scaly young fronds; d, fertile frond; scale from rhizome x 25; scale from stipe x 50; scale from sterile.

Tab. 9. C'est là le specimen lithographié dans l'ouvrage cité (signed) Fée", is hereby chosen as lectotype. This is in accordance with the International Code of Botanical Nomenclature (1966 ed.). The lectotype collection consists of two fertile fronds with attached rhizomes mounted to the left (not figured by Fée), and to the right is a plant bearing four clustered sterile fronds and one fertile (although Fée's illustration shows only two of the sterile fronds). The sterile lamina are elliptic to slightly ovate-elliptic, 9–13.5 x 3.5–4.5 cm, and borne on stipes 2.5–4.5 cm long. The fertile lamina is anguste-elliptic, 8 x 1.6 cm, on a stipe 8 cm long. The sterile lamina has free veins with thickened tips, revolute margins with a distinct brown and cartilaginous border, and the lower surface bears scattered tiny, brown, irregularly substellate scales with glandular-tipped cilia. Somewhat larger and darker scales, subulate with a stellate base, are scattered along the lower surface of the midrib. The fertile frond is much narrower than the sterile, and on a stipe two to three times as long.

The rhizome scales are pale brown to rufous, curling, ovate to linear, 2–5 x 0.5–1.5 mm, with often involute margins bearing more or less long and tortuous glandular-tipped cilia. The scale are composed of a network of thin-walled rectangular cells arranged in rows, often with transverse bands of shorter, squarrish cells. Similar scales are also present on the lower part of the stipe. The rhizome is 4–5 mm thick and bears two dorsal rows of fronds.

Suboptimal environmental conditions appear to cause arrested frond development in *E. lepervanchii.* Mascarene plants growing under more or less exposed conditions subject to repeated drying in *Philippia-Phylica* heath formations or in clearings, for example, are characterized by having fronds resembling those found on juvenile plants. The lamina is usually xeromorphic, elliptic to ovate-elliptic with obtuse apex and strongly decurrent base, margins somewhat inrolled, texture coriaceous, the stipes are short, 1/4 to 1/3 as long as the lamina and the rhizomes are short-creeping. The type of *Acrostichum ovalifolium* (Mauritius, *Bojer* s.n. (K)) is representative of this form.

Under growing conditions protected from drying, e.g. in moist, shady *Sideroxylon* formations, *E. lepervanchii* may attain a maximum frond size of 60 x 6 cm, the stipes being 1–1.5 times the laminar length, lamina elliptic to anguste-elliptic, apex acute to acuminate, base anguste-cuneate and decurrent as low ridges or lines along the upper 1/2 to 2/3 of the stipe, texture subcoriaceous, the rhizome moderately long-creeping with fronds up to 1 cm or more distant (Mauritius, *Lorence* in MAU 15826 (MAU, K, P, REU); Mauritius, *Vaughan* in MAU 12511 (MAU, K, P)). One of the author's collections (Mauritius, *Lorence* in MAU 15828 a-h (MAU)) consists of plants growing on a dry, exposed top of a tree stump (including a fertile individual with sterile fronds only 3–4 cm long), ranging to those rooting in moist humus in shade at the base of the stump (including plants with sterile fronds 28 cm long). This shows well how the plant's growth habit is influenced by the habitat. Transplant experiments were also carried out showing that these depauperate forms gradually progressed into robust mature plants.

Two other species subsequently described by Baker obviously only represent forms of *E. lepervanchii.* The type of *E. borbonicum* Baker (Bourbon (= Réunion), *Balfour* 27 (K)) is a juvenile plant of *E. lepervanchii* possessing rhomboid-ovate to rhomboid-elliptic obtuse fronds strongly decurrent at the base, stipes shorter than or equalling the lamina, and a short-creeping rhizome with clustered fronds. *E. lepervanchii* is often precociously fertile and individuals possessing sterile fronds only 4–6 cm long may produce fertile fronds, as seen in the type collection of *E. curtisii* Baker, upper right hand plant (Madagascar, *Curtis* 121 (K)). Larger plants on the same collection show increased stipe length (1–2 times laminar length) and larger, rhomboid-ovate to rhomboid-elliptic lamina. The fertile frond is narrower and on a stipe 1.5 times that of the sterile. Similarly, the type of *E. didynameum* (Fée) Moore (Réunion, *Lepervanche-Mézière* s.n., in Herb Bory 27, 13 (P)) as shown in Fée's illustration (op. cit.: 37, pl. 16, fig. 2) is a form exhibiting short stipes, narrowly elliptic sterile fronds with acuminate apex and attenuate, decurrent base. The fertile frond has a long stipe, 1.5–2 times that of the sterile, hence the specific name "didynameum".

As in *Elaphoglossum lepervanchii,* the types of *E. borbonicum, E. didynameum* and *E. curtisii* all possess lamina with free veins, bearing scattered tiny glandular-ciliate scales on the lower surface, and characteristic pale brown to rufous, soft, curling rhizome scales with glandular-tipped marginal cilia. When numerous specimens are examined all are seen to possess similar frond and rhizome scales, the differences in size and frond shape intergrade, and it becomes apparent that we are dealing with a single extremely polymorphic species.

In the Mascarenes, *E. lepervanchii* is allied to *E. sieberi* (Hook. & Grev.) Moore in Mauritius and to *E. macropodium* (Fée) Moore in Réunion. The latter two species are distinguishable by their veins which reunite into simple arcs or a commisure along the margin (the Aconiopteroid condition), their extremely thick and short-creeping rhizomes with large scales that are in *E. sieberi* dark brown, 1.0–1.5 cm long with filiform tips and more or less entire margins, and in *E. macropodium* yellowish-brown, 1–2 cm long with entire margins. *E. lepervanchii* also occurs in Madagascar and the Seychelles.

Material Studied

MADAGASCAR. Paralima, *Boiteau* 3006 & 3009 (P); vallée de la Mandraka, *Corréard* s.n. (P); district d'Ambatondrazaka, *Cours* 126 = ANK 100 (P); *Curtis* 121 (K-types of *Acrostichum curtisii*); forêt d'Ambohitantely, *Decary* 7476 (P); province de Mananjary, *Geay* 95 (P), ibid., *Geay* 8300 (P); *Hildebrandt* s.n. (K); central plateau, *Hodgkin & Stansfield* s.n. (K); massif de l'Andrangovalo, *Humbert* 17676 (P); massif de Anjanaharibe, *Humbert* 24657 (K, P); massif de Ankarata, *Humbert* 30265, 30266 (P); vallée du Mandraka, *Humbert* 20501 (P); massif de Marojejy, *Humbert* 22506 (P); montagne au nord de Mangindrano, *Humbert* 24930 (P, K); 25186 (P); forêt d'Analamazoutra, *Perrier de la Bâthie* 6128 (P, centre and right-hand collections), ibid., 6150 (P), ibid., 11914 (P); massif de Manongarivo, *Perrier de la Bâthie* 78608 & 7860E (P); Antananarivo, *Poole* 4/76 (K); Ambohimanza, Raharijaona 12 (P).

MAURITIUS. *coll.?,* in MAU 16927 (MAU); *Bojer* s.n. (K-type of *Acrostichum ovalifolium*); *Bojer* s.n. (K); *coll?* ex Herb. Dorfler 1137 (P, two sheets); Crown Land Declerc, *Julien* in MAU 13318 (MAU); Plaine Champagne/Chamarel road, *Julien* in MAU 14640 (MAU); Piton Grand Bassin, *Lorence* in MAU 14589 (MAU); Macabé/Brise Fer road, *Lorence* in MAU 14588 (MAU); Pétrin Nature Reserve, *Lorence* in MAU 14590 (MAU); ibid., *Lorence* in MAU 14600 (MAU); ibid., *Lorence* 18.3 in MAU 15812 (MAU, K, P, REU); ibid., *Lorence* 1.8 in MAU 15820 (MAU); ibid., *Lorence* 12.1 in MAU 15822 (MAU, K, P, REU); ibid., *Lorence* 2.1 in MAU 15826 (MAU, K, P, REU); ibid., *Lorence* 1.6 in MAU 15827 (MAU); ibid., *Lorence* 1.9 a-h in MAU 15828 (MAU); ibid., *Lorence* 2.8 in MAU 15829 (MAU, K, P, REU); Bassin Blanc, *Lorence* in MAU 14607 (MAU); ibid., *Lorence* in MAU 14610 (MAU); ibid., *Lorence* in MAU 14611 (MAU); ibid., *Lorence* 828 in MAU 16319 (MAU); Plaine Champagne/Chamarel road, *Lorence* in MAU 14722 (MAU); ibid., *Lorence* in MAU 15103 (MAU); ibid., *Lorence* 14.1 in MAU 15811 (MAU, K, P, REU); Black River Gorges, *Lorence* in MAU 14880 (MAU, K, P); Plaine Champagne, *Lorence* in MAU 15010 (MAU, K, P); ibid., *Lorence* 2.3 in MAU 15831 (MAU); Mare Longue Plateau, *Lorence* in MAU 15242 (MAU, REU); Pétrin/Macabé road, *Vaughan* in MAU 12551 (MAU, K, P); *Wallich* s.n. (K).

REUNION (BOURBON). Brûlé, *Bedier* 52 (P, right-hand specimen); *Boivin* s.n. (P, three sheets); *Collector?,* ex Herb. Bory 27, 13 (P); ibid., 27, 14 (P-lectotype of *E. lepervanchii*); Brûlé de St. Denis, *Cadet* 2950 (REU); Cilaos, *Coode* 4938 (K); *Frappier* s.n. (P);

Gaudichaud s.n. (P); *Gaudichaud* A.9 (P); *Lepervanche-Mézière* 1 (P); *Lepervanche-Mézière* & *Richard,* ex Herb. Bory 27, 14 (P); forêt de Béhour near Rivière des Marsouins, *Lorence* in MAU 15617 (MAU, two sheets); ibid., *Lorence* in MAU 15642 (MAU); ibid., *Lorence* in MAU 15643 (MAU, two sheets); *Potier* s.n. (P); *Schlieben* s.n. in MAU 12451 (MAU).

SEYCHELLES. Mahé, *Gardiner* s.n. (K); Silhouette, *Gardiner* x.8 (K); Mahé, Congo Rouge Mossy forest, *Guého* in MAU; Mahe, *Jeffrey* 451 (K).

THE LECTOTYPIFICATION OF ELAPHOGLOSSUM SIEBERI

Elaphoglossum sieberi (Hook. & Grev.) Moore, Ind. Fil.: 14 (1857); excluding C.Chr. in Dansk. Bot. Arkiv. 7: 165 (1932) and Tard. in Humbert, Fl. Mad. 5^{e} fam. 2: 34 (1960) as to Madagascan and Comoran plants.

> *Acrostichum sieberi* Hook. & Grev., Ic. Fil. 10: t. 237 (1830); Bojer, Hort. Maurit.: 413 (1837); Baker, Fl. Maurit. & Seych.: 511 (1877).
> Lectotype: Mauritius, *Bojer* s.n. "very near Acr. longif. from W. Indies Acr. Latifolium Sieber non Sw. Acr. Sieberi Ic. Fil. t. 237" (left-hand specimen, Herb. Hook. K!).
> *Olfersia sieberi* (Hook. & Grev.) Presl, Tent. Pter.: 235 (1836).
> *Acrostichum ellipticum* Fée, Mém. Fam. Foug. 2: 30, t. 4, fig. 2 (1845) (type not seen).

In their type description of *Acrostichum sieberi,* Hooker and Greville indicate both Sieber and Bojer as collectors for this species from Mauritius. According to the International Code of Botanical Nomenclature, 1966 ed., these constitute syntypes and a lectotype must be chosen from amongst them.

There is, in the Herbarium Hookerianum at Kew, a sheet bearing on the left hand side a detached sterile and fertile frond of *E. sieberi* without rhizome, annotated "Mauritius, Sieber". Although obviously not the plant illustrated in plate 237 of *Icones Filicum,* it is apparently the Sieber specimen cited by Hooker and Greville in their text, thus representing one of the syntypes. Mounted adjacently to the right is a plant with rhizome and one fertile frond and one sterile frond collected in Mauritius by Telfair; this also does not correspond to plate 237.

Also to be found in Herb. Hook. is a Bojer sheet with two collections, the left hand one of which consists of a plant with a sterile and a fertile frond exhibiting their abaxial surfaces with attached rhizome and annotated "Mauritius, Bojer. very near Acr. longif. from W. Indies Acr. latifolium Sieber non Sw. Acr. Sieberi Ic. Fil. t. 237"; the specimen corresponds exactly with plate 237 in *Icones Fillicum.* On the right hand side of the same sheet is a large fertile lamina, with a portion of the attached stipe, which is not illustrated by Hooker and Greville. Consequently, the left hand Bojer collection obviously represents the most suitable choice for the lectotype of *Elaphoglossum sieberi* and it is hereby so designated.

Although there has been some confusion as to the actual distribution of the species, various authors having cited it from the Comoro Islands, Madagascar and Réunion Island, *Elaphoglossum sieberi* is apparently endemic to Mauritius. De Cordemoy (1895), in his Flore de l'île de la Réunion, wrongly applies the name *Acrostichum sieberi* Hook. & Grev. to what is actually *Elaphoglossum macropodium* (Fée) Moore, a rather common species on that island. Examination of specimens from Madagascar and the Comoro Islands cited by Madame Tardieu-Blot (1960) has revealed that they represent a different species characterized by having a thinner and longer-creeping rhizome bearing smaller, thinner and sparser scales than are found in *E. sieberi.* Finally, a Commerson specimen supposedly from Madagascar is apparently the result of a mixture in herbarium tickets, for he collected a number of specimens of *E. sieberi* in Mauritius, and the author has seen no recent authentic material from Madagascar.

In Mauritius, *E. sieberi* is one of the commonest species of the genus, generally occuring as an epiphyte on tree trunks from ground level to 10–12 metres high, but is also casually terrestrial on humus tussocks or mossy rocks, usually in the shade of *Philippia* heath, *Sideroxylon* or climax formations ranging from 200 to 900 metres altitude.

ACKNOWLEDGEMENTS

The author would like to express his thanks to the Directors and Curators of the herbaria at the Royal Botanic Gardens, Kew, the Muséum National d'Histoire Naturelle, Paris and the Centre d'Enseignment Supérieur Scientifique, Réunion for the loan of specimens.

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REVIEWS

FERN GROWERS MANUAL by Barbara Joe Hoshizaki, 1975. Alfred A. Knopf, New York. 256 pages, 285 x 220 mm. (10¼ x 8¾ ins). 315 photographs and drawings. Price US $15.00.

The author, a member of our Society, is Professor of Botany at Los Angeles City College, Curator of Pteridophyta at the University of California in Los Angeles, and President of the Los Angeles International Fern Society. She has done much field work on ferns in the Western Hemisphere but in addition to being a well-known botanist she is a keen and knowledgeable grower of ferns and this book is intended as a handbook or reference book for anyone cultivating these plants. It is, of course, aimed at the American grower but we in this country can profitably study its pages and learn a lot.

The introductory chapters give general information on ferns, their structure, how to obtain them by collecting or purchase, and how to grow them, with information on planting and cultural needs, soils and fertilisers, propagation from spores and vegetatively, and also how to deal with pests, disease and poor culture. There is a chapter on landscaping with ferns with lists of the best ones for particular uses, another dealing with the growing of special ferns indoors, in glass terrariums and out of doors, and an interesting one on how ferns get their names.

A long chapter taking about half the book (116 pages) deals with the species and many of their varieties, as well as fern allies, in cultivation in the United States. There is an imposing list, all described and illustrated, each with concise tabloid information on height, form, temperature requirements, light needed, soil, watering, easy or difficult to grow, and evergreen or deciduous. A tremendous amount of work has gone into compiling this information and as so many of the ferns mentioned are grown in this country the book will prove most valuable to the grower over here as well as in the United States. At the end is a glossary, instructions on how to measure light, a list of fern societies and nurseries, where to get special information, a bibliography, and for the botanically inclined a classification of ferns and fern allies. The abundance of drawings and black and white photographs are all excellent, clear and informative, and 8 pages of coloured plates are beautifully produced.

Altogether the book is a magnificent one excellently produced and finished. The author is an expert in her subject and is to be highly complimented on a production which I am greatly delighted to place on my fern bookshelves where it most certainly will not be left in repose to gather dust. At the present rate of exchange the cost is about £7.50 in this country, very cheap for a book of this calibre.

J.W. DYCE

ENUMERATIO PTERIDOPHYTARUM JAPONICARUM: FILICALES by Toshiyuki Nakaike. xiii + 375 pp. 10.5 x 7.5 ins. (263 x 186 mm). University of Tokyo Press, March 1975. Price 8000 Yen.

"Enumeratio" is the clue to this book (in English) by "a fern lover", one of whose wishes "has been to observe and to collect all the (about 800 taxa of) Japanese pteridophytes in the field", thereby needing to "arrange information on each taxon . . . [including] subspecies, variety, form and monstrosity", and to produce a "System of Filicales . . . newly proposed here". Genera are indexed under their botanical (Latin) names. Species are not indexed, except under their vernacular Japanese (transliterated to Latin alphabet) names, but they appear alphabetically in the text under their genera. One purpose the book claims is to "clarify taxonomic status", but the only diagnostic statement is the "System" where the family names form a sequence from Osmundaceae to Azollaceae; but groups and genera are alphabetical and there are no keys. Each entry adds synonyms, the Japanese name and the distribution (Japanese island and world countries). Apart from basionyms being given first, synonyms seem to be cited randomly date-wise and alphabet-wise.

There are many new nomenclatural combinations (un-indexed), mostly at infraspecific level and often to "monstr.". His *Lunathyrium lasiopteris* (p. 175) ante-dates that of Sledge (Gazette 11: 84) but Ching's *Nothoperanema* (Act. Phytotax. Sin. 11: 25) ante-dates his (p. 239).

The main value of the book is as an index to places of publication and to treatments in other works. It is a pity that entries for these other works are not complete and that they could not have been quoted in some shortened code system.

The author must have spent a considerable part of his "several years" in making this compilation which serves a valuable purpose in providing a multitude of references.

J.A. CRABBE

STUDYING FERNS IN THE CAMEROONS. I. THE LAVA FERNS AND THEIR OCCURRENCE ON CAMEROON MOUNTAIN

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ABSTRACT

The author gives an account of lava ferns and their occurrence on Cameroon Mt, with particular reference to the lava flows above Mapanja, at Bibundi, and near Ekona. The conspicuous prevalence of the pumice-fern, *Nephrolepis pumicicola* Ballard, is stressed and elucidated.

INTRODUCTION

The re-establishment of plant growth exterminated by volcanic activity has been the subject for scientific research since the well known Krakatau catastrophe in August 1883, the vegetation of which island had been devastated by volcanic cinders piled up to 60 m in places. It was scarcely three years after this explosion that a new vegetation had reappeared consisting almost entirely of ferns: eleven species were collected by Treub in the interior of the island. In the course of the following 47 years no fewer than 61 species of ferns and fern-allies could be observed (Leeuwen 1936: 323–345), mostly coming by abundant spore-dissemination from the neighbouring islands of Sumatra (at a distance of 37 km in the NNE) and Java (41 km in the E). A thin film of cyanophyceae completely covering the cinders provided the substrate for germination of the fern spores. A similar process might once have taken place in Juan Fernandez and in Ascension. According to Schimper (1898: 201) ferns belonged to the first colonizers of the lava also on the Mt Goentoer in West Java (Pijl 1938: 141).

> "Après qu'une île — ou une partie d'un continent — a été ravagée par une éruption et recouverte de matières volcaniques, les Cryptogames vasculaires — et notamment les Fougères — jouent encore atuellement par exception un rôle qui leur revenait très souvent dans les périodes lointaines où ils avaient la prédominance sur la surface terrestre" (Treub 1888: 223).

OBSERVATIONS IN AFRICA AND THE CAMEROONS

In Africa, Robyns (1932: 14, 28) was the first to study the repopulation of volcanic deposits 14 years after the 1912 eruption of the Rumoka volcano (Kateruzi) — one of the adventive craters of the Nyamuragira (or Nyamlagira) volcano (3056 m), belonging to the Virunga mountain group N of the Kivu lake. Besides 22 species of phanerogams only 4 fern species were recorded by him. but when Lebrun examined the flora and vegetation of the same region in 1937–1938, he mentioned 15 fern taxa, i.e. 20.5% of the various vascular plants, growing in lava crevices: "Les Ptéridophytes jouent un rôle fort important et très actif dans la colonisation des fentes, fissures et crevasses" (1960 288). The total number of pteridophytes all over the lava fields explored by Lebrun was 33.

Like him Léonard (1959: 250–258) ascertained the "classic" process of colonization on various lava streams (emitted between 1912 and 1956) of the Nyamuragira volcano. At the beginning lichens only established, together with some mosses. Ferns then followed before higher plants appeared, thanks to the moisture-retentive capacity of the cryptogamic pioneers. This scheme of plant succession could vary according to conditions of environment, but the ferns always ranked among the first plants in lava field colonization due to their modest ecological requirements and their physiological adaptability to poor soils. Among them *Nephrolepis biserrata* (Swartz) Schott — replaced by *N. exaltata* (L.) Schott in Hawaiian volcanoes, or by *N. abrupta* (Bory) Mett. in Grand Comoro Island — prevailed; it was accompanied by *Pteris vittata* L., *Phymatosorus scolopendria* (N.L. Burm.) Pic. Ser., *Arthropteris orientalis* (J.F. Gmelin) Posth. and *A. monocarpa* (Cordemoy) C.Chr., *Pellaea calomelanos* (Swartz) Link and *P. schweinfurthii* (Hieron.) Diels, *Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf., and *Psilotum nudum* (L.) Beauv.

Concerning the speed at which lava flow colonization takes place, Guillaume (1966) in his brief description of Cameroon Mountain remarked: "The 1959 lava already carries some plant life in the form of ferns, small creeping plants, mosses and lichens. This is all the more remarkable when one realises that, last year, parts of this flow were still warm and steamed during the rainy season".

The first historic outbreak of Cameroon Mountain, the only active volcano in West Africa, is presumed to have occured between 1800 and 1815 (Gèze 1943: 156). In the course of this eruption lava broke forth from a small subsidiary cone, called "Black Crater", streaming in SSE direction towards Mapanja, a Bakweri village famous for Mann's first ascent of the mountain in December 1861. (Gustav Mann was a German botanist of repute, in the service of the British Government). Burton (1862: 242) who described this ascent gives a vivid picture of the scenery: "Bush and forest suddenly ceased as if felled with the axe . . . Nothing met the eye but a broad green slope of small moss and larger fern, all of it the *F. nephrolapis* (sic), based upon a rugged bed of old and degraded lava." In February 1861 G. Mann had collected some of these plants (no 1396, K) not very tall at that time. On 16 February 1895 Preuss — no 1373. *Nephrolepis cordifolia* (L.) Presl (B) — met with the same fern in the same place: "Im Urwald nordwestlich von Mapanja, in größter Menge, aber nur an einer Stelle, darunter Baumchen von *Ericinella mannii,* sonst fast keine Bäume".

We searched for that place on 10 February 1975, and on the track from Mapanja (770 m above sea-level) to Mann's Spring* we met with a lava flow at an altitude of 1430 to 1460 m. Surrounded by dense forest it represents a unique area of *Nephrolepis pumicicola* Ballard (fig. 1), up to 1.31 m in frond length. Of course since 1895 some trees, such as the Ericaceous *Agauria salicifolia* Hooker f. and the Liliaceous *Dracaena fragrans* Ker-Gawler, in part bearded with lichens, as well as some flowering shrubs (e.g. *Begonia poculifera* Hooker f., det. F.N. Hepper) have been interspersed. But in vain did we look for an additional fern growing on the lava surface! The rain forest having advanced more and more from both sides into the decomposed lava, scanty specimens of the pumice-fern are now growing in the forest itself; we even observed it as an "ephemeral" epiphyte on a *Ficus.*

Some more lava ferns may be seen between Isobi (just one house in ruins left!) and the village of Bibundi, on a lava produced from the Waldau—craters over a period of six months amidst the forest belt on the SW flank (1365 m, Gèze 1943: 139). Gèze (1943) stated: "Sur les coulées de laves récentes (coulées de 1922) qui ont coupé la prairie alpine et la forêt, il s'est établi une florule très spéciale comportant deux *Senecio* dont *S. cf. ruwenzoricus,* des *Plectranthus* et *Nephrolepis serrata*" (p. 74), and: "Coulées actuelles (1909 et 1922), commençant seulement à se recouvrir d'une flore spéciale dans la zone d'altération active proche de la mer" (p. 154). The volcanic activity of 1922 began on 3 February near the centre of the mountain, the later Mateer Cone (3540 m), the lava of which did not reach the forest; it was followed by

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* Richards had discovered here *Xiphopteris flabelliformis* (Poiret) Schelpe "on bare lava". *Asplenium adiantum-nigrum* L. had been collected by Mann "on lava fields" (no 1373, K) and by Brenan "on sides of crater near Mann's Spring" (no 4244; BM, K).

FIGURE 1: *Nephrolepis pumicicola,* growing on the lave flow above Mapanja, 1430 m. *(Photo G. Benl).*

eruptions of the later Waldau—craters beginning on 21 February. Maitland had made gatherings of the pumice-fern from the inside wall of one of the 1922 craters at 1320 m (no 1091, K) and, in 1930, even from an old lava flow of the Robert Meyer—craters at an elevation of 2280 m (no 961, K). In August 1922 the flow had finally reached the sea by three partial streams (Semmelhack 1929). Later, various plants were collected there by Mildbread in 1928, by Rosevear in 1936 and 1937, and by Keay in 1951; among these plants eight species of ferns were represented according to Keay (1959: 27): *"Arthropteris cameroonensis, Microgramma owariensis, Microsorium punctatum, Nephrolepis biserrata, N. pumicicola, N. undulata, Pityrogramma calomelanos, Phymatodes scolopendria".*

On 3 February 1975 we entered the southernmost lava tongue, not easily accessible from the coast, and then advanced towards the mountain after crossing the motor road Victoria-Idenau (about 30 m above sea-level). Immediately at the shore the black pahoehoe lava is still kept free from vegetation by the surf (fig. 2). A few metres behind it the decomposition of the basalt lava has proceeded (due to the amply moist conditions caused by the water-laden sea winds and to a uniformly high temperature*) to such an extent that, within a tropical rain forest climate, an almost impenetrable jungle has re-appeared, containing characteristic secondary forest species,

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* "The weathering potency of the water increases 4- or 6-fold with an increase in temperature from 10^{o} to 25 or 30^{o}" (Mohr & v. Baren 1954: 349).

some of which, like *Alstonia boonei* De Wildeman and some *Ficus* species, have already reached heights of 8 to 10 m here. Amongst the ferns, *Nephrolepis biserrata* predominates at the lava base between the coast and the road. The two shade-loving *Asplenium barteri* Hooker and *A. vagans* Baker were not only found growing as epiphytes on *Ficus* buttresses — beside small specimens of *Asplenium dregeanum* Kunze — but also as terrestrial plants, after having fallen from their trees. *Phymatosorus scolopendria* with its slightly fleshy fronds occurs as an epi- and geophyte, as is usual in secondary evergreen forests. Only towards the western road border, where vegetation becomes sparser, may small specimens of *Arthropteris cameroonensis* Alston with their crenate pinnae be seen in limited quantity.

East of the road (1 km from the coast) where the lava is less weathered because of decrease in humidity, there are no tall trees, only bushes. But in this lighter ground *A. cameroonensis* increases considerably in numbers and size (above 80 cm). In addition we observed (at 40 m altitude) *Phymatosorus scolopendria,* rather less numerous *Nephrolepis biserrata,* and *Pityrogramma calomelanos* (L.) Link, as well as some meagre examples of scattered *Asplenium barteri* and of *Microsorium punctatum* (L.) Copel., both growing terrestrially. At 50 m elevation *Microgramma owariensis* (Desv.) Alston [*M. lycopodioides* (L.) Copel.] with dimorphic fronds and the sparingly occurring *Nephrolepis undulata* (Afz. ex Swartz) J.Sm. joined them, the latter as a geophyte, too, its leaves not being adapted to stand a hot dry season. At 60 m, a few individuals of scanty *Pteris atrovirens* Willd. appeared and then the expected *Nephrolepis pumicicola* cropped up in abundance. *Pteris manniana* Mett. ex Kuhn had been collected in this region by Mildbraed (no 10657, B; "häufig in Bachbetten auf Lava"). In other places of this field the pumice-fern descends to 45 m or lower. According to our present knowledge its general occurrence is restricted to the South West Province of Cameroon* and to the Guinea Islands of Fernando Póo and São Tomé, almost exclusively on lava flows.

A real attraction is the lava bed emitted in February 1959 from two subsidiary vents of the multipartite Cameroon volcano into dense forest on its NE slope, at 1100 m above the Ekona-Lisoka area. The process of this eruption was described in an interesting day-to-day record by Hasselo & Swarbrick (1960). The lava had flowed partly over previous volcanic deposits, partly it had burnt a new track through the forest.

We went to see this stream of lava (fig. 3) — the natives appropriately call such a stream "fire-born" — leaving the Victoria-Kumba highway at Ekona Mbenge (395 m) and continuing our journey on the road to Lisoka. After a drive of 3.5 km we faced the tip of a lava tongue towering up to a front height of 6 to 10 metres into a banana plantation. In September 1959, Swarbrick had taken photographs of a small specimen of an unrecognizable fern in this spot; now, on 17 and 19 February 1975, we saw, in the same spot, the virtually pantropical *Pityrogramma calomelanos,* having many xerophytic features and "appearing everywhere in newly cleared ground" (Holttum 1966: 594), *Phymatosorus scolopendria,* usually preferring slightly shaded places, and *Nephrolepis biserrata* usually in more or less sunny positions. Nearby, in open shade, were luxuriant specimens of *Microsorium punctatum.* All representatives bore fertile fronds.

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* The collection of Deistel (Bot. Mus. Berlin) comprises some specimens of this fern gathered by him on 3 March 1900 (no 611) in the top region of the mountain (3700 m): "einfallende Felsspalten, aus denen warme Wasserdämpfe aufsteigen, die sich beständig zu Tropfen an den Rändern dieser Felsspalten verdichten. Diese Ränder sind überzogen mit Moosen 605, 606. Dazwischen dieser Farn mit Sporen. Wedel dunkelgrün. Nur an diesen tiefen, engen senkrechten Felsspalten der höchsten Spitzen, die beständig solch warmen Wasserdampf ausströmen".

FIGURE 2: Front of the lava flow 1922 near Bibundi. Behind the margin being swept by the surf the re-establishment of the rain forest quickly advances.

FIGURE 3: Lava flow of 1959 above Ekona (400 m) showing its colonization by ferns. *(Photos G. Benl).*

Higher up, the arid surface of the "fire-born" is heavily broken, thus looking like a big coke bed, and the scoriaceous masses are piled high above the level of the surrounding land (Hasselo 1961: 19). About 7 m behind the lava front, *Nephrolepis pumicicola* begins to spread (fig. 4), sprouting from crevices, with a vertical rhizome up to 10 cm in length, and a rather extensive root system. We counted roughly 60 plants within an area of four square metres, each with 2–7 fronds, the larger ones with sori. At 410 m altitude we counted 15 distinct patches of this charming fern. Its usual companion, *Arthropteris cameroonensis,* is very sparse here, but it increases in number at higher altitude: at 430 m we counted 17 plants (maximum frond length of 60 cm) within two square metres, though all sterile.

In altitudes above 430 m, one is surprised to find the epiphyte *Platycerium stemaria* (Beauv.) Desv., the elk's-horn fern, growing amidst specific lava ferns, pressing its pergamentaceous sterile leaves closely to lava blocks (fig. 5). But it is known that epiphytic ferns and orchids, forming the principal part of the epiphytic flora in Africa, can become established on lava (Schimper 1898: 202). The inconspicuous *Pyrrosia mechowii* (Brause & Hieron.) Alston, another representative of the Polypodiaceae, is more or less hidden in cracks of fractured lava and on the lower side of projecting rocks. In the hot dry season its fronds are reflexed upward against desiccation, showing only their scaly lower sides. At about 432 m altitude fern growth on the *Ekona lava flow* reaches an optimum, with *Nephrolepis pumicicola* dominating the whole vegetation. At about 500 m another specimen of the leathery-leaved *Microsorium punctatum* was found, showing again, that random distribution plays an important part in the beginning of the re-establishment of plant vegetation.

Among the orchids already established here, and flowering at the time of our excursions, *Bulbophyllum lupulinum* Lindley and *Polystachya dolichophylla* Schlechter (det. Dr. P.J. Cribb) might be regarded as the most remarkable ones. As far as we know, the flora of this lava field has not yet been studied.

DISCUSSION

Let us return to the ferns and compare the respective situations on the lava fields above Mapanja and above Ekona. In both cases the flow penetrated into an evergreen forest; one flow took place about 160 years ago, the other 16 years ago. On the younger flow we recorded eight species of ferns. It might be possible to find still more in the wet season. The considerably older lava (by no means "unrecognizable in the general forest growth", as alleged by Boughey 1955: 147, who did not visit the slopes to the sea-shore in person) bears a single species, as notified by Burton 115 years ago.

There is one plausible interpretation of this seeming discrepancy. As may be inferred from the horizontal position of its numerous pinnules (we counted up to 175 pairs!), *Nephrolepis pumicicola* is a fern demanding much light. Growing plentifully into a bushy plant with stiff vertical fronds more than one metre tall (the longest was 131 cm, above Mapanja), this species produces dense swards in which any other competitor will succumb in the struggle for light.

Doubtless, because of its lesser frond length the pumice-fern will initially be exceeded by *N. biserrata;* but in the long run the latter plant, thriving essentially in the shade and frequently forming a dense vegetation in light forests, will be overcome in this open lava habitat. A similar picture is probably also true for the epiphytic *Platycerium stemaria* and *Microsorium punctatum,* which certainly originate from the adjacent rain forest, where they normally occupy the sunnier and drier sections of emergent trees. (The immediate origin of *N. pumicicola* remains a puzzle!)

The leathery-leaved *Arthropteris cameroonensis* ought to be equal to the ecological conditions of a barren and widely unshaded lava bed; but it will be excluded

FIGURE 4: Prime colonizer in this lava ground is the pumice-fern, *Nephrolepis pumicicola. (Photo G. Benl).*

FIGURE 5: *Platycerium stemaria* establishing on the lava flow of 1959. *(Photo G. Benl).*

by an intense competition with the preponderant *Nephrolepis pumicicola,* the latter being superior in frond length and in its denser bushy growth. The same goes for *Pityrogramma calomelanos,* a fern which usually forms the dominant vegetation in exposed areas. Without human interference the distinct young colonies of the pumice-fern on the 1959 flow may be united to a single large population within less than 50 years. This opinion is justified by the facts stated in the Mapanja area as well as by our corresponding observations in the Southern Uplands of Fernando Po where vast lava flows of prehistoric ages are densely colonized and exclusively occupied by the pumice-fern, the immense masses of which are just sporadically intermingled with some specimens of *Arthropteris cameroonensis* (Benl 1975: 29). The lower temperature and a lower precipitation in the Moka Highland had retarded the decomposition of the lava so that apparently no woody plant could have become established before our fern had completely taken possession of the flow. The necessary moisture will be guaranteed in the dry season by patches of thick moss layers retaining the nightly dew. The populations of *N. pumicicola* there show about the same luxurious growth as the vigorous colony above Mapanja.

If we keep an eye on the fact that primarily the pumice-fern is a light-demanding geophyte, we realize why on the 1922 lava this fern is only seen now in the more open parts providing a larger amount of light.

We looked in vain for the lava from the 1909 outbreak of the Okoli—craters (side vents on the NE flank of the mountain, at 2400 m altitude). This stream is said to have stopped just short of the "road from Muyuka to Ikata between mile 4 and mile 5" (Guillaume 1966: 4), but in that place we only observed a scanty "farm" of coco-yams and bananas among old lava blocks; unfortunately we failed in penetrating to the area above Mokona-Likoko.

The 1954 discharges of Cameroon Mt were caused by a summit cone; there was no flow of lava.

ACKNOWLEDGEMENTS

A lot of people assisted me in my Cameroon fieldwork in December 1970/January 1971, in February/March 1974 and January/March 1975. Among others I am very grateful to Mr James K. Wilkie (Estate Manager, Idenau), M. E.-A. Essono (Chief of Dept. Waters, Forests and Wild Life, Fako Division), Mr R.M. Ngute (Executive Secretary, Mbonge). Most of all I am indebted to Mr N. St. Ekema (Herbarium Assistant, Victoria), my constant helpful companion in February 1975.

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REVIEWS

HYBRIDIZATION AND THE FLORA OF THE BRITISH ISLES by C.A. Stace (Ed.). 626 pp., 9 x 6 ins. (230 x 155 mm.). London, New York, San Francisco: Academic Press and Botanical Society of the British Isles. 25 July 1975. Price £14.80.

Here is not only a magnificent essay (pp. 1—90) on hybrids and hybridization, backed up by over 300 literature references, but also 488 pages wherein 86 specialists enumerate and elaborate on the hybrid vascular plants of Britain, together with exotic examples which are relevant because of their parentage. Non-vascular plants are not given, though "much needed", because of "relative lack of information" and "the rather different principles which can be applied to them". The title says "Flora" which is either a titling result or it links us with CTW; I would prefer it as "flora".

One becomes increasingly aware how many species are of hybrid origin so that on the one hand it seems an almost unending task to try to unscramble the biology, while on the other hand such knowledge helps immensely to comprehend many seemingly illogical phenomena.

Pteridophytes are treated in the following genera: *Asplenium, Ceterach, Cystopteris, Dryopteris, Equisetum, Gymnocarpium, Hymenophyllum, Phyllitis, Polypodium, Polystichum, Pteridium, Woodsia.*

J.A. CRABBE

BRITISH BOTANICAL AND HORTICULTURAL LITERATURE BEFORE 1800, COMPRISING A HISTORY AND BIBLIOGRAPHY OF BOTANICAL AND HORTICULTURAL BOOKS PRINTED IN ENGLAND, SCOTLAND, AND IRELAND FROM THE EARLIEST TIMES UNTIL 1800 by Blanche Henrey. 1128 pp, 32 col. pls, 162 pp. of b & w illustr., 10.9 x 7.3 ins. (275 x 185 mm). Oxford University Press, 4 December 1975. Price £70.

This magnificent work, three volumes weighing eleven pounds in a slipcase, is the result of innumerable diggings and delvings over many years into this huge spectrum. All kinds of printed and manuscript records have been sought, all aspects of horticulture and its personalities have been considered, and the bibliographies contain more than 1500 entries. The three volumes comprise: I 16th and 17th centuries, II and III 18th century. James Bolton's Filices Britannicae is the only British fern book before 1800 and we are given reproductions of his pictures of *Adiantum capillus-veneris, Asplenium ruta-muraria* and *Polystichum lonchitis.* Petiver's Pterigraphia Americana is included, with a reproduction of the 16 woodcuts on Table III.

If, like me, you feel you will not afford to buy this book, every effort should be made to make it available at libraries.

J.A. CRABBE

THE POSITION OF THE MEGAPROTHALLUS OF SALVINIA NATANS

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ABSTRACT

The archegonia of the megaprothalli of *Salvinia natans* (L.) All. are, not as previously reported, directed upwards but are submerged in water and directed downwards; it is usual in the ferns that the archegonia are on the lower surface of the prothallus. The flat, usually archegonium-free part of the megaprothallus lies above the surface of the water. It looks like a small floating leaf and maintains a stable position. The earlier described twisting of the young sporophyte during the development of the scutellum was not observed.

INTRODUCTION

Particularly during the second half of the last century *Salvinia* was the object of many investigations; most work was concerned with its alternation of generations (Hofmeister 1851, Pringsheim 1863, Prantl 1879, Belájeff 1898); later studies on the gametophyte have been made by Arnoldi (1910), Yasui (1911) and Lasser (1924). The majority of modern textbooks (for example Eames 1936, Sculthorpe 1967, Bierhorst 1971, Mägdefrau 1971) are based on the results of Pringsheim (1863) and particularly on the detailed account of Lasser (1924). My observations do not agree with these earlier accounts and are thus worth reporting.

MATERIAL

Material of *Salvinia natans* (L.) All. was collected in Autumn 1974, near Prarolo, Prov. Vercelli, N. Italy. During the winter, even in greenhouse cultivation at University of Zurich Botanic Garden plants became weak, but produced many sporocarps. In January and February 1975 many megaspores and microspores germinated.

OBSERVATIONS

Prantl (1879) reported that the archegonia may be directed upwards or downwards. However, Lasser (1924) said that the normal position is with the archegonia and bulge-like swelling of the megaprothallus directed upwards (figs. 1a-c). His explanations of the further development of the sporophyte are based on this statement (figs. 1d-f). I must agree with Prantl (1879) that the position is not always constant. However, nearly all megaprothalli had the flat, archegonium-free part upwards and the bulge and archegonia downwards (figs. 1g-i). The flat upper part is normally dry and lies slightly above the surface of the water (fig. 1i). Prothalli that are reversed (with the flat side downwards) have most of their tissue submerged and showed poor growth and most of them soon died. These prothalli were never seen to produce sporophytes. When the flat side is above the water surface the wings develop as soon as the embryo is formed. As soon as the scutellum has developed it becomes bouyant and floats while the rest of the megaprothallus becomes submerged in water (figs. 1j, k).

DISCUSSION

In my opinion there are several arguments which can be used to show the advantages of having the flat surface above the water. In the opinion of Lasser (1924) the flat part

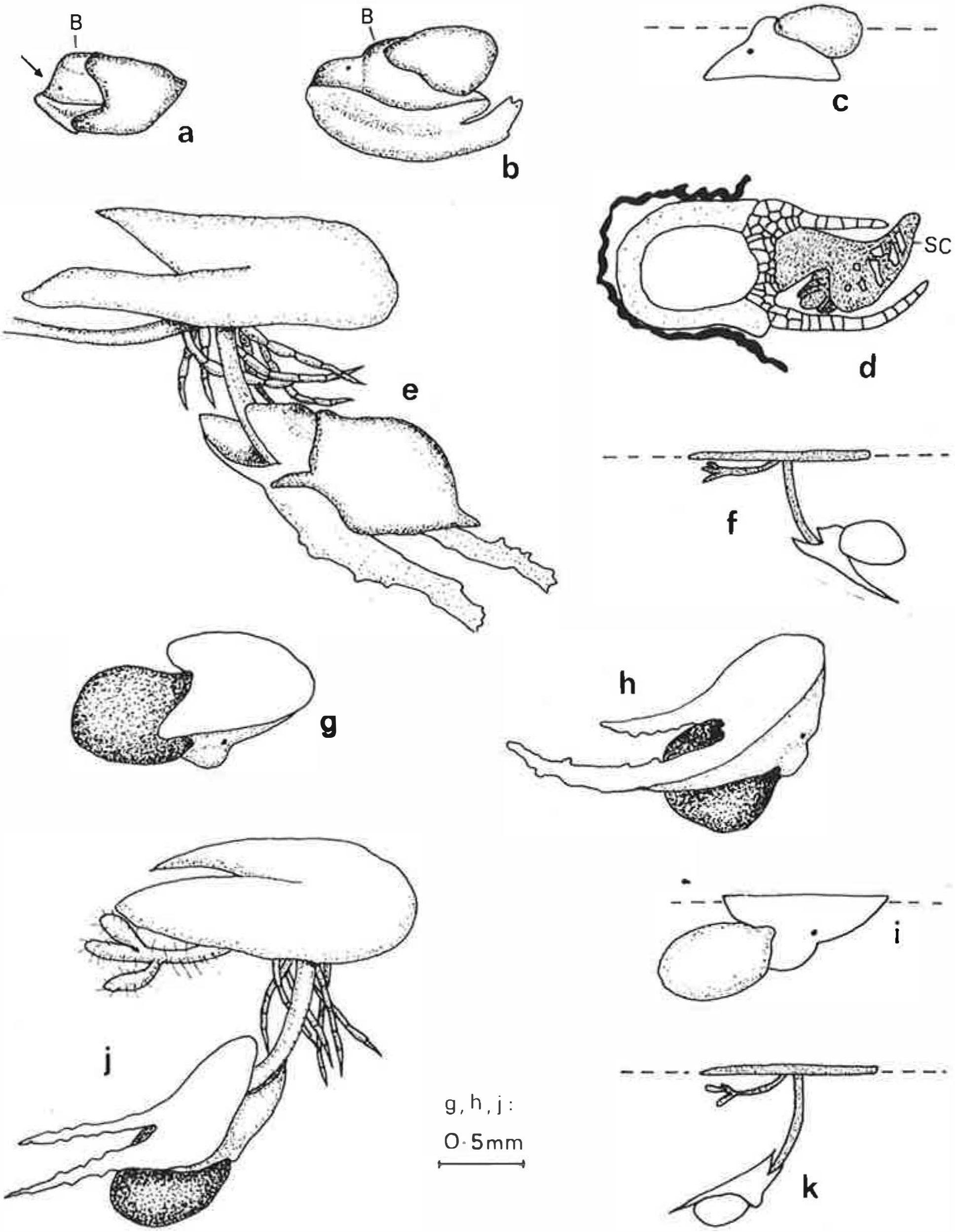

FIGURE 1: *Salvinia natans* (L.) All. (a-f after Lasser 1924, c, f, i, k schematic): a, young megaprothallus emerging from spore (arrow points to an archegonium, also bulge "B" is seen); b, megaprothallus of later stage with developing wings; c, position of megaprothallus in water (broken line indicates water surface); d, section of spore, prothallus and embryo with developing scutellum "SC"; e, gametophyte and sporophyte with well-developed scutellum; f, position of gametophyte and sporophyte in water; g, young megaprothallus of material in Zurich Botanic Garden (flat surface on the upper side); h, megaprothallus of later stage with well-developed wings; i, position of spore and prothallus in water as seen in culture; j, gametophyte and well-developed scutellum (first leaf of sporophyte) — no twisting of scutellum is observed; k, observed position of the gametophyte and the sporophyte in water.

of the gametophyte and its wings remain submerged (figs. 1a-c). If one accepts that the wings have a stabilizing function, then in the submerged state they are exposed to all currents and local turbulences and can hardly fulfill their function. If the flat part and the wings occupy the air-water interface with upper surface exposed to the air (figs. 1g-i), then the whole gametophyte is more stable. Also in this position the development of the sporophyte is not disturbed by changes in position.

The direct contact of the flat (upper) side with the air also allows for a constant exposure to light and presumably has a more effective gas exchange. Gametophytes that are left upside down have been observed to be very weak and die before the sporophyte develops; perhaps because of poor gas exchange.

Lasser (1924) described a twisting of the young sporophyte during the development of the scutellum (figs. 1d-f). When the flat side is uppermost this twisting is not necessary and was not observed (figs. 1j, k).

The floating megaprothallus can be compared to a small floating leaf or frond. From an ecological point of view it occupies the air-water interface with other free floating plants or leaves. From Lasser's description the prothalli are more likely to occupy a position below the inhabitants of the air-water surface and thus come into poor light conditions. The bulge-like swelling on the lower surface of the megaprothallus is surrounded by archegonia and could have a keel-like function.

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REVIEWS

FLORA OF TAIWAN VOLUME 1 PTERIDOPHYTA AND GYMNOSPERMAE. Edited by Hui-lin Li et al. 158 x 235 mm. 562 pp. Taipei, 1975. Price $ 18.00 US from Epoch Publ. Co. Ltd, P.O. Box 1642, Taipei, Taiwan.

This is the first of six volumes on the Taiwan flora, the whole, some 4,300 pages, scheduled to be completed in 1976. There is a readable account of the environmental background at the beginning of this volume. The bulk of the ferns and allies have been tackled by a well-known name in Taiwan pteridology, Prof. Charles E. De Vol; Drs Kuo Chen-meng and Shieh Wang-chueng have also contributed several families. Apart from the Chinese names for genus and species all data are in English. Keys and descriptions are clear and concise; full geographical distribution, both in Taiwan and the rest of the world is given as are relevant references in other regional floristic accounts. There are 169 very fine plates of line drawings of whole plants and close-ups of critical organs. Although I expect every major institute to get this series, this is not a book that everyone will buy but I can see pteridologists with teaching responsibilities wanting their own personal copy.

A.C. JERMY

CYTOGEOGRAPHIC STUDIES ON DRYOPTERIS OF JAPAN by Haruk Hirabayashi, 186 x 261 mm, 176 pp. Tokyo 1974. Harashobo Co. Ltd., 1-25-13 Shinjuku, Shinjuku-ku, Tokyo.

This well-produced little book is based upon a thesis submitted to Tokyo Educational University for the degree of DSc. A summary of the cytological work and chromosome numbers counted in some 62 species of *Dryopteris* in Japan is given: 36 are apogamous, mostly triploid, and 22 are diploid and sexual. Only 15 hybrids were detected and only 6 sexual tetraploids. One cannot help thinking that with 22 diploid species there should be more hybridization with the resulting allopolyploids, if the state of the genus in Europe and N. America is anything to go by. A chart is given showing relationships of the 15 hybrids with their putative parents but no analysis of meiosis is reported. There are 14 plates of photographs each with 6-8 pictures of on the whole, good, chromosome preparations, and the bulk of the work (80 plates) give detailed maps of the distribution of these species in Japan. The author has obviously looked at a great specimens; he has also shown what an enormous task it would be to tackle the biosystematics of Japanese *Dryopteris,* but what a challenge!

A.C. JERMY

A SCANNING ELECTRON MICROSCOPIC INVESTIGATION OF THE SPORES OF THE GENUS CYSTOPTERIS*

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ABSTRACT

An investigation of spore architecture of several species of the fern genus *Cystopteris* Bernh. using scanning electron microscopy was undertaken in order to determine possible taxonomic significance. Distinct morphological differences at the subgeneric and specific levels within the genus are reported. Five spore types are described including types which have not been described previously. Results indicate that spore ornamentation is useful in the taxonomy of the genus.

INTRODUCTION

With the development of the scanning electron microscope (SEM), a strong tool for the taxonomic study of spores has appeared. The limitations in resolution and depth of field of the light microscope have precluded thorough observations of the ultramicroscopic morphological structure of spores and thus, the fine detail of their structure has not been available for taxonomic use to the extent which is now present with the SEM. Works which rely heavily on the systematic use of scanning electron microscopy of fern spores are beginning to appear with increased frequency in the literature. Papers by Tryon (1971, 1972), Wilce (1972), Britton (1972), Crabbe, *et al.,* (1970), Brownsey and Jermy (1973) and Mickel (1974) have shown the potentialities of the SEM.

The present study is concerned with the examination of the spores of the genus *Cystopteris* Bernh. in order to determine possible taxonomic significance. The species studied are from a wide variety of geographic areas throughout the world and cut across species groups within the genus. *Cystopteris* is cosmopolitan in distribution although primarily restricted to temperate regions. According to the latest treatment by Blasdell (1963), the genus consists of ten species and six hybrids.

METHODS AND MATERIALS

Spores for this study were taken directly from herbarium sheets and transferred to double-faced Scotch tape, which had been mounted on standard ¾ inch aluminium SEM studs. These were coated *in vacuo* with vaporized carbon and gold using a Denton vacuum coater with a random rotating head. The random rotating head ensures even distribution of charge in the microscope. The specimens were then viewed on an AMR model 900 Scanning Electron Microscope, made available by the Department of Chemical and Metallurgical Engineering at the University of Tennessee, Knoxville.

The photos selected are representative spores from a larger sample of plant specimens examined and are not the result of the study of single spores or of single specimens. The actual size of the spores studied is in the range of 27–53 microns.

RESULTS

Until now, three basic spore types have been described in the genus (Blasdell, 1963). The echinate, or spiny, spore (fig. 1) is the most common type. Variations, such as

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* Contributions from the Botanical Laboratory of the University of Tennessee, Knoxville, N. Ser. *442.*

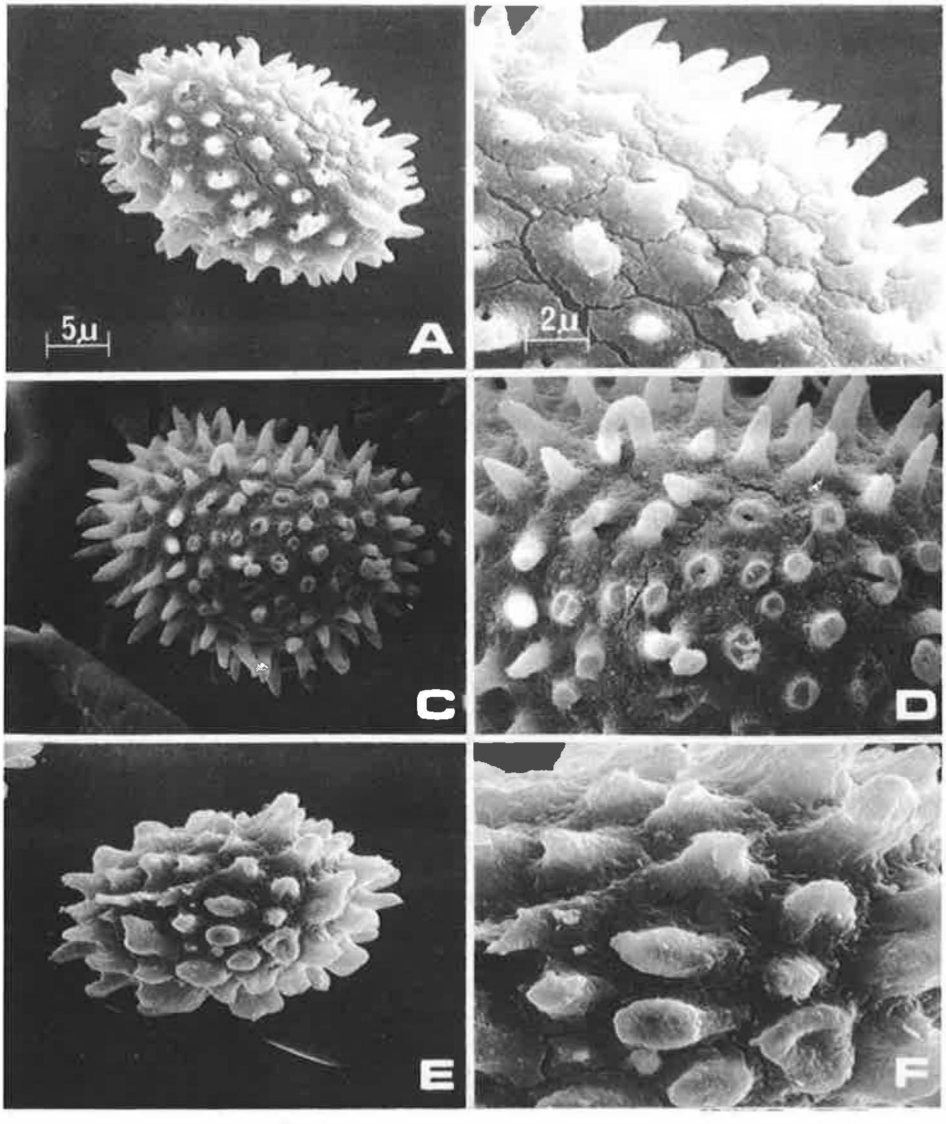

FIGURE 1: Echinate spore types: A-B, *C. protrusa,* Knoxville, Tenn., USA, Pearman 45282 (TENN); C-D, *C. tennesseensis,* Smith Co., Tenn., USA, Pearman 45290 (Type locality, TENN); E-F, *C. bulbifera,* Montgomery Co., Tenn., USA, Pearman 45284 (TENN).

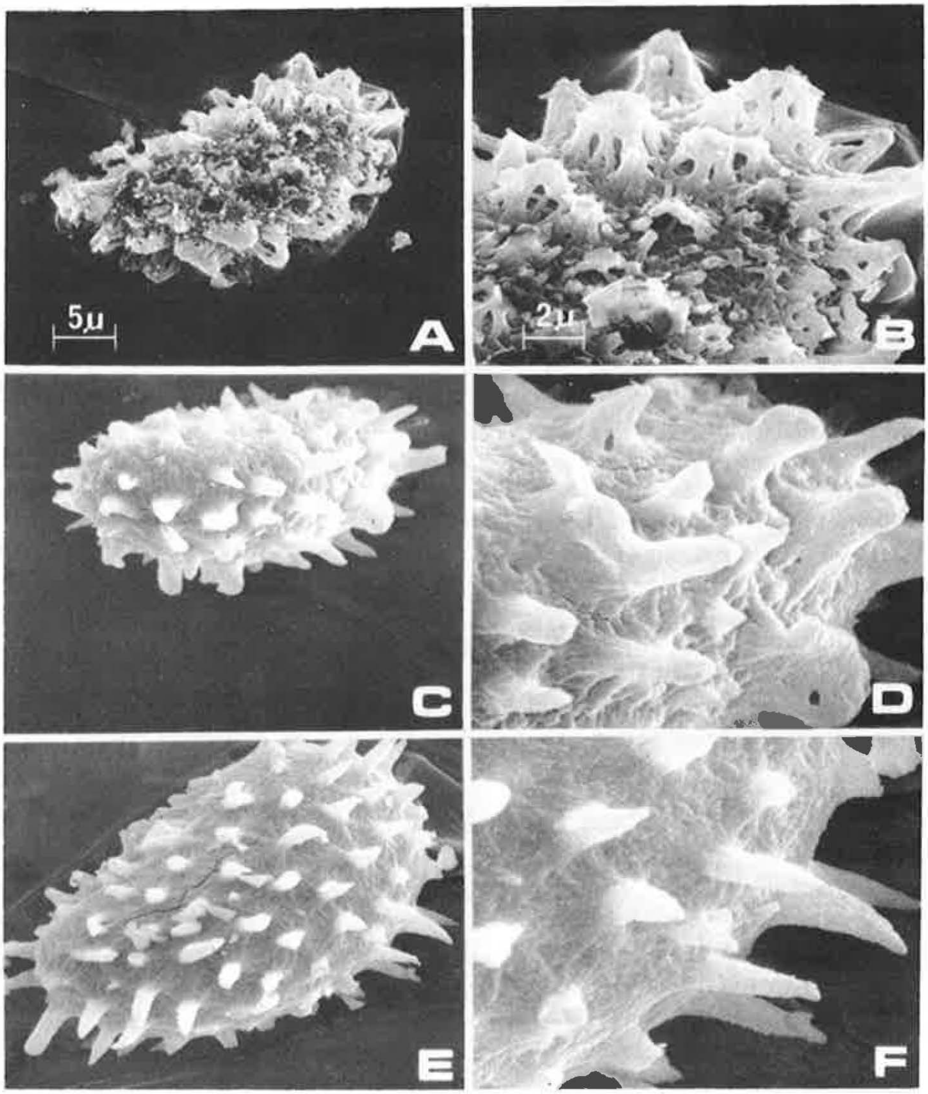

FIGURE 2: Conical-lacunar and echinate spore types: A-B, *C. montana,* Abisko, Lappland, Sweden, Samuelson 39 (NCU); C-D, *C. sudetica,* Silesia, Poland, Milde s.n. (US); E-F, *C. douglasii,* Hawaii, USA, Baldwin s.n. (US)

those with sharp spines (fig. 2, E—F), occur but the basic type is the same. The second type is the saccate or warty type (fig. 3) and is known from only two taxa within the genus. The third type, the rugose or wrinkled spore (fig. 4, E—F) is known from scattered populations of the *C. fragilis* aggregate. As a result of this study, two other types, which will be referred to as the spiny-lacunar type (fig. 5) and the conical-lacunar type (fig. 2, A—B) will be described.

The following are descriptions of the spores of the species included in this study.

Spiny Spores

Cystopteris protrusa (Weath.) Blasdell (fig. 1, A—B). The spores are the basic echinate type. The spines are relatively short and sharp and the surface of the spores has an irregular granular texture. These spores are relatively small in comparison to the other spores in the genus, averaging 27—32 microns.

Cystopteris bulbifera (L.) Bernh. (fig. 1, E—F). The spores are of the echinate type but the spines are extremely blunt and irregular as well as being larger than most echinate types, thus creating a spore type which is characteristic of only this species. The surface texture is rough and irregular.

Cystopteris tennesseensis Shaver (fig, 1, C—D). These spores were varied in morphology but in most cases they approached the spores of *C. protrusa* in appearance. However, in some specimens examined, the spores had the general appearance of *C. bulbifera.* The usual case was that the spores were intermediate between *C. protrusa* and *C. bulbifera.* The surface texture is almost always more granular than *C. protrusa* and not as irregular as *C. bulbifera.*

Cystopteris douglasii Hooker (fig 2, E—F). This species possessses echinate type spores with thin, sharp spines. They are of particular interest because they are the only spores having a very fine grainy surface around the base of the spines and even on the spines. This surface is quite different from the coarser and flatter granular texture found on the spores of *C. protrusa* and *C. tennesseensis.*

Cystopteris sudetica A. Br. et Milde (fig. 2, C—D). The spores are echinate with rough, irregular spines. The surface texture is also very rough and the most irregular found in the echinate type.

Cystopteris fragilis (L.) Bernh. (fig. 4, A—D). These echinate types are variable depending on which geographical area they are found. They vary from small, blunt spines to longer, sharp spines. The spore surface also varies from an irregular surface, approaching *C. sudetica,* to a smooth surface as in fig. 4, A—B.

Warty Spores

Cystopteris tenuisecta (Bl.) Mett. (fig. 3, A—B). The spores are the warty or saccate type. The individual "warts" are made up of clustered columns, each cluster with a common, irregular, dilated, flat-topped apex. The "warts" are so close together that the surface of the spore is out of view.

Cystopteris japonica Luerssen (fig. 3, C—D). The spores are virtually identical in size and morphology to *C. tenuisecta.*

Rugose Spores

Cystopteris fragilis var. *dickieana* (Sim) Lindberg (fig. 4, E—F). The rugose type spore has numerous folds in the outer wall and the surface is covered with small papillate projections. The occurrence of the folds is variable with some spores having none at all.

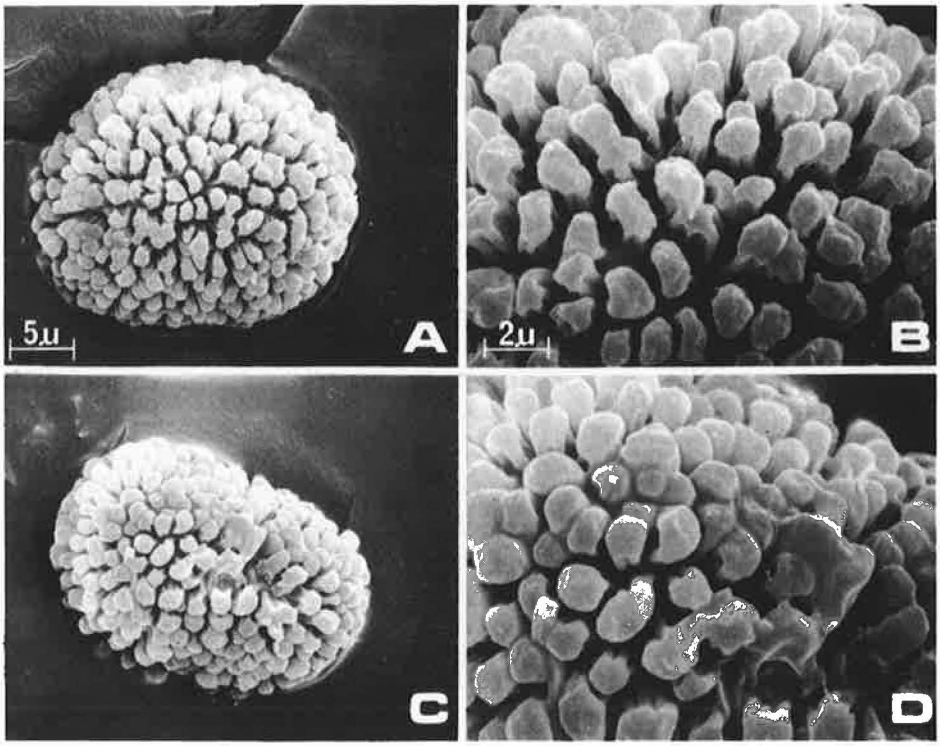

FIGURE 3: Warty type spores: A-B, *C. tenuisecta,* Pahang, Malaya, Molesworth-Allen 2875 (US); C-D, *C. japonica,* Kyushu, Japan, Kido 2006 (NCU).

Conical-lacunar Spores

Cystopteris montana (Lam.) Bernh. (fig. 2, A–B). These spores are a rather radical modification of the echinate type. They are so different that they have been described as a separate type. The spores have large spines with wide and irregular spaces. The surface is irregular and covered with numerous small papillate projections.

Spiny-lacunar Spores

Cystopteris fragilis (L.) Bernh. (fig. 5). The spiny-lacunar type spore has spines which are made up of several small projections of the spore wall which unite at the tip to form one spine. There are two basic variations, one from the Canary Islands (fig. 5, A–B) in which the spines are far apart enough to be distinct and the second from Costa Rica (fig. 5, C–D) in which the spines seem to form an open network across the spore.

DISCUSSION

Cystopteris tennesseensis is a species proposed by Shaver (1950) as a hybrid derived from a cross between *C. protrusa* and *C. bulbifera,* based only on morphological characters. In cytological studies, Blasdell (1963) reported the chromosome number of *C. tennesseensis* as n = 84 and each of the presumed parents as n = 42. The present study shows that *C. tennesseensis* produces good spores in all specimens examined and that they are intermediate between the presumed parents. In spore germination studies

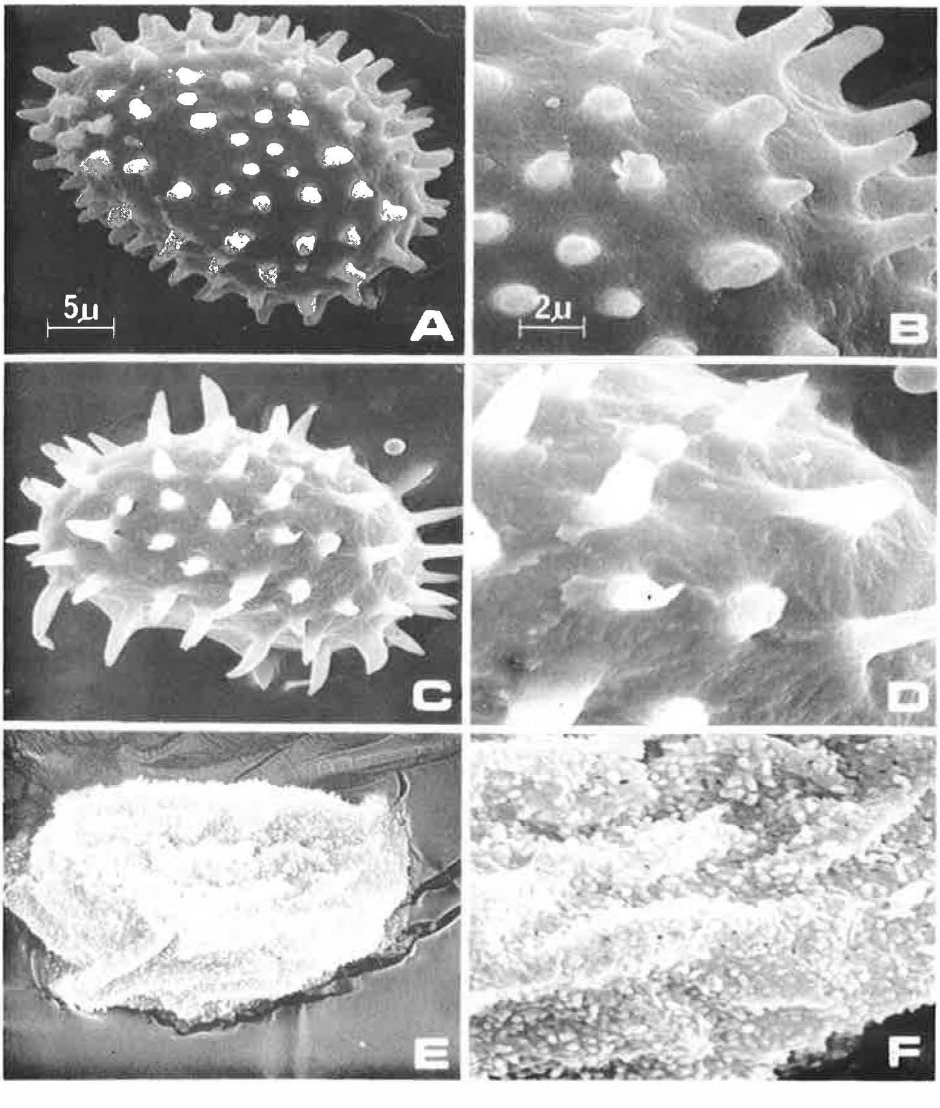

FIGURE 4: Echinate and rugose spores: A-B, *C. fragilis,* Lermatt, Switzerland, Churchill s.n. (US); C-D, *C. fragilis,* Arakamtehetchene Island, USSR, Wright s.n. (US); E-F, *C. fragilis* var. *dickieana,* Harney Co., Ore., USA, Train s.n. (TENN).

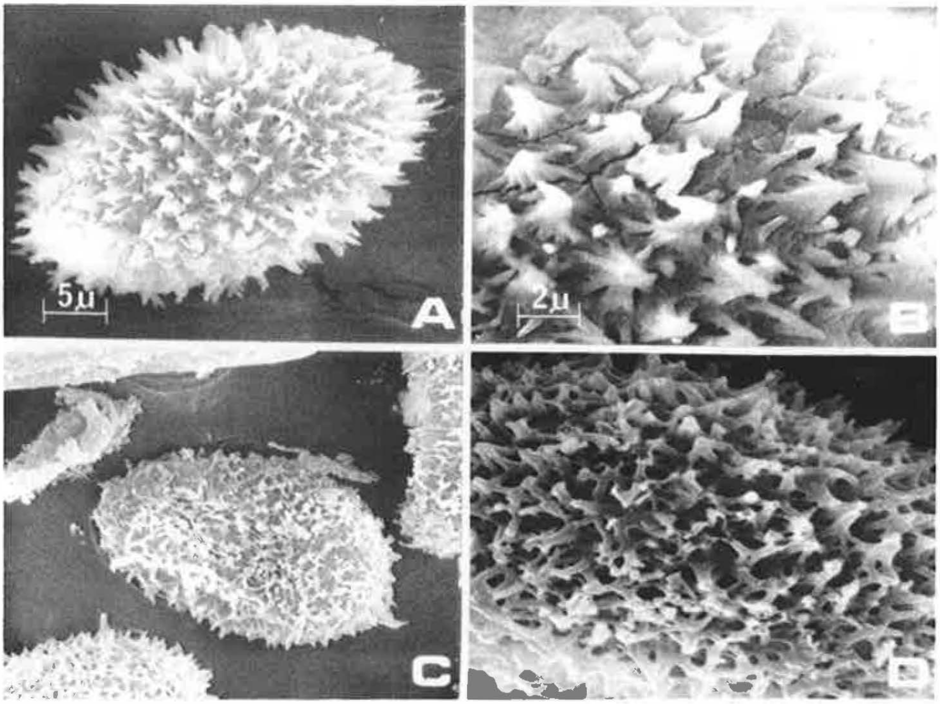

FIGURE 5: Spiny-lacunar spores of *C. fragilis:* A-B, Canary Islands, Knoche 1113 (US); C-D, San Jose, Costa Rica, Evans and Lellinger 100 (TENN).

C. tennesseensis spores germinate normally, produce both archegonia and antheridia and normal sporophytes. All these data indicate that *C. tennesseensis* is an allotetraploid which is able to reproduce itself by sexual means as a good species. Biosystematic studies are continuing to further characterize the assumed hybrid origin of *C. tennesseensis.*

Cystopteris montana produces a unique spore type which possibly reflects the uniqueness of the plant itself. The spines were previously thought to be solid in this species, but are actually hollow. No other spore type duplicates the overall morphology of this type, although the spiny-lacunar type of *C. fragilis* and the warty spores of *C. tenuisecta* and *C. japonica* approach it in different ways. The term *conical-lacunar* has been coined to describe this type.

The sporophyte of *C. sudetica* is very similar in overall appearance to *C. montana* but they are characterized by two distinctly different spore types. The broad, cone-shaped, open spines and the papillate surface of *C. montana* is drastically different from the long, irregular spines and rough surface of *C. sudetica.* The spores of *C. sudetica* are much like those of *C. bulbifera,* which is not as close morphologically to *C. sudetica* as *C. montana.* The usefulness of spore characters should be emphasized here since this single character may be used to easily distinguish *C. sudetica* from *C. montana.*

Often morphological similarities in the plants are reflected by similarities in the spore types. *Cystopteris japonica* and *C. tenuisecta* are good examples. The plants are very close morphologically, and the spores are virtually identical. Using light microscopy, the spores of the warty type appear to have solid projections, but when viewed with the SEM, definite spaces beneath the warts are evident.

Cystopteris douglasii offers another unique spore type with its distinctive fine grainy surface on and around the spines. The overall appearance of the spore is very close to *C. fragilis* and once again the morphology of the two species is similar. *Cystopteris douglasii* is endemic to the Hawaiian Islands and is probably distinctive due to geographic isolation.

By far the biggest problem within the genus lies with the *C. fragilis* complex. This species is one of the most widespread of all ferns, and it has been impossible so far to sample specimens from every geographic area where it is found. The species is still poorly understood and research is continuing in all areas in order to provide greater insight into the complex.

Within *C. fragilis* three spore types were found. The normal echinate type (fig. 4, A–D) is the most widespread. Variations occur in the length of spines and in surface ornamentation where North American material has a rougher, striate surface compared to the smooth surfaced spores found in European material. Blasdell (1963) reported different spore sizes from tetraploid, hexaploid and octoploid cytotypes of *C. fragilis* and Jermy and Harper (1971) have found an increase in density of spines with increase in ploidy level.

The rugose type (fig. 4, E–F) has been reported from scattered locations in Northern Europe and North America and, as a result of this study, from one location in Costa Rica (San Jose Prov., Cerro Chirripo. *Evans and Lellinger* 101 [TENN]). It has long been thought by the present author and reported recently by others (Jermy and Harper, 1971) that the rugosity of these spores is due to shrinkage of the outer wall during drying. The papillate surface alone is unlike any other spore type in the genus even if the rugose surface is not considered. The rugose type has been described by other authors variously as a variety of *C. fragilis,* as *C. dickieana* Sim or as *C. baenitzii* Dorfler based only on spore morphology for its taxonomic treatment.

The spiny-lacunar spore type (fig. 5) is described for the first time in this paper. It has been suggested that the variation with the open network (fig. 5, C–D) may represent an abortive spore from a hybrid. However, in checking the specimens, it was found that 64 normal spores are produced in every sporangium examined. There is absolutely no evidence of abortive spores and both types are representative of normal functional spores. A recent thorough examination of numerous specimens from the Canary Islands and South America using light and scanning electron microscopy show the two spore types are restricted to their respective geographic regions. The Canary Island specimens are always of the type in figure 5, A–B while Central and South American material are either the normal echinate or the spiny-lacunar type of figure 5, C–D.

In the analysis of the spiny-lacunar type, the remainder of the genus must be considered. Most members of the genus produce spores which are more or less distinct at the specific level. Those taxa which are closely related produce spores which are very similar in structure. This is reinforced by current studies of the North American taxa of *Cystopteris* which produce virtually identical spores in varieties of *C. fragilis.* It is concluded that these two spiny-lacunar types represent two taxa other than *C. fragilis.* Blasdell (1963) reported the rather ill-defined taxon, *C. diaphana* (Bory) Blasdell, from the Canary Islands. The Canary Island spore type is possibly *C. diaphana,* however, this will not be known until the type can be studied. Blasdell also showed a considerably expanded range for this taxon into Central and South America but present data indicate that this is not true. Canary Island type spores were not found among Central or South

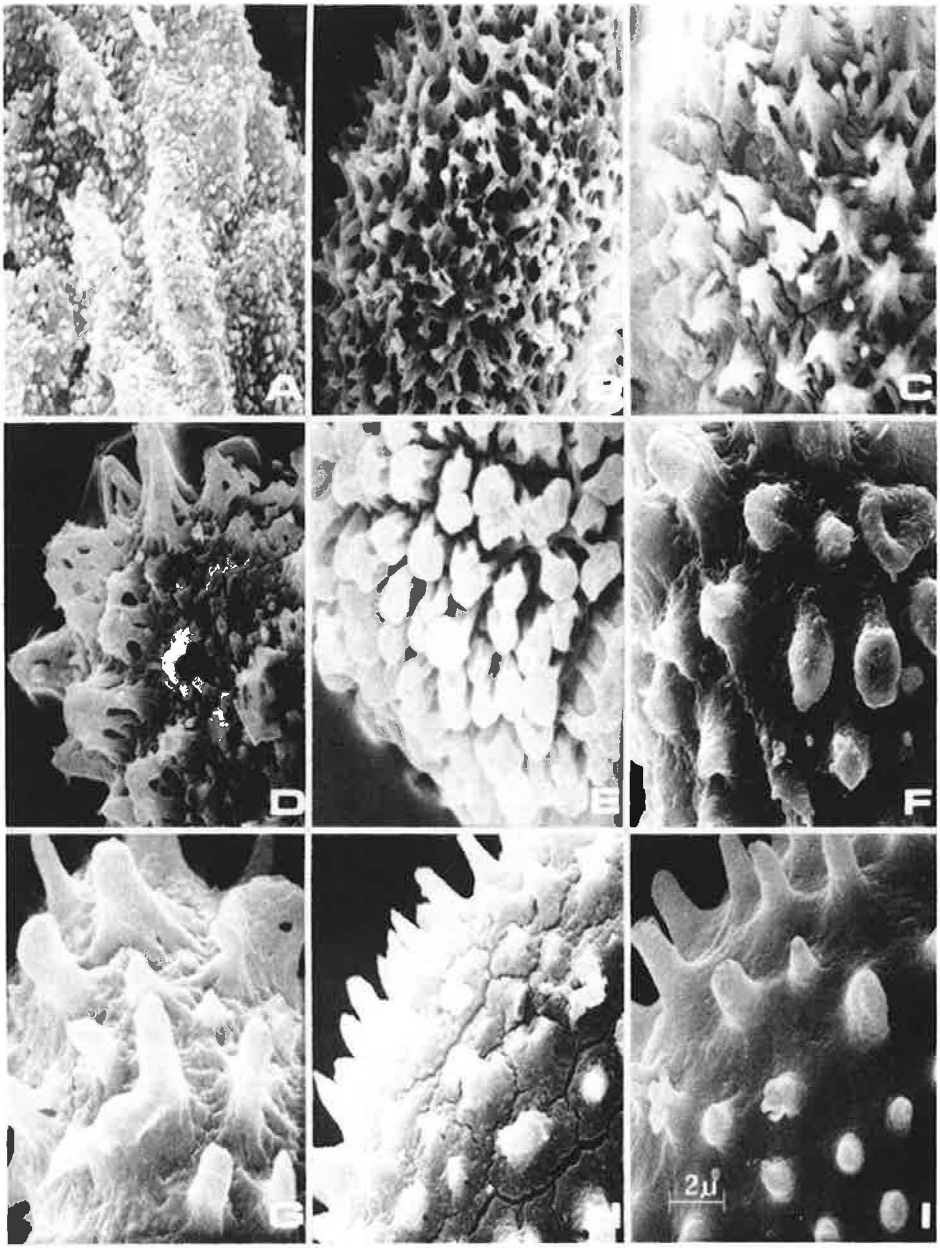

FIGURE 6: Summary of spore types: A, rugose *C. fragilis* var. *dickieana;* B-C, spiny-lacunar *C. fragilis;* D, conical-lacunar *C. montana;* E, warty *C. tenuisecta;* F, *C. bulbifera;* G, *C. sudetica;* H, *C. protrusa;* I, echinate *C. fragilis.*

South American material. Since the overall morphology of the ferns are similar to *C. fragilis,* final determinations are here deferred until such a time as a more definitive understanding of these taxa and their relation to *C. fragilis* can be made.

Figure 6 shows a summary of the different spore types found in the study, arranged in a possible evolutionary progression of perispore development (although not necessarily implying the same evolutionary arrangement of the taxa). 'A' is the rugose type with papillate projections of the perispore of *C. fragilis* var. *dickieana;* 'B' and 'C' are the spiny-lacunar type of *C. fragilis;* 'D' is the conical-lacunar type of *C. bulbifera* and 'G', 'H', and 'I' are echinate types of *C. sudetica, C. protrusa* and *C. fragilis* respectively, showing a progression from a rough surface to a smooth spore surface.

Spore ornamentation as shown by scanning electron microscopy, in conjunction with other traditional morphological studies, can be used to separate taxa within the genus *Cystopteris* and be a guide to possible evolutionary relationships. As with any other morphological unit, spores cannot stand alone in providing systematic answers to biological questions, but these data are presented to further enrich the understanding of the genus *Cystopteris.*

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ECOLOGY AND BIOGEOGRAPHY OF NEW ZEALAND PTERIDOPHYTES

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ABSTRACT

The main New Zealand pteridophyte habitats are outlined and the component species discussed in relation to their ecology. The biogeographical affinities of the pteridophytes are described and the contribution of each biogeographical element to the above habitats and to the intra-New Zealand distribution zones discussed.

INTRODUCTION

The New Zealand pteridophyte flora contains about 171 species of ferns and 19 species of fern allies which are native; in addition there are 11 adventive ferns and 2 adventive fern allies. The main islands of New Zealand extend from a subtropical climate north of lat. 35°S to the cool temperate zone south to lat. 47°S. Pteridophytes form a ubiquitous and important element in the New Zealand flora, occurring from sea-level up to 2560 metres altitude, in a wide variety of habitats and situations. The largest genera are *Asplenium* (17 species), *Blechnum* (17 species), *Lycopodium* (12 species), *Mecodium* (12 species) and *Grammitis* (9 species). In this account the native species are briefly discussed in relation to their ecology and the habitats in which they occur. In addition, the biogeographical relationships of the pteridophyte flora are outlined with reference to the contribution each element makes, not only to the separate habitats but also to the internal distribution zones which are chiefly latitudinal in basis.

The ecological data which form the foundation of the account were compiled by the author over a period of 14 years of field observations, mainly in the North Island, but including a number of expeditions to the South Island. Botanical nomenclature follows Allan (1961), except for species whose authority is given after their first mention in the text.

BIOGEOGRAPHY

The relationships of the New Zealand pteridophyte flora are inevitably complex, and are outlined in Table 1. As would be expected, the greatest affinity lies with Australia, but relatively few species are restricted to Australia and New Zealand, many having a wider distribution throughout South-east Asia and/or the Pacific. Indeed, most of the species common to Australia, New Zealand and Polynesia also occur widely throughout South-east Asia.

The pteridophytes can usefully be assigned to one of the following biogeographic elements.

1. Cosmopolitan; 6 species

This comprises species such as *Anogramma leptophylla, Cystopteris fragilis* and *Asplenium trichomanes* which have a bipolar distribution or which also occur on high mountains in the tropics. It is the smallest element in the New Zealand fern flora.

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TABLE 1

Relationships of the New Zealand pteridophyte flora in decreasing order of importance

	No. of species	*Percentage*
Shared between Australia and New Zealand	97	51.1
Restricted to Australia and N.Z.	34	17.9
Endemic to New Zealand	83	43.7
Shared between Polynesia and New Zealand	35	18.4
Not also in Australia	5	2.6
Shared between New Caledonia and N.Z. (and Australia)	35	18.4
Shared between New Guinea and New Zealand	32	16.3
Not also in Australia	3	1.6
Shared between South America and N.Z.	21	11.1
Not also in Australia	2	1.1
Shared between South Africa and N.Z.	18	9.4
Not also in Australia	1	0.5

2. Old World Tropics; 24 species

Species with a wide distribution extending through Australia and/or Malesia to Polynesia (sometimes even further afield to Africa) are included here, e.g. *Lycopodium cernuum, Dicranopteris linearis, Adiantum hispidulum, Cyclosorus interruptus* (Willd.) Ito *(Thelypteris gongylodes)* (all in Australia, Malesia, New Caledonia, Melanesia, Polynesia, South Africa), *Schizaea dichotoma, Cheilanthes tenuifolia, Adiantum diaphanum, Lunathyrium japonicum* (Thunb.) Kurata, *Blechnum vulcanicum* (all in Australia, New Caledonia, Malesia, Melanesia, Polynesia), *Thelypteris confluens* (Thunb.) Morton (*T. palustris* var. *squamigera*) (New Guinea, South Africa).

3. Polynesia; 16 species

The species of this element are those of Melanesia and/or Polynesia, most of which occur also in Australia and sometimes in New Caledonia and/or New Guinea, e.g. *Lycopodium volubile* (Australia, New Caledonia, Polynesia), *Marattia salicina* (Australia, Polynesia), *Mecodium flabellatum* (Labill.) Copel. (Australia, Melanesia, Polynesia), *Cyathea medullaris, Asplenium shuttleworthianum* (Melanesia, Polynesia), *Reediella endlicheriana* (Presl) Pic.-Ser. (Australia, New Guinea, Melanesia, Polynesia).

4. Australia, New Caledonia (and New Guinea); 11 species

These species are largely restricted to Australia and New Caledonia but a few have also reached southeastern New Guinea, e.g. *Lycopodium deuterodensum, Schizaea bifida, Sphaerocionium lyallii* (Hook. f.) Copel., *Lindsaea linearis, Cheilanthes distans, C. sieberi* (Australia, New Caledonia), *Gleichenia dicarpa* R. Br. *(G. circinata), G. flabellata* (Australia, New Caledonia, New Guinea).

5. Austral; 16 species

This includes species with a purely circum-antarctic distribution, found in at least two of the three southern continents and/or their associated islands, e.g. *Lycopodium scariosum, Botrychium australe, Blechnum penna-marina, Grammitis magellanica* Desv. (Australia, South America), *Sphaerocionium ferrugineum* (Colla) Copel., *Grammitis patagonica* (C.Chr.) Parris (South America), *Hymenophyllum peltatum, Grammitis armstrongii* Tindale (Australia, South America, South Africa).

6. Australia; 34 species

These are species confined to Australia and New Zealand, e.g. *Tmesipteris*

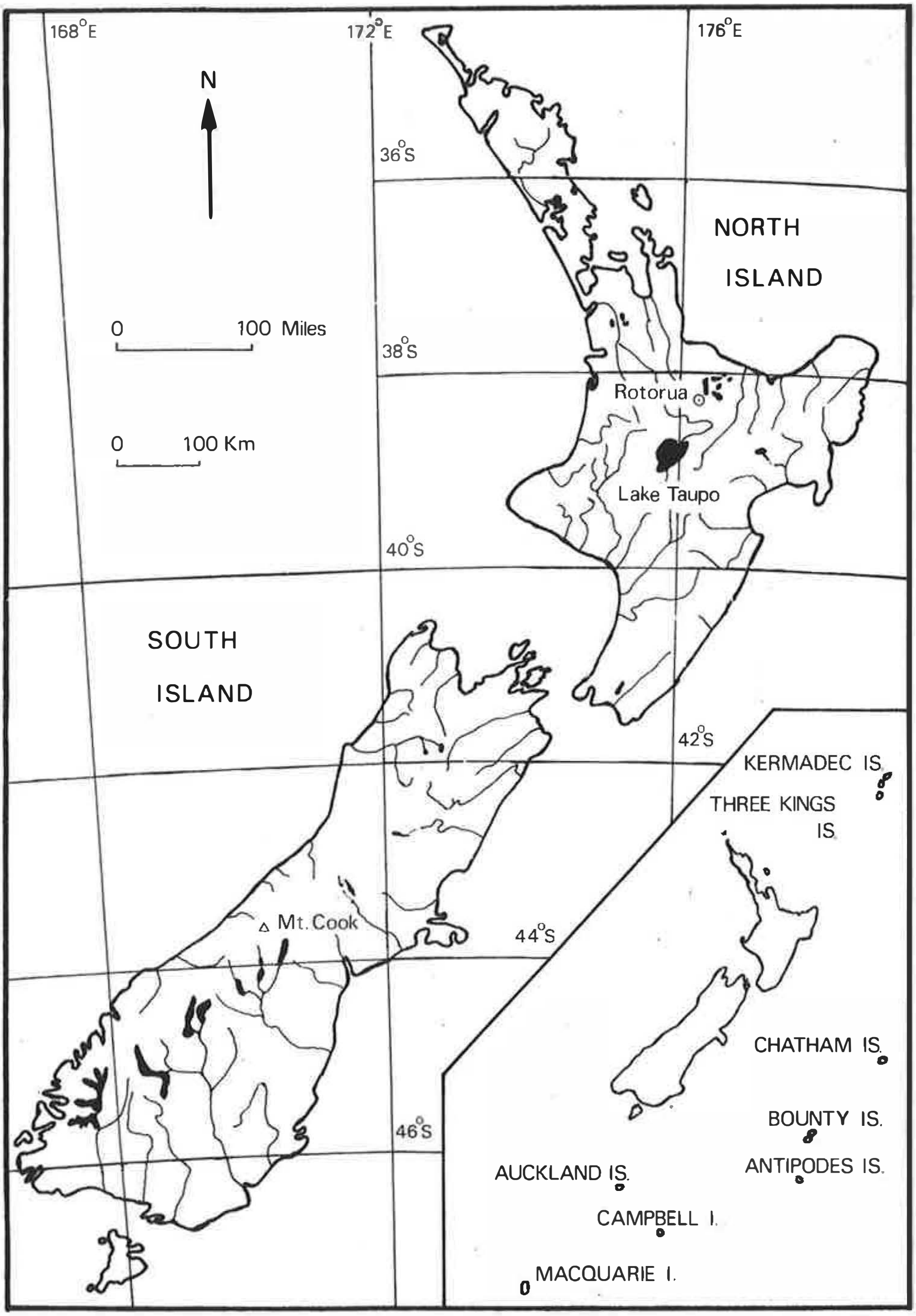

FIGURE 1: New Zealand: map showing latitudes, outlying islands and principal localities mentioned in the text.

elongata Dang., *Phylloglossum drummondii, Lycopodium fastigiatum, Gleichenia microphylla, Mecodium rarum* (R.Br.) Copel., *Hymenophyllum cupressiforme* Labill., *Lindsaea trichomanoides, Pellaea rotundifolia, Cyathea cunninghamii, Arthropteris tenella, Lastreopsis hispida* (Sw.) Tindale, *Pneumatopteris penniger* (Forst. f.) Holttum, *Athyrium australe, Asplenium flabellifolium, Pleurosorus rutifolius, Microsorum diversifolium* (Willd.) Copel., *Grammitis billardieri, Ctenopteris heterophylla* (Labill.) Tindale. This is, after the endemic species, the largest element in the pteridophyte flora.

7. Endemic; 83 species

Species found only in New Zealand represent several different levels of endemism. They may be monotypic genera of isolated taxonomic position, e.g. *Loxoma, Cardiomanes,* or monotypic genera with recognisable relatives elsewhere, e.g. *Leptolepia, Anarthropteris,* or be rather distinct and isolated species in their genera, e.g. *Meringium minimum* (A. Rich.) Copel., *Mecodium pulcherrimum* (Col.) Copel., *Lindsaea viridis, Blechnum filiforme.* Alternatively they may have more or less close relatives outside New Zealand, e.g. *Mecodium dilatatum* (Forst. f.) Copel., *Craspedophyllum armstrongii* (Baker) Copel., *Vandenboschia colensoi* (Hook. f.) Copel., *Paesia scaberula, Adiantum viridescens* Col., *Cyathea dealbata, Blechnum discolor, Pyrrosia serpens,* or be most closely related to other New Zealand species, e.g. *Lycopodium novae-zelandicum, Mecodium rufescens* (Kirk) Copel., *Pteris macilenta, Blechnum durum, B. membranaceum, Asplenium anomodum, A. hookeranum, Microsorum novae-zelandiae* (Baker) Copel., *Grammitis ciliata, G. pseudociliata* Parris.

HABITATS

The habitats described below, although broadly based on the categories recognised by Cockayne (1958), do not follow any single published system as they are modified to reflect more precisely the characteristics of the fern floras. The pteridophytes in each habitat are usually divided into terrestrial, low epiphytes (to 2 m up the main trunks of trees), crotch and main branch epiphytes, and high epiphytes. These last have various modifications for life in an extremely dry and often strongly insolated environment; they may adopt a mat form, such as various small filmy ferns, have a dense frond covering of hairs, or have thickened fronds, to prevent desiccation. Most high epiphytes have creeping, rather than tufted rhizomes. The main branch and crotch epiphytes are less xeromorphic, and more species in this micro-habitat have tufted rhizomes, especially those which grow in association with the large humus-collecting perching lilies, *Astelia* and *Collospermum.* The environment of the main trunk is more humid than higher up in the canopy and consequently a greater variety of species is found here, both creeping and tufted rhizomes being common. With decreased rainfall or humidity, as in more open forest, epiphytes grow lower down on the trees until, in extremely dry forest habitats, the high epiphytes of wet forest may occur rupestrally, as a rock substrate can give the same free drainage as do tree trunks and branches. In microhabitats marginal to forest such as open tracksides and roadside banks the more light-demanding species such as *Hypolepis tenuifolia, Paesia scaberula, Pteridium esculentum* (Forst. f.) Diels, *Cyathea dealbata, C. medullaris, Pellaea rotundifolia* and *Blechnum procerum* (Forst. f.) Sw. are frequent, while *Pteris* species and *Adiantum* species are more common here in the north, especially at low altitudes.

1. Coastal Cliffs; c. 21 species

This comprises both completely exposed sites and those under the protection of a coastal scrub or tree canopy. Although it intergrades with coastal forest at the cliff

FIGURE 2: Exterior of lowland forest with *Cyathea medullaris* at margin, Piha Valley, North Island. *(Photo. J.P. Croxall).*

top, this habitat is characterised by exposure to both sun and salt spray, and extremely free drainage. The ferns growing here are either specialised and restricted to this habitat, or are very hardy sun and salt spray tolerant species which occur in other habitats, sometimes as epiphytes. *Asplenium obtusatum* (a vicariate of the northern hemisphere *A. marinum* L.), *Blechnum banksii* and *B. durum* grow nearest to the high tide mark and are subjected to considerable amounts of salt spray. All are able to produce raw humus from their dead fronds (Cockayne 1958) and thus can colonise open rock surfaces. They are more common in the south of the country than in the north, which may be due to the need for a moist climate to prevent desiccation in an extremely free-draining habitat. *Blechnum banksii* is alone restricted to this habitat, as the other two species are common in coastal forest in the far south of the South Island and on the Subantarctic islands. Higher on the exposed cliffs grow *Cheilanthes distans, C. sieberi* and, south of c. lat. 38°S, *C. tenuifolia*. These three species also grow on equivalent sites in inland localities. At a similar level, where grasses and shrubs are able to establish, *Asplenium flaccidum* is common. It has a number of locally distinct terrestrial coastal forms which differ markedly from the epiphytic ones of inland forests. The widespread epiphytes *Pyrrosia serpens* and *Microsorum diversifolium* grow rupestrally at this level. Underneath the protection of a tree or shrub layer a few of the hardier species of coastal forest can establish, particularly on sheltered or eastern coasts. North of lat. 38°S *Pteris comans* is local on warm north-facing sites on the mainland but is far more common on the climatically milder offshore islands. *Pteris macilenta, P. saxatilis* (Carse) Carse and *P. tremula* are widespread in the North Island, particularly north of lat. 38°S. *Adiantum cunninghamii, Polystichum richardii, Blechnum procerum* and *Asplenium lucidum* are common throughout the country, as are the treeferns *Cyathea dealbata* and *C. medullaris* in particularly sheltered sites.

2. Coastal Forest; c. 77 species

Forest extending from above high tide mark and cliff tops to a few miles inland is subject both to varying amounts of salt spray and the ameliorating effect of a coastal climate. Generally it is more open in character and with fewer epiphytes than lowland forest with which it merges on its landward side. A few species are restricted to cliff and coastal forest and several species are far more common in coastal forest than in other habitats. Terrestrial species predominate in coastal forest. All the species of cliff forest are common on the forest floor, with the addition of *Lastreopsis glabella* (A. Cunn.) Tindale, *L. microsora* (Endl.) Tindale and *L. velutina* (A. Rich.) Tindale, *Blechnum chambersii* Tindale *(B. lanceolatum), B. membranaceum, Asplenium bulbiferum, A. lucidum* and the treefern *Dicksonia squarrosa. Adiantum aethiopicum, A. hispidulum, Doodia media* and *Asplenium lamprophyllum* are more common north of lat. 38°S, Whilst *Blechnum durum, Asplenium obtusatum* and *A. scleroprium* Homb. & Jacq. are common on the Subantarctic islands. On shaded banks and streamsides the more hygrophilic species such as *Mecodium demissum* (Forst. f.) Copel. and *M. sanguinolentum* (Forst. f.) Copel. occur throughout the country. In the north, *Reediella endlicheriana, Adiantum diaphanum, Lunathyrium japonicum* and *Doodia caudata* are restricted to this microhabitat in coastal forest, while in the south *Meringium minimum* is apparently found in similar situations. Epiphytes are not abundant in coastal forest. *Pyrrosia serpens* and *Microsorum diversifolium* can occur at all levels on trees from the main trunk to high branches but *Mecodium rarum, M. sanguinolentum, Arthropteris tenella* and *Microsorum scandens* (Forst. f.) Tindale are restricted to the main trunks, usually no more than 2 m above ground, and *Asplenium flaccidum, A. lucidum* and *A. polyodon* Forst. f. *(A. falcatum)* are usually only in crotches and on main branches. The climbing fern *Blechnum filiforme,* which is ground-rooting and hence not dependent on moisture retention in its epiphytic habitat, can be very common in coastal forest.

The species apparently restricted to cliff and/or coastal forest are *Pteris comans, Lastreopsis velutina, Davallia tasmani, Blechnum durum, Asplenium obtusatum* and *A. scleroprium.*

3. Lowland Forest; c.126 species

This replaces coastal forest within a few miles of the sea and may extend up to 300 m in the North Island and c. 200 m in the South Island, where it merges into upland forest. Structurally it is more dense than coastal forest and the resulting higher humidity favours a greater number of epiphytes. Figures 2 & 3 show respectively the exterior and interior of lowland forest. Lowland forest covers a large area of the country and thus contains more species than any other habitat. Only two species, *Marattia salicina* and *Adiantum formosum,* are restricted to it. Nearly all species are shared with coastal and/or upland forest but many are more common in lowland forest. The ground ferns include those of cliff and coastal forest with the exception of those listed above, but *Pteris* and *Adiantum* species are less common than in coastal forest. Other common ground ferns are *Lindsaea trichomanoides, Lastreopsis hispida, Pneumatopteris penniger* and, in damper places, *Leptopteris hymenophylloides* (A.

FIGURE 3: Interior of wet lowland forest showing dense development of epiphytes, Fox Glacier, South Island. *(Photo J.P. Croxall).*

Rich.) Presl and the filmy ferns *Mecodium demissum* and *Meringium multifidum* (Forst. f.) Copel. The principal low epiphytes, in addition to the two terrestrial filmy ferns, are *Mecodium flexuosum* (A. Cunn.) Copel., *M. flabellatum, M. rarum, M. sanguinolentum, Cardiomanes reniforme* (Forst. f.) Presl (fig. 4) and *Microsorum scandens.* Higher up, in crotches and on main branches, grow *Lycopodium billardieri, Asplenium lucidum, A. flaccidum* and *A. polyodon,* all the low epiphytic species of *Mecodium* except *M. flexuosum, Meringium multifidum, Cardiomanes reniforme, Ctenopteris heterophylla, Pyrrosia serpens* and *Microsorum diversifolium. Anarthropteris lanceolata,* however, is absent from southern forests. High epiphytes include *Mecodium flabellatum, M. rarum, M. sanguinolentum, Asplenium flaccidum, Ctenopteris heterophylla, Pyrrosia serpens* and *Microsorum diversifolium.* A few species are particularly common on treefern trunks; *Tmesipteris elongata* and *Polyphlebium venosum* (R.Br.) Copel. occur throughout New Zealand but *Tmesipteris lanceolata* Dang. is restricted to north of lat. 39°S.

4. Upland Forest; c. 104 species

This extends from c. 300 m to c. 850 m in the North Island, and from c. 200 m to c. 550 m in the South Island. At its lower limits it merges into lowland forest and at its upper level intergrades with montane forest. Structurally it is very similar to lowland forest and also contains relatively high numbers of epiphytes. Rainfall is somewhat higher than in lowland forest and the climate is cooler, hence the epiphytes are even more common. There are no species restricted to upland forest and all are shared with lowland and/or montane forest, but rather few of the common coastal forest ferns are important in upland forest. With the exception of lowland forest, it contains more species than any other habitat. Ground ferns are very numerous and include *Meringium bivalve* (Forst. f.) Copel., *Leptolepia novae-zelandiae, Blechnum discolor, B. fluviatile, B. "minus", B. vulcanicum* and the treeferns *Dicksonia lanata,* and *Cyathea smithii.* The miniature treefern *Blechnum fraseri* is common in the northern kauri *(Agathis australis)* forests, while *Polystichum silvaticum* is local in upland forest south of lat. c.38°S. *Leptopteris superba* (Col.) Presl (south of lat. 38°S), *Mecodium atrovirens* (Col.) Copel. (throughout), *Selenodesmium elongatum* (A. Cunn.) Copel. (mainly north of lat. 38°S), *Blechnum nigrum* (throughout) and *B. colensoi* (Hook f.) Wakefield (south of lat. 37°S) are usually restricted to dark wet streambanks, while the treeferns *Dicksonia squarrosa, Cyathea dealbata* and *C. medullaris* prefer the more open banks of wider streams. The low epiphytes include those of lowland forest together with *Mecodium scabrum* (A. Rich.) Copel., *Sphaerocionium ferrugineum, Hymenophyllum peltatum* and *Grammitis billardieri,* while the epiphytes of crotches and main branches are identical of those of lowland forest, with the addition of *Mecodium scabrum* and *Rumohra adiantiformis. Microsorium novae-zelandiae* is fairly common in this microhabitat, although restricted to the forests of the central North Island. The high epiphytes and climbing ferns are those occurring also in lowland forest, as are the treefern epiphytes, with the addition of *Sphaerocionium lyallii.*

5. Montane and Subalpine Forests; c. 67 species

These include all the forests at higher altitudes than upland forest, up to the treeline where beech is absent and to the lower limits of beech forest where it is present. They occur mainly south of lat. 38°S, tend to be simpler in structure than upland forest, especially at higher altitudes, but still support many epiphytes, although species are fewer than in lowland and upland forests. Rainfall is higher than at lower altitudes, and extensive frequent cloud cover can be very important in reducing the light within the forests. This, together with the colder climate, is doubtless responsible for the reduction in numbers of species compared with the lower forests. No species is restricted entirely to this habitat but several occur only here and in beech forest. Others are shared with lowland and/or upland forest, and a few species common to coastal, lowland and upland forests are still found here. Typical terrestrial species are *Leptopteris hymenophylloides, L. superba, Mecodium villosum* (Col.) Copel., *Meringium multifidum, Polystichum vestitum, Blechnum colensoi, B. "minus"* and the treeferns *Cyathea smithii* and *C. colensoi,* with *Asplenium richardii* and *A. trichomanes* common in the South Island in this habitat. Due to the moist climate, hygrophilic species are not restricted to dark streambanks in this habitat. Filmy ferns are the dominant low epiphytes *(Mecodium rarum, M. dilatatum, M. scabrum, M. flabellatum, M. demissum, M. villosum, Apteropteris malingii* (Hook. f.) Copel. (virtually confined to the trunks of the conifer *Libocedrus bidwillii), Hymenophyllum peltatum, Meringium bivalve, M. multifidum, Cardiomanes reniforme)* together with *Grammitis billardieri* and *G. magellanica* subsp. *nothofageti* Parris. The above filmy ferns, with the exception of *Hymenophyllum peltatum* and *Meringium bivalve* and the inclusion of *Mecodium pulcherrimum* and *Craspedophyllum armstrongii* together with the two *Grammitis* species above, *Asplenium flaccidum* and *Microsorum diversifolium* occur in crotches and on main branches. Higher in the canopy the number of epiphytes is reduced, with *Mecodium flabellatum, M. rarum, M. villosum, Meringium multifidum, Asplenium flaccidum, Microsorum diversifolium* and *Grammitis* species typically present. Most of the treefern epiphytes characteristic of lower altitude forest habitats are, with the exception of *Polyphlebium venosum,* no longer present at

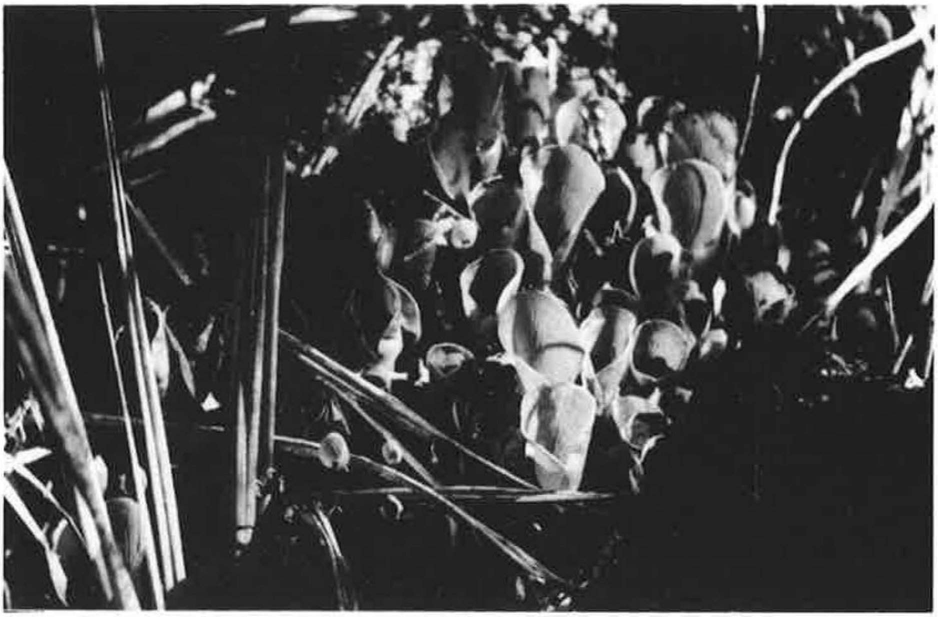

FIGURE 4: *Cardiomanes reniforme,* a common low epiphyte of lowland and upland forest, can also grow on rocks, as here on Rangitoto Island, North Island. *(Photo J.P. Croxall).*

these altitudes, and climbing species are also absent.

6. Beech Forest; c. 61 species

Both pure beech forest at low altitudes in the South Island and mountain beech forest are included here. The vegetation type is only found south of lat. 38°S. Structurally it is a fairly open forest and in the drier parts of the country may completely lack an understory. This leads to free air movement and rapid drying after rain, which markedly restricts the development of epiphytes. Although beech forest contains nearly as many species as montane-subalpine forest, they are, on the whole, far less abundant numerically. No species are restricted to this habitat, all being shared with subalpine-alpine scrub and/or montane-subalpine forest. In very wet beech forest the fern flora is nearly identical to that described for montaine-subalpine forest but in the much drier forests east of the main divide in the South Island the ground ferns may be restricted to *Polystichum vestitum* and *Blechnum penna-marina,* with the more drought-resistant species of filmy ferns, e.g. *Mecodium villosum* and *Meringium multifidum,* growing rupestrally or as low epiphytes, together with the *Grammitis* species of montane-subalpine forest.

7. Subalpine and Alpine Scrub; c. 29 species

Shrubland above the timberline (which occasionally forms mosaics with subalpine forest) mainly occurs south of lat. 38°S. It is essentially a single-story habitat but because it occurs in areas of high rainfall and frequent cloud cover there is usually some development of epiphytes, especially *Mecodium villosum, Craspedophyllum armstrongii, Meringium multifidum* and *Grammitis magellanica.* The climate is cool and snowfalls are frequent in winter, while on fine days the insolation can be intense. No pteridophytes are found solely in this habitat, all being shared with subalpine-alpine non-scrub communities and/or beech forest. *Lycopodium australianum, L. fastigiatum, L. varium, Mecodium villosum, Meringium multifidum, Hypolepis millefolium, Blechnum penna-marina, B. "capense"* and *Asplenium richardii* are terrestrial, while *Polystichum cystostegia* favours the more exposed and free-draining microhabitat of rocky debris and stabilised screes. *Cystopteris fragilis* is chiefly found in fairly open rock crevices. *Grammitis armstrongii, G. givenii* Parris and *G. patagonica* are frequently mat-forming on steep or overhanging rock-faces, a habit which with their coriaceous fronds enables them to withstand desiccating conditions.

8. Subalpine and Alpine Non-scrub Communities; c. 21 species

Subalpine and alpine grassland, herbfield and fellfield are characterised by their lack of woody shrub growth; hence epiphytes are absent. The climate is similar to that of subalpine-alpine scrub in the lower part of this habitat, with cool summers, much cloud cover and high precipitation, falling as snow in winter, but becomes more severe with increasing altitude. Insolation is more intense than in subalpine-alpine scrub. Most species are shared with the previous habitat, with others occurring in open areas at lower altitudes. The species of *Lycopodium* discussed under subalpine-alpine scrub together with *L. scariosum, Mecodium villosum, Meringium multifidum, Ophioglossum coriaceum, Blechnum penna-marina* and *Asplenium richardii* may all be found here more or less in the shelter of taller vegetation, while *Gleichenia alpina* R.Br. is often dominant in damper areas. *Polystichum cystostegia,* together with *Blechnum penna-marina,* is a pioneer of rock debris slopes and, as in subalpine-alpine scrub, *Grammitis* species are frequent on rock faces and overhangs; indeed, *Grammitis armstrongii* reaches higher altitudes than any other fern in New Zealand.

9. Open Areas; c. 12 species

This is essentially an artifically circumscribed habitat as it lacks the relatively definable altitude boundaries of the coastal to montane-subalpine forest habitats, but it includes all parts of these habitats where the canopy is broken and admits much light. Subclimax dune vegetation, open rocky areas and inland cliffs, and margins of swamps where the pteridophyte flora is in marked contrast to that of surrounding forest are included in this habitat, but land cleared from forest for agricultural use which often maintains (in marginal areas) a residual terrestrial forest fern flora of species resistant to high light intensity, grazing and trampling is excluded. All ferns of open areas are light-demanding and tolerant of higher temperatures and lower humidity than those in neighbouring forest areas. Three species, *Ophioglossum pedunculosum* (in fairly level grassy places), the annual *Anogramma leptophylla* (steeper and more rocky grassy sites) and *Pleurosorus rutifolius* (north-facing rock crevices, south of lat. 38°S) seem restricted to this habitat while the majority of the others e.g. *Cheilanthes distans, C. sieberi* (both extremely resistant to drought), *Pellaea rotundifolia, P. falcata* (both more shade tolerant than the other species) and *Asplenium flabellifolium* occur more or less throughout the country.

10. Scrub; c. 31 species

This includes the communities of *Leptospermum scoparium* and *L. ericoides* in lowland to montane habitats (but not subalpine scrub), which are largely seral following forest clearing or burning, and which regenerate in time to the primary forest of the area, so the ferns of mature scrub include the hardy pioneer species of forest. Scrub tends to be quite open in character underneath a fairly dense canopy, so epiphytes are absent. Frequently the ground is covered with a dry layer of dead *Leptospermum* leaves and there may be open areas, particularly on ridges in North

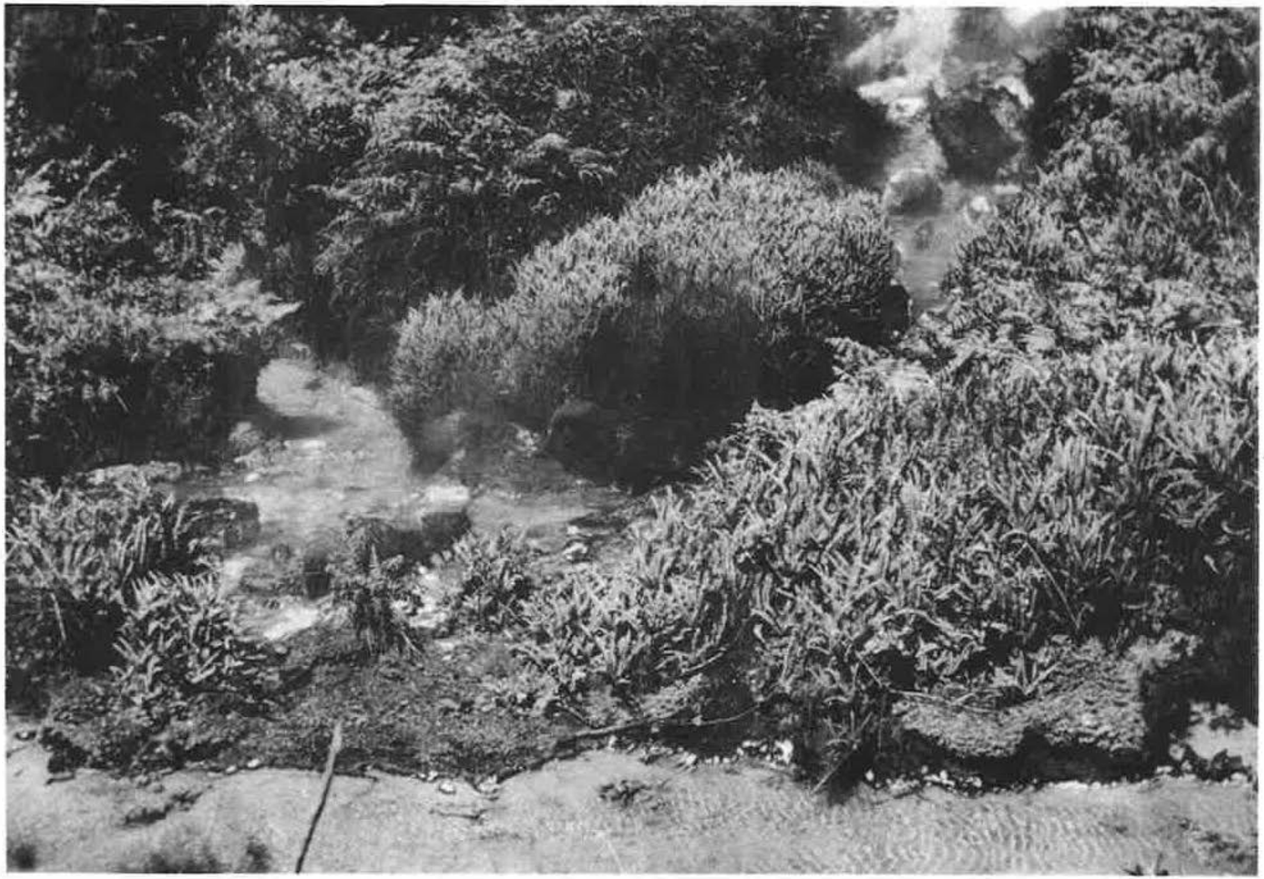

FIGURE 5: *Nephrolepis cordifolia* on banks of warm stream, Otumakokori, North Island. *(Photo J.P. Croxall).*

Auckland province where kauri forest has been destroyed, where the soil is a sterile bare grey or white clay. The pteridophytes of this habitat are usually particularly tolerant of dry conditions. Three species are entirely restricted to this habitat *(Phylloglossum drummondii, Schizaea bifida* and *Lindsaea linearis)* while others, e.g. *Gleichenia* species, are far more common here than in other habitats, where they occur only as marginal species. *Schizaea fistulosa, Gleichenia microphylla, Lindsaea linearis* and *Pteridium esculentum* are widespread, while *Lycopodium laterale, Gleichenia dicarpa* and *Blechnum procerum* are more common in damp areas. Species found only north of lat. 38°S are *Phylloglossum drummondii, Lycopodium cernuum, L. deuterodensum* and *Schizaea bifida,* with *Loxoma cunninghamii* and *Gleichenia flabellata* quite common on streambanks in the far north of the country.

11. Cold Water and Cold Water Swamps; c. 13 species

This ranges from still open water where pteridophytes are free-floating or bottom-rooting, to swamps and bogs which will intergrade at their margins with scrub or forest communities. Six species are restricted to this habitat while the others are also found in damper parts of scrubland. *Azolla filiculoides* Lam. *(A. rubra)* is the only native free-floating fern but in the north of the North Island the recent immigrant *Azolla pinnata* R.Br., a common Australian fern, and the adventive *Salvinia hertzogii* de la Sota may occasionally occur. *Isoetes alpina* (above 300 m), *I. kirkii* (throughout but scattered), *Thelypteris confluens* (north of lat. 39°S) and *Pilularia novae-zelandiae* (throughout) grow fixed to the bottom at lake and pool margins. *Thelypteris confluens* can also grow in very wet areas of swamps in open water and *Cyclosorus interruptus* occupies a similar habitat north of lat. 35°S. *Lycopodium laterale, Gleichenia dicarpa* and *Blechnum procerum* are common swamp pteridophytes but none grow actually in water.

12. Thermal Areas; c.34 species

The hot water swamps, streamsides and steam-heated ground in this habitat are mostly dominated by *Leptospermum ericoides,* but when heat and fumes are less intense a depauperate forest may develop. These communities are best developed in the Rotorua — Taupo district of the North Island. The pteridophytes are tolerant of varying degrees of soil heat, sulphur-laden fumes and mineral-rich warm water. Two species *(Dicranopteris linearis* and *Nephrolepis cordifolia)* are found only in this habitat while some others are more common here than elsewhere (e.g. *Christella dentata* (Forssk.) Brownsey & Jermy, and *Cyclosorus interruptus)* but the remainder are typical of the normal vegetation of the district. *Lycopodium cernuum, Gleichenia microphylla, Dicranopteris linearis, Hypolepis tenuifolia, Pteridium esculentum, Histiopteris incisa* and *Doodia media* grow in heated ground and on the banks of warm streams, while *Nephrolepis cordifolia* (fig. 5) and *Christella dentata* grow almost at water level by the streams, and *Cyclosorus interruptus* is usually restricted to warm water swamps. In the depauperate forest and well-developed *Leptospermum* scrub of the thermal areas, ground ferns include the treeferns *Dicksonia fibrosa, D. squarrosa* and *Cyathea medullaris, Pteris tremula, Adiantum cunninghamii, Polystichum vestitum, Pneumatopteris penniger* and *Blechnum fluviatile* while hardier epiphytes may also occur, e.g. *Mecodium rarum, M. sanguinolentum* and *Meringium multifidum,* together with *Asplenium lucidum, A. polyodon, Pyrrosia serpens, Microsorum diversifolium* and *Ctenopteris heterophylla.*

LATITUDE-BASED ZONES

In addition to the predominantly altitudinal and higher plant community-based habitat classification of the pteridophyte flora, a geographical division based primarily on latitudinal distribution within New Zealand is also possible, and a comparison of this with biogeographical elements is instructive. This classification recognises certain well-defined limits of distribution for both pteridophytes and higher plants.

1. **Northern Islands only**

   Nine species are found only on the Kermadec group in the New Zealand region and one *(Davallia tasmani)* is endemic on the Three Kings Islands off the extreme north of the North Island.

2. **North of lat. 36–38°S**

   24 species including those just reaching the north of the North Island (e.g. *Todea barbara, Doodia aspera* R.Br.) are not found south of this limit.

3. **North Island and to the north of South Island, to lat. c. 42°S**

   27 species have their southern limit here.

4. **Predominantly south of lat. 36–38°S (and usually over 300 m altitude, especially in the North Island)**

   43 species are not found north of this latitude.

5. **Wide New Zealand Distribution**

   82 species occur more or less throughout New Zealand.

6. **Thermal Areas**

   These are distinct in having a much warmer climate than is normal at their latitude. Two species are entirely confined to these areas and another two are found rarely north of lat. 35°S.

DISCUSSION

Table 2 shows the percentage of the pteridophyte flora in each latitude zone attributable to each biogeographic element. From this it can be seen that the cosmopolitan element is relatively unimportant and contributes a small number of the widely distributed and the southern species only. The fern flora of the thermal areas is completely derived from the Old World Tropics element which also provides many of the Northern Islands restricted species, quite a few species restricted to north of lat. 36–38°S and lat. 42°S, but very few of the widely distributed species and those confined to south of lat. 36–38°S. The Polynesian element makes a moderate contribution to both the widely distributed species and those occurring north of lat. 36–38°S, and smaller contributions to the species confined to the Northern Islands and north of lat. 42°S. The Australian-New Caledonian (—New Guinea) species form a moderate proportion of those north of lat. 36–38°S and 42°S, and a smaller proportion of those widely distributed throughout New Zealand. The Austral element provides a fair proportion of the species of more southern distribution and a smaller number of those restricted to north of lat. 36–38°S. The Australian element makes approximately equal contributions to four zones: north of lat. 36–38°S, north of lat. 42°S, wide, and southern distributions. The endemic element forms a large percentage of Northern Islands, north of lat. 42°S restricted, wide, and southern confined species and a considerable percentage of species restricted to north of lat. 36–38°S.

It is interesting now to compare the percentage contribution of the biogeographical elements to each of the previously discussed habitats. The basic data

TABLE 2

Percentage contribution of each biogeographic element to each latitude zone

	Element						
Latitude Zones	Cosmopolitan 6 spp.	Old World Tropics 24 spp.	Polynesia 16 spp.	Australia—New Caledonia (—New Guinea) 11 spp.	Austral 16 spp.	Australia 34 spp.	Endemic 83 spp.
Northern Islands 10 spp.	—	40	10	—	—	—	50
North of lat. 36–38^{o}S 24 spp.	—	20.8	12.5	12.5	4.2	25	25
North of lat. 42^{o}S 27 spp.	—	18.5	7.5	11.1	—	18.5	44.4
South of lat. 36–38^{o}S 43 spp.	9.3	9.3	—	—	16.3	18.6	46.5
Wide distribution 82 spp.	2.4	2.4	12.2	6.1	9.7	18.2	48.9
Thermal Areas 4 spp.	—	100	—	—	—	—	—

are shown in Table 3. From this it can be seen that the cosmopolitan element is most important in open areas, subalpine-alpine non-scrub communities and cold water-cold water swamps, and is absent from the relatively low altitude habitats of coastal and lowland forest, scrub and thermal areas. The Old World Tropics species are most important in thermal areas, less so in cold water-cold water swamps, scrub, coastal and lowland forest and are absent from subalpine-alpine non-scrub communities. The Polynesian element contributes most to coastal cliffs, somewhat less to coastal forest, scrub and thermal areas, and is absent from subalpine-alpine non-scrub, open and thermal areas. The Australian-New Caledonian (—New Guinea) species are important in scrub, open areas and cold water-cold water swamps, and are absent from montane-subalpine and beech forest, and subalpine-alpine scrub and non-scrub communities. The Austral element contributes most to the subalpine-alpine scrub and non-scrub communities, somewhat less to montane-subalpine and beech forest and scrub, and is absent from open areas and cold water-cold water swamps. The endemic species are most important in coastal cliffs, coastal, lowland, upland, montane-subalpine and beech forest and last important in open areas.

In summarising the contribution of the various biogeographical elements several points are significant.

1. The high proportion of endemic species in all latitude-based zones and in all forest habitats, in coastal cliffs and subalpine-alpine scrub, and the reduced importance of this element in the more open and seral habitats. Numerically, endemic species are most common in lowland forest, have a wide distribution throughout New Zealand, and are least common in open areas and on the Northern Islands.
2. The fairly uniform contribution of Australian-New Zealand restricted species to each habitat and to the mainland latitude-based zones. The greatest numbers of species in this element occur in lowland forest and have a wide distribution in New Zealand.
3. The increased proportion of Austral species in the higher altitude habitats and the higher latitude zone. Numerically this element is most common in upland forest and the majority of the species are distributed throughout New Zealand or

TABLE 3

Percentage contribution of each biogeographic element to each habitat.

	Element						
Habitat	Cosmopolitan 6 spp.	Old World Tropics 24 spp.	Polynesia 16 spp.	Aust.-N. Cal. (–N. Guinea) 11 spp.	Austral 16 spp.	Aust. 34 spp.	Endemic 83 spp.
Coastal cliff c.21 spp.	–	4.8	23.8	9.5	4.8	9.5	52.4
Coastal forest c.77 spp.	–	14.3	14.3	1.3	3.9	19.5	48.0
Lowland forest c.126 spp.	–	11.9	9.5	4.0	4.8	20.6	50.0
Upland forest c.104 spp.	1.0	8.7	8.7	1.9	6.3	18.3	55.8
Montane-subalpine forest c.67 spp.	1.5	7.5	9.0	–	7.5	17.9	58.2
Beech forest c.61 spp.	1.6	6.6	9.8	–	8.2	24.6	52.5
Subalpine-alpine scrub c.29 spp.	3.4	3.4	6.9	–	13.8	24.1	48.2
Subalpine-alpine non-scrub c.21 spp.	14.3	–	–	–	19.0	33.3	33.3
Open areas c.12 spp.	33.3	16.6	–	16.7	–	25.0	8.3
Scrub c.31 spp.	–	12.9	12.9	22.6	9.4	9.4	29.0
Cold water-cold water swamps c.13 spp.	15.4	15.4	–	15.4	–	15.4	38.5
Thermal areas c.34 spp.	–	35.3	14.7	5.9	2.9	14.7	26.5

are confined to the south of lat. 36–38°S.

4. The complete absence of the Australia-New Caledonia (–New Guinea) element at high altitudes and its relatively large contribution to the open and seral, compared with the closed, habitats. The greatest number of species is found in scrub and most are distributed throughout New Zealand.
5. The predominantly forest, coastal cliff and scrub-centred Polynesian contribution and the absence of this element from open habitats (except coastal cliff and thermal areas). Most species are found in lowland forest, north of lat. 36–38°S and 42°S.
6. The cosmopolitan element contributes mainly to open habitats and to the closed habitats of high altitudes and high latitudes. Numerically the cosmopolitan element is highest in open areas and south of lat. 36–38°S.

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I wish to thank Dr. J.P. Croxall for much helpful discussion during the preparation of this paper. Miss F.M. Blair kindly prepared the map and Mr K. Grant prepared the photographs from transparencies.

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REVIEWS

COMMON FERNS OF LUQUILLO FOREST, PUERTO RICO by Angela Kay Kepler 215 x 278 mm, vii + 125 pp. San Juan 1975. Price $ 15 US ($ 5 paperback) Spanish editions in both bindings available at same prices. From Inter American University Press, GPO Box 3255, San Juan, Puerto Rico 00936.

"This book is for the casual nature lover, interested amateur or professional biologist" is Mrs. Kepler's claim and I am always suspicious of such claims; but I think this book is excellent for many reasons, not the least being that in my opinion it lives up to it's aim in being an identification book for the interested layman. The drawings that accompany the text throughout are clear in detail and get the "feel" of the plant in habit sketches. Descriptions are readable for the uninitiated yet scientific, as are the ecological notes and geographical distributions; differences from similar species are given. The key looks as if it would work for a layman too, it certainly does for me. Specialists may criticise small points. I wonder about the common names which are so much a personal matter: I would have associated *Hernidictyum marginatum* for instance with *Heliconia* for which I almost mistook it when I first saw it in the forest, by calling it the Wild-plantain Fern, and even for the layman I do not like the use of Latin names without their authorities. We hope some who use this book will turn to other Floras, and Mrs. Kepler should have introduced us to the idiosyncrasies of nomenclature. Nevertheless this is a book worth having — it contains much of use to the indoor fern grower, and even if it had been reprinted at twice the price it would still be a very cheap buy.

A.C. JERMY

MORPHOLOGY OF THE SPOROPHYTE OF THE VITTARIOID FERN ANANTHACORUS

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ABSTRACT

The present studies have revealed that the monotypic genus *Ananthacorus* Und. et Maxon shows all the characters of the Vittariaceae and has several characters in common with those of *Vittaria.* Perhaps the most interesting and unique morphological feature of *Ananthacorus* is the nature of the vascular cylinder of the rhizome with its regular arrangement of leaf gaps representing suppressed leaves. On the basis of morphological comparisons, it is suggested that *Ananthacorus* is probably allied to *Vittaria* and possibly derived from it.

INTRODUCTION

Ananthacorus Und. et Maxon is a monotypic genus of vittarioid fern, the sole species *A. angustifolius* (Sw.) Und. et Max. being restricted in distribution to Jamaica and Tropical America. Goebel (1896) pointed out its relationship to the Vittariaceae on the basis of its spicular cells but did not give it a generic name. Christensen (1938), following Diels (1902), included it with *Vittaria* because of its two-lined sporangial arrangement. Benedict (1911) and Copeland (1947) separated it as a distinct genus. *Ananthacorus* is here considered to be a well marked genus of herbaceous epiphytic fern. The plant is rather inconspicuous because of the grass-like appearance of the fronds. Hitherto, the morphology of the genus has been almost unknown, except for the shape and size of the leaf, nature of the venation pattern and the shape of the sori and paraphyses (Benedict 1911, Copeland 1947).

MATERIAL AND METHODS

The present study of sporophyte morphology is based on material from Jamaica (S.C. Sinha, 63072, LWG), fixed in F.A.A. and stored in 70% alcohol. Anatomical observations recorded here are based on microtome sections stained with safranin and fast green. Stelar organisation has been studied mainly from serial sections (cut at 100 μ) and reconstructions based on camera lucida tracing of the outline of the vascular cylinder in serial section. Spore morphology is based on acetolysed spore samples mounted in glycerine jelly (Erdtman 1952). The spore descriptions are based on Nayar (1964).

OBSERVATIONS

Rhizome

The rhizome is creeping (c 3–4mm thick) and tufted, covered with dark brown basally attached, narrowly lanceolate paleae. The palea are clathrate (i.e. the internal lateral walls of the cells of the paleae thickened and all other walls thin) with a broad base, gradually tapering to an uniseriate apex terminated by a slightly swollen, ovoid, thin walled gladular cell (fig. 1 b, c-g). The stalk is 2–4 cells thick, the margin of the palea dentate, and the marginal teeth are formed by protruding ends of marginal cells (fig. 1 i). Some of the small paleae are hair-like, being uniseriate except at the base where they are two to four cells broad (fig. 1d, e). The thickening of the walls gradually progresses from the apex downwards. Mixed with the paleae on the rhizome, are found usually yellowish brown, long unicellular and septate hairs, some of which are gland tipped and branched (fig. 1 f-h). Structurally the rhizome is soft, parenchymatous and contains dense starch deposits. A characteristic feature of the rhizome is the thickening of the walls of the central cells of the ground tissue (both pith and cortex), the thickening being progressively less conspicuous from the centre towards the periphery of the rhizome. Cells of the inner ground tissue possess silvery, pitted walls. Often the corners of the parenchyma cells of the ground tissue are thickened in a collenchyma-like manner, as is also reported in *Vittaria remota* by Benedict (1914). The epidermis is thin walled. Sclerenchyma is absent.

The vascular cylinder of the rhizome is solenostelic, dissected by two rows of dorsally placed small elliptic leaf gaps (fig. 1a). These gaps are in paired groups. Within each group the members are close to each other but between groups there are wide separations. However, in contrast to other vittarioid ferns all gaps are not associated with leaves. Both gaps of each pair lie one in front of the other and not laterally as reported in other vittarioid ferns. The anterior gap (fig. 1 a "VG") of each pair is not associated with any leaf. Each leaf associated gap (i.e. the posterior one of each pair, fig. 1 a "LG") is similar to the leaf gap of other vittarioid ferns, although these gaps are more prominent.

The leaf traces are paired ribbon-shaped bundles and the leaf gap extends markedly on the posterior side between the leaf trace bundles so that the traces are attached one to either margin of the leaf gap near its middle plane. In each anterior gap a pair of ribbon-like vascular strands (fig. 1 a "V"), similar in shape and size to the leaf trace bundles are given off from each margin, the gap extending on the posterior side between these bundles. These two bundles curve out in the cortex of the rhizome like the leaf trace bundles and end blindly in the cortex well below the periphery of the rhizome. There is no indication of a reduced leaf externally on the rhizome but these gaps, associated with paired blind ending vascular strands, apparently represent suppressed leaves (fig. 1 a "V"). The suppression of this anterior member of each pair of leaves is characteristically regular. The suppressed anterior leaves (fig. 1 a "V"), directly in front of the well developed posterior ones (fig. 1 a "L"), contrasts with other vittarioid ferns where individual gaps alternate and pairs of gaps form two alternate rows.

Branching of the vascular cylinder is dichotomous as in other vittarioid ferns, the branching having no correlation with the leaves. However, each branch (fig. 1 a "B") is associated with a prominent gap in the vascular cylinder which extends to the base of the branch trace.

Roots are found in two irregularly lateral rows. There is no correlation between roots and either leaf or branch. Root traces (fig. 1 a "R") originate as superficial solitary vascular strands from the outer surface of the vascular cylinder.

The xylem tissue of the vascular cylinder is very much reduced and usually consists of only a single layer of tracheids, though at places it may become two layered (fig. 2). It consists entirely of tracheids having scalariform thickenings and there is no admixture of xylem parenchyma within them. The surface of the xylem band is irregular. Protoxylem points are situated at the free ends of the xylem band and also distributed on the outer surface (facing cortex) of the xylem cylinder and occupy an exarch position. A thin sheath of small xylem parenchyma cells envelops the xylem tissue except at the free ends of the xylem band. Phloem tissue is also very much reduced and usually consists of a thin (1—2 row) layer of small cells interrupted especially at the regions of the leaf gaps. The pericycle consists of 2—3 layers of large thin-walled parenchyma cells, becoming one layer towards the free ends of the vascular cylinder. Both the inner and outer endodermis are poorly-differentiated from the cells of the ground tissue.

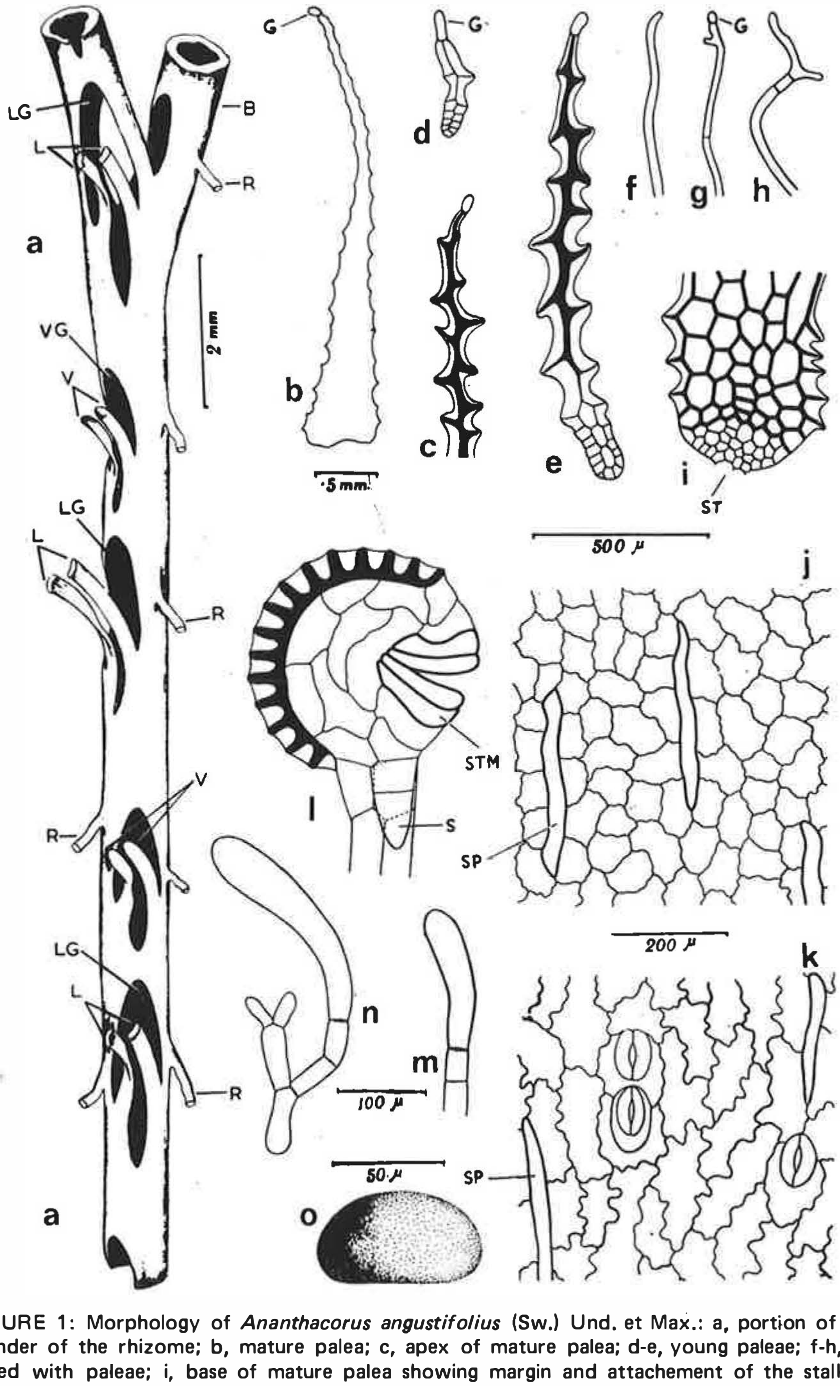

FIGURE 1: Morphology of *Ananthacorus angustifolius* (Sw.) Und. et Max.: a, portion of stelar cylinder of the rhizome; b, mature palea; c, apex of mature palea; d-e, young paleae; f-h, hairs mixed with paleae; i, base of mature palea showing margin and attachement of the stalk; j-k, upper and lower foliar epidermis; l, mature sporangium; m-n, paraphyses; o, lateral view of spore. ("B" = branch trace; "G" = glandular cell; "L" = leaf trace; "LG" = leaf gap; "R" = root trace; "S" = third row of stalk cells; "ST" = stalk; "STM" = stomium; "SP" = spicular cell; "V" = vascular strand representing suppressed leaf; "VG" = suppressed leaf gap).

Leaf

Leaves are simple, narrowly linear, stipitate (fig. 3) and non-articulated to the rhizome. They are arranged alternately in two rows along the upper surface of the creeping rhizome. The stipe and rachis are cylindrical and grooved on the dorsal side. The vascular supply to the stipe consists of a pair of ribbon-shaped strands, the xylem tissue of which is of 2–3 layers of cells, exarch and protostelic. The phloem usually consists of 2–3 layers of cells surrounding the xylem exept on the protoxylem points. The pericycle is of 2–3 layers of large-sized parenchyma cells, and the endodermis is poorly-differentiated.

The lamina is soft, thin and ribbon-like, gradually attenuated at both ends, with an entire margin. The venation is reticulate, with a prominent midrib, and a series of 4–5 rows of polygonal elongated areolae. These areolae are smaller towards the margin of the lamina than near the midrib and devoid of included veinlets. This type of venation, termed "pluriseriate" by Benedict (1911), is also found in the vittarioid ferns *Anetium, Antrophyum* and *Polytaenium.*

The foliar epidermis, on both surfaces, usually has copious long thickened epidermal cells, the so called "spicular" cells (fig. 1 j, k "SP"). The walls of these spicular cells are thicker than the other epidermal cells and have, by contrast, almost smooth margins. The presence of spicular cells along with the polygonal irregular epidermal cells has been reported in other vittarioid ferns by Goebel (1924), Benedict (1911), Bower (1928), Ogura (1938), Christensen (1938), Copeland (1947) and Holttum (1954). In *Ananthacorus* both the upper and lower epidermis are composed of cells with irregular sinuous outlines in surface view. The cells of the upper epidermis (fig. 1 j) are broad and polygonal with a faintly wavy outline. Those of the lower epidermis (fig. 1 k) are larger than the upper, narrow, elongated with their long axis parallel to the long axis of the leaf, and have more sinuous walls with more irregular outlines. Stomata are scattered all over the lower epidermis with their long axis parallel to the long axis of the leaf. The guard cells are elongated and oblong. The subsidiary cell of the stoma differs in shape from other epidermal cells and is broader than long. It surrounds nearly half to two third the circumference of the guard cells at the posterior end, whilst at the anterior end it dovetails into the corners of 2–3 cells or it completely surrounds the guard cells (fig. 1 k). In the latter case the stoma is at the anterior end of the encircling cell where the walls of the two are attached. Rarely a stoma is encircled by two rings of subsidiary cells; while the inner cell is narrow, small and with smooth outline, the outer one is similar to those described above (fig. 1 k). Both the upper and lower epidermis are chlorophyllous.

Sporangia

Fertile leaves are similar to the sterile ones. The exindusiate coenosori are present in two submarginal rows on each side of the midrib, in shallow grooves formed by the veins. Sporangia are borne in an elongated marginal sorus along the outermost veinlets on either side. The sorus usually extends all along the margin. The sporangia are of the common leptosporangiate type (fig. 1 l) with a large pear-shaped capsule borne on a short stalk of two cells thick, except at the capsule base where there is a short third row of cells (fig. 1 l "S") which is formed secondarily during sporangial development as a downward protrusion of the basal wall cell on one side of the sporangial capsule. The wall of the sporangial capsule is thin and composed of one layer of 10–12 flattened wall cells. The annular ring is well demarked with a region of 14–20 highly indurated thick walled cells protruding prominently from the surface of the capsule. As in all other vittarioid ferns, the stomium is of four cells (fig. 1l "STM") with thin walled accessory cells above and below it. Sporangia are usually protected by simple

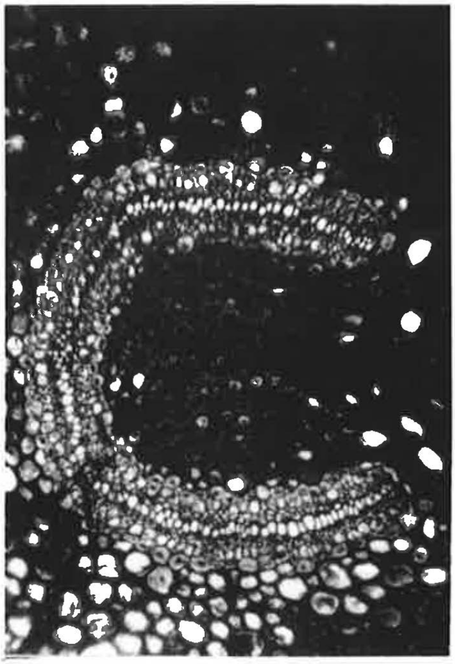

FIGURE 2: *Ananthacorus angustifolius* (Sw.) Und. et Max., transverse section of the stelar portion of the rhizome.

FIGURE 3: *Ananthacorus angustifolius* (Sw.) Und. et Max., habit of frond.

slender paraphyses (Benedict 1911, Copeland 1947) and rarely with branched paraphyses (fig. 1 m, n). The terminal cell of each type of paraphysis is large, swollen, elongated, club-shaped and dark brown. Branched paraphyses have not been previously described in *Ananthacorus,* but have been reported in several species of *Vittaria* (Benedict 1911, 1914; Holttum 1954), *Antrophyum semicostatum* (Holttum 1954) and *A. plantagineum* (Rao and Srivastava 1968).

Spores

The spores of *Ananthacorus* are of monolete-bilateral type, plano-convex or concavo-convex in lateral view (fig. 1 o), elongated oblong in polar view and measure on an average 44 x 80μ (polar diameter x longest equatorial diameter). The laesura is 58μ long. The exine is 2–2.5μ tick; the sexine slightly thicker than nexine and smooth. Perine is absent. The fresh spores are bright greenish yellow in colour, with many small plastids and dense contents including one or two large nearly colourless oil globules.

DISCUSSION

The morphology of the plant described in this paper shows all the characters of the Vittariaceae referred to by Benedict (1911), Bower (1928), Christensen (1938), Ching (1940), Copeland (1947) and Holttum (1954). The present studies have revealed that *Ananthacorus* has several characters in common with those of *Vittaria* as reported by Benedict (1911, 1914), Copeland (1947), Bir & Devi (1971). These include a rhizome with two rows of leaves, basally attached clathrate paleae, solenostelic vascular cylinder, binary leaf trace, xylem tract of the rhizome without admixture of xylem parenchyma; leaf lamina with sori in two submarginal rows along the outermost veinlets; simple and branched paraphyses; and bilateral, non-perinate spores. *Ananthacorus* differs however from *Vittaria* in having a pluriseriate venation pattern; distantly placed leaves over the rhizome; leaf gaps with suppressed leaves; xylem tissue of the rhizome with a single layer of tracheids; thickened ground tissue cells with silvery, pitted walls; and the pair of gaps alternating together to form two rows instead of individual alternating gaps as in other vittarioid ferns. Thus comparative morphology supports the earlier view of Benedict (1911) and Copeland (1947), who segregated *Ananthacorus* from its nearest relative *Vittaria* because of its pluriseriate venation pattern.

On the basis of similar venation in *Ananthacorus* and *Polytaenium,* Copeland (1947) suggested a close relationship of these genera. But the present studies have shown that *Ananthacorus* differs from *Polytaenium* in having a solenostelic vascular cylinder; origin of leaf trace bundles from either margins of the gap; paraphysate sori; two sporangial lines; and typical bilateral spores. However, in contrast to *Ananthacorus, Polytaenium* possesses a dictyostelic vascular cylinder; both leaf trace bundles originating from the same margin; sporangia usually in more than two lines; and typical tetrahedral spores.

Perhaps the most interesting and unique morphological feature of this monotypic genus is the nature of the vascular cylinder of the rhizome: its regular arrangement of leaf gaps representing suppressed leaves, where instead of individual gaps alternating, the paired gaps alternate, forming two rows on the dorsal surface of the rhizome. Thus the vascular cylinder of this genus does not resemble that of other known members of the vittarioid group. The vascular cylinder of the rhizome also presents some advanced features compared with *Vittaria:* namely the less dissected solenostele; xylem tissue reduced to only a thin layer of tracheids; suppressed leaf gaps; thickened cells of the ground tissue; and branches with prominent adaxial gaps. The sum of these characters, together with the specialised venation pattern (Benedict 1911), point to a comparatively advanced position of the genus *Ananthacorus,* and suggest, on balance, that *Ananthacorus* is probably allied to *Vittaria* and possibly derived from it.

ACKNOWLEDGEMENTS

I am indebted to Dr. S.C. Sinha, Institute of Jamaica, Kingston, Jamaica, for procuring the material for the present study. Thanks are due to Dr. Surjit Kaur (Lucknow) for going through the manuscript and to Dr. B.K. Nayar (Calicut) for his guidance in making the stelar reconstruction. I am also thankful to Dr. T.N. Khoshoo, Deputy Director Incharge National Botanic Gardens, Lucknow for facilities and encouragement.

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REVIEW

COMPANION TO BEDDOME'S HANDBOOK TO THE FERNS OF BRITISH INDIA by B.K. Nayar and S. Kaur. 244 pp. Pama Primlane, The Chronica Botanica, Post Box 123, New Delhi-1, India. 1974. $14.00, Rs. 55.00.

Beddome's *Handbook* was first published in 1883 shortly after its author's retirement from Government service. He had spent over 30 years in India and published a bulky illustrated volume on the ferns of Southern India followed by another dealing with all the other ferns of British India known to him and not covered by his first work. The *Handbook* represented a more compact and up-dated distillation of this knowledge and it remained for more than 60 years a pteridologist's *vade mecum,* for few botanists if any have had Beddome's long and intimate field knowledge of Indian ferns. The last 30 years have seen a strong revival of interest in these plants and rapid advances have been made in our ideas about relationships and classification. One consequence of these advances is that Beddome's *Handbook* has lost some of its former value; most of the ferns described in it are now known by different names and often related species are very different from those assigned by Beddome.

The present volume is an attempt to correct the nomenclature of all the species included in the *Handbook* and its *Supplement* and to indicate modern views as to relationships. The book is divided into three parts. The first part entitled "Nomenclatural Changes" consists of a species by species list in the sequence of the *Handbook* with Beddome's name followed by the corrected name in bold-face type. The second part is devoted to Professor Nayar's proposed system of classification of ferns. This is an elaboration of the scheme published in *Taxon* in 1970. The third part consists of a revised list of names of Thelypteroid ferns following Holttum's subdivision of this group. A surprising feature of this section is the large number of new combinations which are made in Holttum's name.

The most important part of this "Companion" – indeed the *raison d'être* of the work – is the first part wherein the authors aim to give the corrected nomenclature for all species in the *Handbook.* It is on the success or failure therefore with which it achieves this aim that the book must be judged. In the opinion of the present reviewer the book fails in this respect to do what it sets out to do.

One of the features of the nomenclatural list is the provision of alternative names. These cover splinter genera in, for example, the Thelypteridaceae and also cases where specific epithets have been linked with several different genera by different authors. The alternative names are given in such cases on the grounds that "there is some difference of opinion among taxonomists regarding the genera to which they properly belong". This is a reasonable approach to a troublesome problem, but there are surely instances where the choice of name is heavily weighted in favour of one combination. The opinions of a taxonomist who has studied and monographed a genus on a world basis transcend in importance the views of those with a more restricted geographical knowledge of the same genus. Dr. Kramer has for many years made the lindsaeoid ferns his special study and no other living pteridologist could claim a comparably wide and deep knowledge of these ferns. One would have expected therefore that Kramer's views would have been reflected in the present list and that his choice of name would have been given priority where alternative names are cited. Yet *Schizoloma* and *Isoloma* which Kramer rejects as distinct genera, are used as the "correct" names in the case of *Schizoloma heterophylla, S. walkerae, S. orbicularis* and *Isoloma divergens* with Kramer's nomenclature cited under alternative names.

A more serious criticism however concerns the numerous errors in this and other groups throughout the list. The correct name for the fern cited by Nayar and Kaur as *Lindsaea lancea* (L.) Bedd. is *L. caudata* Hook. The Linnaean epithet was given to a South American fern. The correct name for the fern Beddome called *L. scandens* – a name which is repeated by Nayar and Kaur – is *L. parasitica* (Roxb. ex Griff.) Hieron. As described in the *Handbook, L. repens* covers two species viz. *Lindsaea repens* (Bory) Thwaites and *L. glandulifera* v.A.v.R. The latter is nowhere mentioned by Nayar and Kaur who do however cite *L. pectinata* Bl. as a second species though this has been reduced by Kramer to varietal status. The correct name for *L. orbiculata* var. *tenera* is not *Schizoloma tenerum* but *L. orbiculata* var. *commixta* (Tagawa) Kramer. The plant to which Beddome refers under the name *Schizoloma lobata* is the fern to which the name *Lindsaea cultrata* (Willd.) Sw. properly belongs and also includes *L. venusta* Kaulf. ex Kuhn (not mentioned by Nayar and Kaur) to which Beddome's illustration, F.S.I.t.27, of *Schizoloma recurvatum* belongs. Poiret's *Lindsaea lobata* which is here used as the corrected name for the Indian fern, is native to Sumatra, Java and eastwards to the Philippine and Caroline Islands but not known in India or Ceylon. Since the paper in which Kramer pointed these facts out is quoted by Nayar and Kaur their errors are inexcusable. Kramer also showed many years ago that the type of the species which had previously been known universally as *L. cultrata* (Willd.) Sw. – a name regrettably once again repeated here for the wrong species – belongs to the fern commonly called *L. decomposita* Willd. and the correct name for *"L. cultrata"* is *L. odorata* Roxb. It is particularly unfortunate that these avoidable errors should have been made since they reintroduce nomenclatural confusion and disorder into a group of ferns the systematics of which has been so carefully clarified by its monographer.

The errors noted above all fall within three pages of the nomenclatural list. The list runs to 106 pages. Other mistakes occur all too frequently. Some of these are due to the authors' having overlooked relevant literature, Dr. T.G. Walker's papers on *Pteris* being one example. The cause of some errors is difficult to understand. How can one reconcile the citation of a taxonomic paper with the fact that its contents are disregarded? My revision of the athyrioid ferns of Ceylon is quoted on p. 40 yet the nomenclature relating to *Diplazium* as given in that paper is ignored and incorrect names are perpetuated.

This is a work which might have been of considerable value to Indian and other pteridologists, but the standard of accuracy falls so far short of what is required in such a list that great care will need to be exercised by those using it. It is to be hoped that a corrected edition will be issued in due course.

W.A. SLEDGE

SIX NEW SPECIES OF SELAGINELLA FROM TROPICAL SOUTH AMERICA

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ABSTRACT

Six new tropical American species of *Selaginella (anisoclada, asplundii, cruciformis, euclimax, glossophylla, leucoloma)* are described on, respectively, pages 255, 257, 257, 259, 259, 262. They should be cited as Alston ex Crabbe & Jermy in Fern Gaz. 11 (1974).

Following our presentation of seven new species (Amer. Fern J. 63: 135–144, 1973) we now present six further new species recognized by A.H.G. Alston and based on his manuscript. We are indebted to Michael Mullin of our Section for help with the photography of the illustrations.

Selaginella anisoclada Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 3a and b)
Species heterophylla inter fere omnes ramulis minutifoliatis distinguenda, ex affinitate *S. porphyrosporae* A. Br. sed foliis lateralibus ovatis (non lanceolatis) obtusioribusque distinguitur.

Stems glabrous, ascending, 4–10 cm high; 0.3 mm in diam. at the base, branched from the base; rhizophores restricted to the basal third; primary branch-system ovate to oblong, with secondary branches about 5–8 mm apart, pinnate, up to 2 cm long, and tertiary branches 2–3 mm long, fertile and simple, or sterile and branched, sometimes appearing swollen at the tips. Leaves heteromorphic becoming isomorphic in the ultimate branchlets; lateral leaves distant, ovate, 0.5–2.0 x 0.25–1.0 mm, subacute, the inner half-leaf* semi-ovate, rotundate at the base and distantly serrulate, the outer half-leaf semi-ovate-oblong, rotundate-truncate at the base and entire; axillary leaves ± the same as the lateral leaves; median leaves ovate or ovate-elliptic, 1.25–0.5 x 0.3–0.8 mm, entire, acute. Strobili single at the apex of or forming the entire ultimate lateral branches, sometimes continuing growth vegetatively at the apex, subtetrastichous, c. 3 x 2 mm. Mega- and microsporophylls similar, 1.25 x 0.5 mm, obliquely lanceolate, carinate, white-margined, serrulate, with acute apices. Megaspores 220–280 μm, yellow, minutely scabrate with a reticulum of low rounded ridges. Microspores c 22–32 μm, yellow, ± smooth.

Type: Venezuela, Aragua, above Guamitas, Parque National, 900 m, on rock in forest stream, bright green, 30 December 1938, *Alston 5814* (holotype BM; isotypes US, VEN).

Paratypes: Colombia, Magdalena, Sierra del Libano, Santa Marta, 1675 m, common locally on open or shady wet rocks in a ravine, pale gray green, 1898–99, *H.H. Smith 2242* (BM, NY, US); Santa Marta, 1898–1901, *H.H. Smith 2567* (BM).

Geographical range: confined to E coastal ranges of Venezuela and Colombia.

This species is distinct in its distant arrangement of both median and lateral leaves which are almost isomorphic on the ultimate branchlets. It varies, in the limited

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* We first, in Amer. Fern J. 63: 135, 1973, used the term "half-leaf" for each of the two parts of the leaf blade divided by the midrib, the "inner" being on the acroscopic side, the "outer" on the basiscopic.

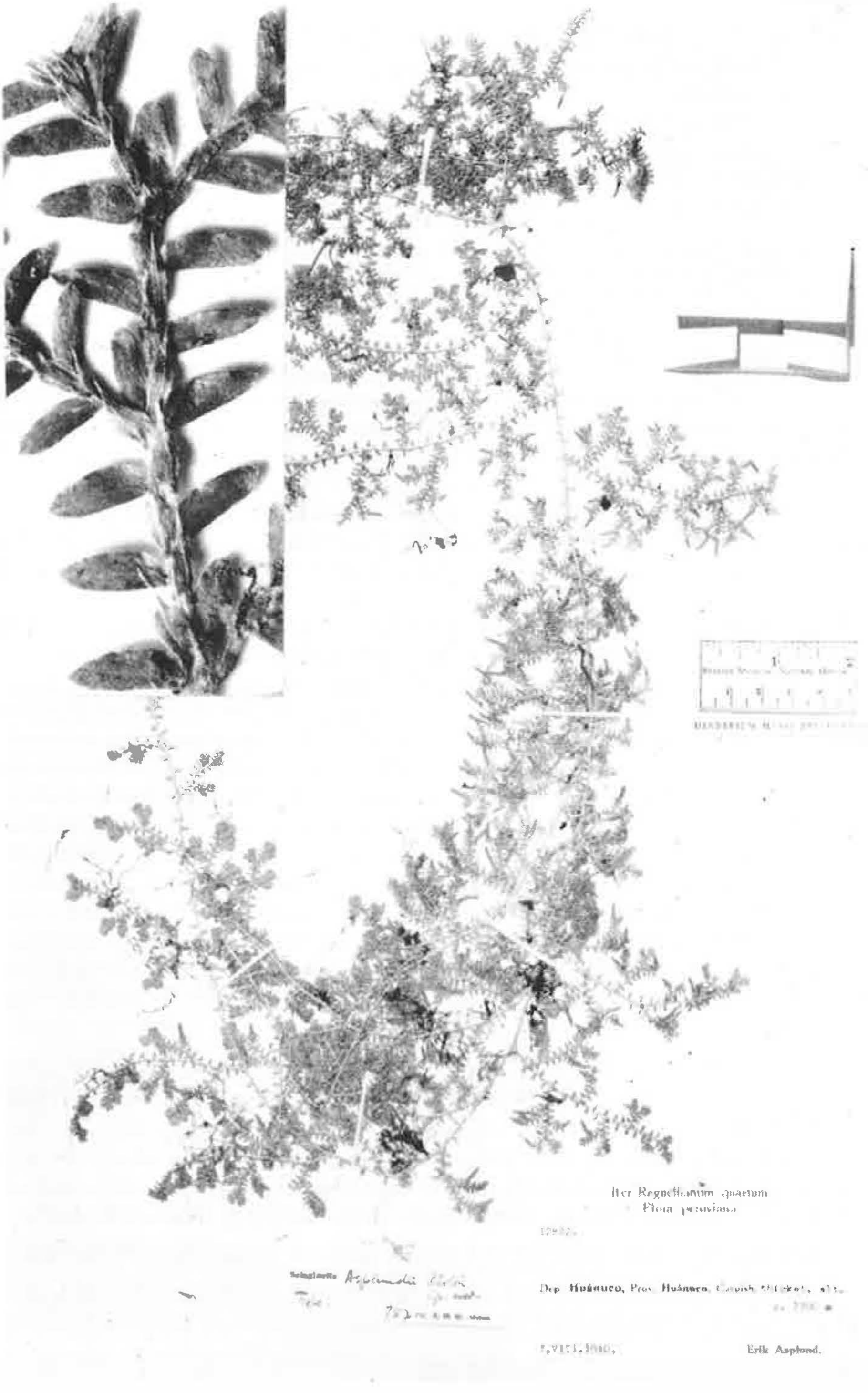

FIGURE 1: Type specimen of *Selaginella asplundii* inset: close-up of dorsal surface x 9.

material seen, in stature of plant and degree of branching, a character obviously affected by the moistness of and competition in the habitat. It is most similar to *S. porphyrospora* A. Br. from Mexico to Panama (type: Mexico, Vera Cruz, *C. Sartorius 1896*, B, isotype BM) but in that species the lateral leaves are large, lanceolate and acute, and there is a tendency for them to show a false nerve when dry. In Venezuela and Colombia *S. lychnuchus* Spring can be similar in habit, but that species has dimorphic sporophylls and large, oblong lateral leaves and long aristate median leaves.

Selaginella asplundii Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 1).
Species heterophylla ex affinitate *S. arenariae* Bak., sed habitu caulibus multo longioribus repentibus (nec habitu compacto) et foliis intermediis valde aristatis (nec acutis) differt.

Stems glabrous, up to 1 m long or more, creeping, prostrate, obscurely articulate, monostelic, pale green-straw coloured, alternately pinnate or irregularly branched with lateral branches, 2- or 3-pinnate, spreading, ovate or irregular in outline; rhizophores dorsal in origin, distant. Leaves heteromorphic throughout; lateral leaves spreading, up to 5 mm apart, but more crowded on the branches, 2.25 x 1.0 mm, with obtuse apices, the inner half-leaf semi-oblong-lanceolate, denticulate towards and gradually rotundate at the base, abruptly cuneate at the apex, the outer half-leaf semi-oblong, shortly rotundate at the base, abruptly cuneate at the apex; axillary leaves oblong-lanceolate, obtuse; median leaves distant, elliptic, denticulate, 1.5 x 0.75 mm, long-aristate at the apex, the outer half-leaf rotund-auriculate at the base. Strobili tetrastichous, c 10 x 1.25 mm, single at the apices of ultimate branches. Megasporophylls 2.0 x 1.2 mm, at the base of the strobili; megaspores c 550 μm, pale brown-yellow, with an irregular crested white reticulum. Microsporophylls 1.5 x 0.9 mm, ovate, denticulate; microspores c 40 μm, hyaline, strongly spiny.

Type: Peru, Huánuco, Carpish, in thicket, 2700 m, 7 Aug 1940. *E. Asplund 12822* (S-P, isotype BM).

Paratype: Peru, Huánuco, Carpish, on shore of rivulet, 2650 m, 7 Aug 1940, *E. Asplund 12843* (S-P).

Geographical range: confined to Peru.

This species is named in honour of the late Erik Asplund, curator of the Regnell Herbarium at Stockholm and a world-famous authority on the flora of South America.

Selaginella cruciformis Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 2).
Species heterophylla ex affinitate *S. chrysoleucae* Spring, sed foliis intermediis ovato-oblongis (nec elliptico-falcatis), brevissime acuminatis (nec longe aristatis), plerumque distantibus (nec crebre imbricatis), et textura flaccidiora differt.

Stems glabrous, suberect from an ascending base, 20—40 cm high, 2 mm in diam. at the base; rhizophores restricted to the basal quarter; branch system pinnate throughout, secondary branches initially perpendicular to main stem (i.e. cruciform), and those towards the base often continuing growth and becoming the primary branch system, sporulation simultaneous on any one primary branch system, colour generally blue green. Leaves everywhere heteromorphic; lateral leaves spreading, subcontiguous or slightly imbricate, oblong, 5.0 x 2.5 mm, obtuse, inner half-leaf semi-oblong-lanceolate, broadly rotundate and distantly serrulate at the base, outer half-leaf semi-oblong, rotundate-cuneate and serrate at the base, serrulate towards the apex, otherwise entire; axillary leaves unequal-sided and ± similar to the lateral leaves;

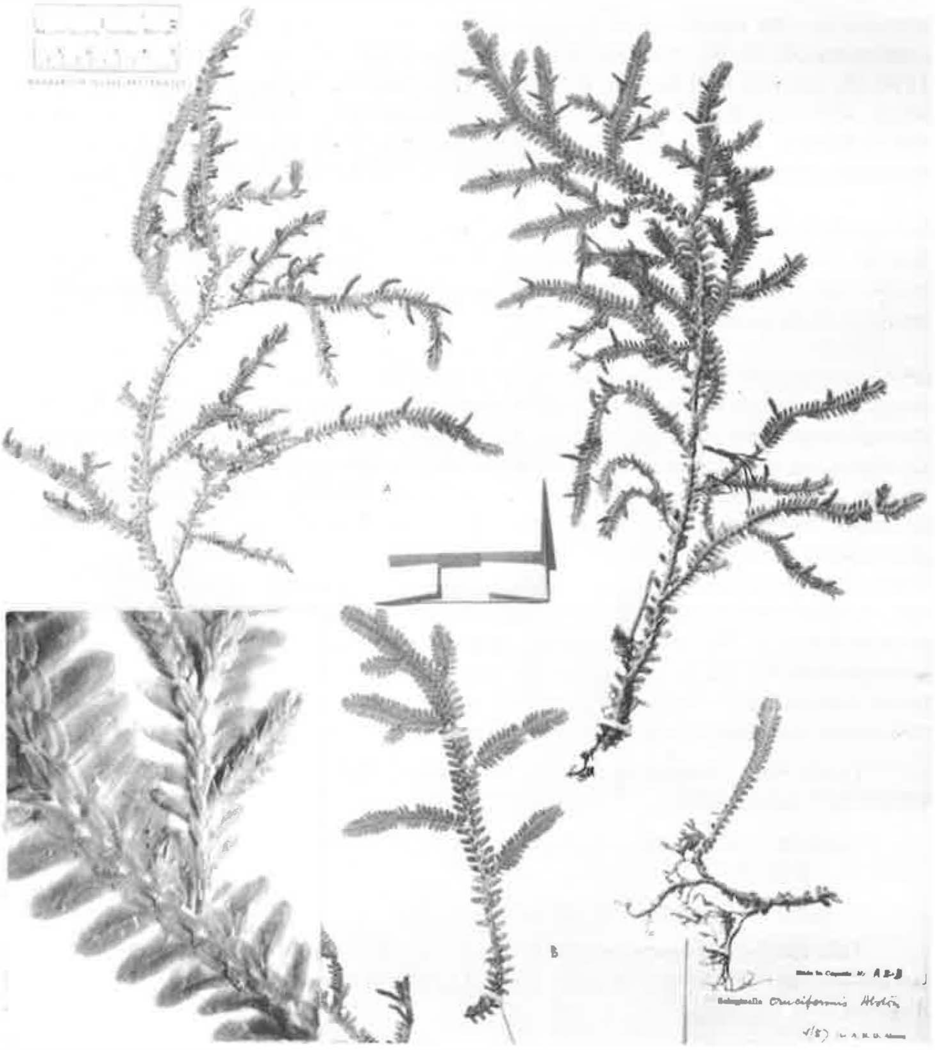

FIGURE 2: Type specimen of *Selaginella cruciformis* inset: close-up of dorsal surface x 9.

median leaves elliptic-oblong, 2.5 x 1.75 mm, minutely apiculate, serrulate. Strobili tetrastichous, 8.0 x 1.5 mm, single as lateral spurs on secondary or tertiary branches. Sporophylls 1.5 x 0.75 mm, ovate-deltate, carinate, serrate, acute. Megaspores c 280 μm, pale brown when moist, minutely granular, cristo-reticulate with prominent proximal ridges. Microspores c 23 μm, pale yellowish when moist, with close elongate papillae.

Type: Venezuela, Carabobo, R. Aguada, by stream in forest, 1800 m, *Alston 6240* (BM).

Paratypes: Venezuela, Aragua, Rancho Grande, 1400 m, *Box 3879* (BM); Colonia Tovar, 915 m, *Fendler 487* (BM); Yaracuy, Cerro La Chapa, N of Nirgua, 120–1400 m, 9/10 Nov 1967, *Steyermark, Bunting & Wessels-Boer 10025* (BM, US).

Geographical range: confined to Venezuela.

This species resembles *S. chrysoleuca* Spring in the lateral strobili and the basal rhizophores. It might also be confused with *S. truncata* A. Br., but that species is prostrate and rooting throughout and has terminal strobili.

Selaginella euclimax Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 3c, d and e).

Species heterophylla ex affinitate *S. huehuetenangensis* Hieron., sed foliis intermediis et lateralibus serratis (nec valde ciliatis, praesertim semifacie lateralium superiore) differt.

Stems glabrous, ascending from a creeping base, c 15 cm high, 1 mm in diam. at the base, with a small but characteristic tubercle at the insertion of the superior margin of the lateral leaf; branching throughout, branch-system ovate-elliptic, branches c 6 mm apart, pinnate or bipinnate, up to 3.5 cm long. Leaves heteromorphic throughout; lateral leaves spreading, closely spaced, oblong, 3.0 x 1.3 mm, obtuse, the inner half-leaf semi-oblong-lanceolate, serrate, gradually rotundate-cuneate at the base, thickened at the point of insertion with the stem, the outer half-leaf semi-oblong, almost entire; axillary leaves ± similar to lateral leaves but less unequal-sided; median leaves elliptic-oblong, 1.5 x 1.0 mm, serrate, aristate at the apex, aristae up to almost half the length of the lamina. Stobili tetrastichous, 4.0 x 1.5 mm, single or paired at the apex of short lateral branches. Sporophylls c 1.4 x 0.9 mm, narrowly ovate--deltate, carinate, serrulate, acute. Megaspores c 300μm, pale yellow-brown when moist, verrucose. Microspores c 30μm, yellow when moist, papillate with elongate papillae.

Type: Colombia, Cauca, W of Tambo, 2300 m, *Haught 5220* (BM, isotype US).

Paratype: Colombia, Antioquia, Rio Guatope, 5–6000 m, *Kalbreyer 1457* (B).

Geographical range: confined to Colombia.

This species also resembles *S. tarapotensis* Bak. which is prostrate (instead of suberect) and with a longer arista. *S. pearcei* Bak. is also very similar but it has broader lateral leaves with acute apices, very short aristae, and is usually less branched below.

Selaginella glossophylla Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 4a and b).

Species heterophylla ex affinitate *S. popayanensis* Hieron., sed foliis lateralibus oblanceolatis, obtusis (nec ovatis, acutis), foliisque intermediis acutis (nec acuminatis) differt.

Stems glabrous from ± creeping base, c 7 cm long, filiform, branched from the base, whitish straw-coloured when dry; rhizophores restricted to the basal part; branch-system irregular, branches c 8 mm apart, simple or pinnate, 1–3 cm long. Leaves heteromorphic throughout; lateral leaves spreading, distant, entire or with a few teeth, 2 x 1 mm, obtuse, round cuneate, sometimes symmetrical, oblong-elliptic, or asymmetrical, the inner half-leaf semi-oblanceolate-oblong, the outer half-leaf semi-oblong-elliptic; axillary leaves broadly oblong-elliptic, slightly oblique; median leaves obovate, mostly 1.0 x 0.5 mm, distant, entire, or with a few teeth, acute. Strobili lax with few sporophylls, 4 x 3 mm, single at the apex of lateral branches. Sporophylls 1.5 x 0.7 mm, of one kind, varying slightly in width and colour, oblong-lanceolate or oblong-elliptic to ovate, acute or slightly acuminate, serrate from a hyaline margin. Megaspores c 330μm, golden yellow, cristate-reticulate, granulate. Microspores c 34μm, golden yellow when moist, smooth or minutely pitted.

Type: Bolivia, Cochabamba, Chaparé, Incachaca (lat. 17° 14'S, long. 65°49'W, 130 kms NE of Cochabamba), 3000 m, 22 Aug 1950, *Winifred M.A. Brooke 6783* (BM).

Paratype: Chile, without exact locality, 1848, *Mercier s.n.* (P).

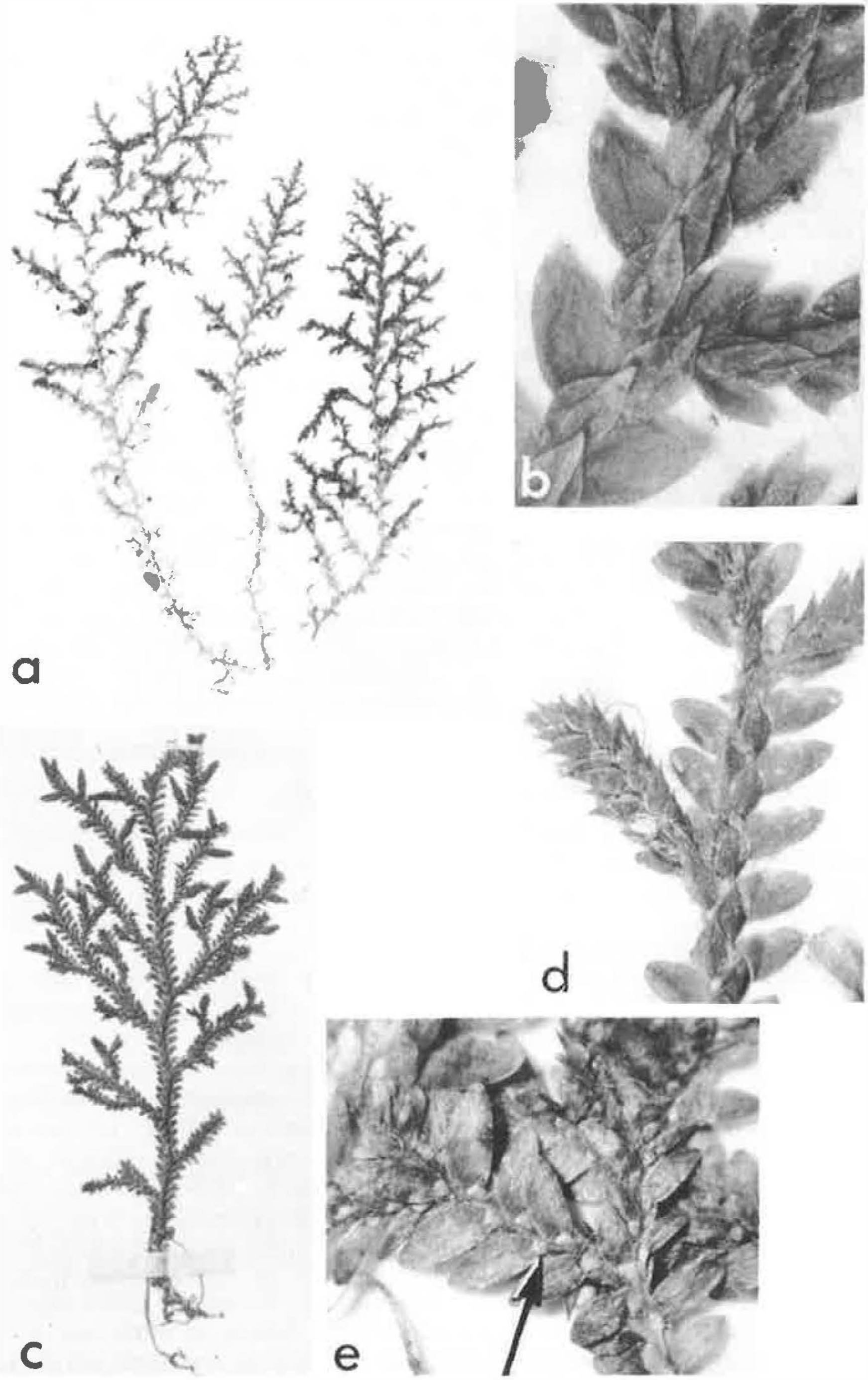

FIGURE 3: a and b, Type specimen of *Selaginella anisoclada;* a, whole plant x 1; b, dorsal surface of main stem x 18; c, d and e, Type specimen of *Selaginella euclimax;* c, whole plant x 1; d, dorsal surface of branch with cone x 9; e, ventral surface showing characteristic tubercles (arrowed) x 9.

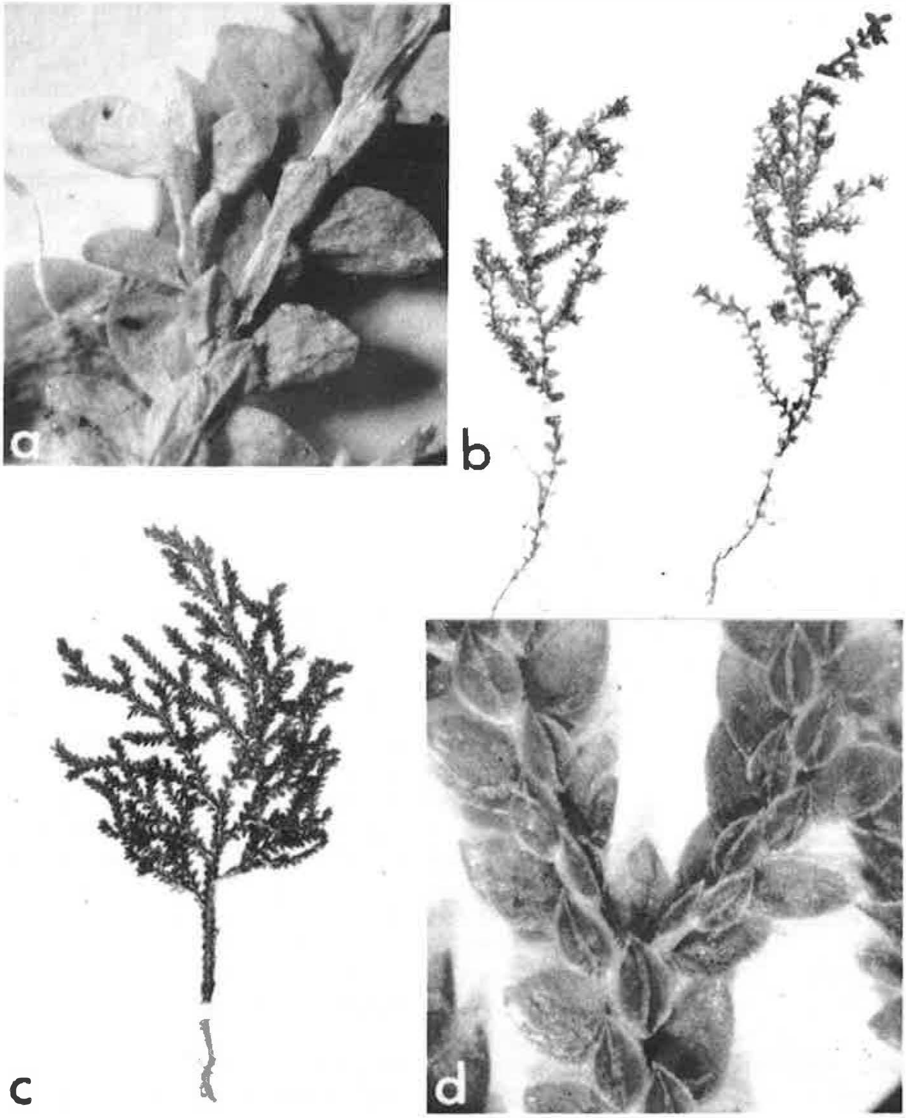

FIGURE 4: a and b, Type specimen of *Selaginella glossophylla;* a, dorsal surface x 18; b, two plants from type sheet (BM); x 1; c and d, Type specimen of *Selaginella leucoloma;* c, whole plant x 1; d, dorsal surface of main branch x 18.

Selaginella leucoloma Alston ex Crabbe & Jermy, *sp. nov.* (Fig. 4c and d).

Species heterophylla ex affinitate *S. novae-hollandiae* (Sw.) Spring, sed foliis intermediis acutis (nec aristatis), albo-marginatis et exauriculatis differt.

Stems glabrous, erect from a very short creeping base, up to 10 cm high, 0.5 mm in diam. at the base, the lower part simple, 1.5—4.0 cm long, pale green-straw coloured when dry; rhizophores restricted to the base; branch-system ovate-oblong, branches up to 5 mm apart, bipinnate, irregular, up to 3 x 1 cm, occasionally a lower primary branch-system developing and becoming dominant. Leaves heteromorphic throughout; lateral leaves spreading, contiguous or distant, broadly ovate-oblong, 1.75 x 1.30 mm, obtuse, rounded at the base, with white margins; inner half-leaf broadly semi-ovate-oblong, ciliate in the lower half, serrate at the apex; outer half-leaf semi-oblong, entire; axillary leaves ovate or ovate-oblong, mostly equilateral, 1.5 mm long, ciliolate at the base; median leaves broadly elliptic, with hyaline white margins (best seen by transmitted light), the lower ones long-ciliate, the higher ones short-ciliate, 1.0 x 0.7 mm, distant or imbricate, acute. Strobili subtetrastichous, lax with few sporophylls, 3 x 1 mm, single at the apex of short lateral branches. Sporophylls 1.2 x 0.6 mm, ovate, carinate, serrate, acute. Megaspores c 200μm, pale brown, minutely warted. Microspores c 37.5μm, pale yellowish when moist, papillose.

Type: Bolivia, La Paz, Hacienda Simaco, on the road to Tipuani, Larecaja, 1400 m, Feb 1920, *Buchtien 5280* (BM, isotype US).

Paratypes: Bolivia, La Paz, Hacienda Simaco, on the road to Tipuani, Larecaja, 1400 m, Feb 1920 *Buchtien 5278[A]* (BM, isoparatype US) — this gathering is a mixture of *S. novae-hollandiae* and *S. leucoloma*, and specimens of the latter at BM & US have been labelled 5278*[A]*; Bolivia, ravin de Pelechuco, 1843—48 or 1851, *Weddell 4779* (P).

In habit this species resembles *S. popyanensis* Hieron., but its branches are denser and its lateral leaves are ciliate (not entire).

FERN GAZETTE VOL. 11 PART 2-3

ERRATA—CORRIGE

On p. 96, 9 lines from bottom, after "light castaneous" insert "in lower half and blackish castaneous upwards, with long flexuous cilia; paleae of stipe castaneous".

On p. 98, line 12, after "melleous to fulvous" insert "concoloroas throughout or"; line 14, after "irregular in length" insert, "direction and distance".

On p. 99, 3 lines from bottom, after "distal part, with" insert, "concolorous edges and".

DRYOPTERIS CAUCASICA, AND THE CYTOLOGY OF ITS HYBRIDS

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ABSTRACT

Meiosis in wild collected plants of *Dryopteris* x *initialis* (= *D. abbreviata* x *D. caucasica*) and *D.* x *euxinensis* (= *D. caucasica* x *D. filix-mas*) has been studied; the results adding much weight to the hypothesis that *D. caucasica* represents the hitherto unknown diploid ancestor of *D. filix-mas.* The cytological results show there to be a certain degree of homology (c 5–23 bivalents) between the two diploid genomes presumably contributed by *D. caucasica* and *D. abbreviata* — which casts doubt on the traditional amphidiploid nature of *D. filix-mas.* Some other diploid species possibly not far removed are also mentioned, and the question of *D. filix-mas* in North America is raised. New localities for *D.* x *euxinensis* (one in Europe) are given, and *D. caucasica* is reported from European Turkey and European Russia along with a diagnostic description of the Flora Europaea format.

INTRODUCTION

Tentative identification of the diploid species *Dryopteris caucasica* (A.Br.) Fraser-Jenkins and Corley as a parent of the tetraploid species *D. filix-mas* has recently been proposed (Fraser-Jenkins and Corley 1973); and the chemical constituents of *D. caucasica* have been investigated with a view to testing out its suitability as a parent of *D. filix-mas* (Widen *et al.* 1973). The other parent of *D. filix-mas* was shown nearly twenty-five years ago by Professor Manton to be *D. abbreviata* (DC) Newman (Manton 1950). However only fragmentary cytological evidence was available to support the position of *D. caucasica,* and further investigation remained to be done.

The present paper gives the results of recent cytological work carried out on cultivated plants of wild hybrids of *D. caucasica.* These hybrids were collected in Turkey and the Caucasus in 1971 and are:

1. *Dryopteris* x *initialis* Fraser-Jenkins & Corley (*D. caucasica* x *D. abbreviata*) — diploid.
2. *Dryopteris* x *euxinensis* Fraser-Jenkins & Corley (*D. caucasica* x *D. filix-mas*) — triploid.

The third hybrid in the group, *D.* x *mantoniae* Fraser-Jenkins & Corley (= *D. abbreviata* x *D. filix-mas*) has already been thoroughly investigated cytologically by Manton in artificially produced plants (Manton 1950) and by Dr. S. Walker in wild plants (Fraser-Jenkins & Corley 1973), both finding it to be triploid with approximately 41 bivalents and 41 univalents at meiosis.

CYTOLOGY

D. x initialis

The plant used for this study was the one from which the holotype and isotypes were taken in the wild. This was found in 1971 growing with *D. abbreviata* and *D. caucasica* in the Caucasus — the upper Teberda valley below the Klukhurskiy Pass at c 2,100 m alt., in mixed forest, CRFJ 3210 (BM, LE and G). Fixed material was prepared from a clonal offset of this plant in May 1974 and meiosis was examined using the standard acetocarmine squash technique (Manton 1950). The results consistently show this hybrid to be diploid (2n = 82) with a number of bivalents ranging from 5 to 23 (mean: 14) and the corresponding number of univalents (fig. 1).

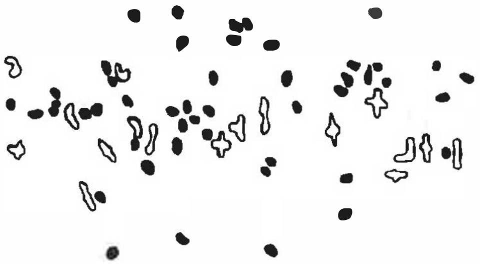

FIGURE 1: Diagram of Meiosis in *D.* x *initialis,* type plant: CRFJ 3210, cult. Radley, May 1974. 17 bivalents, 48 univalents, diploid.

D. x euxinensis

The plants used for this study again came from the Caucasus — the Teberda valley, below the Klukhurskiy pass at c 2000 m alt. (not 2,300 m alt., as stated in Fraser-Jenkins & Corley, 1973) CRFJ 3209 (BM); and also from the Black Sea Coast of Turkey — Bolu province, above Kaynasli on Bolu Dagi at c 900 m alt. CRFJ 2080 (BM), where they were both growing with *D. caucasica* and *D. filix-mas.* Fixed material of clonal offsets of these plants was prepared in May 1974 and meiotic preparations consistently show these hybrids to be triploid (2n = 123) with 41 bivalents and 41 univalents.

Interpretation

Up until now many difficulties have arisen in the interpretation of the cytological evidence that was available. Bivalent formation could perhaps have been the autosyndetic pairing of an autopolyploid, along with suppression of multivalent formation by a genetic mechanism — as has been shown to exist by Riley (1960) and suggested in *Asplenium* and *Adiantum* by Vida and others (Manton, Sinha & Vida 1970; Vida 1970 & Lovis, Sleep and Reichstein 1969). Indeed *Dryopteris marginalis* x *D. filix-mas* found wild in Ontario, Canada and Michigan, U.S.A. has been investigated cytologically and chemically (Wagner 1971; Widen & Britton 1971) and a range of from c 5 to 41 bivalents has been found which is more or less compatible with the result now obtained from *D.* x *initialis.* However, although this has been interpreted by Wagner (1971) as showing *D. filix-mas* to be an autopolyploid there is considerable morphological difference between European *D. filix-mas* and that of the Eastern U.S.A. and the present author strongly suspects that the two are quite different species, which is also suggested by the chemical analyses carried out by Widen & Britton (1971). Stereoscan studies of the spores of these taxa are reported in Britton & Jermy (1974). Against the possibility of autopolyploidy is the presence of artificially induced diploid plants of *D. filix-mas* made independently by Manton & Walker (1954) and Döpp (1961) which show a high number of univalents at meiosis, for example Manton & Walker report between 2 and 5 bivalents which is also a lower number than in most *D.* x *initialis.* More confusing is the possibility of partial homology between the genomes, in particular if both *D. abbreviata* and *D. caucasica* have subsequently evolved away from the original genome or genomes which gave rise to *D. filix-mas.* It is clearly most important to hybridise *D. filix-mas* with a quite unrelated species such as *D. assimilis,* which should not show any genomic homology, and observe the meiotic pairing behaviour in the hybrid, as being representative of the two genomes of *D. filix-mas.*

However the present results on *D.* x *euxinensis* and *D.* x *initialis* throw much light on the situation which has in fact turned out to be most interesting. The two diploid species are clearly not entirely representative of the same genome, otherwise c 41 bivalents would be expected at meiosis. The inability of most of the chromosomes to form bivalents at meiotic metaphase, along with the 41 bivalents present in *D.* x *euxinensis* confirms the identity of *D. caucasica* as genome "C" of *D. filix-mas* — the second hitherto unknown parental diploid, different from *D. abbreviata.* However, the rather high number of bivalents (from 5 to 23), is of interest because it suggests a certain degree of homology between the genomes of the two diploid species; so *D. caucasica,* though quite distinct, is fairly closely related to *D. abbreviata.* This might well be expected on the basis of the very general morphological similarities between them and they would probably both be put into the same group even if the morphologically intermediate *D. filix-mas* did not exist. This also means that the nature of *D. filix-mas* may not be the straightforward amphidiploid that has sometimes been suggested, e.g. Stace (1975: 47), but rather nearer to a segmental allopolyploid.

It is of interest to point out that several other diploid species are superficially similar to this group and might also show a certain degree of genome homology if the diploid hybrids between them and the *D. filix-mas* aggregate could be synthesised — the triploid hybrids between these species and *D. filix-mas* would be less informative as one could not be sure which genomes were responsible for pairing behaviour; this is part of the problem which besets the interpretation of the hybrids mentioned above between *D. marginalis* and *D. filix-mas.* Examples of taxa which might be somewhat related are *Dryopteris fragrans* (L.) Schott, *D. pallida* (Bory) Fomin and its subspecies (including *D. arguta* (Kaulf.) Watt and *D. raddeana* Fomin); *D. villarii* (Bell.) Woynar, *D. barbigera* (Moore) O. Ktze., *D. monticola* (Makino) Christ and *D. goldiana* (Hook) A. Gray. Indeed closeness of *D. villarii* to *D. caucasica* is suggested even more by their having the same chemical constituents (Widen *et al.* 1973), and Vida has already suggested that the *D. villarii* aggregate has a central position in the evolution of most species of European *Dryopteris* (Vida 1969), an opinion which the present author also endorses.

The proposed origin of *D. filix-mas* supposes that it arose spontaneously from *D.* x *initialis* by doubling of chromosomes, a situation similar to the case with *Asplenium adulterinum* (Lovis 1968). This might be confirmed by sowing pure samples of the spores of *D.* x *initialis,* an operation which the author has not yet carried out, to see if some of them are fertile and diploid despite their highly abortive appearance, thus probably giving rise to tetraploid plants. If this is so, one might also expect *D. filix-mas* to be forming *in situ* in the Caucasus and Turkey at the present day, and as *D. caucasica* and *D. abbreviata* show a wealth of minor variation in those areas, so should *D. filix-mas.* More collections from the Caucasus would therefore be highly desirable.

NEW LOCALITIES FOR DRYOPTERIS x EUXINENSIS, D. x INITIALIS and D. CAUCASICA

On an expedition to Turkey and Iran in 1973, three new sites for *D.* x *euxinensis* were discovered though the identity of all these plants has not yet been cytologically confirmed:

IRAN: Gilan, Ardabil-Astara, Tavalesh, 1490 m alt., growing with *D. caucasica,* 14/8/1973, CRFJ 3924 (BM).
TURKEY (Asia): Artvin, S.W. side of Yalnizcam Dag, 1,800 m alt., growing with both parents, 22/8/1973, CRFJ 3988 (BM).
TURKEY (Europe): Kirklarelli, nr. top of Mahya Dag, Istranca Daglari, 1000 m alt., with *D. filix-mas,* 31/7/1973, CRFJ 3899 (BM) and 28/7/1975, CRFJ 4567–8 (BM).

These last specimens represent the first discovery of *D.* x *euxinensis* in Europe; and the author was also able to find a very few plants of *D. caucasica* there in 1975, CRFJ 4566 (BM), though most of the population consisted of hybrids. This therefore represents a species new to Europe and an amended key and diagnostic description follow below to allow it to be inserted in Flora Europaea.

Further specimens of all three *D. filix-mas* group hybrids from the Caucasus were seen by the author in the herbarium at LE in January 1976 and specimens of *D. caucasica* were seen there from the Crimea (Alexeenko 1894; Kotov, Rishakov and Svetev 1955; Busch 1905; Grigoryev; and Wulff 1916) and from the vicinity of Kalarash in Soviet Moldavia (Igoshina 1948; Opatskaya 1958; and Borisova and Kapustina 1949).

(1—4) *D. filix-mas* group

2 Large plant with 1 or only a few crowns; acute pinnule-teeth; non-inflected indusia.
3 Shortly acute pinnule-teeth; rounded lobes at the sides of the pinnules usually bearing teeth singly. Spores greater than 36μm long. **1. D. filix-mas**
3 Long acute pinnule-teeth; square lobes at the sides of the pinnules usually bearing teeth in pairs. Spores up to 37μm long. **1/1. D. caucasica**
2 Small plant with several crowns; obtuse pinnule-teeth; inflected indusia. **3. D. abbreviata**

1/1 D. caucasica (A.Br.) Fraser-Jenkins & Corley, Brit. Fern Gaz. 10(5): 221—31 (1973). Like 1 but distinguished by the thinner texture and paler colour of the fronds which usually have a long stipe and a markedly truncate base to the lamina. Pinnae noticeably wider towards the middle and often asymmetric with longer segments on the basiscopic side. Pinna segments with square lobes at the side and with acute tips bearing long very acute teeth usually in pairs. Sori with wide flat caducous indusia, and spores small (31—37μm long) with distinctive short ridges or verrucae. 2n = 82. *Montane forest in South West Russia, Krym and North West Turkey* Tu, Rs (W, K), ?RM. (Caucasus, N. Turkey and the Caspian area of Iran).

It may be that *D. caucasica* has retreated from most of Europe due to climatic changes but it might be expected to have survived in some suitable relict habitats and it would be well worth looking for in such places as the eastern mountain ranges of Bulgaria and Romania. It also survives on Ulu Dag in Bursa province, Turkey, CRFJ 3904 (BM) along with *D. filix-mas.*

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SHORT NOTES

SELAGINELLA IN RAJASTHAN, INDIA

Despite its wide occurrence in India (Alston 1945, Panigrahi 1967), *Selaginella* has not been previously recorded from any locality in Rajasthan (Mital 1969a). One of us (O.P. Sharma) discovered an isolated patch of *Selaginella* at Gwaparnath – about 20 km from Kota in south east Rajasthan – during a botanical excursion. The same patch was again located by a colleague (C.B. Gena) in 1974. Further study has revealed it to be *S. rependa* (Desv.) Spring, a species reported earlier from Khandwa (Madhya Pradesh) about 360 km south and Mirzapur and Dudi (Uttar Pradesh) about 600 km north east of the present locality (Panigrahi 1967). This material, however, shows some interesting differences from the description of *S. rependa* by Panigrahi (1967). Firstly, the spikes are mostly megasporangiate in this material and it is only in the terminal part of a plant that a spike may also contain 2 or 3 microsporangia. Secondly, both the micro- and megaspores are larger in size (microspores 35–52μ, megaspores 268–315μ) than those of *S. rependa* (where these measure 25–30μ and 150–180μ respectively – Panigrahi 1967). The segregation of the Rajasthan material as a separate species from *S. rependa* on these features alone may not be justified however. The preponderance of megasporangia in this *Selaginella* corresponds to the pattern of the other heterosporous pteridophytes of the state, *Marsilea* and *Isoetes,* where arid conditions prevalent in Rajasthan seem to induce an increase in the megaspore/microspore ratio (Bhardwaja 1959, Gena et al., in press). This material seems to differ from *S. rependa* studied by Mital (1969b) also in features of stomatal distribution. In our specimens stomata have not been found on the adaxial surface of the dorsal leaves, but are reportedly present here in Mital's material. Moreover, stomata, though few in number, have been found on the rest of the lamina besides the midrib region on the abaxial surface of the ventro-lateral leaves of this material, whereas according to Mital the stomata on this surface are confined to the midrib region only.

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ECOLOGICAL NOTES

FERNS IN CANAL NAVIGATIONS IN BIRMINGHAM

In an industrial city, the canals and railways provide an environment which does not suffer from frequent redevelopment and change. Consequently the flora of industrial canal banks and bridges has had considerable time to develop (nearly 150 years in Birmingham, for the Birmingham Canal Navigation was built between 1770 and 1830).

Within a single 100 km grid square in the City of Birmingham no less than 25 miles (c. 40 km) of such canals exist, presenting a wide range of habitats in the form of banks and embankments, canal paths, fragments of woodland and the mortar of old walls and bridges. The following notes show that, even within such an industrial British city and even against the long background of heavy industrial pollution, a significant number of native fern species have succeeded in establishing and persisting.

Equisetum arvense L. Present throughout the area, often forming enormous tangled colonies along canal sides. Colonies invading poor ash-like substrate have abundant cone-shoots in April; those in richer grassy areas appear purely vegetative.

Pteridium aquilinum (L.) Kuhn. Frequent on exposed or wooded banks and embankments and frequent the base of old walls of factories and warehouses. Occasional in cinders of towpath and occasional in the mortar of old walls and between brickwork of aqueduct. Plants remain stunted and sterile on mortar.

Asplenium scolopendrium L. Specimens seen at two localities, one plant somewhat stunted, both in old brickwork mortar of old bridges crossing canals.

Asplenium trichomanes L. Single specimen in crumbling mortar of railway bridge; another in mortar of old road bridge over canal.

Asplenium ruta-muraria L. Several thriving colonies on mortar of one bridge. Of particular interest because the species seems totally absent elsewhere in the Birmingham area.

Athyrium filix-femina (L.) Roth. Surviving in large colonies (perhaps originally planted) in abandoned gardens amongst bramble and invading bracken, established naturally along canal banks and embankments and a single stunted (but fertile) plant amongst brickwork of aqueduct.

Polystichum aculeatum (L.) Roth. Solitary plant on mortar of low retaining wall with young *Dryopteris.*

Dryopteris filix-mas (L.) Schott. Frequent on wooded banks and amongst bracken on canal embankments, occasional amongst bracken at bases of old walls (often sterile). Also amongst brickwork of aqueduct and bridge. Juvenile plants, probably this species, in mortar of low retaining wall.

Dryopteris pseudomas (Will.) Holub & Pouzar. Occasional amongst bracken at bases of old walls (often sterile).

Dryopteris austriaca (Jacq.) Woynar. Occasional with *Athyrium* on embankment in shade of beech trees.

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[A longer account of fern surveying along the Birmingham Canals will appear in the forthcoming edition of the Bulletin. Notes on the prevalence and habitats of ferns in other cities and elsewhere would be welcomed for the Gazette — Ed.]

REVIEW

BEDFORDSHIRE PLANT ATLAS by John G. Dony 242 x 178 mm. 132 pages. Borough of Luton Museum and Art Gallery. 1976. Price £3.00.

This is the result of another meticulous recording exercise by a doyen of county-flora writers and an elder statesman of British botany. It is a neat, attractive presentation of maps showing the tetrad distribution, as a presence or absence, of some 500 species of vascular plants, 15 of which are ferns. Maps are not provided for the following species, but their distributions are as follows:—

Lycopodium inundatum; wet heaths (93G).
Dryopteris pseudomas; woods (92J, 96Q, 01C, 11J).
Thelypsteris (=Oreopteris) limbosperma; heathy woods (93G).
Gymnocarpium robertianum; walls (02S, 03I).
Azolla filiculoides; "introduced into ponds" (02S, 04E).

The figures in brackets refer to some of the 249 tetrads in the County (see map on p. 15). The following have not been refound:—

Lycopodium clavatum — last recorded 1907;
Equisetum hymale, E. sylvaticum, Thelypteris palustris and *Botrychium lunaria* — none of which have been recorded since 1798.

These maps will obviously provide a format for botanical bingo and any new records — and there will surely be many in spite of Dr. Dony's hard work — should be communicated to Luton Museum and Art Gallery. I will recommend anyone finding one of the five last-mentioned species naturally occurring alive in Bedfordshire today for a free year's membership to the B.P.S.

A.C. JERMY