



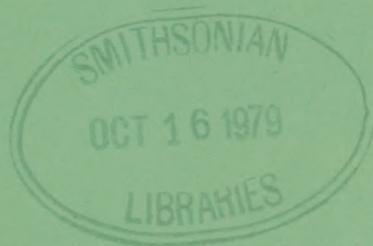


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THE KILLARNEY FERN, *TRICHOMANES SPECIOSUM*, IN WALES

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ABSTRACT

The history of botanical knowledge of the Killarney Fern (*Trichomanes speciosum* Willd.) in Wales is discussed.

The first record of the Killarney Fern (*Trichomanes speciosum* Willd.) in Wales appeared in 1863 when A.M. Gibson drew attention to a note in a Norwich newspaper that the fern had been found in North Wales by J.F. Rowbotham of Manchester (Gibson, 1863).

Rowbotham also reported his discovery to Thomas Moore and his description of the habitat is worth repeating. "I found it", he wrote, "in a large hole formed by fallen rocks alongside a cascade of water; and admission to this hole, which is about five feet high by four feet wide, is obstructed after a depth of about three feet by this Fern falling from the rocks at the top and growing out of the sides in the form of a beautiful curtain, down which the water is constantly trickling" (Moore, 1863). He also added that the fronds were remarkably fine and abundant. The frond he sent to Moore had an overall length of nearly eighteen inches and was seven inches across at the widest part. A second frond in Rowbotham's possession had a total length of about twenty-two inches. Moore does not disclose the locality beyond stating that it was in a part of the Snowdon range.

The following year James Backhouse Jnr. sent specimens of this fern to the Botanical Society of Edinburgh. In the covering letter he stated that they had been found by him and his father, in 1863, "in a truly wild state, in Carnarvonshire," where, he added, the plant was remarkably luxuriant (Backhouse, 1864). His specimens both at Edinburgh and the British Museum (Natural History) are equal to the finest Irish specimens and it is probable that they were from the same locality as Rowbotham's, although Backhouse did not refer to Rowbotham's discovery either then or subsequently.

Five years later Backhouse found the Killarney fern in Merioneth, v.c. 48. His specimen in the British Museum is vaguely localised "Mountains of Merionethshire" and dated 1869. Rather uncharacteristically, this find was not published by Backhouse, but in his next letter to the Botanical Society of Edinburgh, in 1875, he announced that he had "collected *Trichomanes radicans* in a new station in North Wales in 1873" (Backhouse, 1876). Again he gives no locality — not even the name of the county — but it is probable that this was also in Merioneth, for Backhouse is stated to have seen the Killarney Fern in two widely separated localities in the county in 1874: one near Harlech and the other on Cader Idris, and it was flourishing at both of them twenty years later (Percival, 1894). It is almost certain that it was at one of these localities (near Harlech) that Backhouse showed the Killarney Fern to D.A. Jones, the well-known bryologist, who lived in Harlech (Jones, 1898), and to Mrs. Mary Richards of Dolgellau (Benoit & Richards, 1963). Although frequently visited, and no doubt too frequently collected, the fern survived in this site until 1968, but there is now no trace of it left (Dyce, 1975).

These Merioneth localities became known to a number of fern enthusiasts. Specimens were collected from one of them in 1889 and sent to the British Museum by William Robinson, of Weston-super-mare, who claimed to have known the Killarney

Fern there and in "other localities" (all unspecified) for about twenty years (Britten, 1894). D.A. Jones, who knew the county well, gives only two localities for the Killarney Fern in his manuscript 'Flora' and these are the same as those mentioned by Percival (1894). The statement that the Killarney Fern had "been found growing luxuriantly in some abundance in several places extending over several miles in Wales" (Lowe, 1876) seems to be somewhat exaggerated.

In 1887 the Killarney Fern was found independently in Caernarvonshire, v.-c. 49, by J. Lloyd Williams (1887), who was at the time a schoolmaster at the village of Garn Dolbenmaen, near Cricieth. However, he could not be certain that this was not the same locality as that in which the fern had been found previously, because that record had not been localised. Apart from describing the habitat as "a damp hole near the top of a range of mountains" and that it was not on any part of Snowdon, Williams gave no indication of the locality. In his autobiography written many years later he gives a fascinating account of how he found the fern and indicates that the locality was Moel Hebog, near Beddgelert (Williams, 1945). There are, however some curious inconsistencies in Williams's account. According to this the fern was completely removed about a month after he first found it, and even though he made several visits to the site from 1887 until 1893 (when he left the district), he could find no trace of it. Twenty-four years later he visited the place again and was surprised to find the Killarney Fern once more flourishing in its rocky recess. Williams ascribes its recovery to the spores left after the fern itself had been completely removed. However, J.E. Griffith, of Bangor, author of the 'Flora of Anglesey and Carnarvonshire' (1895), gathered a specimen of the Killarney Fern from this locality in 1891 (Hyde, Wade & Harrison, 1969). In his 'Flora', published a few years later, Griffith wrote, "I have seen this fern growing undoubtedly wild, in one place only. This was first found by Mr. J. Ll. Williams. I refrain from giving the locality as it is so rare."

One can only surmise that Williams showed the locality to Griffith, although the latter does not say so. But it seems that he passed through Garn Dolbenmaen, where Williams lived, on his way to Moel Hebog, for he published records of plants which he saw in both these places in August 1891 (Bennett, 1892). It seems that Williams was mistaken when he wrote that the Killarney Fern had been destroyed in his locality before the end of the year 1887. But he was in his late eighties when he wrote this account and perhaps relied too much on his recollection of the events of over fifty years before. However, there is nothing to indicate whether Williams's locality on Moel Hebog was the same as those found by Rowbotham and Backhouse. On the contrary, Rowbotham's description can hardly refer to the Moel Hebog habitat and strongly suggests a different place, possibly one of the two others in which the Killarney Fern was stated to occur in Caernarvonshire.

Professor J. Bretland Farmer (1948) claimed that he had known the Killarney Fern in the Cwm Glas area of Snowdon for over twenty years. Neither this locality nor another, which according to rumour is vaguely localised on the Carneddau, has ever been confirmed. Unfortunately, Farmer did not leave a voucher specimen, but it seems hardly credible that he could have mistaken any other fern for it. Nevertheless his record has remained unconfirmed for fifty years and is now regarded with a good deal of scepticism.

Even when it was first recorded in 1863 there were rumours that the Killarney Fern had been deliberately introduced into Caernarvonshire by a local guide, but Moore (1863) thought that the luxuriant and well-established appearance of the fern found by Rowbotham was not consistent with such a view. Trimen (1871), on the other hand, was of the opinion that there was "reason to suspect an intentional

introduction." Britten (1879-81) also refers to these rumours, but goes on to make the intriguing statement that the Killarney Fern was already known in two localities in Caernarvonshire about thirty years before its discovery by Rowbotham. The discoverers, he adds, were satisfied that the fern was truly native, but had kept their knowledge to themselves.

Unfortunately there is more direct evidence that some planting did take place. In a tribute to the recently deceased Herbert Stansfield, E.H. Hawkins wrote: "I recall that some years ago he spent some time in North Wales, taking with him some plants of the Killarney Fern, which he planted in some wild and congenial places, with the hope that they may be found subsequently by fern hunters. This thoughtfulness was ever typical of him" (Hawkins, 1928). Herbert Stansfield was a nurseryman of the firm of F.W. and H. Stansfield of Sale, near Manchester, who specialised in British ferns and no doubt had access to Irish material of the Killarney Fern.

Stansfield was not the only one who tried to introduce the Killarney Fern into suitable places. Its occurrence in Westmorland (where it was gathered in the Rydal district about 1863), in the Isle of Arran, and in Argyll, were all suspected to be due to deliberate introductions (Moore, 1863), as it was in the only Cornish locality (Davey, 1909). Even in Ireland this fern was planted in many places in Killarney, around Glengarriff and on Valentia Island (Newman, 1844), though the purpose there was to try to preserve the fern from the depredations of collectors, which even then threatened to exterminate it in its original localities.

We shall probably never know where Stansfield made his introductions into North Wales, or indeed whether any of them were successful. His activities were too late to affect the early records, for he was only seven or eight years old in 1863, but they cast a shadow of doubt over all the Welsh localities of the Killarney Fern.

On the other hand Backhouse's remarkably fine specimens from both Caernarvonshire and Merioneth give the impression of being from old, long-established colonies of the fern — an opinion already expressed by Moore (1863). Rowbotham's description of the habitat, quoted above, is also very convincing and does not suggest an introduction. This impression is supported, as far as Merioneth is concerned, by William Robinson's specimen (BM) gathered in 1889, and A.J. Crosfield's two specimens (BM) gathered in 1902 and 1904, although all these Merioneth gatherings may well be from the same locality, possibly that in the Cader Idris area, now lost, or, if known, wisely kept secret.

The much smaller size of specimens (BM) gathered by T.J. Foggitt from "wet rocks near Harlech, Merioneth, 27 Sept. 1929," suggests that they are from a different site. The largest of his two fronds is just under four inches long, including the stipe, and just over an inch wide. They are similar in size and shape to D.A. Jones's specimens (NMW) gathered in 1905 "near Harlech," and to a frond I was once shown which had been gathered from the well-known Merioneth locality where the fern now seems to be extinct.

There is still a good deal of mystery attached to the Killarney Fern in Wales. Its discovery as recently as 1961 in Cardiganshire, v.c. 46, by A. Neville Jones was certainly remarkable, for the colony he found is a luxuriant one, and it is difficult to understand why it remained undiscovered for so long in a comparatively well-botanised area. Perhaps, after all, we can only echo the words of Scully (1916) when referring to the Valentia Island records: that the fern is both indigenous and introduced in different localities in Wales.

However, this should not affect our attitude to its conservation. Its disappearance from its only known Merioneth locality within the last ten years is most

regrettable. Already the Caernarvonshire locality, rediscovered by G.M. Hughes in 1967, has become too well known, as indeed has the Cardiganshire one. Fortunately the Killarney Fern is now protected by the *Conservation of Wild Creatures and Wild Plants Act 1975*, but it is also to be hoped that a new attitude will prevail among botanists who visit the sites of this most attractive fern and that they will be content to look at and admire it without removing a single frond.

ACKNOWLEDGEMENTS

I am grateful to Dr. C.N. Page for his assistance in many ways. Thanks are also due to the Keeper of Botany, National Museum of Wales, the Regius Keeper, Royal Botanic Gardens, Edinburgh, the Keeper of Botany, British Museum (Natural History), Mr. J.W. Dyce, Mr. A.C. Jermy and Mr. M. Morris for their help with many of the references.

REFERENCES

- BACKHOUSE, J. 1864. (Note on *Trichomanes radicans*) *Trans. Bot. Soc. Edin.* 8: 111.
- BACKHOUSE, J. 1876. Miscellaneous notices. *Trans. Bot. Soc. Edin.* 12: Appendix XX.
- BENNETT, A. 1892. *Rep. Bot. Exch. Cl.* 1: 326, 340.
- BENOIT, P.M. & RICHARDS, M. 1963. *A contribution to a Flora of Merioneth.* Ed. 2. Haverfordwest.
- BRITTEN, J. 1879-81. *European Ferns.* London.
- BRITTEN, J. 1894. Editorial note. *J. Bot. Lond.* 32: 372.
- DAVY, F.H. 1909. *Flora of Cornwall.* Penryn.
- DYCE, J.W. 1975. Meetings 1975: Barmouth, Gwynedd. *Brit. Pterid. Soc. Bulletin*, 1 (3).
- FARMER, J.B. 1948. Notes on the flora of Snowdonia, in CARR, H.R.C. & LISTER, G.A. (eds.) *The Mountains of Snowdonia.* Ed. 2: 144-155. London.
- GIBSON, A.M. 1863. *Trichomanes radicans* in Wales? *The Phytologist.* 2nd ser. 6: 608.
- GRIFFITH, J.E. 1895. *Flora of Anglesey and Carnarvonshire.* Bangor.
- HAWKINS, E.H. 1928. Tribute to H. Stansfield. *Br. Fern Gaz.* 5: 220-221.
- HYDE, H.A., WADE, A.E. & HARRISON, S.G. 1969. *Welsh Ferns,* Ed. 5. Cardiff.
- JONES, D.A. 1898. *A Handbook to the Botany of Merionethshire:* ms. in National Museum of Wales, Cardiff.
- LOWE, E.J. 1876. *Our Native Ferns,* 2. London.
- MOORE, T. 1863. *Trichomanes radicans* indigenous to Yorkshire and Wales. *J. Bot. Lond.* 1: 238-239.
- NEWMAN, E. 1844. *History of British Ferns.* London.
- NEWMAN, E. 1864. *History of British Ferns.* Ed. 4. London.
- PERCIVAL, J. 1894. *Trichomanes radicans* in Wales. *J. Bot. Lond.* 32: 372.
- SCULLY, R.W. 1916. *Flora of County Kerry.* Dublin.
- TRIMEN, H. 1871. *Trichomanes radicans* in England. *J. Bot. Lond.* 9: 174-175.
- WILLIAMS, J. LL. 1877. *Trichomanes radicans* in Caernarvonshire. *J. Bot. Lond.* 25: 215.
- WILLIAMS, J. LL. 1945. *Atgofion Tri Chwarter Canrif,* 4. London.

PRELIMINARY INVESTIGATION OF TWO SOUTH-WEST ENGLAND POPULATIONS OF THE *ASPLENIUM ADIANTUM-NIGRUM* AGGREGATE AND THE ADDITION OF *A. CUNEIFOLIUM* TO THE ENGLISH FLORA

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ABSTRACT

Examination of the plants of the *Asplenium adiantum-nigrum* aggregate from south Devon and west Cornwall questions the status of records of *A. onopteris*, but confirms *A. cuneifolium* as new to the English flora.

Asplenium onopteris, *A. adiantum-nigrum* and *A. cuneifolium* form a trio of inter-related species in the British Isles. All three are morphologically variable. Because *A. adiantum-nigrum* is an allotetraploid containing the chromosomes of the other two species (Shivas, 1969), its variation may be particularly wide, approaching and perhaps overlapping that of both its parents. Clearly, without the benefit of a chromosome count, there can be difficulty in separating all specimens in areas where more than one may be suspected to be present. The discovery that *A. cuneifolium* can also exist as a tetraploid species in Britain (Roberts & Stirling, 1974; Sleep et al, 1978) and elsewhere (Deschatres et al, 1978) further complicates the problem of its inter-relationships and taxonomic separation.

The finding of populations of this plant group in the Bovey Tracey area of South Devon during the British Pteridological Society's field week in the summer of 1978, which appeared to contain plants of clear *A. adiantum-nigrum* and ones of extremely attenuate form suggesting the presence of *A. onopteris* stimulated the present investigation to try to distinguish and identify them. The problem was further highlighted by also finding plants in the Lizard area of Cornwall which resembled *A. cuneifolium*, apparently linking through plants of rather intermediate appearance with plants of *A. adiantum-nigrum*. The following investigation was initiated to try to resolve the taxonomic problem arising.

Bovey Tracey Population

These plants occurred as widely-scattered specimens on lightly-shaded earth and rock hedgebanks in the neighbourhood of the village of Bovey Tracey in South Devon. They are very common locally in such habitats, but extraordinarily variable in appearance.

Examination showed them to be mostly large-fronded plants. The cutting of the blade of many suggested they were typical *A. adiantum-nigrum*, but many more showed varying degrees of attenuation, more finely cut and upswept pinna form, through to at least one individual which had such extremely finely cut and attenuate fronds that it appeared very like *A. onopteris* (Page 11370).

Study of the spores showed, however, a surprising uniformity. No specimens showed any significant degree of spore abortion. Compared with those of typical *A. adiantum-nigrum* spores were very slightly paler in colour, and showed an overall greater size range, with those of the most *A. onopteris*-like morphology proving only slightly smaller (31-57 μ) than those of plants of more *A. adiantum-nigrum*-like morphology (37-60 μ). By contrast, plants of known *A. onopteris* from Ireland and the Canary Islands, proved to have distinctly smaller spores (25-43 μ) than those of any of the Bovey Tracey plants. The spores thus present a slightly inter-grading picture

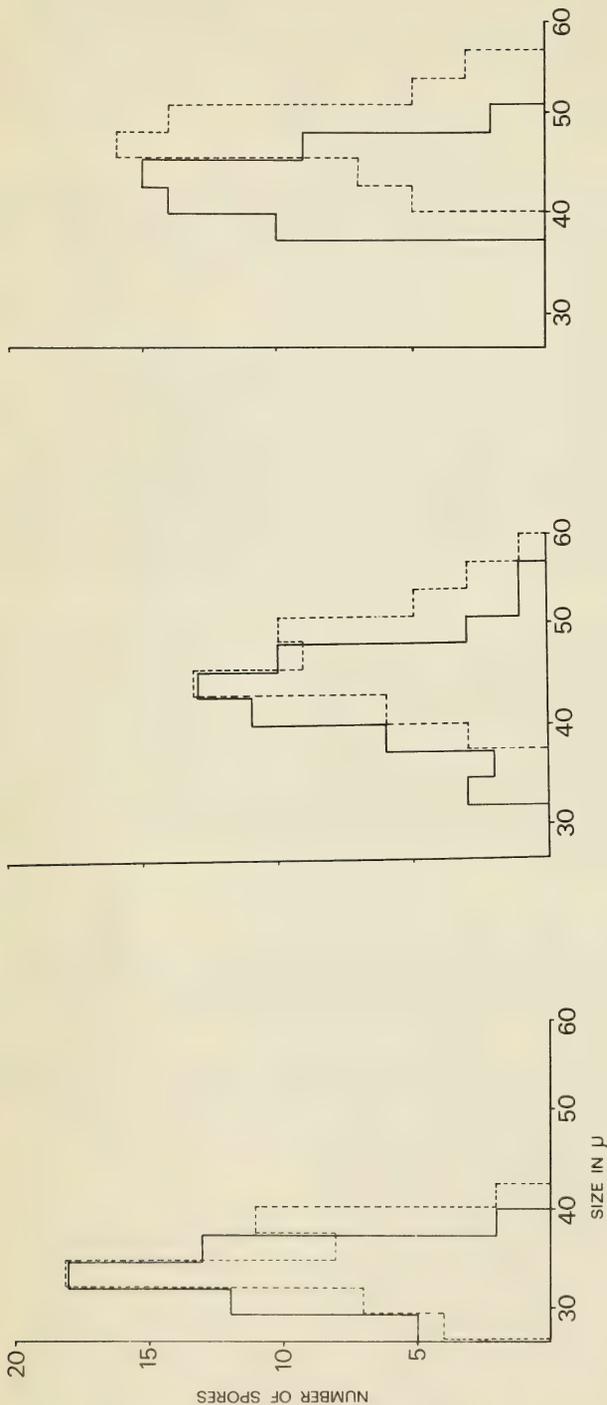


FIGURE 1. Histogram of spore size range (μ) in samples of known *Asplenium onopteris* from Lough Hyne, Co. Cork, Ireland (dotted line — Phillips s.n., E) and La Gomera, Canary Islands (solid line — Page 413, E), showing their relatively small size and similar size range. (Sample size = 50 spores measured from each specimen, mounted in 100% glycerine, and throughout).

FIGURE 2. Histogram of spore size range (μ) in samples of plants from the Bovey Tracey population, to compare those from one of most *A. adiantum-nigrum*-like morphology (dotted line, Page 11407, E) with those from one with most finely-divided and attenuate frond-form (solid line — Page 11370, E). The larger spore size range of each distinguishes them clearly from those of *A. onopteris* in fig. 1, but those from the fine fronds seem consistently slightly smaller than neighbouring good *A. adiantum-nigrum*.

FIGURE 3. Histogram of spore-size (μ) to compare that for plants of *A. cuneifolium* from the block-scrub habitat in the Lizard (solid line — Page 11242, E) with those of a population of known *A. adiantum-nigrum* from a typical inland west Cornwall lanebank habitat at Stennack (dotted line — Page 11165, E). Those of *A. cuneifolium* are very slightly smaller, and in this compare favourably with the situation in Scottish material found by Roberts & Stirling (1974), suggesting that the Cornish *A. cuneifolium* is probably tetraploid.

corresponding with the overall morphology of the plants, but do not suggest, from their size, that *A. onopteris* is present in this south Devon population, at least as this species is recognised in Ireland and the Canary Islands.

Kynance Population

This consists of a large population of plants of the *Asplenium adiantum-nigrum* group in the region of Kynance Cove on the west side of the Lizard Peninsula of West Cornwall. The area is of particular interest not only in being one of the most southerly and climatically oceanic points in the British Isles, but also in containing extensive outcrops of ultrabasic serpentine rock. A preliminary collection of fronds from the area was made by C. Ferreira during the winter of 1977-78, and a more extensive investigation of specimens from different adjacent habitats after examination of the Ferreira material made by one of us (C.N.P.) in the summer of 1978.

Plants were examined in three distinct habitats:

- (a) in a large, natural, block-scrée slope descending steeply from the cliff tops directly into the sea to the west of Kynance Cove
- (b) amongst small outcropping rock bluffs amongst the plateau-like downs running back from the tops of Kynance Cliffs to the north of Kynance Cove
- (c) in a recent man-made scree amongst disused soapstone quarry workings about one mile north-west of Kynance Cove.

Plants from the whole area gave a strong impression of distinctness from those of inland stations for *A. adiantum-nigrum* in West Cornwall. Very many from habitats (b) and (c) differed from *A. adiantum-nigrum* in having fronds with fan-shaped segments, whilst in habitat (a), the plants appeared totally distinctive from *A. adiantum-nigrum* and to indeed be *A. cuneifolium*.

Examination of frond samples from habitat (a) showed them to differ significantly from *A. adiantum-nigrum* in the following features:

1. Overall fronds much less finely cut, with a broader triangular outline and coarser segments varying from slightly more to much more fan-shaped.
2. Ultimate serration of the frond margins less acute (but rarely actually obtuse).
3. Stipe much shorter, usually less than $\frac{1}{2}$ to $\frac{1}{4}$ the length of the blade, sometimes less.
4. The deep red-brown colouration more restricted to the lower part of the stipe, extending only rarely as high as the lower pinnae on the underside and rarely as much as half way up the stipe on the upper side, the remainder of the stipe and the whole of the rachis remaining green.
5. The lowermost pinnae pair much more broadly triangular and held more perpendicularly to the rachis, and not at all swept upwards on the frond.
6. A much stronger tendency for the veins on the frond undersides near to the margins to show as distinct whitish radiating lines (especially in the lowermost pinna pair).

Plants from scattered rock outcrops (habitat 'b') on the top of the Lizard Downs proved much more variable in morphology, although many of them were stunted by varying degrees of exposure. Nevertheless, some approached *A. cuneifolium* in their morphology, whilst others appeared more close to *A. adiantum-nigrum*, with others apparently linking between these extremes. Examination of spores, however, showed none to be wholly abortive, as far as could be judged by light microscope examination, although many contained a proportion (estimated at up to 10%) which were sufficiently mis-shapen to regard as probably abortive.

Plants from the disused soapstone quarry (habitat 'c') proved equally confusing. The habitat was a man-made rough loose boulder slope. *Asplenium* plants were present mainly in sheltered pockets between the boulders, and consequently were rather larger than those on the tops of the downs. They were, however, of equally variable appearance, a few seeming more like *A. adiantum-nigrum*, but most more clearly *A. cuneifolium*, but linked by apparent morphological intermediates. As with those on the Downs, spores appeared mostly good but with up to about 10% mis-shapen ones in many of the plants. One well grown individual which in morphology showed a particularly intermediate appearance, probably had a higher number of abortive spores than this.

The morphology of the fronds in all of the serpentine rock habitats of the Lizard thus suggests that these are all far from typical populations of *A. adiantum-nigrum*, and that each of these habitats ('a'-c') thus contains at least some plants of *A. cuneifolium*, thus adding this species as new to the English flora. These *A. cuneifolium* plants match very closely indeed with those from the Scottish serpentine localities, and provide further evidence in support of the view (A. McG Stirling, personal communication) that these British plants are morphologically distinctive from at least those of central Europe. The close similarity of the spore size to that of the Scottish ones, suggests that these Cornwall plants are likely to prove tetraploid (although this needs cytological confirmation).

In these Lizard habitats, *A. cuneifolium* appears to be the dominant fern in the natural block scree slope, from where it spreads on to the outcropping boulders of the Downs and into the man-made serpentine scree of the soapstone quarry.

Some questions remain about the identity of the plants of most *A. adiantum-nigrum*-like morphology in the latter two habitats, but the lack of obvious hybrids (at least as indicated through lack of total spore abortion) and the complete range of forms intermediate in overall morphology, suggests too that these are probably extreme forms of *A. cuneifolium*, underlining the possibility that these can approach *A. adiantum-nigrum* very closely indeed.

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REFERENCES

- DESCHATRES, R., SCHNELLER, J.J., & REICHSTEIN, T. 1978. A tetraploid cytotype of *Asplenium cuneifolium* Viv. in Corsica. *Fern Gaz.* 11: 343-344.
- ROBERTS, R.H., & STIRLING, A. McG. 1974. *Asplenium cuneifolium* Viv. in Scotland. *Fern Gaz.* 11: 7-14.
- SHIVAS, M.G. 1969. A cytotaxonomic survey of the *Asplenium adiantum-nigrum* complex. *Br. Fern Gaz.* 10: 68-80.
- SLEEP, A., ROBERTS, R.H., SOUTER, J.I., & STIRLING, A. McG. 1978. Further investigations on *Asplenium cuneifolium* in the British Isles. *Fern Gaz.* 11: 345-248.

AN ECOLOGICAL SURVEY OF THE FERNS OF THE BURREN, CO. CLARE, EIRE

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ABSTRACT

A systematic list of the ferns of the Burren (area includes parts of Co. Clare and South East Galway v.-c. H9 and H15) is given based mainly on records made in 1978 by the author. This includes notes on the distribution, abundance and habitats of the taxa. The list includes 35 species and 5 hybrids as recently recorded. The records for *Polypodium x mantoniae* and *Dryopteris x tavelii* are first county records for Co. Clare. The distribution of the commoner 24 species is shown by maps. Species lists are given for the more interesting or characteristic fern habitats. The phytogeographical affinity of the flora is discussed on a European basis and is shown to be basically southern with a lesser western (atlantic) affinity.

INTRODUCTION

The Burren is the most impressive area of karst scenery in the British Isles. It is situated in the middle of the western coast of Eire, on the southern side of Galway Bay. The bed-rock over most of the area is Carboniferous Limestone, which has been stripped bare of soil by past glaciations. From a distance the general aspect of the area therefore is of a bare, grey, uninviting rock but closer examination reveals that this area is botanically one of the most interesting and beautiful of western Europe.

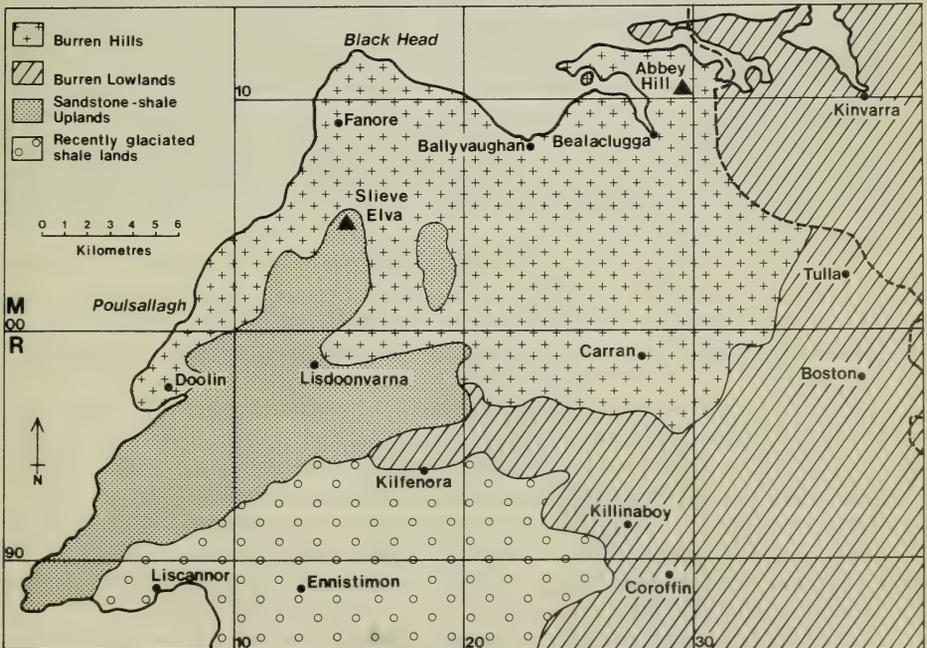


FIGURE 1. The area referred to as the Burren, showing the four topographic regions. The dashed line in the north east corner separates Co. Clare (v.c. H9) to the south west from South East Galway (v.c. H15) to the north east.

Historically the name Burren, which means great rock, referred to the Barony of Burren. The Barony occupied the north of Co. Clare roughly down to a line from Carron through Kilfenora and Lisdoonvarna to Poulsallagh. Botanically the name has a wider sense and includes surrounding areas. It is used here for a large area of northern County Clare (v.-c. H9) and a smaller, adjacent area of South East Galway (v.-c. H15). This is an area approximately 28km. north/south and 40km. east/west (fig. 1). This is slightly less than the area of Ivimey-Cook & Proctor (1966a) in their paper on the plant communities of the Burren, as it excludes a small area to the east around Gort. A bibliography of the area is given in Malloch (1976).

Geologically the area consists of pure Carboniferous Limestone with only a few bands of chert and shale, overlain in the south-east corner by shales and sandstones of the same age. There is little glacial drift and that which there is bears a close relationship to the composition of the rocks it overlies (Finch 1971). Sweeting (1955) describes the topography of the area, which consists of four distinct regions in County Clare (fig. 1). Three of these form a block of high ground to the west of the fourth lower-lying region (Finch 1971). The three upland regions are the Burren Hills, the Sandstone-shale Uplands and the Recently Glaciated Shale Lands, the fourth region is the Burren Lowlands.

The Burren Hills occupy the north-west of the area. They are an elevated block (300m) of horizontally-bedded limestone, dissected by two, broad, dry valleys running south from Ballyvaghan and Bealaclugga. To the east it forms a bold escarpment to the Burren Lowlands from Abbey Hill to Killinaboy and to the south it merges into the Sandstone-shale Uplands. There is a great deal of bare limestone, with soil in the valleys and depressions known locally as dolines. The hill sides are steep, showing the vertical edges of the limestone strata, with flat areas of limestone pavement between. The water table is well below the surface except for the deeper dolines. The only permanent river is the Cahir, which rises north-east of Slieve Elva and runs north-west to the sea at Fanore. The river only exists because the floor of its valley is choked with boulder clay.

The Sandstone-shale Uplands form an elevated block, which drops in altitude from that of the Burren Hills in the north to around 100m in the south. The sub-soil is covered in poorly-drained, acid soils and peat, and there is abundant surface drainage by means of small streams.

The division between the Sandstone-shale Uplands and the Recently Glaciated Shale Lands is not as dramatic as that between the former and the Burren Hills. There is merely a gradual decrease in altitude and an increase in recent glacial deposits. There are ice-deepened valleys in the shale with ridges of sandstone between. The soils are wet and acid.

The Burren Lowlands consists of a low-lying (30–60m) plateau of horizontally bedded Carboniferous Limestone. There is more glacial drift than on the Burren Hills but there are still extensive areas of limestone pavement. However, the water table is only just below the surface and there is a chain of large permanent lakes from Corrofin north-east to Boston. The very similar low-lying area of limestone to the south and west of Kinvarra, in South East Galway, is included here in this region, although it lacks the large Lakes of the Burren Lowlands. This is referred to as the Ardrahan Limestones in Praeger (1934).

The climate of the whole area is highly oceanic like other western areas of the British Isles, though details for aspects other than rainfall are sparse (Finch, 1971; Ivimey-Cook & Proctor 1966a). Rainfall is high in the upland regions, in the range 1250–1500mm but less in the lowlands, around 1125mm. The precipitation-to-evaporation ratio is well in favour of precipitation, which means that most soils, even

shallow soils over limestone (Grime, 1963) are leached and, in areas where the sub-soil is non-calcareous, podzolised. Where drainage is impeded, there are extensive areas of gleyed soils.

The great botanical interest of the area lies in its high floristic diversity due to a mixture of phyto-geographical elements which is unique in western Europe. This is described in Lousley (1950), Praeger (1934) and Webb (1962). Plants which in Europe have a southern distribution, e.g. *Adiantum capillus-veneris**, grow alongside plants of a northern distribution and with yet others of Mediterranean, continental and arctic-alpine distributions. Another remarkable feature is the growth of the arctic-alpine plants at sea-level, which at these latitudes normally grow on mountain tops.



FIGURE 2. Hazel scrub in Glen of Clab showing *Polystichum setiferum* also present was *Pteridium aquilinum*, *Athyrium filix-femina*, *Dryopteris filix-mas* and *D. austriaca*.

A general survey of the vegetation of the area is given in Ivimey-Cook & Proctor (1966a); and, more particularly, of fissures in the limestone in Dickinson *et al.* (1964); of salt-marshes, fens and woodlands in Ivimey-Cook & Proctor (1966b); and of temporarily flooded depressions in the limestone in Praeger (1932). Woodlands are scarce in the area. Semi-natural woodlands of *Fraxinus excelsior* occur on some of the steeper slopes of the Burren Hills. There are small, ornamental plantations throughout the area and recent conifer plantations on the shales around Lisdoonvarna. *Corylus avellana* scrub is abundant on the limestone hills and lowlands (fig. 2) and there are scattered hedges of *Crataegus monogyna* on the shale regions. Tall herb communities are common throughout the area, as are grasslands of an acidic nature on the shales and of a calcareous nature on the limestone. These range from semi-natural communities to small areas of improved grassland on the best soils. These communities merge into marsh and fen communities, especially around the lakes in the Burren

*Nomenclature follows Clapham *et al.* (1962) for angiosperms and Jermy *et al.* (1978) for pteridophytes.

Lowlands. Blanket bogs with small areas of heath are common on the shales and grit-stones, with some raised bogs around the lakes in the Burren Lowlands. Sandstone or shale outcrops are occasional in their areas, and outcrops of limestone and limestone pavement (fig. 3) dominate large tracts of their areas. Stone walls are common in the area, generally of stone local to the region. These are usually drystone walls but occasionally, and more often in the shale and sandstone areas, there is soil between the stones. Mortared walls of all stone types also occur throughout the area.



FIGURE 3. Limestone pavement with grykes near the lighthouse Black Head, the habitat of *Adiantum capillus-veneris*, *Asplenium scolopendrium* and *A. marinum*.

METHODS

Field records on the distribution maps (figs. 4–7) refer to records made by the author in August 1978. These were gathered on the basis that two to three examples of each relevant habitat were visited, in each of the 10 km. grid squares of the Irish national grid in the area. A relevant habitat was defined as a major habitat type, that occurred commonly in the topographical region in which the grid square was situated. These major habitat types are outlined in the previous section. At each site visit a subjective estimate of the abundance of each fern present was made, for each habitat type in which it occurred (see under *Habitat Lists* for explanation of abbreviations used). No attempt was made to record where habitats contained no ferns. There is a bias in the records to sites near roads, due to the time available to study the area, but it is impossible to assess the strength or significance of this.

A search was made of the major works that give fern records for the Burren: Corry (1880), Foot (1860), Ivimey-Cook & Proctor (1966a), More (1898), Praeger (1901, 1909 & 1934) and Scannel & Synnott (1972). Where these give significant extensions to the geographical or ecological ranges of species, above that recorded here, details are given in the systematic list. Records given in Ivimey-Cook & Proctor (1966a) are plotted on the distribution maps (figs. 4–7) as they are given on a 1 km. grid square basis.

SYSTEMATIC LIST OF TAXA

Each taxon recorded in the field for the study area is given, with notes on (a) its distribution, abundance and habitats as recorded in the survey and (b) significant extensions to these from the literature. Taxa, recorded in the literature but not this survey, are given a (b) type entry. Reference to abundance in habitats in (a) refers only to abundance in examples of the habitat where the species occurred; no account is taken of how often a species was present in the particular type of habitat. Grid references prefixed with *circa* are my interpretations of localities originally given without a reference.

3.1 *Huperzia selago*

(b) Recorded for summit of Gleninagh Mountain (c.M/17.09) and Slieve Elva (c.M/15.04) records communicated by D.A. Webb (Pers. comm. 1978) and in Jermy *et al* (1978) for M/1.0, M/1.1 and R/0.8. The card for the M/1.0 record in Jermy *et al* (1978) gives the habitat as blanket bog.

5.1 *Selaginella selaginoides* (fig. 4)

(a) Scattered in small amounts in damp, calcareous, herbaceous communities in flushes around coast near Black Head and lakes in the Burren Lowlands.

(b) Recorded in Jermy *et al* (1978) for M/2.1 and R/2.9.

7.1 x 2 *Equisetum x trachyodon*

(b) Recorded in Jermy *et al* (1978) for R/3.9 and in Praeger (1901) near the outlet stream to Lough Inchicronan (c.R/38.86). These are specimens in BM for the outlet stream to Lough Inchicronan dated 1925 and for the east shore of Lough Bunney (c. R/38.97) dated 1966.

7.2 *E. variegatum*

(a) Widely distributed but very local in the Burren Hills and Lowlands. Rare to locally abundant in tall, damp, herbaceous vegetation dominated by monocotyledons, associated with flowing water or loughs. Specimens from Carran (R/28.99) and Lough Bunney (R/38.97) determined as probably var. *majus* Syme by C.N. Page. Also recorded Cahir River (M/15.08).

(b) Recorded in Jermy *et al*. (1978) for M/1.2 & M/3.1.

7.3 *E. fluviatile* (fig. 4)

(a) Widespread but local in the Burren Lowlands and shale regions. In the Burren Lowlands, it is locally frequent to occasional as an emergent along the edges of loughs, and frequent to occasional in marshes fringing them. Occasional to frequent in damp, tall grass and marshy patches in fields in the Burren Lowlands and shale regions. Recorded once growing in old peat workings on blanket bog, Slievebeg (R/16.89).

(b) Recorded in Jermy *et al*. (1978) for M/1.0, M/1.1, % M/2.0 in the Burren Hills and R/0.9.

7.4 *E. arvense* (fig. 4)

(a) Widespread throughout the Burren but usually only occasional to frequent, and it is less common in the limestone regions. Occurs usually in tall, often damp, grass and rarely in woods.

(b) Recorded in Jermy *et al*. (1978) for M/1.1, M/3.0 and R/3.8.

7.4 x 3 *E. x litorale*

(a) Recorded as occasional in tall grass at northern end of Lough Bunney (R/38.97); and frequent on Cahir River (M/15.08) in tall, marshy grass by river and amongst stones in bed of river.

(b) Recorded in Jermy *et al*. (1978) for M/1.1.

7.6 *E. sylvaticum*

(a) Restricted to the shale regions away from the coast but only very local even there. Occasional in damp, tall herbaceous vegetation and locally frequent in the recent, conifer plantation of Cragan West Wood (M/18.01). Recorded for R/13.90 and R/15.97.

(b) Recorded in Jermy *et al*. (1978) for R/1.8.

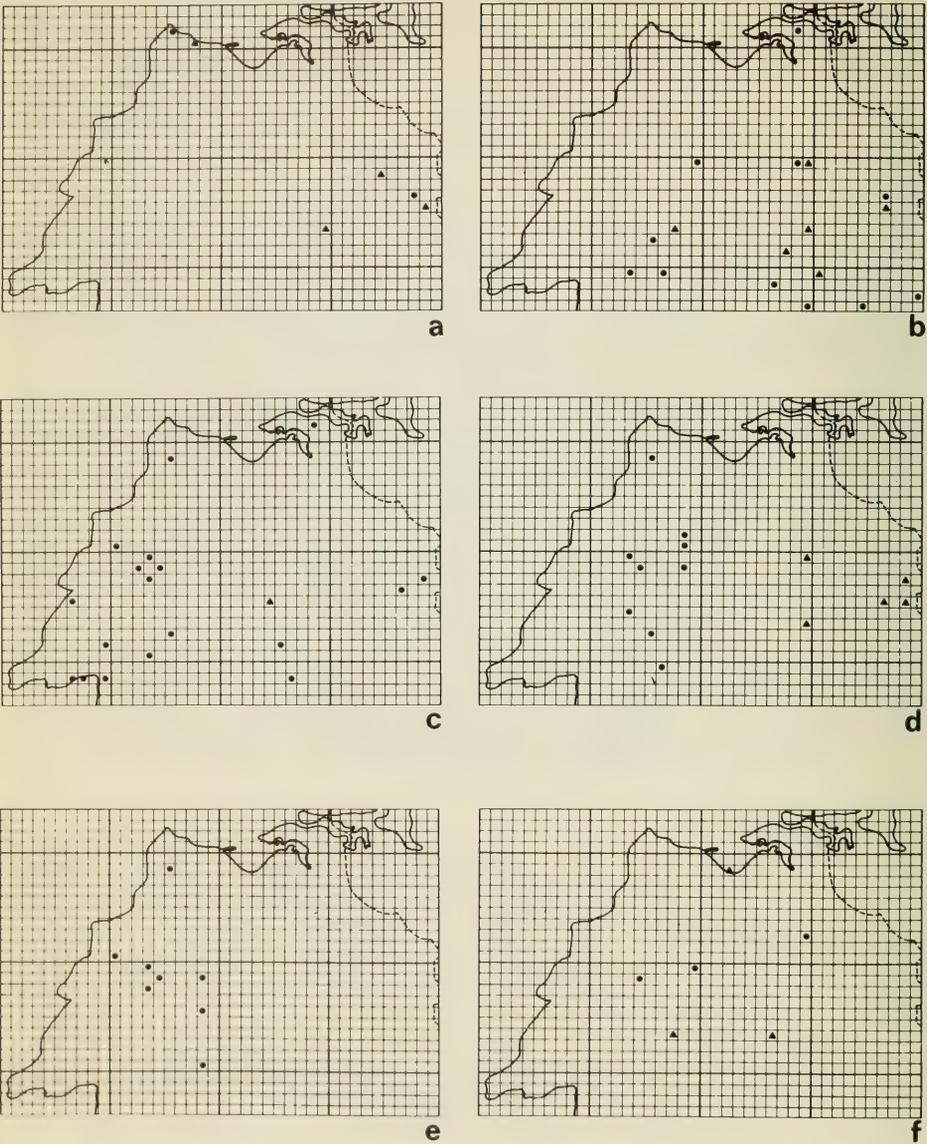


FIGURE 4. The distribution of the following in the Burren, circles Willmot 1978 and triangles Ivimey-Cook & Proctor (1966a); a, *Selaginella selaginoides*; b, *Equisetum fluviatile*; c, *E. arvense*; d, *E. palustre*; e, *E. telmateia* and f, *Ophioglossum vulgatum*.

7.7 *E. palustre* (fig. 4)

(a) Widespread but local in the shale regions away from the coast, although where it occurs it is occasional to frequent. Seen only once growing in a limestone region (M/15.08) and there on boulder clay. Habitats were mostly damp, tall grass and occurred once in old, peat workings on blanket bog, Slievebeg (R/16.89).

(b) Ivimey-Cook & Proctor (1966a) record it frequently in the Burren Lowlands and Jermy *et al.* (1978) for the same region in R/3.8.

7.8 *E. telmateia* (fig. 4)

(a) Widespread but local in the shale regions, and occasional to frequent where it grows. It is very local in the Burren Hills on limestone, and in at least one of its two localities there, it grows on boulder clay (M/15.08). It usually occurs in tall grass and is especially abundant along roads round Lisdoonvarna.

(b) Recorded in Jermy *et al.* (1978) for R/0.9, and in the Burren Lowlands for R/3.9.

8.1 *Botrychium lunaria*

(b) Recorded in Jermy *et al.* (1978) solely for the coastal squares M/1.0, M/1.1, M/2.1 & R/0.9. Older records give inland records for pasture near Lisdoonvarna (Corry 1880) and pasture near Inchironan Lough c. R/38.86 (specimen in Herb BM dated 1905). Original cards for records in Jermy *et al.* (1978) for M/1.0, M/2.1 & R/0.9 give grassland as habitat.

9.1 *Ophioglossum vulgatum* (fig. 4)

(a) Widespread but local throughout the region on acidic and basic sub-soils, in tall grass, where it is rare in abundance.

(b) Recorded in Jermy *et al.* (1978) for M/1.0, M/1.1, M/2.1, R/0.8, R/0.9, R/2.9 & R/3.9. Ivimey-Cook & Proctor (1966a) recorded it for damper, tall grass (R/17.93) and *Corylus avellana* scrub (R/26.93). Recorded in Praeger (1909) for *Plantago* sward near the sea.

10.1 *Osmunda regalis* (fig. 5)

(a) Widely distributed but local on the shale regions and Burren Lowlands. It is occasional to frequent in areas of blanket bog and heath on the shale and at the edge of raised bogs around lakes in the Burren Lowlands.

(b) Recorded in Jermy *et al.* (1978) for M/1.0, R/0.8, R/1.8, and R/3.9.

13.1 *Adiantum capillus-veneris* (fig. 5)

(a) Widespread but local in the Burren Hills near the coast. It is occasional in grykes and damp crevices in the limestone.

(b) Recorded for a wider area of the Burren Hills and Lowlands in Jermy *et al.* (1978): M/2.1, M/3.0, M/3.1, R/1.9 and R/2.9; and Praeger (1901) records it for two areas of crags north of Corofin (c. R/28.89).

The present records and those in Jermy *et al.* (1978) when viewed on a 10 km. basis indicate a distribution throughout the limestone areas. However, when these, along with the older records in Foot (1860) and More (1898), are viewed on a 1 km. basis there is a tendency for a coastal distribution.

14.2 *Hymenophyllum wilsonii*

(b) Recorded in Jermy *et al.* (1978) for M/2.0 and M/3.0, habitats on original record cards are "under moss-covered boulder" and "tree trunk" respectively. D.A. Webb (Pers. Comm. 1978) records the species as an epiphyte on a tree trunk and as growing on a sandstone erratic in *Fraxinus excelsior* woodland come *Corylus avellana* scrub in the Poulavallan doline (c. M/28.02).

16.1–3 *Polypodium vulgare* agg. (fig. 5)

(a) Widespread and common throughout the area on walls where it is occasional to frequent. Widespread but less common on outcrops of limestone and shale, where it is occasional in abundance. It is also widespread, but much less common, as an epiphyte on *Corylus avellana* in *C. avellana* scrub, on *Acer pseudoplatanus* trees and rarely on *Alnus glutinosa* trees and *Crataegus monogyna* bushes. It is locally frequent on moss-covered rocks on the floor of *C. avellana* scrub on limestone, and on the floor of woods on limestone and shale. It was also recorded once, as occasional, on the banks of hedges in the shale regions (R/09.91). All segregated records below have been determined by J.M. Mullin of the British Museum (Nat. Hist). As only a few of the

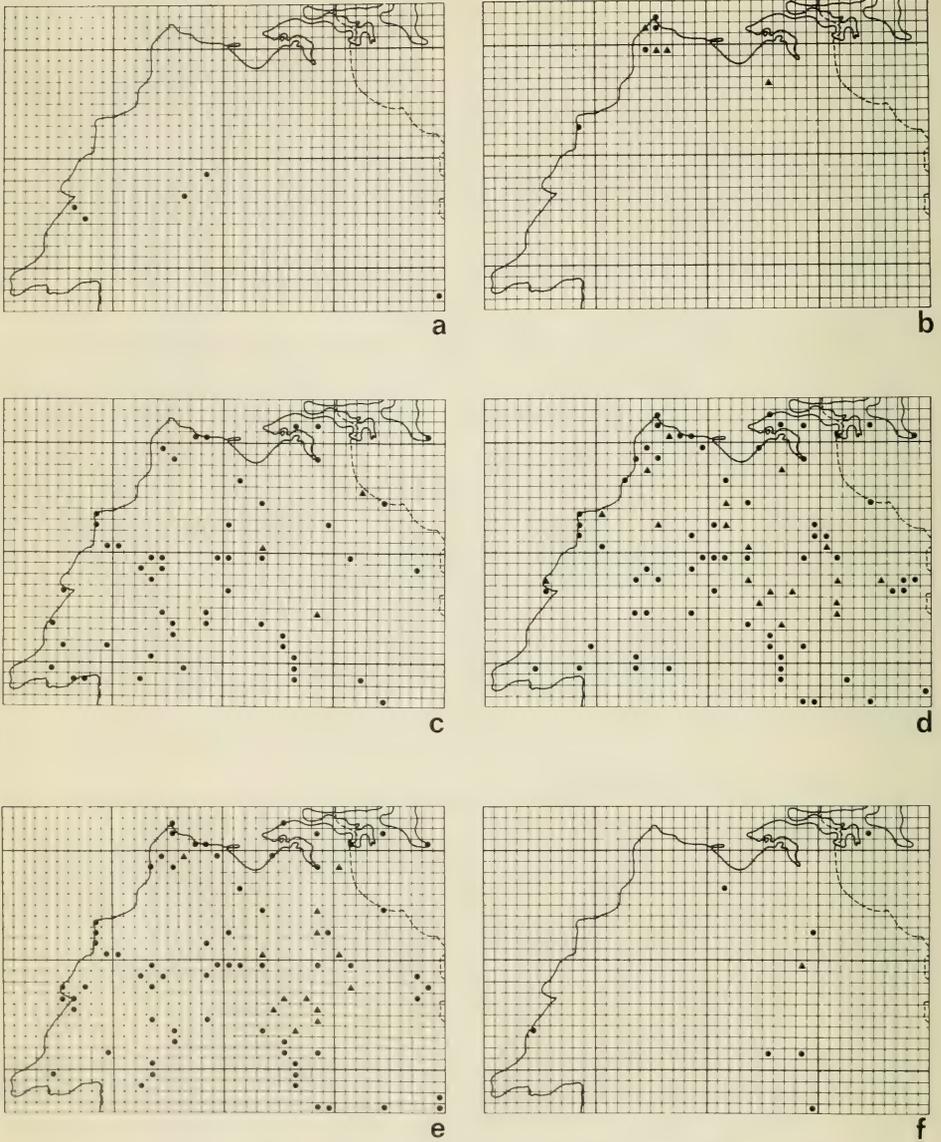


FIGURE 5. The distribution of the following in the Burren, circles Willmot 1978 and triangles Ivimey-Cook & Proctor (1966a): a, *Osmunda regalis*; b, *Adiantum capillus-veneris*; c, *Polypodium vulgare* agg.; d, *Pteridium aquilinum*; e, *Asplenium scolopendrium* and f, *A. adiantum-nigrum*.

records for the *P. vulgare* aggregate were critically determined, it is not possible to be completely confident of the differences in the ecologies of the species as recorded here. However, the preference of *P. interjectum* and *P. australe* for lime-rich substrates and the avoidance of such by *P. vulgare* support findings elsewhere Benoit (1966) and Jermy *et al.* (1978).

16.1 *P. vulgare*

(a) Widespread in the shale regions. Recorded as frequent on shale walls near Ballybreen (R/15.92 & 15.93) and occasional as an epiphyte on base of tree in mixed, deciduous woodland near Lisdoonvarna (R/12.98).

(b) Recorded by Jermy *et al.* (1978) for R/2.8 and there is an herbarium specimen in BM for a wall (most probably limestone) near sea at Blackhead (M/1.1) dated 1962.

16.2 *P. interjectum*

(a) Widespread throughout the area. Occasional to frequent on limestone walls both mortared and drystone (R/05.96, 18.93, 18.94, 23.93 & 26.89). Rare as an epiphyte on an *Acer pseudoplatanus* tree (R/14.94) and a *Corylus avellana* bush in hazel scrub (M/29.02). Occasional on a hedge bank near Moymore House (R/09.91).

(b) Recorded by Jermy *et al.* (1978) for M/1.1, M/2.1 & M/3.0,

16.2 x 1 *P. x mantoniae*

(a) Recorded once for a mortared limestone wall at Ennistimon (R/13.90) as occasional. First county record for Co. Clare.

16.3 *P. australe*

(a) Scattered throughout the area. Occasional to frequent on mortared and drystone limestone walls (M/10.00, M/17.10 and R/25.92); and rare on grykes at Burrin (M/28.11) and on moss-covered boulders in hazel scrub at Dromore Woods (R/34.86).

(b) Recorded by Jermy *et al.* (1978) for M/3.0 with habitat given as "limestone karst" on original card, and R/3.9.

17.1 *Pteridium aquilinum* (fig. 5)

(a) Common throughout both the limestone, and sandstone and shale regions. It is occasional to frequent in tall, acidic grassland; widespread and frequent in abundance in short grassland over limestone; and occasional to frequent in *Corylus avellana* scrub and scrub in general. It is locally abundant in acidic, tall grass and herb communities in a few places. It is also rare to frequent in grykes in the limestone pavements.

18.1 *Thelypteris thelypteroides*

(a) Recorded once as locally abundant in marsh next to Lough Inchicronan (R/39.87) where it was recorded by Praeger (1901).

(b) Jermy *et al.* (1978) also give M/2.0. There are old records for Ballycullinan Lough (c. R/28.86) in Praeger (1901) and a specimen in herb. BM for marsh in Inchiquin Lough dated 1905 (c. R/26.89).

20.1 *T. limbosperma*

(b) Jermy *et al.* (1978) give M/1.1 and an old record for R/1.9.

21.1 *Asplenium scolopendrium* (fig. 5)

(a) Widespread and common throughout the area in both areas of limestone and of sandstone and shale, more abundantly in damper and shaded habitats. It is rare to frequent on walls and outcrops of all rock types; occasional in grykes in the limestone; rare to occasional on the floor of *Corylus avellana* scrub and woods; and occasional on hedge banks in shale regions.

21.2 *A. adiantum-nigrum* (fig. 5)

(a) Widespread but local in the limestone regions and very local in the sandstone and shale regions. Rare on outcrops of limestone and shale.

(b) Recorded over a wide range of both the limestone and shale regions in Jermy *et al.* (1978): M/1.0, M/1.1, M/2.1, R/1.9, R/3.8 and R/3.9. Ivimey-Cook and Proctor (1966a) record it for limestone pavement at Carran (R/28.99).

21.5 *A. billotii*

(b) Recorded in Jermy *et al.* (1978) for M/1.0.

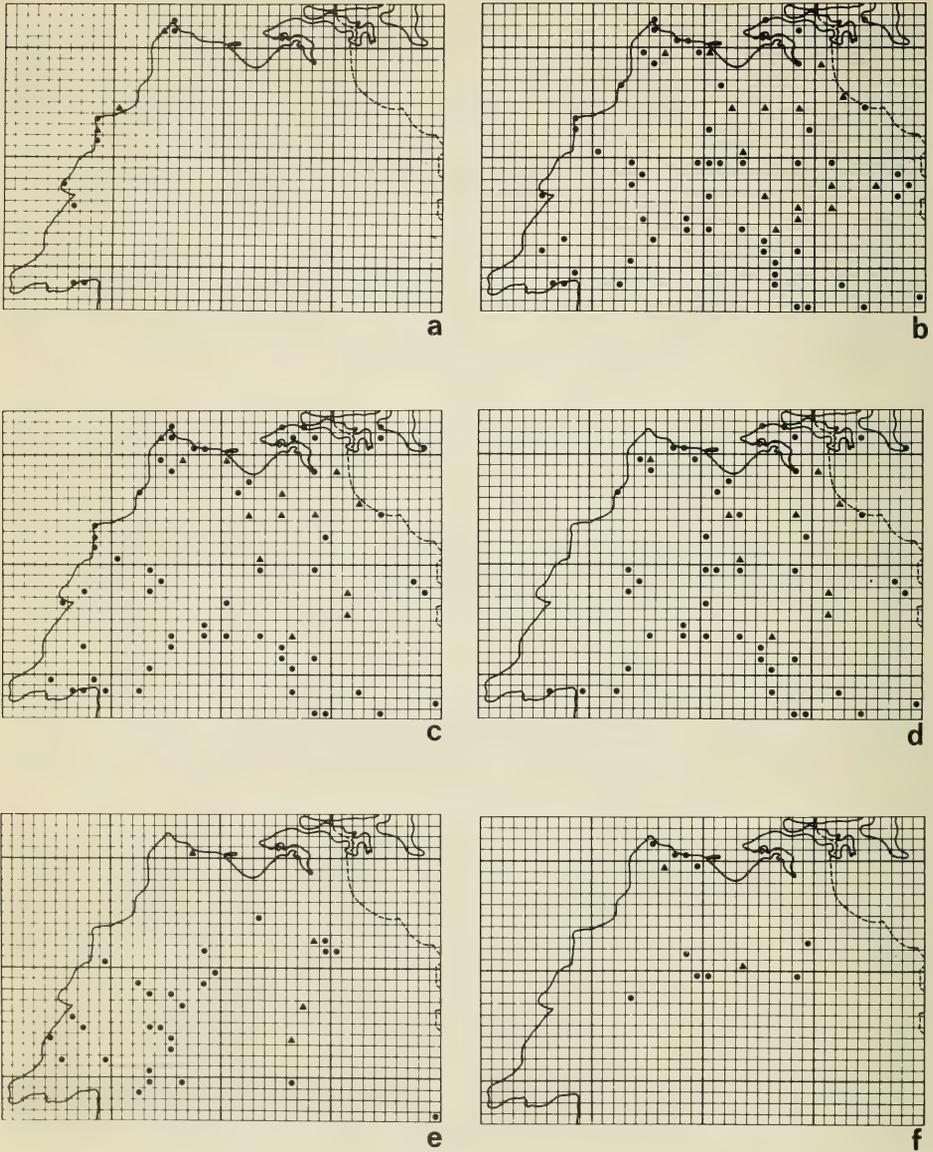


FIGURE 6. The distribution of the following in the Burren, circles Willmot 1978 and triangles Ivimey-Cook & Proctor (1966a): a, *Asplenium marinum*; b, *A. trichomanes* agg.; c, *A. ruta-muraria*; d, *A. ceterach*; e, *Athyrium filix-femina* and f, *Cystopteris fragilis*.

21.6 *A. marinum* (fig. 6)

(a) Widespread but local along the coast particularly the western coast. Occasional on walls and outcrops of both limestone and shale and frequent in grykes in the limestone (fig. 3).

(b) Recorded in Jermy *et al.* (1978) for M/1.0 and in Praeger (1901) for Ballyvaghan (c. M/22.08).

21.7 *A. trichomanes* agg. (fig. 6)

(a) Widespread and common throughout the area. Occasional to frequent on limestone outcrops; and on walls of limestone and of shale. Rare in grykes in the limestone. Recorded once, as rare, in *Corylus avellana* scrub.

(b) Ivimey-Cook & Proctor (1966a) record it more commonly in *C. avellana* scrub.

All specimens collected would appear to be referable to subsp. *quadrivalens*, which is the common subspecies on lime-rich substrates, but no specimens were critically determined.

21.9 *A. ruta-muraria* (fig. 6)

(a) Widespread and common throughout the area. Frequent to occasional on outcrops of limestone; and on walls of limestone or shale. Recorded once as occasional in grykes in limestone.

(b) Ivimey-Cook & Proctor (1966a) record it more commonly in grykes.

21.11 *A. ceterach* (fig. 6)

(a) Widespread and common throughout the area except near the coast between Lisconnor and Black Head. Widespread and occasional to rare on outcrops of limestone. Widespread and frequent to rare on walls of limestone, but much more local on shale walls.

(b) Ivimey-Cook & Proctor (1966a) record it more commonly in grykes, and Jermy *et al.* (1978) record it for R/0.9.

22.1 *Athyrium filix-femina* (fig. 6)

(a) Widespread and common in the shale regions, but less widespread and less frequently encountered in the limestone regions. Frequent to occasional in damp, tall grass in the shale regions. Occasional in hedges; in *Corylus avellana* scrub on limestone; and in woods throughout the area.

(b) Jermy *et al.* (1978) record it for M/1.1, R/0.8 and R/2.9.

Plants with red rachises and with green rachises occur in the area.

23.1 *Gymnocarpium dryopteris*

(b) Praeger (1901) records this species on outcrop by road between Roadford and Cliffs of Moher.

24.1 *Cystopteris fragilis* (fig. 6)

(a) Widespread but local throughout the Burren Hills and the Sandstone-shale Uplands. Rare to occasional on damp outcrops of shale and limestone. One favoured situation in this type of habitat is around swallow-holes on the edge of the limestone, where streams passing off the shales go underground. Only occurs on limestone walls at their base amongst other vegetation. Recorded once in grykes as occasional.

(b) Jermy *et al.* (1978) record it for a wider range: M/2.1, M/3.0, M/3.1, R/0.8, R/1.8, & R/3.9. Prof. Webb considers it rarer in the Burren Lowlands than elsewhere in the area (D.A. Webb Pers. Comm. 1978).

26.2 *Polystichum aculeatum* (fig. 7)

(a) Widespread but local throughout the Burren Hills and very local in the shale regions. Rare to occasional on limestone outcrops, in grykes and tall grass. Occasional in *Corylus avellana* scrub; and rare in shale hedgebanks.

(b) Recorded for the Burren Lowlands and for a wider range of the Burren Hills in Jermy *et al.* (1978) M/3.0 and R/3.9. Much less common and abundant than *P. setiferum*.

26.2 x 3 *P. x bicknellii*

(a) Recorded once as rare on rock outcrops in quarry by road north east of Cross Bridge (R/25.91).

(b) Recorded for R/2.9 in Jermy *et al.* (1978), with habitat given as walls of old mineshaft on original card.

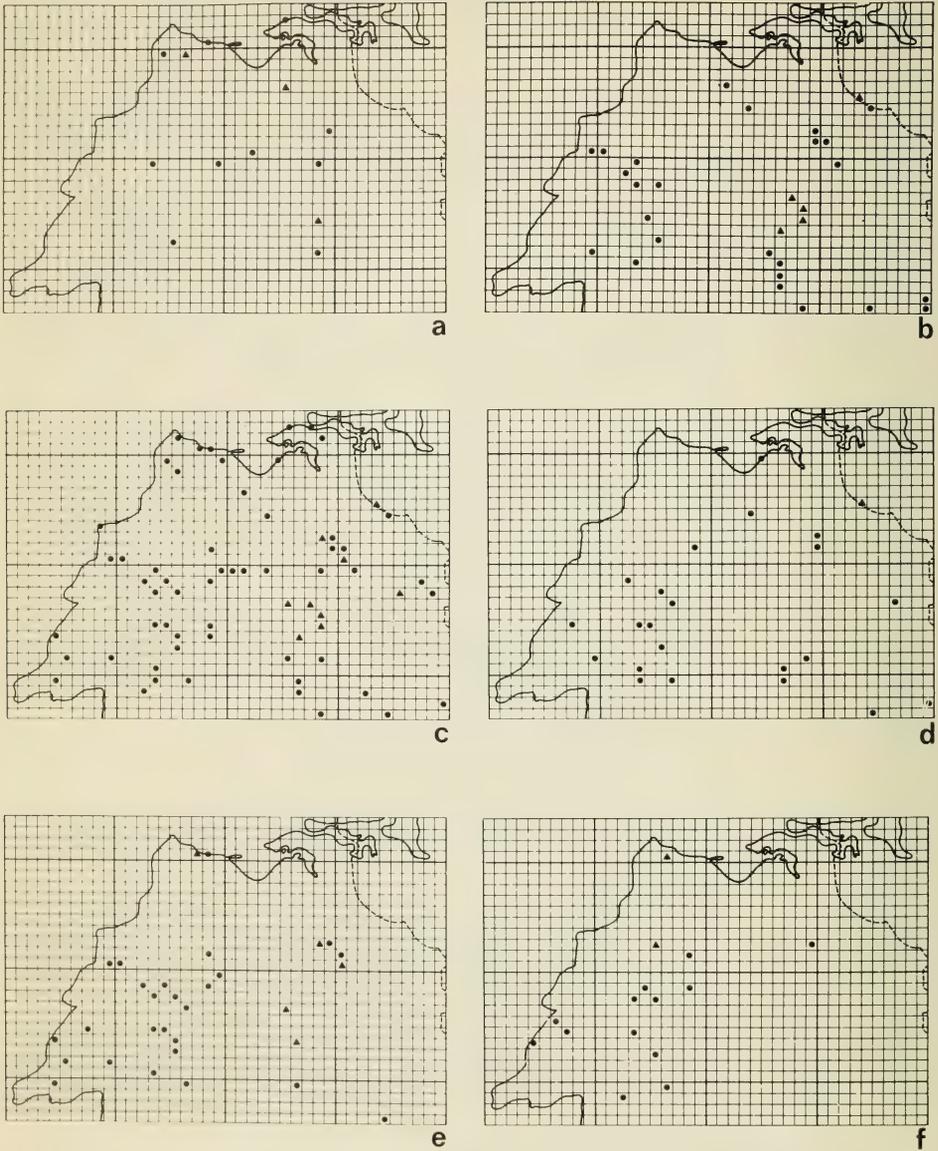


FIGURE 7. The distribution of the following in the Burren, circles Willmot 1978 and triangles Ivimey-Cook & Proctor (1966a): a, *Polystichum aculeatum*; b, *P. setiferum*; c, *Dryopteris filix-mas*; d, *D. pseudomas*; e, *D. austriaca* and f, *Blechnum spicant*.

26.3 *P. setiferum* (fig. 7)

(a) Widespread but rather local throughout the area. Occasional to frequent in woods. Rare to occasional in *Corylus avellana* scrub on limestone, though sometimes locally abundant in the latter habitat (fig. 2). Occasional in hedges in a few places in the shale regions. Rare on walls and rare to occasional in tall grass.

(b) Jermy *et al.* (1978) give records for M/1.1, M/2.1, & M/3.1.

27.2 *Dryopteris filix-mas* (fig. 7)

(a) Widespread and common throughout the area but never in large amounts. Occasional in deciduous woods and *Corylus avellana* scrub on limestone. Rare to frequent in tall herb and grass communities. Occasional on limestone walls. Occasional to rare, on limestone outcrops and walls.

27.2 x 3 *D. x tavelii*

(a) Recorded once as rare, with parents, in tall grass by roadside near Ennistimon (R/13.90). First county record for Co. Clare.

27.3 *D. pseudomas* (fig. 7)

(a) Widespread but rather local throughout the area. Occasional in woods and *Corylus avellana* scrub on limestone. Rare in grykes. Occasional in damp, tall grass communities in shale regions.

(b) Recorded for M/3.0 in Jermy *et al.* (1978).

27.5 *D. aemula*

(a) Widespread but very rare throughout the area. Recorded three times: frequent in mixed deciduous wood Lisdoonvarna (R/15.97); occasional in *Corylus avellana* scrub Poulavallan (M/29.02); and rare in damp, tall, herbaceous vegetation Slievebeg (R/16.89).

27.9 *D. austriaca* (fig. 7)

(a) Widespread and common in the shale regions, while less widespread and rare in the limestone regions. Rare to occasional in mixed deciduous woods; occasional but much less common in *Corylus avellana* scrub on limestone and rare to occasional in damp, tall grass and blanket bog in the shale regions.

(b) Recorded more commonly in *C. avellana* scrub on limestone by Ivimey-Cook & Proctor (1966a).

28.1 *Blechnum spicant* (fig. 7)

(a) Rare but widespread in the shale regions and recorded once for the Burren Hills, as rare in *Corylus avellana* scrub. Occasional to frequent in heath and short, acid, grass communities in the shale regions. Occasional in woods on shale and very local but frequent where it does occur on shale outcrops.

(b) Recorded over a wider part of the western and central portions of the area in Jermy *et al.* (1978): M/0.0, M/1.1, R/0.8, R/2.8 & R/2.9.

HABITAT LISTS

Species lists are given for some of the more interesting and/or characteristic fern habitats of the Burren. As in the systematic list, abundance only refers to abundance in examples of the habitat in which the species in question occurred. The abbreviations 'D', 'A', 'F', 'O', & 'R' stand for Dominant, Abundant, Frequent, Occasional and Rare respectively and '()' means exceptionally. 'L' stands for locally. How often the species occurred in the habitat is given as a percentage frequency, rounded to the nearest ten percent.

Woodland

No examples of woodlands consisting of "an open tree layer over-topping the hazel (scrub)" were examined (Ivimey-Cook & Proctor, 1966a). However, as these merge into hazel scrub, its species list can be taken as a good approximation for this habitat. The list here refers to mixed deciduous woodlands of an obviously planted nature, and to eight examples of the vegetation.

Species	Abundance	Occurrence (%)
<i>Equisetum arvense</i>	R	30
<i>Polypodium vulgare</i> agg.	O	40
<i>Pteridium aquilinum</i>	R - O	40
<i>Asplenium scolopendrium</i>	O - F(LA)	80
<i>Athyrium filix-femina</i>	O	50
<i>Polystichum setiferum</i>	O - F(LA)	100
<i>Dryopteris filix-mas</i>	O	80
<i>D. pseudomas</i>	O	50
<i>D. aemula</i>	F	10
<i>D. austriaca</i>	R - O	90
<i>Blechnum spicant</i>	O	30

The paucity of the flora for deciduous woods on limestone probably reflects the planted nature of the woodlands and lack of damp areas.

Hazel Scrub

This is one of the most characteristic types of vegetation in the Burren (fig. 2). It is species-rich and has a typical, woodland-ground flora. Although often restricted to more-sheltered situations and often wind-cut in more exposed areas, it is considered that hazel scrub could cover much more of the Burren (Ivimey-Cook & Proctor, 1966a), presumably if grazing pressure was reduced. Pollen analysis (Watts, unpubl.), however, indicates that it is not the climax vegetation at least in the east of the area. The list refers to eleven examples of the vegetation.

Species	Abundance	Occurrence (%)
<i>Polypodium vulgare</i> agg.	R	10
<i>Pteridium aquilinum</i>	O - F	80
<i>Asplenium scolopendrium</i>	R - O	70
<i>A. adiantum-nigrum</i>	R	10
<i>A. trichomanes</i> agg.	R	10
<i>Athyrium filix-femina</i>	O (LF)	30
<i>Polystichum aculeatum</i>	O	10
<i>P. setiferum</i>	R - O(LA)	80
<i>Dryopteris filix-mas</i>	R - F	90
<i>D. pseudomas</i>	O	30
<i>D. aemula</i>	O	10
<i>D. austriaca</i>	O	30
<i>Blechnum spicant</i>	R	10

Allowing that my samples are much larger than those of Ivimey-Cook and Proctor (1966a), there is a close similarity between their values and mine for the occurrence of ferns in hazel scrub. The only large differences are that they record *Asplenium trichomanes* agg. and *Dryopteris austriaca* more commonly. Assuming these are real differences, there are no obvious explanations. Generally the flora has a woodland aspect apart from *Asplenium adiantum-nigrum* and *A. trichomanes* agg. These are rock crevice plants and grow on limestone outcrops in the scrub.

Grykes

Grykes (fig. 3), which are vertical fissures in limestone pavement, have long held a special fascination for botanists in the Burren (Dickinson *et al.*, 1964; Heslop-Harrison, 1960), probably because they contain a rich flora, in stark contrast to the bare

pavement around them. They do not constitute a single habitat, as pointed out by Ivimey-Cook & Proctor (1966a), but a mixture of several distinct types, including gryke floors and rock crevices. Nevertheless grykes are considered a single habitat here, as this was considered sufficient for the survey. The list refers to fourteen examples of the vegetation.

Species	Abundance	Occurrence (%)
<i>Adiantum capillus-veneris</i> (M)	O	10
<i>Polypodium vulgare</i> agg.	R	20
<i>Pteridium aquilinum</i>	R - F	60
<i>Asplenium scolopendrium</i>	O	90
<i>A. marinum</i> (M)	F	20
<i>A. trichomanes</i> agg. (R)	R	20
<i>A. ruta-muraria</i> (R)	O	10
<i>Cystopteris fragilis</i> (R)	O	10
<i>Polystichum aculeatum</i>	O - R	20
<i>P. setiferum</i>	R	10
<i>Dryopteris filix-mas</i> (W)	O - R	20
<i>D. pseudomas</i> (W)	R	10

- (W) = Woodland-floor elements
 (R) = Rock-crevice elements and
 (M) = Maritime element

The flora illustrates the multiple habitat nature of grykes, containing as it does woodland-floor and rock-crevice elements. The presence of the former is explained by the micro-climate of the gryke floors being like that of woodland floors in the vicinity (Dickinson *et al.*, 1964). A third element is the two species that only occur commonly in grykes near the sea, however, these species occur separately. Ivimey-Cook & Proctor (1966a: Table XL) give a species list with higher frequencies of the rock-crevice element and also include *Asplenium ceterach*. This is probably because their list refers to limestone pavement in general and not just grykes. However, Webb (1962) also records the *Asplenium* spp. as common on the pavement.

Limestone outcrops

The list refers to natural outcrops and not man-made ones. However, this does not mean that it describes or even resembles the flora of outcrops before the advent of agriculture. No doubt originally outcrops would have been generally more shaded and have harboured a different flora at least in quantitative terms. This is the only commonly-occurring terrestrial habitat apart from walls, which are artificial rock outcrops, where ferns are the dominant element in the vegetation. The list refers to twenty-eight examples of the vegetation.

The two maritime-element species only occurred in crevices near the sea. They occurred separately with practically no other vascular plants. Ivimey-Cook & Proctor (1966a) note similar differences between crevices near and away from the sea. *Asplenium scolopendrium* and *Cystopteris fragilis* occurred more commonly in damper areas. This list only differs significantly from the Ivimey-Cook & Proctor (1966a) list by the greater frequency of *A. scolopendrium*. This may be due to the fact that *A. scolopendrium* prefers damper habitats and thus more often grows at the base of outcrops. I may have been more likely to record it as on the outcrop in such situations than Ivimey-Cook & Proctor.

Species	Abundance		Occurrence (%)	
<i>Adiantum capillus-veneris</i> (M)	R		10	
<i>Polypodium vulgare</i> agg.	O		20	
<i>Asplenium scolopendrium</i>	O		60	
<i>A. adiantum-nigrum</i>	R		10	
<i>A. marinum</i> (M)	O		10	
<i>A. trichomanes</i> agg.	O - F		70	
<i>A. ruta-muraria</i>	O - F		60	
<i>A. ceterach</i>	R - O		50	
<i>Cystopteris fragilis</i>	R - O		20	
<i>Polystichum aculeatum</i>	R - O		10	
<i>P. setiferum</i>	R		10	
<i>Dryopteris filix-mas</i>	R - O		20	
<i>D. pseudomas</i>	O		10	

(M) = Maritime element

Limestone walls

This is the most striking habitat for ferns because it is so common, especially near roads, and because ferns constitute a large part of its vascular flora. The distribution maps of *Asplenium trichomanes* agg., *A. ruta-muraria* and *A. ceterach* for my records show the pattern of major roads in the south of the area. The list refers to twenty-five examples of the vegetation on drystone walls and to twenty-two examples on mortared walls.

Species	Abundance		Occurrence (%)	
	Drystone	Mortared	Drystone	Mortared
<i>Polypodium vulgare</i> agg.	O - F	O - F	60	60
<i>Asplenium scolopendrium</i>	O	R	70	40
<i>A. adiantum-nigrum</i>	R - O	-	10	0
<i>A. trichomanes</i> agg.	O - F	O - F	60	80
<i>A. ruta-muraria</i>	O	O - F	40	100
<i>A. ceterach</i>	O - F	R - F	50	80
<i>Cystopteris fragilis</i>	O	-	10	0
<i>Polystichum setiferum</i>	R - F	R	10	10
<i>Dryopteris filix-mas</i>	O	O - R	20	10

Cystopteris fragilis and *Dryopteris filix-mas* only occurred at the base of drystone walls, undoubtedly due to the preference of these species for damper habitats. The overall similarity of the floras of limestone walls and outcrops is obvious but there are important differences. Walls in the area often have soil cappings but outcrops rarely do and in at least one area *Polypodium vulgare* agg. shows a preference on limestone, for areas of thin soil (Willmot, 1977). The major differences in occurrence of species between drystone and mortared walls may be due to differences in size of crevices. Mortared walls have a predominance of smaller, presumably drier, crevices, whereas drystone walls have larger, presumably damper, ones. It is possible then that *Asplenium ruta-muraria* and *A. ceterach*, which amongst the outcrop-ferns occur in the driest situations, are commoner on mortared walls because they grow in the smaller, drier crevices. On the other hand *A. scolopendrium* may occur more commonly on the drystone walls because it prefers damper crevices.

Shale walls

These are less numerous than limestone walls. The list refers to eight examples of the vegetation of drystone walls and to nine examples of that on mortared walls.

Species	Abundance		Occurrence (%)	
	Drystone	Mortared	Drystone	Mortared
<i>Polypodium vulgare</i> agg.	O - F	O	60	40
<i>Asplenium scolopendrium</i>	F	R	30	30
<i>A. marinum</i>	—	O	0	20
<i>A. trichomanes</i> agg.	R	O - F	10	70
<i>A. ruta-muraria</i>	O - F	O - F	40	80
<i>A. ceterach</i>	O	O - F	10	30
<i>Athyrium filix-femina</i>	O	F	10	10
<i>Cystopteris fragilis</i>	—	F	0	10
<i>Polystichum setiferum</i>	—	A	0	10
<i>Dryopteris austriaca</i>	O	—	10	0

The difference in abundance and occurrence between the two types of wall for *A. scolopendrium*, *A. ruta-muraria* and *A. ceterach* mirror the differences for these species between the two types of limestone wall. This is presumably for the same reason. In terms of occurrence the mortared, shale walls are more like limestone walls than the drystone, shale walls. This is possibly due to the mortar increasing the base status of the otherwise acid soil that collects in the crevices of the shale walls. The hypothesis that the soil in shale walls is acid if mortar is not present, is supported by the appearance of a calcifuge element on shale walls e.g. *Dryopteris austriaca* and *Athyrium filix-femina*.

SUMMARY OF FLORA

Thirty-five species are recorded from the area, which is 60% of the native fern flora recently recorded for Ireland (Jermy *et al.* 1978). An idea of the richness of the flora of the area can be obtained from Jalas & Suominen (1972). They record only seven out of forty-eight 50 km squares with more species than the square containing this study area. Note that the study area is about half the area of one of their squares. Also five hybrids out of nine recently recorded for Ireland were found. Two, of these, *Polypodium x mantoniae* and *Dryopteris x tavelii* are first county records and a third *Polystichum x bicknellii* a second county record for Co. Clare. The record for *D. x tavelii* is only the second for Ireland, though the hybrid is doubtless under-recorded there.

The most valuable contribution of the fern flora of the area to that of the British Isles is the abundance of *Adiantum capillus-veneris*. This has nine of its thirty-three recent localities (Jermy *et al.* 1978) in the area. Efforts should therefore be made to conserve the best of these localities. Two species, *Asplenium viride* and *Dryopteris carthusiana*, which are widespread elsewhere in Ireland in habitats that occur in this area are absent from the study area. The ease of recognition of the species and the extent to which the area has been studied suggest that these are probably genuine absences. However, they should be looked for in the area.

The ferns illustrate the well-known commingling of northern and southern elements in the flora (Praeger, 1934). Examples of northern species are *Huperzia selago* and *Selaginella selaginoides* and of southern species *Adiantum capillus-veneris* and *Polypodium australe*. There is, however, a complete absence of any arctic-alpine element although there is one in the flowering plant flora (Praeger 1934). A more

detailed analysis of the phytogeographical affinities of the flora is given below and in Table 1. This is based on the European distribution of species as recorded in Jalas & Suominen (1972) and Jermy *et al.* (1978). The figures for the British Isles refer to recently-recorded, native species of the British Isles excluding the Channel Isles. Minor elements are excluded, as are a few species whose distribution is intermediate between the classes given or is indeterminate. On the same basis there are eleven widespread species in Europe which all occur in the Burren; seven arctic-alpine species none of which occur; and seven northern, montane species two of which occur.

TABLE 1 : THE PHYTOGEOGRAPHICAL AFFINITIES OF THE FERN FLORA OF THE BURREN

	Atlantic		Sub-atlantic		Continental		Total	
	British Isles	Burren						
Northern	2	1	4	2	6	2	12	5
Southern	2	2	6	6	—	—	8	8
Widespread	6	3	8	6	1	0	15	9
Total	10	6	18	14	7	2	35	22

Overall Table 1 shows the atlantic/sub-atlantic and southern affinities of the flora. Most striking is the presence of all species of southern, atlantic and southern, sub-atlantic affinity in Europe which are in the British fern flora. This is particularly so since the area is so far north relative to the definition of southern Europe in Tutin *et al.* (1964). This is probably due to the relatively mild climate of the area for a region 53°N, which is caused by the warming effect in winter of air masses moving over the area from the Atlantic. This southern nature to the flora is not so marked in the bryophyte flora of the area. Ratcliffe (1968) records 18 out of his 25 northern atlantic bryophytes in Mid-West Ireland, and 16 out of his 27 southern atlantic. Note, however, that Ratcliffe's Mid-West area is much larger than the Burren. The relatively high representation of atlantic/sub-atlantic species and low representation of continental species is to be expected in an area on the western seaboard of Europe. Although the relatively higher over-representation of sub-atlantic compared to atlantic species is worthy of comment. This may be due to the fact that although the Burren is on the western seaboard of Europe and thus has a damp, oceanic climate, this is partially ameliorated by the exposed and/or free-draining nature of many of the habitats in the area.

Birks (1976) gives a more detailed analysis of the phytogeography of European pteridophytes, dividing them into twenty-one floristic elements, that is groups of species with similar distributions. Examination of the placing of the thirty-five species from the Burren amongst Birks' groups confirms the southern and western (atlantic) affinities of the flora and lack of northern, eastern and alpine elements. However, the character of the flora that emerges from this examination is rather more southern and less western than the previous analysis (Table 1) suggested. This is probably a truer picture of the affinities of the flora as Birks' methods were more objective.

One ecological problem in the area has not been discussed: the occurrence of species in more acidic habitats than those in which they usually occur. The best example is *Pteridium aquilinum*, a calcifuge which occurs commonly in short calcareous grassland over limestone pavement. Webb (1962) records it in such habitats more especially in the east of the area. In such grassland it is usually stunted (Webb

1962) being about 40 cm. high and it does not grow in dense masses but as separate fronds. It is tempting to suggest this anomalous occurrence is due to leaching of the top layers of the soil caused by the high rainfall of the area. However, Grime (1963) demonstrates that some calcifuges occur in calcareous soils in the area without surface leaching. Jermy *et al* (1978) suggest an alternative hypothesis that there might be a calcicole ecotype involved, similar to the diploid cytotype on limestone in Spain. As no calcicole ecotypes have been found in calcifuge species growing on calcareous soils (Grime 1963), the ecotype explanation appears unlikely. As a number of calcifuge flowering plants occur in similar habitats in the area (Grime 1963 & Webb 1962), a more general explanation appears probable. However, Grime (1963) has analysed the ecologies of a number of calcifuge species growing on calcareous substrata in various sites in the British Isles and could find no general explanation.

Amongst the other species growing in more calcareous habitats than usual, *Oreopteris limbosperma* & *Blechnum spicant* have each been recorded once in a locality which suggests that they were growing in a habitat similar to *P. aquilinum*. I have recorded *O. limbosperma* once growing in soil over Carboniferous Limestone in Derbyshire. *Dryopteris pseudomas* is recorded in Clapham *et al.* (1962) as usually on acid soils but is recorded here as growing once on a limestone outcrop, once in a gryke and once amongst limestone blocks. Willmot (1977) records the species as growing rarely on Carboniferous Limestone in Derbyshire.

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REFERENCES

- BENOIT, P.M. 1966. Some recent work in Wales on the *Polypodium vulgare* aggregate. *Fern Gaz.* 9 : 277–282.
- BIRKS, H.J.B. 1976. The distribution of European pteridophytes : A numerical analysis. *New Phytol.* 77 : 257–287.
- CLAPHAM, A.R., TUTIN, T.G. & WARBURG, E.F. 1962. *Flora of the British Isles*. Cambridge.
- CORRY, T.H. 1880. Notes of a botanical ramble in the County of Clare, Ireland. *Proc. Rep. Belf. Nat. Hist. Phil Soc.*, 167–207.
- DICKINSON, C.H. PEARSON, M.C. & WEBB, D.A. 1964. Some micro-habitats of the Burren, their micro-environments and vegetation. *Proc. R. Ir. Acad.* 63B : 291–302.
- FINCH, T.F. 1971. *Soils of County Clare*. Dublin.
- FOOT, F.J. 1860. On the Ferns of West Clare, being a list of those growing west of a line drawn north and south through the town of Tulla. *Nat. Hist. Rev.* 7 : 36–40.
- GRIME, J.P. 1963. Factors determining the occurrence of calcifuge species on shallow soils over calcareous substrata. *J. Ecol.* 51 : 375–390.
- HESLOP-HARRISON, J. 1960. A note on temperature and vapour deficit under drought conditions in some microhabitats of the Burren limestone, Co. Clare. *Proc. R. Ir. Acad.* 61B : 109–114.
- IVIMEY-COOK, R.B. & PROCTOR, M.C.F. 1966a. Plant Communities of the Burren, Co. Clare. *Proc. R. Ir. Acad.* 64B : 201–311.
- IVIMEY-COOK, R.B. & PROCTOR, M.C.F. 1966b. The application of association analysis to phytosociology. *J. Ecol.* 54 : 179–192.
- JALAS, J. & SUOMINEN, J. 1972. *Atlas Florae Europaeae*, Vol. 1. Helsinki.

- JERMY, A.C., ARNOLD, H.R., FARRELL, L & PERRING, F.H. 1978. *Atlas of ferns of the British Isles*. London.
- LOUSLEY, J.E. 1950. *Wild flowers of Chalk and Limestone*. London.
- MALLOCH, A.J.C. 1976. An annotated bibliography of the Burren *J. Ecol.* 64: 1093–1105.
- MORE, A.G. 1898. *Cybele Hibernica* 2nd Edn. Dublin.
- PRAEGER, R.L. 1901. Irish Topographical Botany. *Proc. R. Ir. Acad.* 7B.
- PRAEGER, R.L. 1909. *A tourist's flora of the West of Ireland*. Dublin.
- PRAEGER, R.L. 1932. The flora of the turloughs : a preliminary note. *Proc. R. Ir. Acad.* 41B : 37–45.
- PRAEGER, R.L. 1934. *The Botanist in Ireland*. Dublin.
- RATCLIFFE, D.A. 1968. An ecological account of the atlantic bryophytes in the British Isles. *New Phytol.* 67 : 365–439.
- SCANNELL, M.J.P. & SYNNOTT, D.M. 1972. *Census Catalogue of the Flora of Ireland*. Dublin.
- SWEETING, M.M. 1955. The landforms of north-west County Clare, Ireland. *Trans. Inst. Br. Geogr.* 21 : 33–49.
- TUTIN, T.G., HEYWOOD, V.H., BURGESS, N.A., VALENTINE, D.H., WALTERS, S.M. & WEBB, D.A. 1964. *Flora Europaea*. Vol. 1. Cambridge.
- WATTS, W.A. Unpubl. Quoted in Ivimey-Cook & Proctor (1966a).
- WEBB, D.A. 1962. Noteworthy plants of the Burren : a catalogue raisonné. *Proc. R. Ir. Acad.* 62B : 117–34.
- WILLMOT, A. 1977. A pteridophyte flora of the Derbyshire Dales National Nature Reserve. *Fern Gaz.* 11: 279–284.

REVIEW

THE EIGHTIETH BIRTHDAY OF R.E. HOLTUM, 1975. A special issue of the Gardeners' Bulletin Singapore, Vol. 30, 312pp published 15th October 1977 edited by Chang Kiau Lan. Available from the Botanic Gardens, Singapore 9, price \$49.40 (about £11.12) post free.

This birthday issue for Richard Eric Holttum contains introductory biographical accounts and 22 papers of which 13 are about ferns. Descriptive taxonomical papers including B.J. Hoshizaki on *Platyserium* (13–15); G.J. de Joncheere on *Humata* (45–58); K. Iwatsuki on *Meringium* (63–74); M.G. Price on *Dryopteris* (239–250) and A.C. Jermy & T.G. Walker on *Botrychium*. Three papers describe spore morphology: E. Soepadmo & E.E. Khoo on Malayan Dennstaedtiaceae (85–95); F.S. Liew, on Oleandraceae (101–110) and K.U. Kramer on 'Synaptosporia : a hypothesis' (79–83) in which the author elaborates an interesting theory in which spore ornamentation is said to hold spores together thus allowing *two* prothalli to establish themselves, and thus help cross fertilization. A very interesting account and discussion by Herb and Florence Wagner (251–267) on fertile-sterile leaf dimorphism is stimulating and that by D.W. Lee (21–29) on iridescence in *Selaginella* is similarly so. Two floristic papers: A.G. Piggott, the ferns of Gunong Ulu Kali (31–43) and a larger paper on the limestone hill flora of Malaya I, by S.C. Chin (165–219) make interesting reading. The latter gives notes and a key to 97 species of ferns in 43 genera. Last, a paper listing all Holttum's new taxa and name changes in ferns to July 1975 by J.A. Crabbe (221–238) which lists over 700 items abstracted from 420 papers and shows the productivity of this Grand Old Man of Pteridology, whom this journal seeks to honour.

A.C. JERMY

THE ASSOCIATIONS BETWEEN PTERIDOPHYTES AND ARTHROPODS

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ABSTRACT

Insects belonging to 12 orders, as well as mites, millipedes, woodlice and tardigrades have been collected from Pteridophyta. Primitive and modern, as well as general and specialist arthropods feed on pteridophytes. Insects and mites may cause slight to severe damage, all plant parts being susceptible. Several arthropods are pests of commercial Pteridophyta, their control being difficult due to the plants' sensitivity to pesticides. Efforts are currently underway to employ insects for the biological control of bracken and water ferns. Although Pteridophyta are believed to be relatively resistant to arthropods, the evidence is inconclusive; pteridophyte phytoecdysones do not appear to inhibit insect feeders. Other secondary compounds of pteridophytes, like prunasine, may have a more important role in protecting bracken from herbivores. Several chemicals capable of adversely affecting insects have been extracted from Pteridophyta. The litter of pteridophytes provides a humid habitat for various parasitic arthropods, like the sheep tick. Ants often abound on pteridophytes (especially in the tropics) and may help in protecting these plants while nesting therein. These and other associations are discussed. It is tentatively suggested that there might be a difference in the spectrum of arthropods attacking ancient as compared to modern Pteridophyta. The Osmundales, which, in contrast to other ancient pteridophytes, contain large amounts of phytoecdysones, are more similar to modern Pteridophyta in regard to their arthropod associates. The need for further comparative studies is advocated, with special emphasis on the tropics.

INTRODUCTION

This is the fourth and final installment in a series of review papers intended to explore the relationships between arthropods and the lower green plants. These reviews, while not intended to be comprehensive, are meant to draw attention to some hitherto-neglected areas of arthropod-plant inter-relationships. Former parts dealt with mosses, lichens and algae, respectively (Gerson, 1969; 1973; 1974-76).

The associations between arthropods and pteridophytes have been of some recent interest to entomologists. The continuing weed problem of bracken (*Pteridium aquilinum*) in some parts of the world (Braid, 1959), and the relatively new problem of *Salvinia* as a nuisance in Asian and African waterways (Anders and Bennett, 1975) are being tackled by a biological control approach. Some Pteridophyta, of ornamental interest, are grown commercially; their pests have become of economic importance. Finally, the discovery of insect moulting hormones in many pteridophytes has brought forth a series of biochemical studies and some speculations concerning the role of these and other compounds in regard to insects. Balick, Furth and Cooper-Driver (1978) compiled a fairly comprehensive list of about 420 insects and mites believed to be herbivorous on pteridophytes. The presence of primitive as well as advanced insects among these arthropods suggested to Balick *et al.* (1978) the possibility of co-evolution of arthropods and pteridophytes, both before and after the radiation of angiosperms. The main interest of Balick *et al.* (1978) concerned arthropod feeding on Pteridophyta. This will be the first association to be discussed.

ARTHROPODS FEEDING ON PTERIDOPHYTA

Diverse arthropods, mainly insects and mites, feed on pteridophytes wherever these grow. The insects include representatives of several orders (Table 1). Among the sucking insects, the Hemiptera are dominant. Some examples are the mirid bugs *Bryocoris pteridis* and *Monalocoris filicis*, which feed mainly on sporangia (Southwood and Leston, 1959). The whiteflies *Aleurotulus nephrolepidis* and *Filicaleyrodes williamsi* (Mound, 1966), the mealybugs *Nesopedronia cibotii* (Beardsley, 1971) and *Spilococcus filicicola* (Hussey, Read and Hesling, 1969) and the aphids *Idiopterus nephrolepidis* and *Sitobion ptericolens* (Robinson, 1966) all settle on and suck from the fronds. Among the Thysanoptera (thrips), the fern thrips, *Leucothrips nigripennis* and the gall-making *Pteridothrips pteridicola* will serve as examples. Many fly (Diptera) larvae are found on pteridophytes, the Anthomyiid genus *Chirosia* being restricted to them. Other representatives are the gall midges *Dasineura filicina* and *D. pteridicola*, which form galls on bracken fronds, the Agromyziid *Phytoliriomyza pteridii* which mines in bracken (Spencer, 1973) and the Drosophilid *Drosophila notha* induces multiple galls on bracken in New Guinea (Kirk, 1977). Several beetles (Coleoptera) feed on pteridophytes. These include the notorious fern weevil, *Syagrius fulvitaris* and its relatives (Marshall, 1922), the pteridophyte-specific *Megacolabus* (May, 1973), some Chrysomelids (Kirk, 1977) and *Poecilips pteridophytae*, a Scolytid from New Guinea (Gray, 1970). Many caterpillars of butterflies and moths (Lepidoptera) were collected from Pteridophyta. The Pyralid *Samea multiplicalis* was tried for the biological control of *Salvinia* in Africa (Bennett, 1972). The leatherleaf fern borer, *Undulambia polystichalis* (Pyraustidae) is a pest of *Rumohra adiantiformis* in Florida (Short, Driggers, Kuitert and Roberts, 1971) as is the Florida fern caterpillar, *Callopistria floridensis*, a Noctuid (Pirone, 1970). *Theichobia verhuellella* induces galls on several pteridophytes (Hering, 1937). The Hymenoptera have many pteridophyte-feeders among members of the Selandriinae, including the *Equisetum*-associated *Loderus* and *Dolerus* (Benson, 1962), *Blasticotoma filiceti* and many *Strongylogaster* spp. (Smith, 1969). Mites reported from Pteridophyta comprise the gall-making Eriophyids

TABLE 1 : THE ORDERS OF INSECTS (BASED ON RICHARDS AND DAVIES, 1977). ORDERS WITH WHICH ARTHROPODS ARE KNOWN TO BE ASSOCIATED ARE MARKED BY AN ASTERISK.

APTERYGOTA	
1. Thysanura (Bristle-tails)	14. Isoptera (Termites)
2. Diplura	15. Zoraptera
3. Protura	16. Psocoptera* (Booklice)
4. Collembola* (Spring-tails)	17. Mallophaga (Biting Lice)
	18. Siphunculata (Sucking Lice)
	19. Hemiptera* (Bugs)
	20. Thysanoptera* (Thrips)
PTERYGOTA	
EXOPTERYGOTA	
5. Ephemeroptera (Mayflies)	
6. Odonata* (Dragonflies)	ENDOPTERYGOTA
7. Plecoptera (Stoneflies)	21. Neuroptera (Lacewings)
8. Grylloblattodea	22. Coleoptera* (Beetles)
9. Orthoptera* (Grasshoppers and Crickets)	23. Strepsiptera (Stylopids)
10. Phasmida (Stick Insects)	24. Mecoptera* (Scorpion Flies)
11. Dermaptera (Earwigs)	25. Siphonaptera (Fleas)
12. Embioptera	26. Diptera* (Flies)
13. Dictyoptera* (Cockroaches and Mantids)	27. Lepidoptera* (Butterflies and Moths)
	28. Trichoptera (Caddis Flies)
	29. Hymenoptera* (Wasps, Ants)

Phytoptus pteridis (Lawton, 1976) and *Nothopoda paupopus* (Anthony, 1974), the fern mite *Hemitarsonemus tepidarium* (Cameron, 1925) and several Tenuipalpids, among them *Tenuipalpus lygodii* (DeLeon, 1966). A detailed list of insects and mites reported from Pteridophyta was compiled by Balick *et al.* (1978).

Few other arthropods are known from pteridophytes. Hussey *et al.* (1969) reported that the woodlouse *Porcellio laevis* damages *Adiantum* roots in greenhouses. Kühnelt (1976) cited observations on the Diplopods *Taueriulus* and *Pteridoiulus*, both said to live in pteridophyte rhizomes. Unspecified millipedes (Diplopoda) and sowbugs and pillbugs (Isopoda, woodlice) were reported to feed on the tender new growth of pteridophytes (Hoshizaki, 1975). Horning, Schuster and Grigarick ((1978) collected Tardigrades from Pteridophyta in New Zealand.

Feeding may be on any part of the plants. Roots, rhizomes, stems, fronds and spores are eaten. Members of pteridophyte-feeding genera may utilise different parts of the same plants. Thus *Chirosia parvicornis* mines in bracken frond-tips, *C. crassiseta* mines the stem, and *C. albitarsis* mines in both the stem and leaf stems (Lawton, 1976). Most feeding insects (Coleoptera, Hymenoptera, Lepidoptera) have chewing mouth parts; many of them in fact skeletonise fern fronds (Beer, 1955; Swezey, 1921). Others, such as aphids, whiteflies and scale insects, suck out the contents of pteridophyte tissues. Feeding aphids induced circular, chlorotic areas on pteridophyte fronds, chlorosis extending along the midrib (Severin and Tompkins, 1950). As damage extended to newly developing fronds, it was concluded that the causative agent had a systemic nature. There was no evidence that plant viruses were involved (but see below).

Pteridophyte feeders comprise species confined to one plant alone (monophagous), others which feed on several species of Pteridophyta but on no other plants (oligophagous) and arthropods which attack pteridophytes as well as higher plants (polyphagous). A special, minor group are some aphids which alternate between Pteridophyta and other angiosperm host plants. Examples are *Shinjia pteridifoliae*, alternating between bracken (*Pteridium*) and *Viburnum* (Miyazaki, 1968) and *Aulacorthum pterinigrum*, on *Pteris* and *Vaccinium* (Richards, 1972).

Gall makers are usually monophagous. Several arthropods induce galls on pteridophytes, mites being said to cause more than half of the known galls (Mani, 1964). This author, however, included only mites and Diptera among arthropod gall makers (Mani, 1964; fig. 126), ignoring Hemiptera (Beardsley, 1971), Coleoptera and Thysanoptera (Docters van Leeuwen, 1938), as well as Hymenoptera and Lepidoptera (Buhr, 1964-65). The Pteridophyta appear to have fewer arthropod-incuded galls than other large plant groups (Mani, 1964). Several quite specific insects were found during projects aimed at the biological control of pteridophyte weeds (Bennett, 1966; Wieczorek, 1973). Such specificity is of paramount importance in these projects, the insects therefore undergoing vigorous starvation tests. In other cases, the reported specificity may reflect only lack of knowledge, as most pteridophyte feeders appear to be oligophagous. Feeding on several pteridophyte species has been reported in mites (Beer, 1954; DeLeon, 1966). Thysanoptera (Hussey *et al.*, 1969), Hemiptera (Mound, 1966; Gosh, 1974; McKenzie, 1967; Southwood and Leston, 1959), Diptera (Wieczorek, 1973), Coleoptera (Kirk, 1977; Swezey, 1921), Lepidoptera (Swezey, 1921; Hering, 1937) and Hymenoptera (Benson, 1962; Smith, 1969).

Many of the polyphagous insects which feed on Pteridophyta are pests of agricultural crops (Table 2). While listing these species, it became evident that two superfamilies of plant-feeding Hemiptera, namely the Aphidoidea (aphids) and Coccoidea (scale insects) show a marked difference in specificity to pteridophytes. Among aphids, specificity is the rule, only very few species feeding on other plants also. Pteridophyte-associated scale insects, on the other hand, are by and large not restricted to these plants (see also Eastop, 1973). Even the fern scale, *Pinnaspis aspidistrae*, has many angiosperm host plants (Dekle, 1976).

Primitive arthropods are believed to be more closely associated with Pteridophyta than recent ones. Cooper-Driver (1978) has suggested that the more ancient insect orders (except the Orthoptera) are better represented among pteridophyte feeders than would be expected. This was taken to indicate a prolonged association between pteridophytes and these insect orders. Gall makers in particular are said to have been recruited from the older arthropod groups. Mani (1964) who considered the mites to be "undoubtedly" the oldest group of cecidozoa (gall-forming animals), stated that they are responsible for more than half of all known pteridophyte galls. He further wrote that of the Thysanoptera (thrips), only the more general (and thus presumably older) Terebrantia induce pteridophyte galls. The millipedes (Diplopoda) *Taueriulus* and *Pteridoiulus* live in pteridophyte rhizomes; Kühnelt (1976) finds this interesting in view of "the great geological age of ferns and diplopods". Members of the sub-family Selandriinae (Hymenoptera: Tenthridinidae) are regarded as the most generalised in the family, and the genus *Hemitaxonus* as especially primitive (Smith, 1969). Members of this genus feed on Pteridophyta. On the other hand, *Heptamelus*, a related but highly advanced genus, also lives on these plants (Smith, 1969).

As the latter case shows, pteridophytes have also become hosts to arthropods in more recent geological periods. For instance, Docters van Leeuwen (1938) notes that despite the reported antiquity of the Pteridophyta, relatively few galls occur on their older members, most galls being found on what are nowadays called "Polypodiaceous" ferns (Lovis, 1977). Feeding of the Scolytid beetle *Poecilips pteridophytæ* on bracken in New Guinea was believed by Gray (1970) to be of recent origin, due to the highly specialised feeding and the relatively recent geological origin of New Guinea. Occurrence of the endemic Hawaiian mealybug *Nesopedronia* on introduced pteridophytes is probably also quite recent (Beardsley, 1971). Hering (1951) concluded that several Dipterous leaf miners have only recently transferred to the Pteridophyta.

A special form of feeding is on the "nectaries" or on sap exudates. Darwin (1877) noted that the secretion of bracken nectaries is attractive to ants. Bees, Elaterid beetles, numerous flies as well as ants were reported by Meikle (1937) to visit these nectaries. Adult sawflies, whose larvae feed on bracken, drink sap exuding from wounded fronds (Beer, 1955). Little is known concerning pteridophyte litter breakdown in the soil through arthropod activity. C. Overgaard Nielsen (in Elton, 1966) reported that the polyphagous millipede *Glomeris marginata* is an important consumer of bracken litter in Denmark. Harding and Stuttard (1974), reporting on former work, found large numbers of the Oribatid mite *Platynothrus peltifer* and the springtail *Onychiurus procampatus* in bracken litter. These authors concluded that . . . "much remains to be investigated concerning the role of microarthropods in the decomposition of litter of pteridophytes and other cryptogams".

ARTHROPODS AS PESTS OF PTERIDOPHYTA

Several pteridophytes (*Asplenium bulbiferum*, *Rumohra adiantiformis* and others) are commercially cultivated; arthropods which damage them are plant pests which require control measures. The fern mite, *Hemitarsonemus tepidarium*, lives in the innermost recesses of unopened frond and pinnae, and feeds there. Damage is manifested as minute brown depressions, leaf deformations and stunted and asymmetric growth, resulting in dwarfed, weak plants (Cameron, 1930). The fern aphid, *Idiopterus nephrolepidis*, is another destructive pest of glasshouse pteridophytes. Infested fronds curl and turn black (Hussey *et al.* 1969). The leatherleaf fern borer, *Undulambia polystichalis*, has recently become a major pest of *Rumohra adiantiformis* in Florida (Short *et al.*, 1971) requiring weekly control measures. Several non-insect arthropods, like Isopoda (sowbugs and pillbugs) and Diplopoda (millipedes) feed on the tender new growth of commercial pteridophytes (Hoshizaki, 1975). Other pteridophyte pests are polyphagous insects which damage many agricultural plants. Some representative, non-specific pteridophyte pests are listed in Table 2.

Many of these pests must be controlled by chemicals, a problem aggravated by pteridophyte sensitivity to certain insecticides. Pirone (1970), for instance, advocated using only pesticides of plant origin (like pyrethrum or nicotine), and warned against organophosphorus compounds. Fluffy ruffle fern, *Nephrolepis exaltata*, was very sensitive to acaricides like Omite and Plictran, Acarol causing leaf deformations and burns (Short and McConnell, 1973). The chemical control of pteridophyte pests thus poses some special problems.

The fern weevil, *Syagrius fulvitaris*, invaded the Hawaiian Islands and became a destructive pest of the large *Sadleria cyatheoides* there in 1919. Pemberton (1948) discovered that the weevil originated from Australia and found an efficient natural enemy (the Hymenopterous Braconid *Ischiogonus syagrii*) in New South Wales. This parasite was introduced to Hawaii and controlled the pest there. Pemberton collected several other pteridophyte-infesting weevils, belonging to the genera *Syagrius* and *Neosyagrius*; these were described by Marshall (1922). The fern weevil also invaded England and Ireland, infesting many Pteridophyta in the Dublin Botanical Gardens (Lloyd, 1944). One way of controlling weevils, as narrated by Lloyd (1944), was by placing infested plants into water, the beetles then floating to the surface. Dozens of weevils and their larvae were thus found to infest single pteridophyte plants.

BIOLOGICAL CONTROL OF PTERIDOPHYTA

The tables are turned when pteridophytes become weeds and insects are brought in to control them by feeding on them. The prime example of a pteridophyte weed is bracken, which has long been an agricultural pest in various parts of the world (Rymer, 1976). *Salvinia*, on the other hand, has only become a nuisance in tropical and subtropical waterways in more recent times (Bennett, 1966). While chemical and agrotechnical measures were being taken, biological control by insects was not neglected. The resultant surveys (Bennett, 1966; Kirk, 1977; Simmonds, 1967; Wieczorek, 1973) have materially contributed to general knowledge concerning pteridophyte arthropods. Of the ten phytophagous insects found on *Salvinia* by Bennett (1966), three, namely the Pyralid *Samea multiplicalis*, the weevil *Cyrtobagous singularis* and the Orthopteran *Paulinia acuminata*, were considered most promising. They were subsequently released at various sites in Central Africa, and *P. acuminata* became established there (Anders and Bennett, 1975).

TABLE 2 : SOME POLYPHAGOUS PESTS WHICH ALSO FEED ON CULTIVATED PTERIDOPHYTA.

Thysanoptera	<i>Heliothrips haemorrhoidalis</i> <i>Thrips tabaci</i>	Schneider, 1966 Pirone, 1970
Hemiptera	<i>Trialeurodes vaporariorum</i> <i>Coccus hesperidum</i> <i>Planococcus citri</i> <i>Chrysomphalus aonidum</i>	Schneider, 1966 Pirone, 1970 Hussey <i>et. al.</i> , 1969 Dekle, 1976
Orthoptera	<i>Tachycines asynamorus</i>	Schneider, 1966
Coleoptera	<i>Otiorrhynchus sulcatus</i>	Schneider, 1966
Lepidoptera	<i>Argyrotaenia citrana</i>	Pirone, 1970

Other cases of insect injury to bracken include reduced germination due to spore feeding by deep soil springtails (Collembola) (Conway, 1953), and conspicuous injury to isolated stands by sawflies (Beer, 1955). Balick *et al.* (1978) reported that arthropod damage to wild pteridophytes in tropical Mexico may affect the reproductive capacity of these plants. Invertebrates thus have the potential to affect pteridophyte survival in the field.

PTERIDOPHYTE RESISTANCE TO ARTHROPODS

Notwithstanding all cases of arthropod feeding on Pteridophyta, a concept of intrinsic pteridophyte resistance to insects and mites has found its way into the literature. This concept was formulated in the following quotation: "In spite of the similarity of their foliage to that of the flowering plants, ferns do not commonly serve as food plants for insects. They are, in fact, strikingly immune from insect pests of all sorts. This is hardly what might be expected from the long presence of this group of plants, their enormous development in the past, and their persistence at the present time in quite considerable abundance. Why they should be so sparingly selected as food plants does not seem to have been adequately explained" (Brues, 1920). Although this generalization was already challenged by Swezey (1921), Brues later (1946) reinforced it. This concept was supported by studies in plant galls (Docters van Leeuwen, 1938; Mani, 1964), by Elton's (1966) observations on bracken arthropods and more recently by Cooper-Driver (1978).

Apparent pteridophyte resistance to grazers was subjected to experimental studies. Soo Hoo and Fraenkel (1964) incorporated *Nephrolepis exaltata* frond extracts into a diet for the polyphagous moth *Prodenia* (= *Spodoptera*) *eridania*, and reported that this extract contained a water-soluble feeding deterrent. Soon afterwards (Kaplanis, Thompson, Robbins and Bryce, 1967; Takemoto, Ogawa, Nishimoto, Arihara and Bue, 1967) it became known that many Pteridophyta contain ecdysones (insect moulting hormones). These were believed to play a role in pteridophyte defence against herbivorous arthropods (Slama, 1969). Carlisle and Ellis (1968), however, reported that a diet of air-dried bracken fronds did not interfere with the moulting cycle of the desert locust, *Schistocerca gregaria*. Furthermore, there were indications that these insects do not take up ecdysones from the food into their blood. Hikino, Ohizumi, and Takemoto (1975) reviewed and studied the effect of ingested

phytoecdysones on insects. They concluded that the absorption of these compounds by insects is slow and limited, their excretion rapid, and absorbed ecdysterone is rapidly catabolised into compounds with little or no moulting hormone activity. Jones and Firn (1978) showed that amounts of phytoecdysteroids obtained from bracken were considerably below levels which affected several phytophagous insects belonging to three different orders. These authors believed that ecdysteroids might still act as nontoxic feeding deterrents. Hendrix (1977) offered dried bracken-leaf meal to larvae of the polyphagous moth *Trichoplusia ni* and reported some inhibition of feeding, which was not, however, considered to be due to phytoecdysones.

The effect of prunasine, a cyanogenic glycoside present in bracken, on herbivorous insects was studied by Cooper-Driver and Swain (1976). In the south of England bracken was found to be polymorphic in regard to this glycoside, as well as to its hydrolase. Although 96% of individual plants of most populations contained prunasine and its hydrolase (and were thus cyanogenic), there were a few populations in which most individual plants were acyanogenic. Bracken disks from the various populations were offered to *Schistocerca gregaria*. Those originating from cyanogenic plants were hardly touched by the locusts, whereas the others, even though they contained the cyanogenic glycoside itself, were eaten to a large extent. The authors concluded that the production of hydrocyanic acid from prunasine probably has a positive role in protecting bracken against herbivores. In a later study (Cooper-driver, Finch, Swain and Bernays, 1977) they showed that when bracken was periodically collected and offered to the locusts, there were two peaks in inhibition, during late May and in late August. The first period coincided with a maximum of cyanogenesis, the second with a peak in tannin production. The importance of these feeding deterrents for general feeders like locusts was thus demonstrated.

The level of several possible feeding deterrents produced by bracken during its growth cycle was studied by Lawton (1976). He did not exclude any bracken component, including phytoecdysones, from inhibiting arthropod herbivores. As noted, there is no clear evidence that such hormones actually protect ferns, but their occurrence in pteridophytes provides an unexpected link between these two groups. Lists of phytoecdysone-containing Pteridophyta were presented by Hikino, Okuyama, Sin and Takemoto (1973) and by Russell and Fenemore (1971).

As recent studies on pteridophyte-associated arthropods show, these plants actually have a considerable number of herbivores. Lawton (1976) compared the bracken fauna to that of other English plants and showed that the *Pteridium*-supported fauna is not an improvised one. (See also Lawton and Schroder (1977) in regard to *Dryopteris villarii*). Further studies will likely provide similar results in regard to other Pteridophyta. Although, as noted, pteridophytes are supposed to deter the feeding of arthropods, Milne (1968) obtained complete development of several springtail species which were given bracken spores as their only nutrient. Balick *et al.* (1978) reported that insects appeared to prefer pteridophytes over angiosperms as a food source in tropical Mexico.

Another kind of defence mechanism was called the "set a thief to catch a thief" principle (Lawton, 1976). Ants which visit pteridophyte nectaries may repel other insects, coming for that or other purposes. Little is known about this mechanism at present, but Bentley (1977) believes that most plants gain some protection from herbivore damage by the ants which visit their nectaries.

TABLE 3 : TOXICITY OF SOME PTERIDOPHYTE EXTRACTS TO THREE SPECIES OF INSECTS.

(A: Effect of injecting pteridophyte extracts into American cockroaches, *Periplaneta americana*; 1 = 100% paralysis at 1 day, without recovery; 2 = 100% paralysis at 2 days, without recovery; 3 = 50% mortality at 3 days; 4 = less than 50% mortality at 3 days. B and C: Effect of immersion of German cockroaches, *Blattella germanica*, and milkweed bugs, *Oncopeltus fasciatus*, respectively, into aqueous fern extracts for one minute; N = less than 20% average mortality in 4 days). (From Table 1 in Heal *et al.*, 1950).

Pteridophyte	Part of Plant	A	B	C
<i>Adiantum</i> sp.	Entire	3	N	—
<i>Anemia mexicana</i>	Entire	2	N	—
<i>Cheilanthes microphyllus</i>	Entire	3	N	N
<i>Dryopteris filix-mas</i>	Leaves	3	N	N
<i>D. marginalis</i>	Rootstocks	3	—	—
<i>Equisetum arvense</i>	Entire (fresh)	1	—	—
<i>E. arvense</i>	Entire (dry)	2	—	—
<i>E. bogotense</i>	Entire	3	N	N
<i>E. hyemale</i> var. <i>californicum</i>	Stems	4	N	N
<i>E. robustum</i>	Stems	3	N	N
<i>Isoetes dodgei</i>	Entire	2	N	N
<i>Lycopodium clavatum</i>	Entire	4	N	N
<i>L. complanatum</i> var. <i>flabelliforme</i>	Fronds	4	N	—
<i>Marsilea vestita</i>	Entire	1	N	—
<i>Notholaena sinuata</i>	Entire	3	—	—
<i>Osmunda claytoniana</i>	Rhizomes	3	N	N
<i>Pellaea ornithopus</i>	Entire	4	N	N
<i>Polypodium angustifolium</i>	Entire	2	N	N
<i>P. neriifolium</i>	Entire	2	N	N
<i>Polypodium</i> sp.	Rhizomes	4	N	N
<i>Pteridium aquilinum</i>	Leaves	2	N	—
<i>P. aquilinum</i>	Stems	3	N	—
<i>P. caudatum</i>	Leaves	3	N	N
<i>P. caudatum</i>	Stalks	4	N	N
<i>Selaginella myosurus</i>	Entire	2	N	N

ANTI-ARTHROPOD SUBSTANCES FROM PTERIDOPHYTA

Heal, Rogers, Wallace and Starnes (1950) assayed extracts from many plants for insecticidal properties. Some of their results, in regard to pteridophyte extracts, are presented in Table 3. It is noteworthy that bracken was not among the most toxic. In a further set of tests, extracts of fewer Pteridophyta were assayed against more insect species. Extracts of *Lycopodium annotinum*, *L. clavatum*, *L. complanatum* var. *flabelliforme* and *L. quadrangulare*, as well as *Anemia mexicana*, *Dryopteris marginalis* and *Marsilea vestita* were used. Of several household pests, only the black carpet beetle, *Attagenus piceus*, was consistently affected. Woollen fabric impregnated with extracts of all *Lycopodium* spp., *Anemia mexicana*, and *Dryopteris marginalis* reduced feeding injury of this pest by 90% or more. Filicin, a drug originating from *Dryopteris*, gave 90% kill of the aphid *Aphis rumicis* (Hartzell and Wilcoxon, 1941). Additional information on the insecticidal activity of *Dryopteris* and other Polypodiaceae was provided by Jacobson (1958). Seaward (1976) suggested that bracken layers placed in Roman dwellings at Vindolanda (north England) produced an insecticidal exudate which adversely affected stable flies. A liquid from boiled bracken fronds was reported to be very effective against rose aphids (Long and Fenton, 1938). Botanists at a European meeting were seen by Rymer (1976) to burn bracken in order to repel nuisance midges. Rhizomes of *Pellaea involuta* (crushed in milk) are being applied by

Southern Sotho (Africa) tribesmen to counteract spider bites. They also use a decoction from rhizomes of *Polystichum pungens* as an enema for horse bots (Watt and Breyer-Brandwijk, 1962).

ARTHROPOD-TRANSMITTED VIRUSES IN PTERIDOPHYTA

Feeding by sucking insects (especially Hemiptera) is often accompanied by transmission of plant viruses. Eastop (1977, appendix 1-11-2) maintains that no aphid-transmitted viruses occur in the Pteridophyta. Nienhaus, Mack and Schinzer (1974), however, suggested that a viral disease of *Polypodium vulgare* and *Dryopteris filix-mas* may be vectored by aphids. They innoculated the angiosperm test plant, *Nicotiana glutinosa*, with this virus. Aphids (*Myzus persicae*, a vector of many plant viruses) were allowed to feed on *N. glutinosa* for one minute, and then placed onto healthy test plants. These *N. glutinosa* later showed symptoms of the same fern virus. The disease may therefore be transmitted by aphids.

PTERIDOPHYTES AND THEIR LITTER AS SHELTER FOR ARTHROPODS

Old or dying pteridophytes are inhabited by various non-specific insects in Hawaii (Swezey, 1921). Many beetles, belonging to the families Nitidulidae, Staphylinidae and Curculionidae were reported from insect-damaged pteridophytes by Gray (1970, 1972), none of these beetles apparently feeding on Pteridophyta. Roaches deposit and live in older tuber ferns (Gómez, 1974; Yapp, 1902); the latter author also found a centipede in that habitat. Bracken litter maintains a considerable dampness, allowing arthropods to flourish there (Elton, 1966). Though none of these arthropods appear to be specific to bracken, their numbers may exceed those found in oak litter (Elton, 1966). Certain members of the bracken litter, like the pill millipede, *Glomeris marginata*, are important consumers of bracken litter (Elton, 1966). Frankland (1966), in her study of bracken breakdown in the soil, noted some mites and Collembola in decaying petioles, but found no evidence that they were actually feeding on bracken. She considered them to be mycophagous, and even to aid in fungal dispersal. Bracken litter arthropods may occur on the plant above ground; the mite *Chamobates* is one example (Lawton, 1976).

The bracken litter fauna may have some value as prey for small vertebrates, like the bank vole, which uses bracken as cover (Elton, 1966). Other small vertebrates also shelter there, and their parasites and inquilines possibly find the litter suitable for host finding and resting. An example is the sheep tick, *Ixodes ricinus*, which completes its life cycle in the humid bracken litter (Nicholson and Patterson, 1976).

ANTS AND PTERIDOPHYTA

Ants are often associated with pteridophytes. At least two species visit bracken nectaries, where they suck up the abundant secretion and possibly also gnaw shallow excavations (Darwin, 1877). In the tropics many ants nest fortuitously in pteridophytes (Yapp, 1902), but many more constant associations have also been reported. *Camponotus* sp., for instance, regularly visits the Neotropical potato fern, *Solanopteris brunei*, although it was never observed to breed there (Gómez, 1974). At a more advanced level, the ants consistently nest within a certain pteridophyte species; this relationship is regarded as symbiotic. *Azteca* sp. regularly built its nest on and in-touch with the potato fern (Gómez, 1974). The tubers served queen ants to start new colonies, and were also used as brooding chambers, in which eggs were deposited and larvae tended by worker ants.

Two Malaysian "myrmecophilous" Pteridophyta and their ant associates were reported by Yapp (1902). *Polypodium* (= *Lecanopteris*) *carcosa* was associated with the ant *Crematogaster yappi*, and *Polypodium* (= *Lecanopteris*) *sinuosum* with *Technomyrmex albipes*. Ants entered both plants through openings excavated in large-celled, thin-walled tissue (with apparent water-storing functions), which, upon breaking down, gives rise to the galleries that run throughout the plant. These and other Malaysian *Lecanopteris* and their ant associates were also discussed by Holttum (1954). *Lecanopteris* was recently revised by Jermy and Walker (1975), who provided additional data on the accompanying ants, like a *Camponotus* sp. on *L. spinosa*. Daniels (1974) briefly referred to *Iridomyrmex cordatus*, an ant living in the rhizome galleries of *Drynaria quercifolia* in Australia. Advantages accruing to ants from this relationship are shelter, moisture and carbohydrates present in the plants' "ripe" parenchymatous cells (Gómez, 1974). Pteridophyta appear to have evolved towards mutualism with ants, as suggested by various anatomical modifications; thin-walled points of entry, ready-made galleries and carbohydrate-containing tissues. *Solanopteris brunei* produces an aldehyde-like substance which attracts the ant *Azteca* and may serve as an allomone, restricting these ants to the plant. What the pteridophytes gain from this association is not clear. Darwin (1877) rejected the possibility of defence against herbivores, a possibility which Lawton (1976) termed the "set a thief to catch a thief" principle. Such protection is usually ruled out in regard to tropical ant ferns (Gómez, 1974; Jermy and Walker, 1975; but see Bentley, 1977 for a divergent view). Other postulated advantages include imported minerals and nitrogen from ants' excreta (Holttum, 1954), and CO₂ provided by actively respiring ants in the green rhizomes of *Lecanopteris spinosa* (Jermy and Walker, 1975).

Janzen (1974) conducted a comparative study of the relationships between several epiphytes (including *Phymatodes* (= *Lecanopteris*) *sinuosum*) and their associated ant, *Iridomyrmex myrmecodiae*. He thought that ants may prefer epiphytes for nesting as they provide relatively dry cavities of long duration (in the tropics). He also pointed out that epiphyte-ant associations often occur when epiphytes develop on slow-growing vegetation with an insufficient supply of nutrients. Without the ants, which supply their remnants as well as CO₂, the epiphytes, including Pteridophyta, may not have been able to survive in low productivity habitats. One such association appears to have implications for a Lepidopteran herbivore, the Lycaneid *Hypochryps theon medocus*, whose larvae feed on *Drynaria quercifolia*. Ovipositing Lycaneid females alight on the undersurface of the fronds and walk about. Eggs are laid only if ants are encountered; otherwise females search other fronds. Larvae feed within rhizome galleries, where they coexist with the attendant ant, *Iridomyrmex cordatus*, which apparently never molests the larvae (Daniels, 1974). This appears to be another case of Lycaneid-ant symbiosis, a little understood series of associations (Owen, 1971).

EPIZOIC SYMBIOSIS

A different form of pteridophyte-arthropod mutualism was reported by Gressitt (1969) within the context of "epizoic symbiosis". This involves weevils which support extensive plant growths on their backs. The beetles — mostly belonging to the subgenus *Symbiopholus* in the genus *Gymnopholus* — are structurally modified to accommodate the plants growing on them. These modifications include dorsal depressions surrounded by ridges, as well as various adapted setae and scales. A sticky secretion, which may promote propagule germination and subsequent growth, is also produced. Most plants found were fungi, algae, lichens and mosses; but a specimen of

Gymnopholus (Symbiopholus) lichenifer had an unidentified pteridophyte gametophyte growing on it. The association was believed to be mutualistic; the weevils providing a favourable environment for the plants, the latter serving as protective covering for the beetles (Gressitt, Samuelson and Vitt, 1968).

DISPERSAL AND AN ETYMOLOGICAL ASSOCIATION

Some herbivores of Pteridophyta, especially those which attain pest status, were probably inadvertently brought to various parts of the world with their host plants by humans. The aforementioned fern weevil, of Australian origin, is one example. Arthropod dispersal of pteridophytes appears to be of minor importance. Ants were seen to carry spores on their bodies, thus transferring them from tree to tree. Such spore transport was considered by Holttum (1954) to be "hardly necessary" as wind dispersal of spores was very effective. Thompson (1977) observed that *Apirocalus*, a New Guinean weevil, sometimes has pteridophyte sporangia attached to it, although the beetles were never collected on cryptogamic plants. Many spore feeders possibly void some viable spores away from the feeding site and thus disseminate them.

Finally, on a whimsical note, it might be mentioned that the scientific name for pteridophytes, and the names of the insect subclasses (as well as many orders) (Table 1) have a common root, the Greek word *Pteron*, a wing. Thus the names Pteridophyta, Apterygota, Pterygota, Diptera, Lepidoptera *etc.*, have all originated from the same word.

DISCUSSION

The most interesting current problem in regard to pteridophyte-associated arthropods is the extent to which the plants' defences deter or inhibit insect feeders. The opinions of Brues (1920, 1946), Elton (1966) and more recently Cooper-Driver (1978), were that Pteridophyta have far less than their share of herbivores. The discovery of phytoecdysones in pteridophytes (Kaplanis *et al.*, 1967), as well as other feeding deterrents (Lawton, 1976; Cooper-driver, 1978) tended to support the hypothesis that Pteridophyta are highly resistant to insect attack (Hendrix 1977; Slama, 1969). However, other, contradictory data were concurrently becoming available. The search for natural enemies of bracken and water pteridophytes disclosed that these plants were actually being attacked by a large and diverse arthropod fauna (Bennett, 1966; Kirk, 1977; Simmonds, 1967; Wiczorek, 1973). An analysis of the structure of an arthropod community on bracken (Lawton, 1976) showed that the size of this fauna fits well within the range of comparative angiosperm-associated faunas. Working in tropical Mexico, Balick *et al.* (1978) reported that pteridophytes were apparently preferred over angiosperms as food for insects.

On theoretical grounds, there is no reason why the pteridophyte fauna should be depauperated. Strong, McCoy and Rey (1977, and former papers) strongly argue that host-plant range is the most important factor determining the species-richness of its herbivores. Age of a host within a given region was considered to be of minor importance. Smith (1972) concluded that the number of endemic pteridophyte genera is less than half that of the flowering plants and that pteridophyte genera and species, on the whole, are more widely distributed than angiosperms. Upon applying the concept stated by Strong *et al.*, (1977) to Pteridophyta, it becomes reasonable to expect that these plants may actually have as many, or more, arthropods associated with them as the angiosperms. As to the role of pteridophyte chemical defences, the secondary substances, there is no doubt that they confer some protection upon the Pteridophyta (Cooper-Driver *et al.*, 1977). However, this by itself does not mean that

TABLE 4 : SOME ANCIENT PTERIDOPHYTA AND THE SPECIFICITY OF THEIR HERBIVORES.

(Monophagous: feeding only on one genus; oligophagous: feeding on ancient as well as modern ferns; polyphagous: feeding on ferns and on flowering plants).

Pteridophyte	Arthropod taxon	Monophagous	Oligophagous	Polyphagous	Source
<i>Equisetum</i>	Dolerini (Hymenoptera: Tenthredinidae)	+			Benson, 1962
	<i>Liriomyza</i> spp. (Diptera: Agromyzidae)	+			Spencer, 1972
	<i>Sitobion equiseti</i> (Hemiptera: Aphidoidea)	+			Ossiannilsson, 1964
	<i>Aphis equiseticola</i> (Hemiptera: Aphidoidea)	+			Ossiannilsson, 1964
<i>Selaginella</i>	<i>Phenacoccus solani</i> (Hemiptera: Pseudococcidae)	+		+	McKenzie, 1967
	Cecidomyiidae (Diptera)				Docters van Leeuwen, 1938
	<i>Euptychia westwoodi</i> (Lepidoptera: Nymphalidae)	+			Singer, Ehrlich & Gilbert, 1971
	<i>Boreus reductus</i> (Mecoptera: Boreidae)	+			Penny, 1977
<i>Dicranopteris</i>	<i>Nesopedronia</i> spp. (Hemiptera: Pseudococcidae)	+			Beardsley, 1971
<i>Lygodium</i>	<i>Saissetia coffeae</i> (Hemiptera: Coccidae)			+	Hussey, Read & Hesling, 1969
	<i>Tenuipalpus lygodii</i> (Acari: Tenuipalpidae)	+			DeLeon, 1966
<i>Marattia</i>	<i>Agromyza</i> sp. (Diptera: Agromyzidae)	+			Swezey, 1921
<i>Osmunda</i>	<i>Micromyzus osmundae</i> (Hemiptera: Aphididae)	+		+	Miyazaki, 1968
	<i>Utamphorophora filicis</i> (Hemiptera: Aphididae)			+	Miyazaki, 1968
	<i>Chirosia hystricina</i> (Diptera: Anthomyiidae)			+	Hering, 1937
	<i>Phytoliriomyza hiiarella</i> (Diptera: Agromyzidae)			+	Hering, 1951
	<i>Hemitaxonus dubitatus</i> (Hymenoptera: Tenthredinidae)			+	Smith, 1966
	<i>Hemitaxonus albidoptictus</i> (Hymenoptera: Tenthredinidae)				Smith, 1969
	<i>Strongylogaster osmundae</i> (Hymenoptera: Tenthredinidae)			+	Okutani, 1967
	<i>Strongylogaster secundus</i> (Hymenoptera: Tenthredinidae)	+			Okutani, 1967
	<i>Euplexia lucipara</i> (Lepidoptera: Noctuidae)	+		+	Heslop-Harrison, 1944
	<i>Polia assimiles</i> (Lepidoptera: Noctuidae)			+	Godfrey, 1972
<i>Todea</i>	<i>Syagrius intrudens</i> (Coleoptera: Curculionidae)		+		Lloyd, 1944

the protection afforded to pteridophytes is much more efficient than that given to angiosperms. The latter are extremely diverse from the chemical point of view, and lumping all flowering plants together in order to compare them with pteridophytes, in regard to number of associated arthropods (Brues, 1920), is not convincing. What may be needed is a comparative study on one or two angiosperm groups with similar numbers of species, distribution and apparency (*sensu* Feeny, 1976). Plant chemistry alone possibly makes little difference to the total number of insect species which eventually evolve to exploit a given plant (Lawton, in press); or, as stated by Levin (1976), "no defence is sacrosanct". The considerable insect and mite guilds which live on bracken and *Salvinia* suggest that arthropods have indeed evolved mechanisms to circumvent the plants' protective chemicals. Other often ignored factors in host-plant selection are temperatures and specific habitats (especially in the tropics), as shown by Eastop (1973) in regard to aphids, and the non-chemical (i.e., plant architecture, abundance, seasonality) components of apparency. There is no cause to exclude the Pteridophyta from such considerations.

And yet, some of the available literature tentatively suggests that a distinction could perhaps be made between the ancient Pteridophyta (including *Selaginella* and *Equisetum*) and the modern ones. Although records of ancient pteridophyte-associated arthropods are meagre, the pattern of these associations appears to differ from those of modern Pteridophyta.

A difference between the number of animal-induced galls formed on ancient and modern Pteridophyta was noted by Docters van Leeuwen (1938). A listing of arthropods currently known to feed on and live on ancient pteridophytes suggests that most insects and mites which feed on them are either monophagous (restricted to one pteridophyte species or genus), or else polyphagous (subsisting on Pteridophyta as well as flowering plants). Aside from two exceptions (see below), ancient Pteridophyta are only very rarely attacked by arthropods which also feed on modern pteridophytes (Table 4).

The exceptions are *Osmunda* and *Todea*, both members of the order Osmundales. They are attacked by aphids, sawflies, leaf-mining fly maggots and a weevil (Table 4), all of which also occur on one or more modern Pteridophyta. In so far as further collections confirm these observations, it could be argued that from the herbivore point of view, *Osmunda* and *Todea* are more similar to modern pteridophytes than to the ancient ones. According to current ecological concepts, the similarity is probably biochemical in nature. Hikino *et al.* (1973), while assaying Japanese Pteridophyta for phytoecdysones, found no activity in most ancient pteridophytes. These included Equisetaceae, Lycopodiaceae, Selaginellaceae, Ophioglossaceae, Marattiaceae, Schizaeaceae and Hymenophyllaceae. Only in *Hicriopteris glauca* (Gleicheniaceae) and in six members of *Osmunda* (Osmundales) were phytoecdysones found. The related *Todea* also showed insect moulting hormone activity (Russell and Fenimore, 1971). Nothing is known about arthropods of *H. glauca*, so it will not be further discussed. The Osmundales remain as almost the only group of ancient Pteridophyta with high phytoecdysone activity, and the only group which has herbivores in common with modern pteridophytes. It is tempting to postulate that these phenomena are related.

As already noted, available experimental data do not confirm that phytoecdysones act as feeding deterrents in Pteridophyta. This does not imply that they did not affect herbivores in the past; the phytoecdysones may have played an important role in the co-evolution of Pteridophyta and their associated herbivores, but have now become a "redundant defence mechanism" (Jones and Firn, 1978). The associations between arthropods and the ancient Osmundales may well have initiated

later co-evolutionary processes with modern pteridophytes. A relatively advanced state of Osmundales-arthropod co-evolution is also suggested by the disproportionately high number of insects found on the few extant species of Osmundales, as pointed out by G. Cooper-Driver (in lit.).

The comparative studies of Lawton (1976) and Kirk (1977) on bracken arthropods in England and Papua New Guinea, respectively, emphasize the differences in these faunas between temperate and tropical regions. Britten (1881), and Cooper-Driver (1978), among others, noted dissimilarities in the extent of pteridophyte susceptibility to insect attack between temperate and tropical regions, but quantitative data are scarce. And yet over 90% of all extant Pteridophyta grow in the tropics (Manton, 1973) and evolution in tropical regions operates in fundamentally different ways than in temperate zones (Dobzhansky, 1950). Tropical Pteridophyta doubtless carry a multitude of unstudied arthropods (Balick *et al.*, 1978); relevant studies thus promise to enrich and modify our concepts about pteridophyte-arthropod associations.

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REFERENCES

- ANDERS, L.A. and F.D. BENNETT. 1975. Biological control of aquatic weeds. *Annu. Rev. Entomol.* 20: 31–46.
- ANTHONY, M. 1974. Contribution to the knowledge of cecidia of Singapore. *Gardens' Bulletin.* 27: 17–65.
- BALICK, M.J., D.G. FURTH and G. COOPER-DRIVER. 1978. Biochemical and evolutionary aspects of arthropod predation on ferns. *Oecologia.* 35: 55–89.
- BEARDSLEY, J.W. 1971. New genera and species of Hawaiian Pseudococcidae (Homoptera). *Proc. Hawaiian Entomol. Soc.* 21: 41–58.
- BEER, R.E. 1955. Biological studies and taxonomic notes on the genus *Strongylogaster* Dahlbom (Hymenoptera : Tenthredinidae). *Univ. Kansas Science Bull.* 37: 223–249.
- BENNETT, F.D. 1966. Investigations on the insects attacking the aquatic ferns, *Salvinia* spp. in Trinidad and northern South America. *Proc. Southern Weed Conf.* 19: 497–504.
- BENNETT, F.D. 1972. Current status of the biological control of *Salvinia* in Africa. *Abst. 14th International Congress Entomology, Canberra*, p. 208.
- BENSON, R.B. 1962. Holarctic sawflies (Hymenoptera : Symphyta). *Bull. British Mus. (Nat. Hist). Entomology* 12: 381–409.
- BENTLEY, B.L. 1977. Extrafloral nectaries and protection by pugnacious bodyguards. *Annu. Rev. Ecol. Syst.* 8: 407–427.
- BRAID, K.W. 1959. Bracken: a review of the literature. *Commonwealth Agricultural Bureaux.* No. 3/1959.
- BRITTEN, J. 1879–1881. *European Ferns.* Cassell, Petter, Galpin & Co., London.
- BRUES, C.T. 1920. The selection of food-plants by insects with special reference to lepidopterous larvae. *Amer. Natur.* 54: 313–332.
- BRUES, C.T. 1946. *Insect Dietary.* Harvard University Press.
- BUHR, H. 1964–65. *Bestimmungstabellen der Gallen (Zoo- und Phytocecidien) an Pflanzen Mittel- und Nordeuropas.* Jena, Fischer Verlag.
- CAMERON, A.E. 1930. Two species of antomyiid Diptera attacking bracken and their hymenopterous parasites. *Scottish Natur.* 182: 137–141.

- CAMERON, W.L.P. 1925. The fern mite. *Tarsonemus tepidariorum* Warburton. *Ann. Appl. Biol.* 12: 93–112.
- CARLISLE, D.B. and P.E. ELLIS. 1968. Bracken and locust ecdysones: their effects on molting in the desert locust. *Science* 159: 1472–1474.
- CONWAY, E. 1953. Spore and sporeling survival in bracken (*Pteridium aquilinum* (L.) Kuhn). *J. Ecol.* 41: 289–294.
- COOPER-DRIVER, G.A. 1978. Insect fern associations. *Entomol. Exp. Appl.* 24: 310–316.
- COOPER-DRIVER, G.A., S. FINCH, T. SWAIN and E. BERNAYS. 1977. Seasonal variation in secondary plant compounds in relation to the palatability of *Pteridium aquilinum*. *Biochem. Syst. Ecol.* 5: 177–193.
- COOPER-DRIVER, G.A. and T. SWAIN. 1976. Cyanogenic polymorphism in bracken in relation to herbivore predation. *Nature* 260: 604.
- DANIELS, G. 1976. The life history of *Hypochrypsops theon medocus* (Fruhstorfer) (Lepidoptera: Lycaenidae). *J. Australian Entomol. Soc.* 15: 197–199.
- DARWIN, F. 1877. On the glandular bodies on *Acacia sphaerocephala* and *Cecropia peltata* serving as food for ants. With an appendix on the nectar-glands of the common brake fern, *Pteris aquilina*. *Jour. Linn. Soc. (Botany)*. 15: 398–409.
- DEKLE, G.W. 1976. *Florida Armored Scale Insects*. Arthropods of Florida, Vol. 3. Florida Department of Agriculture.
- DELEON D. 1966. A new fern mite from Trinidad, West Indies (Acarina: Tarsonemidae). *Florida Entomol.* 49: 127–129.
- DOBZHANSKY, T. 1950. Evolution in the tropics. *Amer. Sci.* 38: 209–221.
- DOCTERS van LEEUWEN, W.M. 1938. Zooecidia. In: Verdoorn, Fr. (ed), *Manual of Pteridology*. pp. 192–195. Martinus Nijhoff, The Hague.
- EASTOP, V.F. 1973. Deductions from the present day host plants of aphids and related insects. In: van Emden, H.F. (ed.), *Insect/Plant Relationships*, pp. 157–178. Blackwell Scientific Publications.
- EASTOP, V.F. 1977. Worldwide importance of aphids as virus vectors. In: Harris, K.F. and K. Maramorosch (ed.), *Aphids as Virus Vectors*, pp. 3–62. Academic Press, London.
- ELTON, C.S. 1966. *The Pattern of Animal Communities*. Methuen, London.
- FEENY, P. 1976. Plant apparency and chemical defense. *Recent Advances in Phytochemistry* 10: 1–40.
- FRANKLAND, J.C. 1966. Succession of fungi on decaying petioles of *Pteridium aquilinum*. *J. Ecol.* 54: 41–63.
- GERSON, U. 1969. Moss-arthropod associations. *Bryologist* 72: 495–500.
- GERSON, U. 1973. Lichen-arthropod associations. *Lichenologist* 5: 434–443.
- GERSON, U. 1974–76. The associations between algae and arthropods. *Revue Algologique* 11: 18–41; 213–247.
- GHOSH, A.K. 1974. Fern infesting aphids (Insecta: Homoptera) in India. *Indian J. Hort.* 31: 104–109.
- GODFREY, G.L. 1972. A review and reclassification of larvae of the subfamily Hadeninae (Lepidoptera: Noctuidae) of American north of Mexico. *USDA Tech. Bull.* 1450.
- GOMEZ, L.D. 1974. Biology of the potato-fern *Solanopteris brunei*. *Brenesia* 4: 37–61.
- GRAY, B. 1970. Observations on the first scolytid, *Poecilips pteridophytæ* (Coleoptera: Scolytidae) to be found in association with a fern (Pteridophyta). *Can. Entomol.* 102: 578–585.
- GRAY, B. 1972. Observations on *Poecilips cardamoni* (Schaufuss), the second species of Scolytidae to be found in bracken fern *Col. Entomol. TS. Arg.* 93: 229–237.
- GRESSITT, J.L. 1969. Epizoic symbiosis. *Entomol. News* 80: 1–5.
- GRESSITT, J.L., G.A. SAMUELSON and D.H. VITT. 1968. Moss growing on living Papuan moss-forest weevils. *Nature* 217: 765–767.
- HARDING, D.J.L. and R.A. STUTTARD. 1974. Microarthropods. In: Dickinson, C.H. and G.J.H. Pugh (eds.), *Biology of Plant Litter Decomposition*, Vol. II, pp. 489–532. Academic Press, London.
- HARTZELL, A. and F. WILCOXON. 1941. A survey of plant products for insecticidal properties. *Contr. Boyce Thompson Inst.* 12: 127–141.
- HEAL, R.E., E.F. ROGERS, R.T. WALLACE and O. STARNES. 1950. A survey of plants for insecticidal activity. *Lloydia* 13: 89–162.
- HENDRIX, S.D. 1977. The resistance of *Pteridium aquilinum* (L.) Kuhn to insect attack by *Trichoplusia ni* (Hubn). *Oecologia* 26: 347–361.
- HERING, M. 1937. *Die Blattminen Mittel-und Nord-Europas Einschliesslich Englands*. Verlag Gustav Feller, Neubrandenburg.

- HERING, M. 1951. *Biology of the Leaf Miners*. W. Junk, S'-Gravenhage.
- HESLOP-HARRISON, J.W. 1944. A novel food-plant for *Euplexia lucipara* L. (Lep., Caradrinidae). *Entomol. Mon. Mag.* 80: 283.
- HIKINO, H., Y. OHIZUMI and T. TAKEMOTO. 1975. Detoxication mechanism of *Bombyx mori* against exogenous phytoecdysone ecdysterone. *J. Insect Physiol.* 21: 1953-1963.
- HIKINO, H., T. OKUYAMA, H. JIN and T. TAKEMOTO. 1973. Screening of Japanese ferns for phytoecdysones. *J. Chem. Pharm. Bull.* 21: 2292-2302.
- HOLTUM, R.E. 1955. *A revised Flora of Malaya*. Vol. II. *Ferns of Malaya*. Government Printing Office, Singapore.
- HORNING, D.S. Jr., R.O. SCHUSTER and A.A. GRIGARICK. 1978. Tardigrada of New Zealand. *New Zealand J. Zool.* 5: 185-280.
- HUSSEY, W.W., W.H. READ and J.J. HESLING. 1969. *The Pests of Protected Cultivation*. Edward Arnold, London.
- JACOBSON, M. 1958. Insecticides from plants, a review of the literature, 1941-1953. *U.S. Dept. Agr.; Agr. Handb.* 154.
- JANZEN, D.H. 1974. Epiphytic myrmecophytes in Sarawak: mutualism through the feeding of plants by ants. *Biotropica* 6: 237-259.
- JERMY, A.C. and T.G. WALKER. 1975. *Lecanopteris spinosa* - a new ant-fern from Indonesia. *Fern. Gaz.* 11: 165-176.
- JONES, C.G. and R.D. FIRN. 1978. The role of phytoecdysteroids in bracken fern, *Pteridium aquilinum* (L.) Kuhn as a defense against phytophagous insect attack. *J. Chem. Ecol.* 4: 117-138.
- KAPLANIS, J.N., M.J. THOMPSON, W.E. ROBBINS and B.M. BRYCE. 1967. Insect hormones: alpha ecdysone and 20-hydroxyecdysone in bracken ferns. *Science* 157: 1436-1437.
- KIRK, A.A. 1977. The insect fauna of the weed *Pteridium aquilinum* (L.) Kuhn (Polypodiaceae) in Papua, New Guinea: a potential source of biological control agents. *J. Australian Entomol. Soc.* 16: 403-409.
- KÜHNELT, W. 1976. *Soil Biology, With Special Reference to the Animal Kingdom*. Faber & Faber, London. Second Edition.
- LAWTON, J.H. 1976. The structure of the arthropod community on bracken. *Bot. J. Linn. Soc.* 73: 187-216.
- LAWTON, J.H. (in press). Host-plant influences on insect diversity: the effects of space and time. In: *Diversity of Insect Fauna. Symposia of the Royal Entomological Society of London*.
- LAWTON, J.H. and D. SCHRODER. 1977. Effects of plant type, size of geographical range and taxonomic isolation on number of insect species associated with British plants. *Nature* 265: 137-140.
- LEVIN, D.A. 1976. The chemical defenses of plants to pathogens and herbivores. *Ann. Rev. Ecol. Syst.* 7: 121-159.
- LLOYD, R.W. 1944. Occurrences of *Syagrius intrudens* Waterh. (Col., Curculionidae) in Britain confirmed. *Entomol. Mon. Mag.* 80: 4.
- LONG, H.C. and E.W. FENTON, 1938. The story of bracken fern. *J. Royal Agric. Soc. England.* 99: 15-36.
- LOVIS, J.M. 1977. Evolutionary patterns and processes in ferns. *Adv. Bot. Res.* 4: 229-419.
- MANI, M.S. 1964. *Ecology of Plant Galls*. W. Junk, The Hague.
- MANTON, I. 1973. Closing address. In: Jermy, A.C., J.A. Crabbe and B.A. Thomas (eds.), *The Phylogeny and Classification of the Ferns*, pp. 257-263. Academic Press, London.
- MARSHALL, G.A.K. 1922. On the Australian fern weevils. *Bull. Entomol. Res.* 13: 169-179.
- MAY, B.M. 1973. A new species of *Megacolabus* and descriptions of the immature stages of *M. decipiens* (Coleoptera: Curculionidae). *J. Royal Soc. New Zealand.* 3: 255-262.
- McKENZIE, H.L. 1967. *Mealybugs of California*. University of California Press.
- MEIKLE, A.A. 1937. The insects associated with bracken. *Agric. Progress* 14: 58-60.
- MILNE, S. 1960. Studies of the life histories of various species of arthropod Collembola. *Proc. Royal Entomol. Soc. London.* 35A: 133-140.
- MIYAZAKI, M. 1968. A revision of the fern aphids of Japan with descriptions of three new species (Homoptera: Aphididae). *Insecta Matsumurana* 31: 13-24.
- MOUND, L.A. 1966. A revision of the British Aleyrodidae (Hemiptera: Homoptera). *Bull. British Mus. (Nat. Hist.) Entomology* 17: 399-426.
- NICHOLSON, I.A. and I.S. PATTERSON. 1976. The ecological implications of bracken control to plant/animal systems. *Bot. J. Linn. Soc.* 73: 269-283.
- NIENHAUS, F., C. MACK and U. SCHINZER. 1974. The isolation of viruses from fern plants. *Zeit. Pflanzenk. Pflanzensch.* 81: 533-537.

- OKUTANI, T. 1967. Food plants of Japanese Symphyta. *Jap. J. Appl. Entomol. Zool.* 11: 90-99.
- OSSIANNILSSON, F. 1964. On three Swedish aphids (Hom., Aphidoidea), with description of a new species. *Entomol. Tidsk.* 85: 4-6.
- OWEN, D.F. 1971. *Tropical Butterflies*. Clarendon Press, Oxford.
- PEMBERTON, C.E. 1948. History of the Entomology Department Experiment Station, H.S.P.A., 1904-1945. *Hawaiian Planters' Record.* 52: 54-90.
- PENNY, N.D. 1977. A systematic study of the family Boreidae (Mecoptera). *Univ. Kansas Science Bull.* 51: 141-217.
- PIRONE, P.P. 1970. *Diseases and Pests of Ornamental Plants*. Ronald Press, New York.
- RICHARDS, O.W. and R.G. DAVIES. 1976. *Imms' General Textbook of Entomology*. Chapman & Hall, London.
- RICHARDS, W.R. 1972. Three new species of *Aulacorthum* from British Columbia with a key to the Canadian species (Aphididae: Homoptera). *Can. Entomol.* 104: 1017-1023.
- ROBINSON, A.G. 1966. Review of the fern aphids in North America with descriptions of a new species and a new genus. *Can. Entomol.* 98: 1252-1259.
- RUSSELL, G.B. and P.G. FENEMORE. 1971. Insect moulting hormone activity in some New Zealand ferns. *New Zealand J. Sci.* 14: 31-35.
- RYMER, L. 1976. The history and ethnobotany of bracken. *Bot. J. Linn. Soc.* 73: 151-176.
- SCHNEIDER, J. 1966. Ennemis des fougères ornementales. *Phytoma* 18: 26-32.
- SEAWARD, M.R.D. 1976. Observations on the bracken component of the pre-Hadriatic deposits at Vindolanda, Northumberland. *Bot. J. Linn. Soc.* 73: 177-185.
- SEVERIN, H.H.P. and C.M. TOMPKINS. 1950. Symptoms induced by some species of aphids feeding on ferns. *Hilgardia* 20: 81-92.
- SHORT, D.E., D.P. DRIGGENS, L.C. KUITERT and C.R. ROBERTS. 1971. Control of leatherleaf fern borer (Lepidoptera: Pyraustidae) with systemic insecticides. *Flo. Entomol.* 54: 325-328.
- SHORT, D.E. and D.B. McCONNELL. 1973. Pesticide phytotoxicity to ornamental plants. *Proc. Florida Hort. Soc.* 86: 439-442.
- SIMMONS, F.J. 1967. Possibilities of biological control of bracken, *Pteridium aquilinum* (L.) Kuhn (Polypodiaceae). *PANS (C)* 13: 200-203.
- SINGER, M.C., P.R. EHRLICH and L.E. GILBERT. 1971. Butterfly feeding on lycopsid. *Science* 172: 1341-1342.
- SLAMA, K. 1969. Plants as a source of materials with insect hormone activity. *Entomol. Exp. Appl.* 12: 721-728.
- SMITH, A.R. 1972. Comparison of fern and flowering plant distributions with some evolutionary interpretations for ferns. *Biotropica* 4: 4-9.
- SMITH, D.R. 1969. Nearctic sawflies. II. Selandriinae: adults (Hymenoptera: Tenthredinidae). *USDA Tech. Bull.* 1398.
- SOO HOO, C.F. and G. FRAENKEL. 1964. The resistance of ferns to the feeding of *Prodenia eridania* larvae. *Ann. Entomol. Soc. America.* 57: 788-790.
- SOUTHWOOD, T.R.E. and D. LESTON. 1959. *Land and Water Bugs of the British Isles*. F. Warne, London.
- SPENCER, K.A. 1972. *Handbook for the Identification of British Insects*. Vol. 10, 5g. *Diptera, Agromyzidae*. Royal Entomol. Soc., London.
- SPENCER, K.A. 1973. A new species of Agromyzidae (Diptera) mining bracken (*Pteridium aquilinum* L.). *Entomol. Gaz.* 24: 315-317.
- STRONG, D.R. Jr., E.D. McCOY and J.R. REY. 1977. Time and the number of herbivore species: the pests of sugarcane. *Ecology* 58: 167-175.
- SWEZEY, O.H. 1921. Insects attacking ferns in the Hawaiian Islands. *Proc. Hawaiian Entomol. Soc.* 5: 57-65.
- TAKEMOTO, T., S. OGAWA, N. NISHIMOTO, S. ARIHARA and K. BUE. 1967. Insect moulting activity of crude drugs and plants. *J. Pharma. Soc. Japan.* 87: 1414-1418.
- THOMPSON, R.T. 1977. A revision of the New Guinean weevil genus *Apirocalus* Pascoe (Coleoptera: Curculionidae). *Bull. British Mus. (Nat. Hist.) Entomol.* 36: 193-280.
- WATT, J.M. and M.G. BREYER-BRANDWIJK. 1962. *The Medicinal and Poisonous Plants of Southern and Eastern Africa*. Livingstone, Edinburgh and London.
- WIECZOREK, H. 1973. Zur Kenntnis der Adlerfarninsekten. Ein Beitrag zum Problem der Biologischen Bekämpfung von *Pteridium aquilinum* (L.) Kuhn in Mitteleuropa. *Zeit. angew. Entomol.* 72: 337-358.
- YAPP, R.H. 1902. Two Malayan "myrmecophilous" ferns, *Polypodium (Lecanopteris) carnosum* (Blume) and *Polypodium sinuosum* Wall. *Ann. Bot.* 16: 185-231.

REVIEWS

SPORES OF INDIAN FERNS by Santha Devi, pp. 228. New Delhi: Today & Tomorrow's Printers and Publishers. 1977. 280 x 225 mm. Price RS. 75.00 (about £4.50).

Dr. Devi starts her book with a brief preview of the history and recent studies on spore morphology and then describes systematically the spores of over 720 fern species in 134 genera. In describing techniques she rightly points out the dangers of only looking at external features with the S.E.M. There follows (pp. 99–122) a comparative analysis of the spore morphology, family by family, following B.K. Nayar's treatment. Both description and discussion is illustrated by 172 light micrographs of varying quality, which are printed on the kind of paper we have come to expect in Indian publications. This is not Santha Devi's fault, however, and she must be congratulated for carrying out the considerable amount of work that is needed to produce such a book. She is making a major contribution to fern palynology, for, although it is not apparent from the title of this book, more than half of the spores investigated were obtained from outside India. In fact when one reads Appendix II, which gives the source of spores, a large proportion of them are from cultivated botanical garden material of unknown provenance and some, one might think, of dubious name.

A.C. JERMY

FERNS OF THE OTTAWA DISTRICT by William J. Cody, Canada Department of Agriculture Publ. 1974, pp. 112; revised 1978. 210 x 133 mm. Available from Printing & Publishing Services, Canada, Hull, Quebec KA1 0S9. Price \$3.90 (about £1.60).

This is a little fern flora of 48 km (30 miles) radius of the centre of Ottawa – some 2,800 sq. miles; 18 genera, 36 species and one hybrid (*Dryopteris* x *bootii* (Tuckerm.) Underw.) are described and dotmaps and photographs (of pressed specimens, but very informative) are given.

After the earlier edition, published in 1956 it was thought that little would be added except a few dots on the distribution maps. Nevertheless five new species were found for the area: *Asplenium platyneuron*, *Pellaea atropurpurea*, *P. glabella*, *Woodsia obtusa* and *W. oregana*. In the text, ecological notes are good and references are given to further reports.

A.C. JERMY

FERNS OF FLORIDA – AN ILLUSTRATED MANUAL AND IDENTIFICATION GUIDE by Olga Lakela and Robert W. Long, pp. 178; 1976. Banyan Books, Miami, Flo. 33143. Price \$10.00 (about £4.70).

This is an extremely attractive little book with 117, mostly full page, illustrations (mainly photographs). Many of the species described and illustrated are familiar to British horticulturists and to those interested in ferns. From a botanical point of view, the number of genera (53) is wide and gives a good insight into ferns generally. I thoroughly recommend it whilst it is still available.

A.C. JERMY

THE PHILIPPINE PLATYCERIUM GRANDE

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ABSTRACT

For the first time *Platycerium grande* (Fée) Presl, a rare, giant staghorn fern from the Philippines, is fully described, based upon cultivated material.

INTRODUCTION

The two first-mentioned authors remarked in an earlier publication (De Joncheere & Hennipman, 1970) on the confusion existing with regard to the application of the name *Platycerium grande* (Fée) Presl. Although typified by a Cuming collection from the Philippines, it became commonly attached to a well-known and extensively cultivated Australian staghorn fern. As that element proved to be different from the Philippine type, the Australian taxon had to be given a new name, viz. *Platycerium superbum* Jonch. & Hennipm. Both these species were regarded as closely related to *P. wandaë* of New Guinea, and also to the newly described *P. holttumii* Jonch. & Hennipm. of Thailand and Indo-China.

A difficulty encountered when reaching these conclusions was the surprising scarcity of authentic *P. grande* collections from the Philippines, and the poor quality of the few specimens present in large herbaria. Only one complete fertile leaf of *P. grande* (the type; BM) was traced.

Although the taxonomy of the giant staghorn ferns is primarily based upon differences in shape and size of the foliage leaves, other features of interest such as the rhizome scales, and the shape of the nest leaves are also important and were unknown for *P. grande*. They could therefore not be taken into consideration earlier.

Although our classification was accepted by others, e.g. Hoshizaki (1972), others expressed doubts.

We long tried unsuccessfully to obtain a complete living or dried specimen of true *P. grande*. Obviously this species is very local. Quite accidentally, young specimens of *P. grande* said to have been collected from the wild in Davao, were traced in 1975 at a local nursery in Cebu, southern Philippines. One of these plants was sent to Leiden and another to Kew. The specimen at Leiden was placed in the tropical greenhouse of the Leiden Botanical Garden, and reached maturity in the summer of 1977.

The cultivated material thus available makes it possible now to complete the description of *P. grande* proper, and to discuss its systematic position within the group of the giant staghorn ferns.

THE CULTIVATED MATERIAL OF *PLATYCERIUM GRANDE* (FÉE) PRESL

Platycerium grande (Fée) Presl, Epim. Bot. (1851) 154; (J. Smith, Hook. J. Bot. 3 (1841) 402, nom. nud.). — *Neuroplatyceros grandis* Fée, Hist. Acrost. (1845) 103, p.p. — *Alcicornium grande* Underwood, Bull. Torr. Bot. Club 32 (1905) 594, p.p. — Lectotype: Cuming 157, Philippines, Luzon, Mt. Cristobal (BM). — figs. 1–2.

Rhizome short, but massive, the apex densely covered by scales which are basally attached, 4–7 times as long as wide, 13–18 by 2–4 mm, stiff-herbaceous, light brown with the central and basal part somewhat darker coloured, margin with a c. 0.5 mm wide fringe of uniseriate (always?) unbranched multicellular hairs, apex acute. *Nest leaves* upright, forming huge basket, sessile,

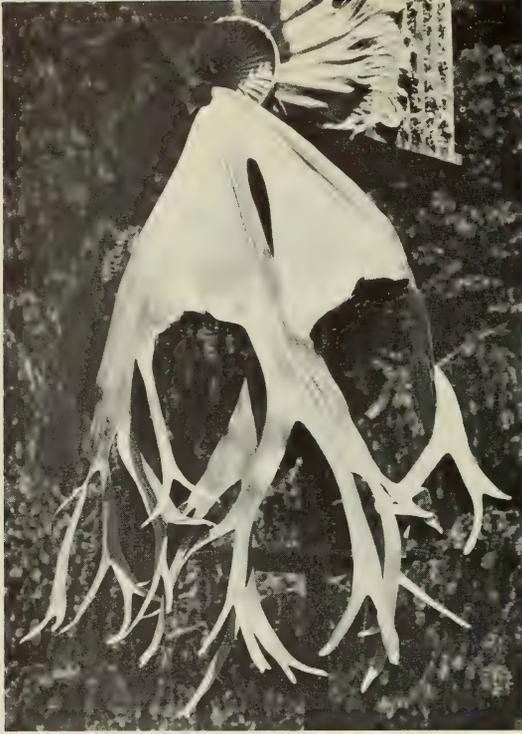


FIGURE 1. *Platycerium grande* plant in cultivation showing the upper side of the bipartite fertile frond.



FIGURE 2. The same specimen, showing the lower side of the fertile frond, with the two conspicuous soral patches.

obliquely reniform, 80–90 by 150–180 cm, greyish green, soft-coriaceous, recurved and withered when old; basal part appressed, auriculate, semi-circular (radius c. 45 cm), nearly completely encircling the growing point and with a conspicuous, thin, projecting frill up to 8 cm long around the petiole base of the foliage leaves; the lateral margins entire, wavy; upper part lobed, lobes spreading, 3–5 times dichotomously divided, 15–25 cm wide at the base, 40–50 cm long, sinuses narrow, ultimate segments rather coarse with blunt tips. veins anastomosing with prominent veins running in pairs to the lobes, otherwise dichotomously forked up to the ultimate segments. *Fertile leaves* produced in pairs, c. 120 by 150 cm, fleshy-coriaceous, greyish green, stalk to 4 cm long, woody, striated, in cross-section elliptic, 1.5 by 1.0 cm, gradually widening distally; lamina pendent, symmetrically divided into two equal parts, separated by a long narrow sinus; each part c. 85 by 130 cm and c. 20 cm wide at the cuneate base (20–30 by 40–50 cm) which largely covered by a soral patch measuring c. 15 by 20–30 cm, distally divided into strap-like segments by 3–5 oblique, inwardly directed, dichotomous divisions, the lowest sinuses dilated, ultimate segments up to 25 by 2.5 cm; veins anastomosing with some prominent veins running parallel to the margin. *Indument*: leaves on both sides thinly covered by a felt of whitish, \pm sessile stellate hairs 300–600 μ m in diam., with 8–11 slender arms. *Sporangia* stalked, pyriform, 300–500 μ m long, with 18–22 indurated cells; spores bean-shaped, somewhat dented, 55–80 by 35–45 μ m, brown, smooth; paraphyses stellate, stalked, 150–200 μ m in diam., with 9–11 arms.

Notes. 1. An earlier remark (De Joncheere & Hennipman, l.c.) that the size of this species is smaller than that of its relative *P. superbum* is incorrect; the size of the specimens in cultivation at Leiden and Kew \pm equals that of *P. superbum* and *P. holttumii*.

2. The rhizome scales are similar to those of *P. holttumii* being flat (not \pm bullate as in *P. superbum*), and lacking a so-called midrib (present in *P. wandae*). Also, the marginal fringe of hairs on the scales is similar to that of *P. holttumii*, differing from that of both *P. superbum* and *P. wandae* (hairs few-celled).

3. In our cultivated specimens, mature nest leaves of *P. grande* differ from those of *P. holttumii*; being less deeply cut, of a greyer colour, of a softer texture, and with less conspicuous veins. Further, the main veins in the nest leaves of *P. grande* run up to the ultimate lobes, in *P. holttumii* they run up to the penultimate lobes only.

DISCUSSION AND CONCLUSIONS

P. grande is a distinct species easily recognized by the shape of the fertile leaves. Those formed on our cultivated plant are similar in shape to the type specimen at BM, although much larger. This confirms the treatment of *P. grande* as a separate species. By its fertile leaves *P. grande* is easily distinguished from its relatives *P. holttumii* and *P. wandae* (fertile leaves with two strongly unequal halves, each with one soral patch), and *P. superbum* (fertile leaf with one soral patch only).

The rhizome scales of *P. grande* turned out to be similar to those of *P. holttumii*, and different from *P. superbum* and *P. wandae*.

The sterile leaves of *P. grande* show conspicuous differences from those of *P. holttumii*.

A discussion on the phylogenetic relations within the genus will be included in a forthcoming paper on the genus *Platynerium* by Mr. M.C. Roos, a graduate student from Leiden University.

ACKNOWLEDGEMENTS

It is a pleasure to express our gratitude to Mr. A. Mulder, who skilfully handled this beautiful ornamental fern in horticulture. The photographs were made by Mr. B.N. Kieft.

REFERENCES

- JONCHEERE, G.J. DE, and E. HENNIPMAN. 1970. Two new species of *Platynerium* and the identification of *P. grande* (Fée) Presl. *Brit. Fern Gaz.* 10: 113–118.
- HOSHIZAKI, BARBARA JOE. 1972. Morphology and phylogeny of *Platynerium* species. *Biotropica* 4: 93–117.

REVIEW

EVOLUTIONARY PATTERNS AND PROCESSES IN FERNS by J.D. Lovis in *Advances in Botanical Research*, 4: 229-440; 1977 (ed. H. Woolhouse). Academic Press 228 x 155mm. Price: £16.80.

This substantial paper is a review of up-to-the minute literature presented with a depth of knowledge and critical appraisal that few, if any, pteridologists could surpass. It is divided into six chapters. After an Introduction, Prof. Lovis reminds the reader of a number of trends seen in the fossil record (pp. 232-255). There follows a short introduction to the development of cytological studies in ferns followed by the largest chapter (pp. 258-319): cytology in relation to classification and phylogeny. Lovis accepts a single class (Filicopsida) and includes at subclass level the Psilotales as suggested by Bierhorst (1971); *Osmunda* and the Eusporangiates are given similar subclass status. Within the Filicidae are nine orders containing 23 families, the Marsileaceae with chromosome numbers 10–20 are placed next to Adiantaceae with a base number 29 or 30, a situation which seems sound. Three families, Hymenophyllaceae, Loxsomaceae and Plagiogyriaceae are regarded as *incertae sedis*. At the subfamily level those accepted are similar to Crabbe *et al* (1975) except the 'aspidiaceous' group are placed under Dryopteridaceae and the latter authors are rightly criticised for not segregating Onocleoidae. A full list of genera and chromosome numbers is given with levels of ploidy, and number of species both known and counted. The gaps are most interesting and will hopefully lead to further work. Polyploidy in ferns is discussed in relation to systematic and geographical distribution.

The rest of the work (pp. 330–400) is given over to a detailed account of the biosystematics of ferns describing as the basis for such work, genome analysis, species interrelationships in temperate genera: *Asplenium*, *Cystopteris*, *Dryopteris*, *Polypodium* and *Polystichum*; and tropical complexes: *Adiantum caudatum*, *Asplenium aethiopicum* and *Ceratopteris*. The role of introgression, breeding systems and apomixis generally is considered in the process of evolution. There are over 500 references and author and subject indices.

This is a work that should be read by all taxonomists, especially pteridologists. Every word is carefully weighed, precise and meaningful, be it criticism or praise, and all points of view are fairly given. The reader is left in no doubt, however, of Professor Lovis' own assessment.

REFERENCES

- BIERHORST, D.W. 1971. *Morphology of Vascular Plants*. New York.
 CRABBE, J.A., JERMY, A.C. & MICKEL, J.T. 1975. A new generic sequence for the pteridophyte herbarium. *Fern Gaz.*, 11: 141-162.

A.C. JERMY

A FURTHER CHROMOSOME COUNT FOR CHRISTENSENIA (MARATTIALES)

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ABSTRACT

A chromosome count of $n=40$ is recorded for a diploid plant of *Christensenia* from Sarawak. The only previous determination showed a Solomon Islands representative to be tetraploid. The base number of $x=40$, so characteristic of the Marattiales, is thus confirmed.

INTRODUCTION

Christensenia is a small member of the Marattiales and whilst it shares many of the highly distinctive features of this order, it stands well apart from the other members in its palmately-divided fronds with round synangia scattered on the lower surface and with reticulate venation. In some systems of classification (for review and discussion see Pichi Sermolli, 1959, 1977) these differences have been considered sufficient to justify the erection of a separate family, Christensiaceae (= Kaulfussiaceae).

CYTOLOGY

Christensenia occurs in Assam, Malaysia, through much of Indonesia and the Philippines, with a noteworthy extension of its range to Melanesia reported by Braithwaite (1977). One of the plants from San Cristobal in the Solomon Islands was cytologically investigated by Braithwaite and found to have $n=80$, $2n=160$. From these chromosome counts he concluded that he was dealing with a tetraploid plant based on $x=40$. This assumed base number is in conformity with the $x=40$ found in other members of the Marattiales that have been cytologically examined, namely *Angiopteris* (Manton and Sledge, 1954; Mehra and Singh, 1955; Ninan, 1956; Ghatak, 1962), *Danaea* (Walker, 1966) and some species of *Marattia** (Walker, in Manton, 1959; Walker, 1966).

Whilst a member of the Royal Geographical Society Expedition to Gunong Mulu in Sarawak in the summer of 1978, I collected several plants of *Christensenia* for cytological fixation. Of these only one proved suitable for the purpose but it gave numerous cells clearly showing 40 pairs of chromosomes at meiosis. One such cell is illustrated in fig. 1. This count of $n=40$ thus confirms Braithwaite's deductions as regards both the basic chromosome number of the genus and of the tetraploid nature of his plant in contrast to the diploid status of my Sarawak specimen.

Christensenia has been considered to consist of a small number of species but Copeland (1947) states that these all may better be regarded as forms of the one species *C. aesculifolia* (Bl.) Maxon. The presence of at least two cytotypes has now been demonstrated but whether or not these are recognizable on morphological grounds requires further sampling.

ECOLOGY AND CULTIVATION

All my specimens were gathered from several localities in lowland alluvial forest in or near the Gunong Mulu National Park in Sarawak and were growing in fairly deep shade in permanently damp or wet alluvial silt at c. 65 m (c. 200 ft) above sea level. Holttum (1954) records that it has been found up to 3000 ft altitude in Malaya. Although Schneider (1893) declares that this species (under the name *Kaulfussia aesculifolia*) is easy to grow in cultivation this has not been my experience. Plants sent in the past to Newcastle have not proved easy to establish and those that survived for a time were preferentially grazed by slugs which attacked and destroyed the growing apices.

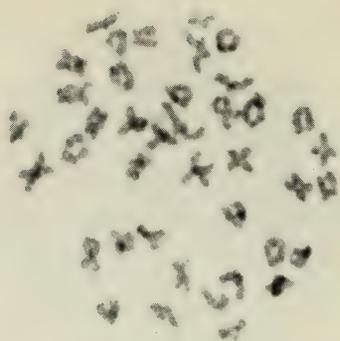


FIGURE 1. Meiosis in diploid *Christensenia aesculifolia* (Bl.) Maxon from Sarawak (T13319) showing 40 bivalents, x 1000. Permanent acetocarmine squash preparation.

ACKNOWLEDGEMENTS

My thanks for financial assistance are due to the Research Fund of the University of Newcastle upon Tyne.

REFERENCES

- BRAITHWAITE, A.F. 1977. A chromosome count and range extension for *Christensenia* (Marattiaceae). *Amer. Fern J.* 67(2): 49–50.
- BROWNLIE, G. 1961. Additional chromosome numbers of New Zealand ferns. *Trans. Roy. Soc. New Zeal. Bot.* 1: 1–4.
- COPELAND, E.B. 1947. *Genera Filicum*. Chronica Botanica, Waltham.
- GHATAK, J. 1962. Observations on the cytology and taxonomy of some ferns from India. *Nucleus* 5: 95–114.
- HOLTUM, R.E. 1954. *Flora of Malaya, II. Ferns*. Government Printing Office, Singapore.
- MANTON, I. 1959. Cytological information on the ferns of West Tropical Africa. In A.H.G. Alston, *The flora of West Tropical Africa*, 2nd ed.: 75–81. Crown Agents, London.
- MANTON, I & SLEDGE, W.A. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. *Phil. Trans. R. Soc. (B)* 238: 127–185.
- MEHRA, P.N. & SINGH, H.P. 1955. Cytology of Cyatheaceae, Woodsiae and Marattiaceae. *Curr. Sci.* 24: 425.
- NINAN, C.A. 1956. Studies on cytology and evolution of the pteridophytes I. Observations on the Marattiaceae. *J. Indian Bot. Soc.* 35: 233–239.
- PICHI SERMOLLI, R.E.G. 1959. Pteridophyta. In W.B. Turrill (Ed.), *Vistas in botany*: 421, 493. London.
- PICHI SERMOLLI, R.E.G. 1977. Tentamen pteridophytorum genera in taxonomicum ordinem redigendi. *Webbia* 31(2): 313–512.
- SCHNEIDER, G. 1893. *The book of choice ferns*. Vol. 2. Gill, London.
- WALKER, T.G. 1966. A cytotaxonomic survey of the pteridophytes of Jamaica. *Trans. R. Soc. Edinb.* 66: 169–237.
- WALKER, T.G. 1973. Evidence from cytology in the classification of ferns. In A.C. Jermy, J.A. Crabbe and B.A. Thomas (Eds.). *The phylogeny and classification of the ferns*. *Bot. J. Linn. Soc.* 67, Suppl. 1: 91–110.

*Footnote. The existence of $x=39$ in other species of *Marattia* has been confirmed (Ninan, 1956; Brownlie, 1961). This number has doubtlessly been secondarily derived from $x=40$ (Walker, 1966, 1973).

PELTATE SCALES IN SACCOLOMA

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ABSTRACT

Peltate scales are described in *Saccoloma elegans* Klf.

INTRODUCTION

In ferns, peltate scales are mainly confined to essentially epiphytic groups. According to Alston (1956) "peltate scales seem to be found only in Polypodiaceae, Grammitidaceae and Davalliaceae". They occur also in terrestrial representatives of essentially epiphytic groups, but to my knowledge their occurrence in entirely terrestrial groups has not been reported before. This account is to report the presence of peltate scales on the rhizome and petiolar base of the terrestrial neotropical fern *Saccoloma elegans* Klf.

The genus *Saccoloma* was established by Kaulfuss in 1820. On account of its pouch-shaped indusia it was usually associated with, or even combined with, *Davallia*, where peltate scales are of regular occurrence.

At present, *Saccoloma* (with its segregate genus *Orthiopteris*) is usually placed near *Dennstaedtia* and its relatives (e.g. Copeland, 1947: 49; Holttum, 1955: 305–306; Tardieu-Blot, 1958: 14; Mickel, 1973), although it seems somewhat distinctive because of its scaly rhizome, the other genera of the *Dennstaedtia* alliance having consistently uniseriate, pluricellular dermal appendages usually called hairs (Nair, 1973). The presence of peltate scales in *Saccoloma* was observed in the course of monographic work now in progress.

MATERIALS AND METHODS

These observations are based on study of the following specimens:

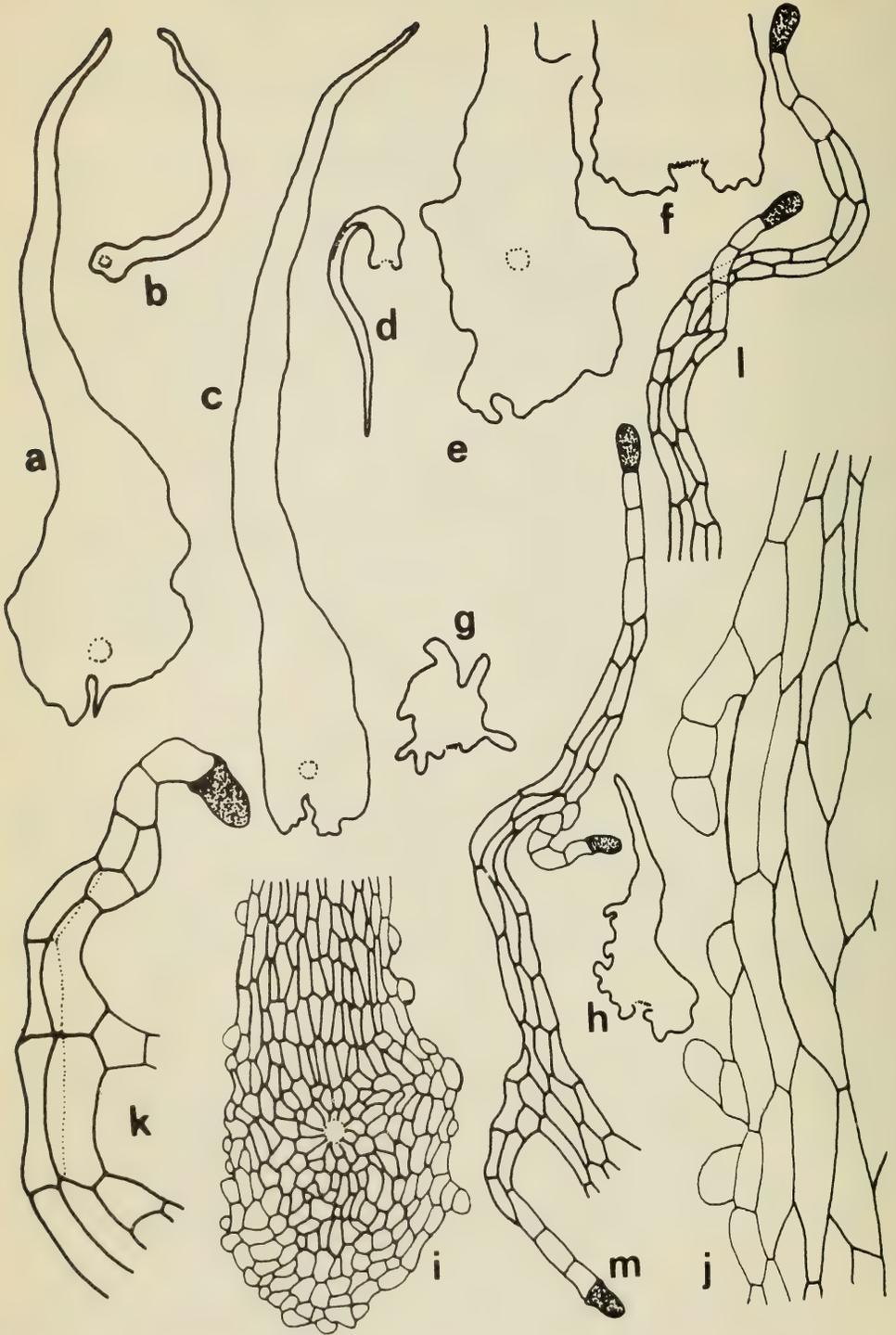
Saccoloma elegans Klf. ECUADOR: Provincia Esmeraldas, Playa Rica, Parroquia de concepcion, Ynes Mexia 8429 (US, UC, U, NY, G, B). BRAZIL: Minas Gerais, Ilheu, Ynes Mexia 4694 (UC, US, NY, GH); Vicoso, Ynes Mexia 4639 (US, NY, B, U, G); Amazonia, Territorio do Roraima, G.T. Prance *et al.* 13611 (NY, U, US). GUYANA: S. Pakaraima Mts. Kopinang Falls, Bassett Maguire *et al.* 46064A (NY, U, US).

Dermal appendages were carefully removed after flooding the dried specimen with wetting agent for 15-20 minutes, washed, and mounted in lactic acid for observation.

OBSERVATIONS

The growing regions of the rhizome and the young circinate coiled fronds are covered by numerous scales. Hairs, however were found to be completely absent from the rhizome (cf. Copeland 1947: 49) but present on the young frond. Only soft-textured, multicellular, non-glandular hairs (5-12 cells long) have been found in *Saccoloma*. In *Dennstaedtia*, on the other hand, both multi-cellular acicular or multi-cellular glandular and non-glandular hairs have been observed in all the species so far studied (Nair, 1973). In *Saccoloma*, the scales at the apex of the rhizome are densely crowded. The majority are peltate in structure, and these remain intact far from growing region on the parts of the rhizome that are buried in the soil.

Among such peltate scales, variously modified other scales of smaller size occur on the growing parts of the rhizome ('basifixed scales'). These often show some degree of lateral expansion giving a cordate appearance near to the scale base (fig. 1 : d, f &



h). Both types of scales occur abundantly also on the basal parts of the stipe.

Mature peltate scales are 5-12mm long and 3-7mm wide at the broadest region. They are linear-lanceolate to lanceolate in shape. Sometimes the scales are smaller in size and almost circular in outline (fig. 1g). On the older parts they are dark brown in colour and on the younger parts light brown. The proximal end of some peltate scales shows a v-shaped insertion (fig. 1 : a & c), except when well-developed (fig. 1 : e & i). The stalk is dark brown, firm, 0.1-0.2mm long. The persistent scale bases (stalks) later develop into often backwardly pointed, firm, spine-like structures, particularly on the basal half of the stipe. The distance from the base of the point of attachment of the scale may vary considerably. The cells of the scale are uniformly thick in the central portion of the scale and the marginal cells pale and thin. The scale margins often bear lateral appendages of varying length (fig. 1 j). The distal part of the scale is frequently branched, their tips ending in a uniseriate row of cells (fig. 1 k-m). The cells of the marginal appendages are indistinguishable from the rest of the cells. The terminal cells of the branches contain a granular substance of unknown chemical nature.

ACKNOWLEDGEMENTS

I am greatly indebted to Professor K.U. Kramer for his suggestions, criticism and encouragement. I am also grateful to Professor C.D.K. Cook for reading the manuscript and to the Directors of herbaria from whom material was borrowed.

REFERENCES

- ALSTON, A.H.G. 1956. The subdivision of the Polypodiaceae. *Taxon*. 5 (2) : 23-25.
 COPELAND, E.B. 1947. *Genera Filicum*, Waltham Mass: Chronica Botanica.
 HOLTUM, R.E. 1955. *A revised flora of Malaya, II. ("1954") Ferns of Malaya*. Singapore: Government Printer.
 MICKEL, J.T. 1973. The classification and phylogenetic position of the Dennstaedtiaceae. In A.C. Jermy et al. *The Phylogeny & Classification of the Ferns. Journ. Linn. Soc. Bot 67: (Suppl.)* 135-144.
 NAIR, G.B. 1973. *Studies in the morphology and anatomy of some Dennstaedtioid ferns* (Ph.D. thesis Kalyani University, India).
 TARDIEU-BLOT, M.L. 1958. Polypodiacées, in: H. Humbert, *Fl. Madag. Com.* Paris.

FIGURE 1. Scales of *Saccoloma elegans*: a & c, peltate scales with incised base; b, peltate scale with an undivided base; d & f, basifixed scales; e & i, the proximal portion of a peltate scale showing point of attachment; g & h, basifixed scales from a circinnately coiled frond; j, portion of a peltate scale showing the marginal appendages; k-m, distal portions of peltate scale showing the terminal granular cell and branchings of the scales.

SHORT NOTES

A NEW NAME FOR A EUROPEAN DRYOPTERIS

The name *Dryopteris pseudomas* (Wollaston) Holub et Pouzar is illegitimate, its basionym of 1855 being predated by *Nephrodium affine* Lowe.

A different taxon, "*Dryopteris affinis*" Newman, was never validly published at the specific rank, but only as a variety, so the following new combination is made and replaces the name *Dryopteris pseudomas*:-

Dryopteris affinis (Lowe) Fraser-Jenkins, comb. nov.

Basionym : *Nephrodium affine* Lowe, Tr. Camb. Phil. Soc. 6 : 528 (1838).

The type from Madeira in Key (K!) represents the atlantic European diploid taxon, common also in western Britain.

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DRYOPTERIS HYBRIDS : A CORRECTION

Due to the temporary loss of Fraser-Jenkins' original manuscript the name *Dryopteris x sarvelae* was inadvertently misspelt as *Dryopteris x sarvelii* (*Fern Gaz.* 11(5) : 339 (1977), as has been pointed out to us by Mr. Sarvela. The following new country records for *D. x ambroseae* were also omitted : Romania, Austria, Czechoslovakia, Sweden, Norway, North Turkey, West and Central Caucasus (all from collections of Fraser-Jenkins deposited in BM).

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EQUISETUM VARIEGATUM NEW TO TURKEY

The presence of *Equisetum variegatum* Schleich ex Weber & Mohr has recently been confirmed from Turkey from a herbarium specimen (Davis & Coode 38422, E) collected in 1962 in Kastamonu Province, North side of Ilgaz Dag, which had been formerly regarded as *E. ramosissimum* Desf. in *Flora of Turkey*, vol. 1 : 32 (1965). The occurrence of this plant in north central Turkey (N. Anatolia) adds significantly to the range of *E. variegatum*, the nearest other stations to which occur in scattered localities high in the main Caucasus mountains of the USSR. This new Turkish station represents the most southerly known Eurasian outpost from the extensive northern circumboreal range of this species.

This typically high-altitude streamside horsetail occurs at about 1350 m, in an area of *Abies* forest on the northern slope of the highest mountain in this part of Turkey, where mist and rain is frequent. It is of interest that the area also includes a number of other outlying Euro-siberian or circumboreal elements, such as all the Turkish species of *Pyrola*, *Orthilia secunda* and *Moneses uniflora* (all Ericaceae) (P.H. Davis, personal communication).

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EQUISETUM X TRACHYODON IN WESTERN SCOTLAND

For more than 100 years, *Equisetum x trachyodon* A. Br. (= *E. mackaii* Newm. of older literature, the presumed hybrid between *E. hyemale* L. and *E. variegatum* Schleich. ex Web. & Mohr), has been known in Scotland only as a single station* on the banks of the River Dee in Kincardineshire (VC 91), where it was first reported growing in the mid 19th-century (Brichan, 1842). It occurred in patches along several miles of river bank, with both parents nearby. *E. x trachyodon* is known to have still grown in the Kincardineshire locality in 1935 (Matthews, 1940), and is believed to have persisted into the 1950's (J.G. Roger, personal communication), although more recent searches (since 1971, by the author and A.C. Jermy) have failed to find it. The correct identity of the Deeside plant is confirmed by herbarium material housed at Edinburgh (E).

It is therefore of interest that in the last few years, no less than *three* further stations for undoubted *Equisetum x trachyodon* have been confirmed in Scotland. None seems to result from recent spread or formation of the hybrid. All appear to be long-established colonies which have been hitherto unrecognised as hybrids. All three are remote from the previously-known station and all occur in the Hebrides: one on the island of South Harris (VC 110), one on the Isle of Rhum (VC 104) and one in the north of the Isle of Skye (VC 104). Records for all three have been included in the 'Atlas of British Ferns' (Jermy et al., 1978), and the purpose of this note is to add some field observations and diagnostic details.

Subsequent to these finds, *E x trachyodon* has been confirmed from a similar habitat in England, and is discussed by Barker (1979) (see below).

The first of the new Scottish finds was that in South Harris, at a site to which my attention had been drawn by Dr. W.A. Clarke of Newcastle University, who had found, some years earlier, a horsetail resembling *E. variegatum*, but about the identity of which some doubts had been expressed at the time. With instructions, I was able to refine the exact locality near Nisabost in the field in June 1972, and established that this horsetail was indeed *E. x trachyodon*.

At this South Harris locality the hybrid forms a colony several square metres in extent. Most shoots of the plant are little larger than those of typical *E. variegatum* in dune-slack habitats, and most are similarly decumbent for much of their length, becoming ascending or erect only towards their tips. These plants could clearly easily be overlooked for a form of *E. variegatum*.

The colony occupies the steep ESE slope of a gradually eroding dune of calcareous shell sand, and the habitat is kept continually moist by percolating fresh water. The site is a maritime one, no more than 2-4 m above normal high-tide level and scarcely 2 m horizontal distance from the sea. Although sheltered from exposure to the west, it is unprotected in other directions, and the hybrid seems likely to receive some salt spray, at least intermittently. The seepage water originates from acidic peaty moorlands, but doubtless becomes calcium-enriched as it percolates through the shell-sand of the dunes before emerging at the site of the hybrid. The slight erosion of the slope by the slowly seeping water keeps the habitat both a moist and a more or less continually open one, colonised only by this horsetail which continually pioneers the site.

*An old Loch Tummel, Perthshire, locality given in the 'Atlas of British Ferns' as an open circle (Jermy, et al., 1978) remains unconfirmed and doubtful.

The Isle of Skye station on the river Hinnisdal was discovered in November 1974 by Mrs. C.W. Murray, who sent a specimen to Edinburgh for confirmation. The site is possibly that from which an old record for *E. variegatum* exists, and the shoots of the *E. x trachyodon* are only a little larger than those of robust riverside forms of *E. variegatum* and could easily have been confused with this species, or taken for a small plant of *E. hyemale*.

As with the Harris station, this Skye site is an essentially open one, with the hybrid occurring on two portions of collapsed bank of a small river, about half a mile (c. 1 km) from the sea and 25 ft (c. 8 m) altitude. The hybrid grows at the edge of the river in a basic sandy silt derived from basalt and the site is permanently moist. The habitat is kept open by gradual erosion by river water, which intermittently floods it (C.W. Murray, personal communication).

The Isle of Rhum station was first determined in 1975 from a herbarium specimen collected by Dr. C. Ferreira in November 1960, and housed in the herbarium of the Nature Conservancy Council in Edinburgh. The specimen originated in an area of low-lying slack in machair sand at Kilmory dunes in the north of the island, near the mouth of a small river, about 150 m distance from the strand-line of the sea and about 1 m above the spring-tide level. The plant is probably under some influence of saline groundwater at least intermittently, but is also flushed by fresh-water seeping from sandstone slopes above, keeping the habitat more or less permanently moist. The seepage water flows through dunes of shell-sand and thus, as in the Harris station, doubtless becomes considerably calcium-enriched before entering the slack, the shell-sand soil of which also contains a thin organic horizon. Although partially sheltered from the sea by surrounding slightly higher ground, the habitat is nevertheless rather exposed and most shoots of *E. x trachyodon* are nearly prostrate on the sand (C. Ferreira, pers. comm.). A further specimen collected in July 1978 by Dr. C. Ferreira from near this former site, but in *Ammophila* fixed-dune machair, also proved to be *E. x trachyodon*. Here too the plant is reported to be locally frequent and spreads into adjacent moist-slack grassland, associated with *Festuca rubra*, *Bellis perennis*, *Lotus corniculatus* and *Galium verum*. The hybrid thus appears locally widespread and well-established in this habitat.

It is significant that in each of these new Scottish stations, *E. x trachyodon* occurs in open sites where one of both parent species are absent, at least in the immediate vicinity. Near the Harris station, *E. variegatum* is known in a sand-dune slack about 4 km away, but *E. hyemale* remains unknown in the whole of the Outer Hebrides. In Skye, both *E. variegatum* and *E. hyemale* are present on the island, but both are rare, and absent near to the hybrid site. In Rhum, both parents are recorded for the island, but only *E. variegatum* grows near the *E. x trachyodon*.

Specimens from the Harris and Rhum stations have somewhat smaller shoots (mostly less than 20 cm high and less than 2 mm stem diameter) than those from Skye and Deeside (which reach 20-30 cm in height and up to 3 mm stem diameter), but are otherwise morphologically similar. The size differences probably result in part from the more exposed habitat of the Harris and Rhum colonies, as well as their probably involving a smaller dune ecotype of *E. variegatum*, rather than a larger river-side one, in the parentage of the hybrid. The following points of diagnosis may help in location of possible further sites for this hybrid.

As seen at these stations, *E. x trachyodon* is best distinguished from its parents by the following characters. The sheaths typically have a much broader black band (occupying most of the upper 1/2 to 2/3 of each sheath), and end in teeth which are long, dark, slender and flexuous and have only a very narrow white margin to their slightly dilated bases. The teeth normally persist either indefinitely on the shoot, or at

least for a time after the shoot has fully expanded (depending on degree of exposure of the habitat), but as they become lost, break along preformed abscission zones at the top of the fused portion of the sheath to leave an irregularly crenate sheath margin. This latter character contrasts strongly with both parents: in *E. variegatum* the teeth are almost always persistent, in *E. hyemale* they are almost always shed during the actual expansion of the shoot (during which process they become torn off to collectively form small pagoda-like caps on the tips of the shoot). The shape of the teeth, the broadness of the black band and the absence of broad white scarious teeth margins thus distinguish most shoots of *E. x trachyodon* even from large specimens of *E. variegatum*, whilst the persistence of the teeth, as well as absence of the ash-grey coloured band around the upper sheath margin, more clearly biangulate internodal ridges and teeth which are clearly 2-ribbed, separate most shoots of *E. x trachyodon* even from small specimens of *E. hyemale*. In the hybrid, sheaths are longer in relation to their width than in either parent. Cones, where present, contain only highly misshaped abortive spores, thus confirming its hybrid status.

Herbarium specimens from each of these three localities are deposited at R.B.G., Edinburgh (E).

REFERENCES

- BARKER, M. 1979. *Equisetum x trachyodon* in Cheshire, new to the English flora. *Fern Gaz.* 12: 59–60.
- BRICHAN, J.B. 1842. Description of *Equisetum hyemale*, *Mackaii* and *variegatum*, as found on the Banks and in the bed of the River Dee; with additional observations. *Phytologist* 1: 369–377.
- JERMY, A.C., ARNOLD, H.R., FARRELL, L.A. & PERRING, F.H. 1978. *Atlas of Ferns of the British Isles*. London.
- MATTHEWS, J.R. 1980. *Equisetum trachyodon* as a Scottish plant. *Trans. and Proc. Bot. Soc. Edinb.* 33: 29–32.
- NEWMAN, E. 1844. *A History of British Ferns and Allied Plants*. London.

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EQUISETUM X TRACHYODON IN CHESHIRE, NEW TO THE ENGLISH FLORA

Some specimens of *Equisetum*, recently sent to C.N. Page, were determined as the hybrid *Equisetum x trachyodon* A. Br. (*Equisetum hyemale* L. x *Equisetum variegatum* Schleich. ex Web. & Mohr). These specimens came from the Cheshire Conservation Trust's Red Rocks Nature Reserve and the adjoining Royal Liverpool Golf Course at Hoylake, Merseyside, (v.c. 58, Cheshire).

Here, the *E. x trachyodon* grows on the leeward side of a slightly brackish marsh at the base of some 'yellow' sandhills, which are still reached by blown sand from the foreshore. The colony is extensive and abundant in rough grassland at the base of the sandhills, and stretches for 1.3 km south from the Red Rocks. The dominant vegetation of the habitat is a turf of *Festuca rubra* L. and *Ammophila arenaria* (L.) Link. It is the density of the *Ammophiletum rubrae* community which effectively limits the growth of *E. x trachyodon* at this site. Consequently, it is most vigorous where this community is sparse or where the ground has been recently burnt. In such bare sandy situations associated plants are: *Agrostis stolonifera* L., *Myosotis ramosissima* Rochel., *Galium verum* L., *Rubus caesius* L., *Rose pimpinellifolia* L. and *Taraxacum officinale* agg. (predominately *T. brachyglossum* (Dt.)Dt.).

The morphology of *E. x trachyodon* at Red Rocks varies within the population. In the north of the site there is a form resembling *E. variegatum* (and this is where the only pure *E. variegatum*, in a small quantity, grows at Red Rocks), while in the south it resembles *E. hyemale* more closely. Dr. Page has commented that the Red Rocks *E. x trachyodon* is unusual in that it branches and that these branches, because of their small size, have a morphology close to that of *E. variegatum* (and in isolation could easily be confused with it), although the main stem exhibits the characters of *E. x trachyodon*.

This colony is of particular interest because it is the first station found in England. Elsewhere in Britain, it has a mainly Atlantic distribution, in North and Western Ireland and Western Scotland (Jermy et al., 1978; Page, 1979 — see above). This new site extends the range of the species now to the coast of north-west England. The other notable feature of the colony is that, apparently, only one of its parents, *E. variegatum*, still grows with it.

In both Floras of Cheshire (Newton, 1971; Warren, 1899) *E. variegatum* is recorded from Wallasey on the North Wirral coast and along the Dee estuary to Gayton (which includes the Red Rocks site). It is also recorded in the earlier Liverpool Floras from the North Wirral coast (Hall, 1838; Dickinson, 1851; and Liverpool Naturalists Field Club, 1872.) However, the other parent, *E. hyemale* was first recorded at Red Rocks in 1968 by A. Newton (Newton, 1971). The voucher specimen for this record has not been obtainable and recent intensive searches have failed to find *E. hyemale* at Red Rocks. The only verified record for *E. hyemale* from the Wirral is from, 'sandhills, Heswell Cheshire', collected by Brown in 1871 (LIV), a site 7 km south of Red Rocks, along the River Dee shore. The 19th century Liverpool Floras (Dickinson, 1851; Liverpool Naturalists Field Club, 1872), also record *E. hyemale* from Parkgate and Thurstaston (sites which are also south of Red Rocks along the Dee shore) but neither of these records are supported by herbarium specimens. Recent searches of all these localities, have failed to find *E. hyemale*, but it is possible that it may yet be found in the area.

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I am indebted to Mr. & Mrs. E.F. Greenwood, who first introduced me to the population of *Equisetum* at Red Rocks and for their subsequent help, and to Dr. H.A. McAllister and Dr. C.N. Page for their advice.

REFERENCES

- DICKINSON, J. 1851. *The Flora of Liverpool*.
 HALL, T.B. 1838. *A Flora of Liverpool*.
 JERMY, A.C., ARNOLD, H.R., FARRELL, L.A. & PERRING, F.H. 1978. *Atlas of Ferns of the British Isles*. B.S.B.I. & B.P.S. London.
 LIVERPOOL NATURALISTS FIELD CLUB. 1872. *The Flora of Liverpool*.
 NEWTON, A. 1971. *Flora of Cheshire*. Cheshire Community Council Publications Trust Limited, Chester.
 PAGE, C.N. 1979. *Equisetum x trachyodon* in western Scotland, *Fern Gaz.* 12: 57–59.
 WARREN, J.L. 1899. *The Flora of Cheshire*. Ed. S. Moore. London.

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A SECOND BRITISH RECORD FOR *EQUISETUM* x *FONT-QUERI*, AND ITS ADDITION TO THE ENGLISH FLORA

In June 1978, an unfamiliar *Equisetum* was noticed by one of us (R.H.R.) on the site of a disused railway near Evesham, Worcs., v.c. 37. At a first glance it looked like a somewhat slender *E. telmateia* Ehrh., but closer inspection showed that cone-bearing shoots were present at this time of the year. These cone-bearing shoots had numerous whorls of long, green branches and seemed almost identical with the vegetative shoots. No unbranched, fertile stems, such as are characteristic of *E. telmateia*, could be found despite a prolonged search. The plant appeared to answer closely to the description of *E. x font-queri* Rothm., first reported for the British Isles by Page (1973). A representative sample of freshly-gathered material was sent to Edinburgh, where its identification was confirmed (by C.N.P.) as the second British station for *Equisetum x font-queri* Rothm. (*Equisetum palustre* L. x *E. telmateia* Ehrh.), and the first for England (the previously known British station being on the Isle of Skye).

The Worcestershire site on which the hybrid *Equisetum* grows is a disused railway embankment by the River Avon meadows near Evesham. A comparison between the Evesham plants of *E. x font-queri* and those known from Skye, shows the existence of strong overall similarities, yet some interesting differences in detail.

The overall shoot outline of the Evesham plants is very similar to that of the Skye plants and distinctly intermediate between those of *E. palustre* and *E. telmateia*. Thus the outline is slender, and tapers in most specimens to a long terminal branchless portion in the upper 10 cm or so of the shoot (see illustrations in Page 1973) — this is probably the best feature to look-out for in spotting plants of this hybrid. The overall size of the Skye and Evesham plants is similar, both being much larger than *E. palustre* (reaching 60-70 cm in the Evesham plants and about 65 cm in the Skye ones). In both Evesham and Skye material the whorled branches are abundant throughout the middle two-thirds of the shoot, and are quite strongly ascending (inheriting this feature from the *E. palustre* parent). Both have about 8-12 ridges to the main stem. The Evesham plants however differ from the Skye ones in having even more conspicuously white internodes, and longer free teeth to the main stem sheaths, and in these characters the Evesham plants approach the condition found in *E. telmateia* more than do those from Skye. However, the Evesham plants also have less distinctly bi-angulate and more rounded branch internode ridges, and less strongly 2-ribbed teeth to both the main stem and branch sheaths than do the Skye plants, and in these characters the Evesham plants approach nearer to the condition of *E. palustre* than do the Skye ones.

Despite these small morphological differences, there can be little doubt that the Evesham plants, like the Skye ones, are the result of crossing between *E. palustre* and *E. telmateia*. The differences, if not environmentally induced (which cultivation alongside the Skye plants at Edinburgh will determine), might either reflect differences in the relative genetic dominance of the particular characters in the original parents, or might result from the cross having occurred in the other direction, or a combination of both phenomena.

In the Evesham locality, the single colony of the hybrid forms a dense stand for a distance of about 75 metres on both sides of the top of a railway embankment, which is capped by a layer of ballast composed of coarse limestone chippings. As the habitat is entirely man-made, the origin of the hybrid *Equisetum* is problematic. It seems rather unlikely that it could have arisen on this site, for neither of the putative parents occurs anywhere near it at present. The ten-mile section of the old L.M.S. railway from Evesham to Alcester was opened in 1866 (Evesham Journal, July 14,

1866). The remaining section from Alcester to Redditch and Birmingham was opened later. It is most likely that the material used to build the embankment came from the large cutting between the embankment and the station in Evesham (B.G. Cox, pers. comm. 1978). The cutting was made through a ridge of well-drained soil and hence this too seems a most unlikely source of origin for the *Equisetum*.

A more likely explanation is that a piece of rhizome was introduced with the ballast brought in at a later date, as the material making up the embankment became consolidated. This implies that another colony of *E. x font-queri* existed (and perhaps still exists) elsewhere in Worcestershire, or in one of the adjoining counties. The Evesham to Redditch railway was closed in 1963 (Cox 1977: 109), and parts of the disused track to the north of the embankment have been sold. But the embankment itself, which at this point is about 4 metres above the level of the ground on either side, has so far remained undisturbed.

The dense and vigorous stand of the hybrid in the Evesham locality, in a habitat which does not appear particularly favourable to the growth of either *E. palustre* or *E. telmateia*, lends support to the observation already made on the very large colony on the Isle of Skye (Page 1973) that this hybrid is very vigorous and, once established, is capable of considerable vegetative spread even into habitats in which the occurrence of the parents would be unlikely.

Specimens of *E. font-queri* from Evesham have been deposited at BM, E, and P.

REFERENCES

- COX, B.G. 1977. *The Book of Evesham*. Chesham.
 PAGE, C.N. 1973. Two hybrids in *Equisetum* new to the British flora. *Watsonia* 9: 229–237.

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OBSERVATIONS ON LIGHT RESPONSE IN MARSILEA CRENATA

Ferns, like other plants, are phototropic — their fronds tend to turn towards the direction of greatest illumination. In addition, different species have distinct preferences for particular conditions of light and shade. *Marsilea crenata* Presl is a small aquatic fern which grows in full sunlight, rooting in the mud of rice fields, ponds and irrigation ditches. Where illumination is restricted, at the edge of a rice field or by competing plants, the fronds lean in the direction of maximum light intensity.

During the wet season the rhizome is long-creeping, producing fronds at intervals of 4-6 cm, but during the dry season it is short-creeping, producing small fronds close together. The lamina consists of two close pairs of pinnae arranged in a square at the apex of the stipe. Laminae of submerged plants either float on, or project above, the surface of the water. The following observations have been made in Malaysia.

In the field, under conditions of full illumination, the stipes are either vertical or lean with the flow of the water. The pinnae of projecting mature laminae lie in a horizontal plane during the middle of the day. Early or late in the day the lamina tilts to face towards the sun. When the light intensity decreases towards sunset, or when a heavy storm approaches, the pinnae fold together and the closed lamina assumes a nodding position. At dawn, or when the storm has passed, the lamina re-opens.

The daily variation in water temperature in rice fields can be more than 20°C, but this appears to have little or no effect on the opening and closing of the lamina, except that at temperatures greater than 40°C the stipes tend to wilt and the laminae then close. Both open and closed laminae were observed throughout the range of temperatures from 23° – 39°C.

In order to study the sensitivity of fronds of *Marsilea crenata* to light intensity and direction of illumination under more controlled conditions, plants were taken from a wet rice field near Rembau in Malaysia and grown in an aquarium tank. The rhizomes were planted at random, their elongating tips facing in all directions. Light intensities were measured with a photographic light meter and converted to foot-candles, using the formula quoted in Hoshizaki (1976):

$$\text{Foot candles} = \frac{20 (f)^2}{T S}$$

where f = aperture in f stop, T = shutter speed in seconds, and S = film speed in ASA units. The position of the tank was changed from time to time and the various responses were recorded.

The following observations were made:

1. During the day the stipes of mature fronds assumed a position pointing in the direction of illumination. The open laminae were at right angles to this, tilted towards the east in the morning and gradually changing their angle through the day until, in the early evening, they tilted towards the west.

2. Towards sunset, when the intensity of illumination decreased to 294 foot-candles, the laminae started to close (fig. 1 a-b). As the light dimmed, first the upper pair of pinnae gradually moved together, their upper surfaces facing. Then the lower pair started to close around them. Movement originated at the point of attachment of each pinna to the stipe apex. Finally, just before it was fully closed, the lamina changed position. Fronds facing both the elongating tips of their rhizomes and the direction of illumination during the day nodded in that direction. Fronds facing away from the elongating tips of their rhizomes either nodded in its direction or took up a vertical position. The process of closing, which took place over a period of 1-1.25 hours, was complete before sunset.

3. At dawn, when the light intensity reached 294 foot-candles, the laminae started to open again. First the lower or outer pair of pinnae moved apart, then the upper or inner pair, followed by tilting of the lamina towards the sun. Opening was complete after 1-1.25 hours on a normal sunny day.

4. As storms approached during the hours of daylight and the light intensity dropped below 294 foot-candles, the lamina closed as at night. The length of time taken depended on the speed of reduction of the light intensity. As soon as the storm passed and illumination increased again, the laminae re-opened. When prolonged heavy rain caused the light intensity to remain low, the laminae stayed closed until the following day. The critical light intensity for this response thus appears to be of the order of 294 foot-candles.

5. Placing the aquarium tank in a dark cupboard overnight delayed the opening of the lamina until such time as it was replaced in sunlight. The period taken for the lamina to open was dependent on the intensity of the sunlight when the tank was replaced. Removal of the tank from darkness to very bright sunlight, about 4500 foot-candles, reduced the time taken to half an hour.

6. Removal of the tank into the dark cupboard during the day also caused the laminae to close. They re-opened when the tank was replaced in sunlight. This effect was repeated several times in one day.

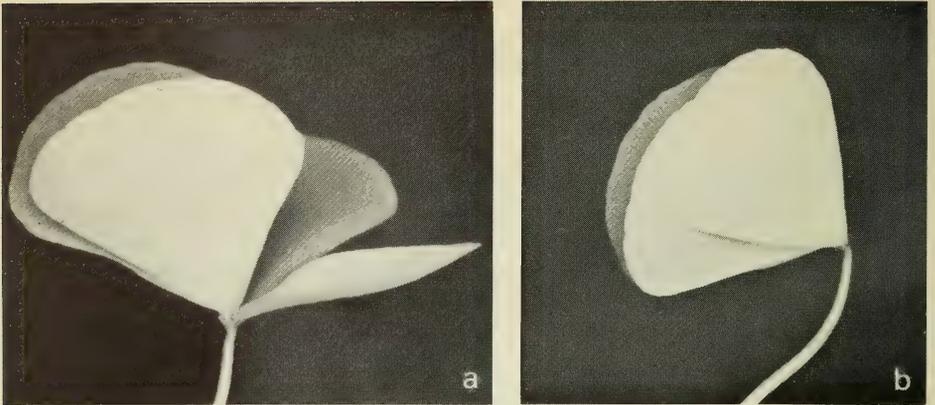


FIGURE 1. Lamina of *Marsilea crenata* (X 2 approx.): a, upper pinnae folded together; b, lower pinnae enclosing upper pair and the whole assuming a nodding position. (Photos C.J. Piggott)

7. The artificial illumination provided by ordinary electric lights was insufficient to cause the laminae to remain open at dusk, but by placing a powerful spot-light close to the tank it was possible to cause the laminae to re-open during the hours of darkness. They closed again when the spot-light was withdrawn.

8. During the observation period, new fronds were produced regularly. Very young fronds started to uncoil facing towards the tip of the rhizome. As elongation took place, the stipes twisted so that the fronds uncoiled facing the direction of illumination.

9. The water level in the tank was raised until several of the open laminae were floating on the surface. At dusk, or when placed in the dark, the smaller floating laminae remained open. Those with larger pinnae managed to overcome the effect of surface tension and close. Sometimes only one, two, or three, of the four pinnae were able to assume the folded position. Thus, where the laminae are not projecting but are floating on the surface of the water, only those fronds with large pinnae are able to overcome the surface tension and close their laminae.

10. Some small plants with short-creeping rhizomes were collected from the dry bank of an irrigation ditch and added to the tank. The small fronds of these dry season plants showed little response to changes in direction of illumination or to changes in light intensity. As the now submerged rhizomes elongated and produced larger fronds, the laminae became sensitive to such changes.

REFERENCE

HOSHIZAKI, B.J. 1976. *Fern Growers Manual*. New York.

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Kuala Lumpur 23-05, Malaysia.

THE FERN GAZETTE

Original papers, articles, or notes of any length on any aspect of pteridology will be considered for publication. Contributions will be particularly welcomed on floristic, biogeographical and ecological aspects of ferns and their allies, worldwide. Members are especially encouraged to make use of short notes for reporting pteridophyte field observations and records. All may be illustrated with black and white photographs of good technical quality and line drawings.

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THE BRITISH PTERIDOLOGICAL SOCIETY

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Membership is open to all interested in ferns and fern-allies, worldwide. Subscription rates (due on 1st January each year) are: Full Personal Members £4; Personal members not receiving the *Fern Gazette* £3; Student Members (full-time students) £3; Subscribing Institutions £5. Applications for membership should be sent to the Membership Secretary (address above), from whom further details can be obtained. (Remittances made in currencies other than Sterling are £0.50 extra, to cover bank conversion charges.)

Back numbers of the *Gazette* and *Bulletin* are available for purchase from J.W. Dyce (address above), from whom further details can be obtained.

HISTORICAL NOTES ON WOODSIA ILVENSIS IN THE MOFFAT HILLS, SOUTHERN SCOTLAND

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ABSTRACT

The main part of the account, which is based on literature sources, traces the historical background to the discovery and subsequent virtual extirpation of the rare fern *Woodsia ilvensis* in the Moffat Hills, Southern Scotland, during the second half of the 19th century.

In 1977, an investigation was carried out by the author on behalf of the Nature Conservancy Council into the past and present status of *Woodsia ilvensis* (L.) R.Br. in the Moffat Hills, Southern Scotland. It was found that the initial examination of literature sources gave not only the required list of published records, but also a fascinating insight into the background to the fern's virtual extirpation from its former principal station in the British Isles.

The discovery of a rare plant or animal species occurring abundantly at a hitherto unknown locality, only to be brought to the brink of extinction within a few years by over-collecting is an only too familiar story. Britain's native ferns have been no exception to this form of wanton destruction, and the few scattered populations of *W. ilvensis* suffered worse than most. The beginning of what was almost the end for this rare fern in the north-eastern portion of Dumfriesshire (v.c. 72) can be precisely dated to 1848, the year of completion of the Caledonian Railway linking Beatock (2 miles from Moffat) with Edinburgh, Glasgow and Carlisle. Moffat's hotel proprietors vied with one another for the immediate influx of visitors, many of who came seeking relief from their aches and pains at the famous but up to then rather remote local mineral wells, meeting each incoming train with horse-drawn omnibuses to convey prospective guests to their respective establishments (Turnbull, 1871). It was one such visitor to the area, a botanist named Stevens, who chanced upon *W. ilvensis* 'in considerable abundance' at White Coomb in the nearby Moffatdale Hills (Stevens, 1849). In the following year (1849) a second station for the *Woodsia* was found just north of Moffat at the Devil's Beef Tub (Oliver, 1850). With several additional localities being discovered in the district during the next few years, including a ravine near Loch Skene (Newman, 1854), Hartfell (Balfour, 1858) and the head of the Carrifran Burn (Sadler, 1857), the Moffat Hills became recognised as the headquarters for *W. ilvensis* in the British Isles.

Steven's disclosure that *W. ilvensis* was apparently to be found in some quantity at Moffat could not have been more unfortunately timed, coinciding as it did with an impending wave of 'Pteridomania' or 'Fern fever' that was to grip Victorian Britain for at least two decades from the late 1840s. The middle-class's obsession with obtaining and cultivating hardy native ferns proved insatiable, the unprecedented demand resulting in the emergence of a new type of fern dealer/nurseryman who scoured the countryside for much of his stock (Allen, 1969). In the Moffat area, the effect of the more selective trade in wild ferns was felt first at the Devil's Beef Tub, for, within three to four years, professional collectors had completely eradicated all the *Woodsia* plants from this readily accessible site (Keddie, 1854). Fern dealers' activities in the district evidently continued, shown by an article that appeared in the *Moffat Register and Annandale Observer* on 6th October 1860 accusing York nurseryman James Backhouse (not mentioned by name, but see Backhouse, 1860) of unscrupulously

uprooting a number of *W. ilvensis* plants and disposing of them to his clients at half-a-guinea a time (Sadler, 1860). It is probable this indignant outburst drawing attention to the high monetary value being placed on the fern did not have quite the effect intended, for Hope (1929) states that the local hill shepherds (seemingly not slow in sensing a remunerative side-line), joined in the gathering of *Woodsia* plants for sale. Despite the inclusion in the fern nurserymen's catalogues of *W. ilvensis* imported from abroad, plants of British origin continued to sell at relatively high prices throughout the 1860s. Collecting *W. ilvensis* from the wild may have been profitable but was not without its dangers, for several lives were apparently lost in its pursuit on the precipitous cliffs of Glyder Fawr in North Wales (Step, 1908). In the Moffat Hills, the treacherous broken rocks above the Carrifran falls almost claimed a future Curator of the Royal Botanic Garden, Edinburgh, as he unsuccessfully attempted to obtain a tuft of *W. ilvensis* just beyond his reach (Sadler, 1860).

Nurserymen and gardeners were not alone in casting covetous eyes on this attractive miniature fern, for good specimens were much in demand for private and institutional herbaria. Such was the appeal of the rare *W. ilvensis* to collectors, it was to hold a permanent place in the Botanical Exchange Club's 'List of Desiderata' from the 1850s right up to the turn of the century, contributors to the scheme being encouraged to submit a minimum of ten specimens for distribution to other club members. To judge from the few surviving sheets of *W. ilvensis* housed in University and Museum herbaria (see Rickard, 1972), the peak period of collecting from the Moffat Hills for 'scientific purposes' occurred in the 1850s. Visiting botanical parties were often extremely large, and it is recorded that one such well attended excursion led by Professor J.H. Balfour in July 1856 gathered *W. ilvensis* 'in considerable quantity' (Balfour, 1858).

Amongst the proliferation of books on British ferns that appeared in the 1850s and 1860s was a fairly recent innovation popularly known as a 'Fern Album'. These albums consisted of annotated sets of pressed ferns from named localities in various parts of Britain and elsewhere. The 'Moffat Fern Album' (Carruthers, 1863), or under its correct bibliographical title *The Ferns of Moffat*, first made its appearance in 1863. Written by Dr. W. Carruthers, a native of Moffat employed at that time as Assistant Keeper in the Department of Botany at the British Museum, this unsigned descriptive work appears to have been issued with the specimen pages left blank for the visiting fern enthusiasts to insert their own self-collected examples. It is likely however, that enterprising local entrepreneurs would take on the task of filling-in the blank spaces with specimens, in order to re-sell the completed or part-completed album at a suitably increased price to the less energetic or invalid visitor. Of five copies of the Moffat Fern Album examined by the present writer, two contained pressed specimens of *W. ilvensis* on the appropriate page.

Under intense collecting pressure from locals and visitors alike, Moffat's once thriving population of *W. ilvensis* — estimated at 'hundreds of plants' in 1856 (Scott-Elliot, 1896) — was eventually reduced to just one known solitary tuft by 1891 (Johnstone, 1893). Recriminations inevitably followed, and in *The Flora of Dumfriesshire* (Scott-Elliot, 1896) the author firmly places the blame on 'the ravages of the Innerleithen Alpine Club'. On the face of it this accusation seems a little unjust, as the club was not formed until 1889, long after most of the damage is known to have been done. It is possible however that the members were responsible for administering the *coup de grâce* to a remnant colony of *W. ilvensis* at the head of the Midlaw Burn, near Loch Skene, when the Innerleithen Alpine Club visited the upper glen in strength in 1889 and again in 1894, returning with 'vasculum crammed' and 'stuffed vascula,

quite pleased if not happy with the spoils' (Todd & Young, 1895). What appears to have been the last recorded incident in the whole sorry story involved G. Claridge Druce, a leading field-botanist of the period, when in August 1909 he was shown the supposed one remaining tuft of *W. ilvensis* in the Moffat Hills (Druce, 1910). Druce wished the sole surviving plant well for the future, but could still not resist helping himself to a few fronds before taking his leave.

Looking back with the advantage of hindsight, the almost complete extirpation of *W. ilvensis* from its British headquarters in the Moffat Hills was inevitable. As Raven & Walters (1956) so aptly describe the fate of the now extinct colony of *W. ilvensis* in upper Teesdale, North-East England — it 'suffered the misfortune of too much publicity'. To those charged with attracting and sustaining the lucrative tourist trade to Moffat during the second half of the 19th century, the local ferns (in particular the rare *W. ilvensis*) would have seemed an obvious natural resource to be promoted in much the same way as the alleged healing properties of the local mineral waters had been for the previous hundred years. Successive editions of the Moffat guide book referred in glowing terms to the choice ferns and wild flowers that were to be readily found in the surrounding countryside. Even when the current enthusiasm for collecting and cultivating ferns eventually waned, Moffat's publicists appeared reluctant to accept the change in Victorian taste. The Moffat Fern Album was still being advertised for sale in 1894 and as late as 1902 the 5th edition of the guide book was suggesting that *W. ilvensis* ('much valued by collectors') *might* still be found at the Devil's Beef Tub, although it was known to have been collected-out from this particular spot fifty years earlier. Yet by this time the fern craze had been over for a good number of years, exemplified by a leading nurseryman's catalogue price for the once much sought after *W. ilvensis* having slumped to a shilling.

With the death of veteran Moffat botanist J.T. Johnstone in 1922, the last personal knowledge of the exact whereabouts of some of the former *W. ilvensis* sites in the district appears to have been lost. Nothing more was seen or heard of the fern in the Moffat Hills until 1954, when a small population of about 25 plants was found by D.A. Ratcliffe while undertaking a botanical survey of the upland area (Ratcliffe, 1959). Eighteen years later, a second small colony was turned-up by M.H. Rickard during a field meeting of the British Pteridological Society in 1972 (Dyce, 1972). Curiously, the re-discovery of *W. ilvensis* in the Moffat area again coincided with an awakening of public interest in the collecting and growing of ferns. In the last few years a number of popular books and articles on cultivating ferns have been published, some of them even advocating a revival of the once discarded and almost forgotten 19th century Wardian cases and bell-glasses as a solution to the modern fern-grower's problem of centrally-heated flats and houses. It is of regrettable necessity therefore, that the precise localities of the two recently found *W. ilvensis* colonies in the Moffat Hills must remain a closely guarded secret for at least the foreseeable future.

ACKNOWLEDGEMENTS

I would like to express my appreciation for the assistance given in tracing published literature on the occurrence of *Woodsia ilvensis* in Moffatdale to the library staffs at the Nature Conservancy Council Headquarters for Scotland, the Royal Botanic Garden, Edinburgh, and the Ewart Library, Dumfries. Also to John H. Harvey and Jeannette Ratcliffe for readily making available the results of their researches into early horticultural catalogues specialising in ferns. It is a particular pleasure to thank Dr. Derek Ratcliffe, not only for the original suggestion of drawing together this historical account, but for kindly reading through the initial draft.

REFERENCES

- ALLEN, D.E. 1969. *The Victorian Fern Craze*. London.
- BACKHOUSE, J. 1860. Botany of the Breadalbane Mountains. *The Phytologist* 4(NS) : 65–67.
- BALFOUR, J.H. 1858. Notice of a Botanical Trip to Moffat in July 1856. *Transactions of the Botanical Society of Edinburgh* 5 : 166–169.
- CARRUTHERS, W. 1863. *The Ferns of Moffat*. Moffat.
- DRUCE, G.C. 1910. Plants of some Southern Scottish Counties. *The Annals of Scottish Natural History* 30 : 39–43; 95–102.
- DYCE, J.W. 1972. Report of a field meeting at Teesdale and Moffat, 21–30 July 1972. *British Pteridological Society Newsletter* No. 10, pp 11–15.
- HOPE, M.I. 1929. Report of a field meeting at Loch Skene, 25 July 1928. *History of the Berwickshire Naturalists' Club* 26 : 306–308.
- JOHNSTONE, J.T. 1893. Notes on the Flora of Moffat District for 1891. *Transactions of the Dumfries & Galloway Natural History & Antiquarian Society* 8(NS) : 18–21.
- KEDDIE, W. 1854. *Moffat: Its Walks and Wells*. Glasgow, Edinburgh & London.
- NEWMAN, E. 1854. *A History of British Ferns*. London.
- OLIVER, D. 1850. Note on *Serratula tinctoria*, *Alsine stricta*, and a species of *Woodsia*. *The Phytologist* 3 : 775.
- RATCLIFFE, D.A. 1959. The Mountain Plants of the Moffat Hills. *Transactions of the Botanical Society of Edinburgh* 37 : 257 – 271.
- RAVEN, J. & WALTERS, M. 1956. *Mountain Flowers* (New Naturalist Series). London.
- RICKARD, M.H. 1972. The distribution of *Woodsia ilvenis* and *W. alpina* in Britain. *British Fern Gazette* 10 : 269 – 280.
- SADLER, J. 1857. *Narrative of a ramble among the Wild Flowers on the Moffat Hills in August 1857*. Moffat.
- SADLER, J. 1860. A Botanist's ramble up Moffatdale. *The Moffat Register and Annandale Observer* (Saturday 6th October 1860).
- SCOTT-ELLIOT, G.F. 1896. *The Flora of Dumfriesshire*. Dumfries.
- STEP, E. 1902. *Wayside and Woodland Ferns*. London & New York.
- STEVENS, W. 1849. Notes on the Flora of Dumfriesshire. *The Phytologist* 3 : 390–393.
- TODD, J. & YOUNG, T. 1895. *Principal Excursions of the Innerleithen Alpine Club during the years 1889–1894*. Galashiels.
- TURNBULL, W.R. 1871. *History of Moffat*. Edinburgh.

POLYPODIUM MACARONESICUM AND P. AUSTRALE : A MORPHOLOGICAL COMPARISON

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ABSTRACT

Some of the morphological characters of *Polypodium macaronesicum* Bobrov have been studied and a comparison with those of *P. australe* Fée has shown that several of them can be used to separate these taxa unequivocally. In particular the characters of frond serration, shape of the rhizome scales, the size and branching of the paraphyses and the structure of the sporangium have been found useful to differentiate between them. The recognition of *P. macaronesicum* as a species distinct from *P. australe* is considered to be justified.

INTRODUCTION

Polypodium macaronesicum Bobrov occurs on the Atlantic islands of the Azores, Madeira and the Canaries (Page, 1977; Ward, 1970). It looks superficially like a well-grown *P. australe* Fée with larger, proportionately broader fronds and more coarsely serrated pinnae.

The Azorean plants have been referred to as *P. vulgare* L. var. *serratum* Willd. (Seubert, 1844), *P. vulgare* L. subsp. *azoricum* Vasc. (Vasconcellos, 1968) and even as a distinct species *P. azoricum* (Vasc.) R. Fernandes (Fernandes, 1968). However, Fernandes has based her conclusions on only one specimen of *P. macaronesicum* and observations on a wider range of material have shown that the characters used by Fernandes to distinguish *P. azoricum* are unreliable, as was also noticed by Ward (1970). In plants from both the Canary Islands and the Azores these characters are much more variable than this author assumed. The azorean plants are thus better regarded as conspecific with *P. macaronesicum*, although there are some indications which suggest that it may eventually be possible to separate them as a subspecies of this taxon. Nardi (1977) has also concluded that the separation of *P. azoricum* from *P. macaronesicum* at species level is not justified.

Recently *P. macaronesicum* has been reported from the extreme southern tip of the Iberian peninsula (Garretas & Salvo-Tierra, 1979). This is the first recorded occurrence of this species from continental Europe.

Because of their superficial resemblance to *P. australe* these plants have sometimes been recorded as this species, for example, in Flora Europaea (Valentine, 1964), or placed under it as a subspecies (Nardi, 1977). However, there are several characters by which *P. macaronesicum* can be separated quite unambiguously from *P. australe* and these are summarised below.

FROND CHARACTERS

In *P. macaronesicum* the fronds are normally very large with a broadly triangular to ovate-triangular blade (fig. 1a). Although there is a considerable overlap in frond shape between it and *P. australe*, the ratio of blade length to breadth ($\frac{L}{B}$) differs in the two species. In *P. macaronesicum* this ratio varies from 0.9 to 2.2, in *P. australe* from 1.2 to 2.4.

The pinnae of *P. macaronesicum* are also very coarsely serrate with blunt teeth, or in some specimens crenate, while those of *P. australe* vary from prominently to shallowly serrate (occasionally with no appreciable serration) and with more acute teeth. An additional difference which became evident during the course of this study

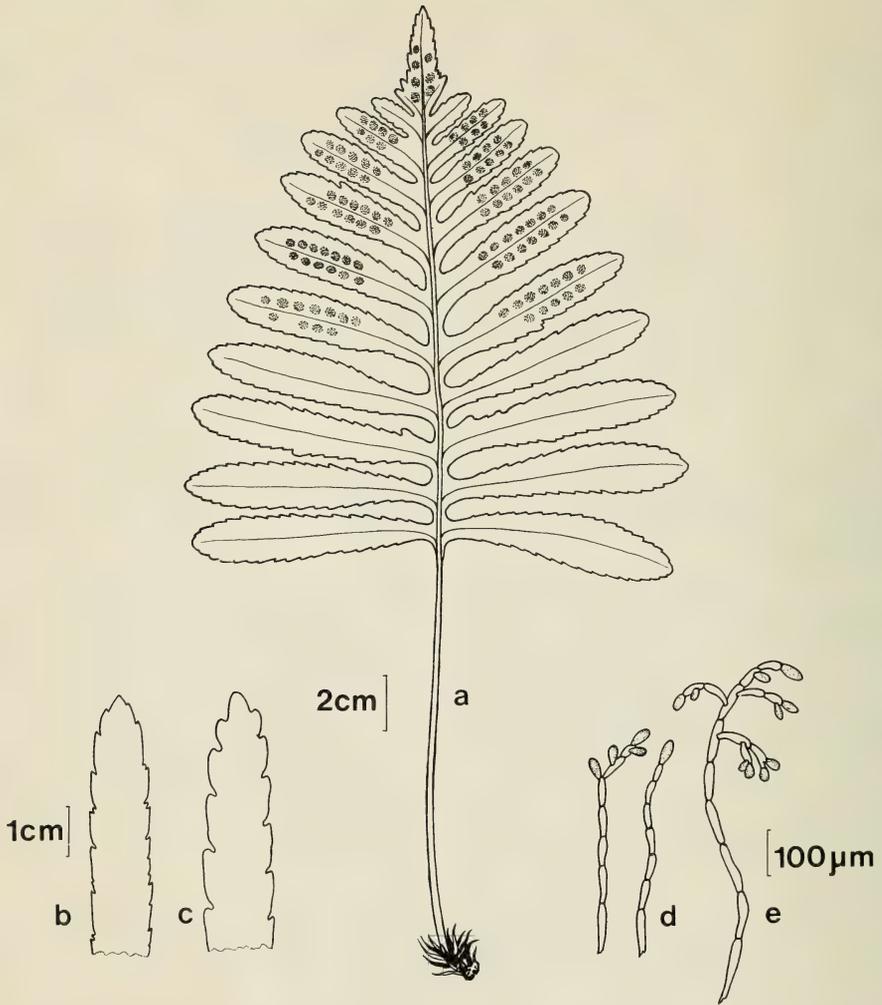


FIGURE 1. *Polypodium macaronesicum* and *P. australe* compared: a, whole frond of *P. macaronesicum*; b, tip of pinnae of *P. australe*; c, tip of pinna of *P. macaronesicum*; d, paraphyses of *P. macaronesicum*; e, paraphysis of *P. australe*.

is that the pinnae of *P. macaronesicum* are almost constantly simply serrate, while those of *P. australe* are doubly serrate. These differences can easily be observed with a X 10 lens (fig. 1b, c).

RHIZOME SCALES

There is a very noticeable difference between *P. macaronesicum* and *P. australe* in the shape of the rhizome scales. Those of the former are more broadly ovate-lanceolate (up to 13.5mm long and 4mm wide) than those of the latter (up to 16mm long and 3.2mm wide), and their margins are more coarsely denticulate.

Bobrov (1964) described a dark central stripe in the rhizome scales of *P. macaronesicum*, but Fernandes (1968) could not find it in those of the azorean plants. Ward (1970), however, observed that the scales of some specimens from Flores had a

faint stripe. This feature seems to be so variable as to have little, if any, taxonomic value.

SPORANGIUM CHARACTERS

The annulus of the sporangium in *P. macaronesicum* is very similar to that of *P. australe*, although there is a small difference in the ranges of annulus width. This varies from 60 to 96 μm in the former species; from 70 to 105 μm in the latter. On the other hand the mean lengths of the indurated cells of *P. macaronesicum* (measured when the annulus of a dehiscid sporangium is flattened between two glass slides), were found to be nearly identical with those of *P. australe* (Roberts, 1966).

The two species also differ in the ranges of the number of indurated cells in the annulus: (7-) 9-20 in *P. macaronesicum*, (2-) 4-18 in *P. australe*. The following figures give the mean number of indurated cells based on 50 sporangia from each plant: *P. macaronesicum*, 10-14; *P. australe* 5-11. Badré & Prelli (1978) have found similar values for this character in *P. australe* during a recent study of the *P. vulgare* aggregate in the Armorican Massif, France.

The basal cells of the sporangium, however, provide an absolute criterion for separating the two species. In *P. macaronesicum* the number of these cells is (0-) 1-2; in *P. australe* (2-) 3-4 (-5). This character is most easily observed in dehiscid sporangia (fig. 2a, b) and examination of 5 or 6 sporangia is then sufficient to give a clear separation.

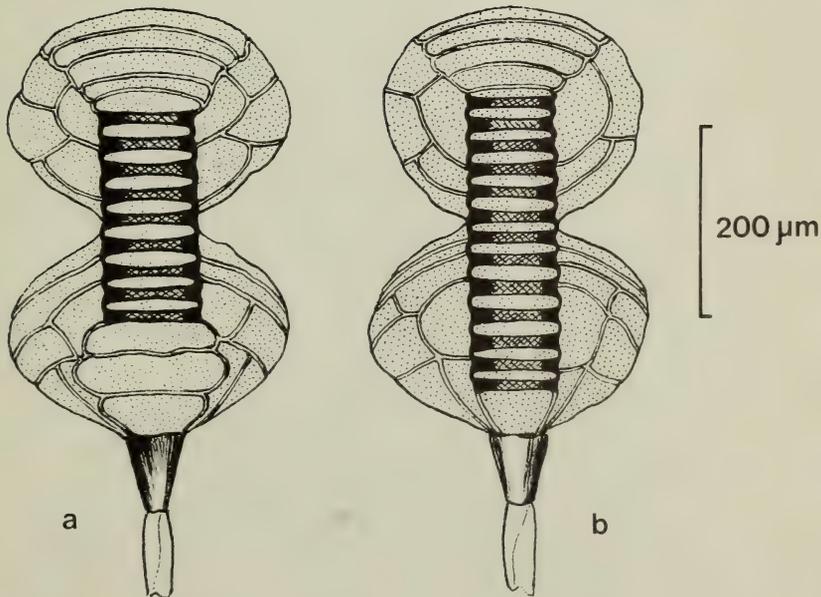


FIGURE 2. Dehiscid sporangia of (a) *P. australe*; (b) *P. macaronesicum*.

PARAPHYSES

Fernandes (1968) was uncertain whether true paraphyses occurred among the sporangia of *P. macaronesicum*. However, they have been found in all specimens of this species examined during the present study and in those seen by Garretas & Salvo-Tierra (1979).

The paraphyses of *P. macaronesicum* differ from those of *P. australe* in being much shorter and either unbranched or with a few, very short branches (fig. 1d, e). They are also not so abundant as in most plants of *P. australe*, though it should be noted that the abundance of paraphyses in this species is very variable: occasionally plants are encountered with only 2 or 3 paraphyses in each sorus.

The following figures show the difference between the two species in the length of the paraphyses: *P. macaronesicum*, (200-) 300-400 (-800) μm ; *P. australe*, (400-) 600-1,200 (-1,800) μm .

SPORES

Shivas (1961) studied spore length in the *P. vulgare* aggregate. She measured samples of 50 spores from each plant and found that the range of mean values for *P. vulgare* (56-68 μm) shows a large overlap with the range for *P. australe* (62-74 μm). Those of *P. interjectum* alone (74-88 μm) were large enough to be of taxonomic use.

Only a small number of spore samples of *P. macaronesicum* have been available during this study. Random samples of 50 have been measured and the mean values obtained from them were seen to vary from 57 to 63 μm . These figures correspond most nearly to those of *P. vulgare* given by Shivas, but they also overlap with her values for *P. australe*. It thus seems that measurements of spore length will have at best only a limited taxonomic usefulness. Further measurements of spores from a larger sample of plants from the Atlantic islands and the Iberian peninsula are desirable.

HABITAT

Page (1977) has described the habitat preferences of *P. macaronesicum* in the Canary Islands. He found that, with *Asplenium noopteris* L. and *Davallia canariensis* (L.) Sm., it is one of the three most abundant ferns of the heath forests, growing extensively along the mossy forest floor, on exposed roots, over rocks and moss-covered boulders, upon the trunks of fallen trees, and as an epiphyte along large branches of mature tree heaths. It also grows on exposed rock faces and cliffs, situations which dry out in summer. Page observed that the fern can adapt to such habitats by shedding its fronds and surviving the summer drought as thick, scale-covered rhizomes. In light shade it tends to remain evergreen.

In Flores Ward (1970) found this fern commonly growing on the tops of walls, on roadside banks and as an epiphyte on trees. Garretas & Salvo-Tierra (1979) have found that in the Iberian peninsula it shows similar habitat preferences, being found in acidic, shaded situations and epiphytic on trees.

P. australe, on the other hand, is well known to be a calcicole and is mainly found in crevices of limestone or other base-rich rocks, on mortared walls, and occasionally as an epiphyte on trees in limestone woodland.

The two species thus not only differ morphologically, but also in their habitat preferences. Moreover, Garretas & Salvo-Tierra (1979) have found several specimens showing a mixture of the characters of the two species and with aborted sporangia. They grow in the ecotone between the habitats of the species and these authors suggest that they may be hybrids. Their existence opens the way for experimental work which may throw further light on the relationship of *P. macaronesicum* and *P. australe*.

KEY TO THE EUROPEAN SPECIES OF POLYPODIUM

The main characters which can be used to separate the four European species are summarised in the following key. This is based mainly on the work of Shivas (1961), Benoit (1966), Roberts (1966; 1970) and the results reported here.

1. Rhizome scales 5 to 13.5mm long (or more); sori with paraphyses; blade of frond usually broadly triangular-ovate (ratio of length to breadth 0.9 - 2.4) 2
Rhizome scales 3 to 10mm long; sori without paraphyses; blade of frond usually lanceolate (ratio of length to breadth 1.4 - 4.3) 3
2. Sori with large, branched paraphyses; number of basal cells of the sporangium (2-) 3 - 4 (-5); rhizome scales narrowly lanceolate, up to 15mm long. *P. australe* Fée
Sori with small, unbranched or shortly branched paraphyses; number of basal cells of the sporangium 0 - 1 (-2); rhizome scales broadly lanceolate, up to 13.5mm long *P. macaronesicum* Bobrov
3. Number of indurated cells in the annulus (4-) 7 - 10 (-13); ripe annulus colourless or pale golden-brown; number of basal cells of the sporangium 2 - 3; rhizome scales broadly ovate-lanceolate, up to 10mm long *P. interjectum* Shivas
Number of indurated cells in the annulus (7-) 11 - 14 (-18); ripe annulus reddish-brown; number of basal cells of the sporangium (0-) 1; rhizome scales broadly ovate with acuminate tip, 3 to 6mm long *P. vulgare* L.

It is hoped that further work in progress will help to elucidate the morphological relationships of the different populations and the possibility of separating them into subspecies (Page & Roberts, in preparation), whilst a hybridisation programme is in progress to establish their genetic interrelationships with the rest of the *P. vulgare* aggregate in Europe and North America (M.G. & T.G. Walker, in preparation).

ACKNOWLEDGEMENTS

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REFERENCES

- BADRE, F. & PRELLI, R. 1978. Les espèces du groupe *Polypodium vulgare* du Massif armoricain. *Candollea* 33: 89-106.
- BENOIT, P.M. 1966. Some recent work in Wales on the *Polypodium vulgare* aggregate. *Br. Fern Gaz.* 9: 277-282.
- BOBROV, A.E. 1964. A comparative morphological and taxonomical study of the species of *Polypodium* L. of the flora of the U.S.S.R. *Bot. Zh. SSSR* 49: 534-545.
- FERNANDES, R.B. 1968. Sobre a ocorrência do complexo *Polypodium vulgare* nos Açores. *Bol. Soc. broteriana*, 2a sér. 42: 35-158.
- GARRETAS, B.D. & Salvo-Tierra, A.E. 1979. Sobre la existencia de *Polypodium macaronesicum* Bobrov en le S. de la Península Ibérica. *Acta Bot. Malacitana* 5: 5-13.
- NARDI, E. 1977. Note sistematiche sur *Polypodium australe* s.l. della Isole Atalantiche (Azzorre, Madera, Canarie). *Webbia* 31: 79-96.
- PAGE, C.N. 1977. An ecological survey of the ferns of the Canary Islands. *Fern Gaz.* 11: 297-312.
- ROBERTS, R.H. 1966. Some observations on *Polypodium australe*. *Br. Fern Gaz.* 9: 283-287.
- ROBERTS, R.H. 1970. A revision of some of the taxonomic characters of *Polypodium australe* Fée. *Watsonia* 8: 121-134.
- SEUBERT, M. 1844. *Flora azorica quam collectionibus schedisque Hochstetteri patris et filii elaboravit.* Bonn.

- SHIVAS, M.G. 1961. Contributions to the cytology and taxonomy of species of *Polypodium* in Europe and America, II : Taxonomy. *J. Linn. Soc. (Bot.)* 58: 27-38.
- VALENTINE, D.H. 1964. *Polypodiaceae*, in Tutin, T.G. et alia (eds.) *Flora Europaea* 1: 23.
- VASCONCELLOS, J.C. 1968. Nota sobre o polipódio dos Açores. *Bolm. Soc. broteriana*, 2a sér. 42: 159-160.
- WARD, C.M. 1970. The pteridophytes of Flores (Açores) : a survey with bibliography. *Br. Fern Gaz.* 10: 119-126.

REVIEW

HOW TO KNOW THE FERNS AND FERN ALLIES by John T. Mickel 229 pp., 1979. *The Pictured Key Nature Series, Brown, Dubuque. Price: \$5.95 (£3.25 from B.P.S. Booksales.)*

This book, written by the Curator of Ferns at New York Botanic Garden, is about the pteridophytes of North America. The first 32 pages give an excellent introduction to fern structure and life history, hybridization and chromosome counting; for the horticulturist is a chapter on growing and collecting. A short chapter on 'How ferns are named' helps to explain to the layman the logic behind professional vascillations. There is a key to 60 genera found on the Continent and further keys to species are found throughout the text in which the genera are arranged in alphabetical order; 392 species and 38 hybrids are discussed and the majority are illustrated by quarter page, often thumbnail, but quite clear and adequate line drawings. For each of these species a minimap shows the distribution throughout the Continent.

The data content of this book is really excellent value: over sixty percent of the British ferns are included and only slightly less of our European taxa. Of greatest interest are those American counterparts of species restricted to Western Europe, such as *Polypodium virginianum* and *P. glycyrrhiza*, (cf. *P. vulgare*) *Dryopteris campyloptera* (cf. *D. austriaca*) *Isoetes macrospora* (cf. *I. lacustris*) *Polystichum andersonii* (cf. *P. aculeatum*). A diagrammatic relationship chart of some *Polystichum* species is given on p. 175, showing how diploid species have hybridised to form fertile tetraploid species. This occurs in many genera and I would like to have seen more such charts. There is scope, I think, even in a work like this, which aims to be definitive, for discussion on putative species complexes. For instance no mention is made of the two cytotypes in *Polypodium virginianum* and *Asplenium trichomanes* or the problems that exist in *Cystopteris fragilis/protusa* where in North America there exists the only diploid race found in the complex. Hybrids are seen to be common in *Asplenium* (including *Camptosorus*) and *Dryopteris* and *Equisetum*.

Interestingly *Woodsia ilvensis* is said to form a hybrid (*W.* x *abbeae*) but the other parent is not known: *Osmunda* x *ruggii* is a spectacular hybrid between *O. claytoniana* (the Interrupted Fern) and *O. regalis*. There is also a hybrid between *Gymnocarpium dryopteris* and *robertianum* (*G.* x *heterosporum*) which should be looked for in Britain and Europe. I am surprised there are no hybrids recorded in *Cheilanthes* and *Pellaea* or in *Polypodium*, where triploid cytotypes certainly exist, and in *Lycopodium* (*Diphasiastrum*).

These are small points, however. Everyone will want this book and I hope its publishers will assure its availability.

A.C. JERMY

STUDIES IN THE PLANT SOCIOLOGY OF FERN-DOMINATED WALL COMMUNITIES ON THE ISLAND OF CORFU

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ABSTRACT

In the first of a series of papers on fern-dominated vegetation of rocks, screes and walls of western Europe, the problems associated with the description and classification of pioneer, fern-dominated vegetation are discussed. A simple descriptive and classificatory method is recommended and exemplified by reference to the vegetation of calcareous walls in Corfu and the distribution of the Mediterranean association of *Selaginella denticulata* and *Anogramma leptophylla* (Selaginello-Anogrammetum leptophyllae). The classification of Mediterranean and Lusitanian rock and wall vegetation is reviewed and a phytosociological system of nomenclature proposed as a basis for future research on the plant sociology and ecology of pteridophytes.

INTRODUCTION

The analysis of fern-dominated rock and wall vegetation has been rather a neglected subject throughout the history of British and continental European plant sociology. Perhaps one of the main reasons for the apparent lack of attention is that such vegetation types are relatively species-poor, pioneer communities, that are seldom well developed structurally. However, over the past fifty years, there have been developed a number of systems of classification of vegetation which include fern-dominated communities, but which are difficult and often confusing to interpret. There remain many questions to be answered, and the collection of simple ecological and floristic data by pteridologists would certainly help to reduce such confusion and provide a vital contribution to a unified system of European plant sociology. The work of Segal (1969) on the ecology of the vegetation of European walls has provided a major contribution to an understanding of the floristic relationships of many fern-dominated communities, and it is perhaps his modification of the Braun-Blanquet scale of cover-abundance which could be adopted as the basis of a relatively simple field method. According to Segal (1969: 16, 101) at each sample quadrat or relevé, the following data should be recorded:

date and locality;

exposure and angle of slope (e.g. NNE 70°);

nature of substratum and the relative surface area of mortar joints;

size of quadrat (relevé) (for communities dominated by small vascular plants e.g. most rupestral ferns, this should be 1 sq. m; for those with larger vascular plants such as *Gymnocarpium robertianum* and *Thelypteris limbosperma* a 2 sq. m quadrat should be taken;

a complete list of all flowering plants, ferns, bryophytes and macrolichens; microlichens and fungi are traditionally omitted, but if expertise allows their identification, they should be included;

visually estimated cover of the herb layer and bryophyte/lichen layer;

cover/abundance values according to the Segal/Barkman scale (see table 1).

TABLE 1: BRAUN-BLANQUET SCALE OF COVER/ABUNDANCE AS MODIFIED BY SEGAL (1969)

		Cover %
r, +r	1-2 individuals	
+p	not frequent, 3-20 individuals	1%
+a	not frequent, 3-20 individuals	1-2%
+b	not frequent, 3-20 individuals	2-5%
1p	frequent 21-100 individuals	1%
1a	frequent 21-100 individuals	1-2%
1b	frequent 21-100 individuals	2-5%
2p	very frequent > 100 individuals	1%
2m	very frequent > 100 individuals	5%
2a	numbers of individuals various, but cover	5-12%
2b		12-25%
3a		25-36%
3b		37-50%
4a		50-62%
4b		62-75%
5a		75-87%
5b		87-100%

Following the field description there are five steps in the characterisation and classification of the quadrats to enable neat presentation and rapid comprehension of the data (Shimwell 1971):

aggregation of the field data into tables to represent the local variations in vegetation;

checking in the field, the ecological reality of the units extracted from the tabulation by simple field observations or measurement of environmental features; are the units described in the table readily recognisable in the field?

investigation of similar patterns in other localities, thereby obtaining an overall pattern of variation within a particular vegetation type; do the patterns recur in different geographical regions?

erection, differentiation and characterisation of associations; what species serve to label the communities and define the main lines of variation within them?

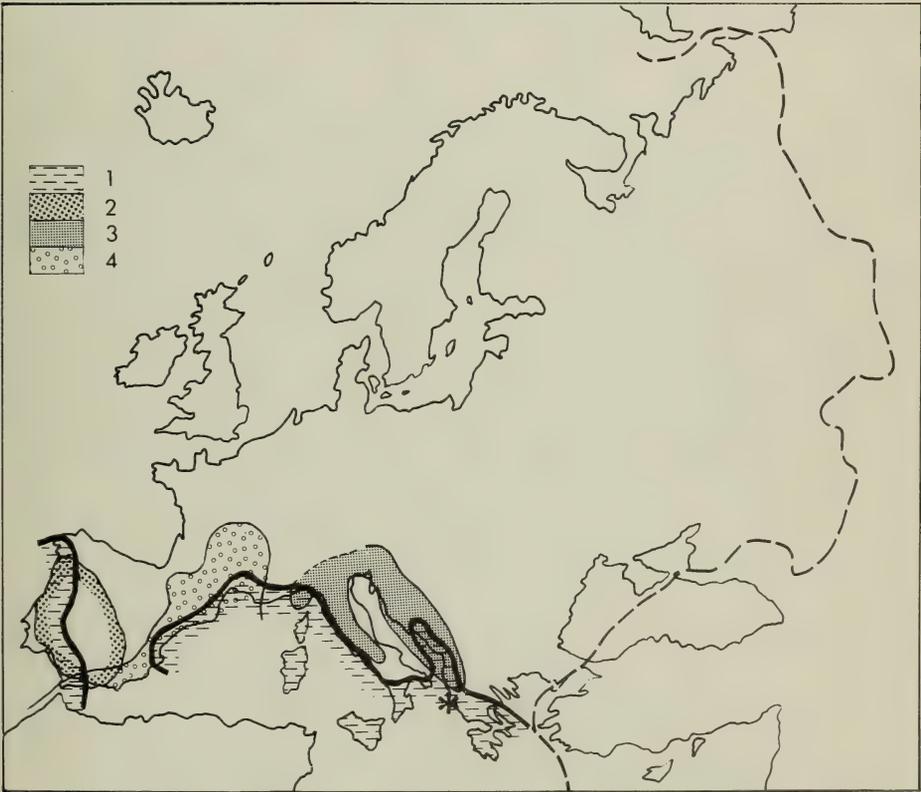
classification of the associations into a hierarchical system of alliances, orders and classes of vegetation by reference to previously published work using an internationally accepted code of nomenclature. (Moravec 1968).

The general approach to description and classification is probably best exemplified by a specific example, as follows.

The coincidence of *Selaginella denticulata* and *Anogramma leptophylla* in rock and wall crevices in the more humid localities of several islands and coastal regions in the Mediterranean region from Crete to Sardinia (Zaffran 1970, De Joncheere 1963), and on the Atlantic islands of Sao Miguel in the Azores (Wilmanns & Rasbach 1973) and Madeira (Benl 1970) is quite a well known phenomenon. But despite this familiarity, the only detailed records available are those of Molinier (1937) from the Isle of Hyères, France, of Braun-Blanquet (1966) from Guipuzcoa Province, northern Spain and of Segal (1969) from the Island of Elba, Italy and Ramatuelle in the Var district of southern France. This lack of data may partly be due to the persistence of the annual *A. leptophylla* only through the humid period of the year from November

to May and its subsequent desiccation, along with other cryptogams. During a visit to the island of Corfu in late April, it became apparent that this mural community was probably at the best stage of its annual development and some 21, one sq. m. quadrats were thus collected as a contribution to an understanding of fern-dominated vegetation in the Mediterranean region and to clarify the plant sociological affinities of this community. In France, the community is known to plant sociologists as the association *Selaginello-Anogrammetum*, but as yet, it has not been described from the eastern Mediterranean region.

FIGURE 1. Distribution of Mediterranean and Lusitanian fern-dominated, wall and rock vegetation types: 1, Association *Selaginello-Anogrammetum leptophyllae*; 2, Alliance *Cheilanthon hispanicae*; 3, Alliance *Asplenion fissi*; 4, Alliance *Asplenion glandulosi*. * = Corfu.



SELAGINELLA-ANOGRAMMA COMMUNITIES IN CORFU

Representative stands of the vegetation were recorded mainly on south-west-, west- and north-west-facing calcareous walls built from rocks of the Cretaceous period in the west of the island, and on the mortar walls of Corfu Town. The best developed stands occurred on the terrace walls of the olive groves between Lakones and Palaeocastritsa, where the dense canopy of *Olea* and, occasionally, *Quercus coccifera* reinforced the humid winter microclimate of the island. With an annual rainfall of between 1000 and 1200mm and between 90 and 100 rain days, the island and the other Ionian Islands represent the wettest coastal areas of Greece and the central Mediterranean region. Similarly, with a mean annual temperature of 18°C and a maximum monthly mean of

25.5°C in July, the island also experiences the coolest coastal climate (Kayser & Thompson 1964). Even so, the summer temperatures and microclimate of the olive groves are insufficient to prevent the desiccation of many components of the vegetation, including *Anogramma* and *Selaginella*, which behave as winter annuals in a community with its best development in March and April. The vegetation was recorded in the crevices and spreading over the faces of calcareous walls between 10 and 250 metres altitude, with the pH of associated lithosols ranging between 6.8 and 7.6.

The association is characterised by the presence and dominance of *Selaginella denticulata* and *Anogramma leptophylla* along with *Ceterach officinarum* ssp. *officinarum*, *Parietaria lusitanica* and/or *P. judaica* (Table 3). Other species which are widespread in related mural communities include *Umbilicus rupestris*, *Mycelis muralis*, *Parietaria officinalis*, *Veronica cymbalaria* and the moss, *Tortula muralis*. *Asplenium adiantum-nigrum* is the only other commonly-associated pteridophyte. Companion species of high constancy which give the vegetation a distinct appearance are the Mediterranean bryophytes *Scorpiurium circinatum* and *Fossombronina angulosa*; ubiquitous species of dry calcareous rocks and walls, such as *Geranium robertianum* and *Cardamine hirsuta*, and shade species such as *Poa nemoralis*, *Smilax aspera* and *Arisarum vulgare*. These overall characteristics confirm that this vegetation type may be referred to the association **Selaginello-Anogrammetum**.

Three distinct sub-associations that reflect different ecological conditions within the association are recognisable.

1. The typical sub-association has the basic features described for the association and is generally rich in species characteristic of wall vegetation. It occurs both under olive groves and in the open, and predominantly on north- and west- facing walls with a full range of exposure from SW (220°) through to NNE (20°). The major variation within the sub-association is to be seen in a community dominated by *Polypodium vulgare*, found on shady N and NNE-facing walls near the village of Krini. In plant sociological terms this community may be referred to as the sub-association **typicum**.
2. A second community is found on mortared walls in deep shade, where there is always some surface seepage during periods of precipitation. The community is recognisable by the predominance of the rare Mediterranean leafy liverwort *Southbya tophacea* and the three calcicolous mosses *Aloina aloides*, *Gymnostomum calcareum* and *Tortella nitida*, which often deposit a thin tuffaceous crust on the vegetation and tend to eliminate the more xeric wall species. This mesic, almost sub-hydric community is virtually a transition to tufa-forming, rock vegetation typically characterised by *Adiantum capillus-veneris*, and it is noteworthy that Adam *et al.* (1972) describe a community of *Adiantum* and *Eucladium verticillatum* from Montenegro in which *Southbya tophacea* is a prominent species. This sub-association is thus known as **southbyetosum**.

TABLE 2: LOCALITIES OF QUADRATS

1-4	Roadside walls between Ayios Simeon and Lakones
5-7	Walls at Krini
8	Angelokastron
9-14	Walls and rocks beneath olive groves, Palaeocastritsa
15-18	Walls between Ayios Simeon and Dhoukadhes
19-21	Mortared walls of Kerkira (Corfu Town)

TABLE 3: SELAGINELLO-ANOGRAMMETUM LEPTOPHYLLAE MOLINIER 1937

Relevé Nr.	10	17	11	9	15	1	12	18	5	16	6	7	8	20	19	21	3	13	2	3	13
Exposition (Degrees)	330	20	360	310	230	220	300	270	350	330	20	15	350	250	310	270	250	310	140	160	200
Vegetation Cover (%)	60	70	50	50	70	50	90	70	90	60	90	80	80	70	80	50	70	40	50	80	60
Olea Cover (%)	100	-	100	100	50	100	-	100	-	-	-	-	60	100	100	100	-	10	-	-	-
Species Nr.	15	10	21	25	15	14	21	15	19	9	17	13		11	12	10	19	9	13	18	19

Association, Alliance & Class Character Species

<i>Selaginella denticulata</i>	4a	2a	3b	3b	3b	+a	2a	3a	4a	+b	2b	+p	3a	2b	2b	2b	2b	+b	+b	+b	3b	3a
<i>Anogramma leptophylla</i>	.	+b	+b	+b	+a	.	+b	+b	+p	+a	+p	.	+b	2m	+b	+b	.	+b	2b	.	.	2a
<i>Ceterach officinarum</i>	.	1b	+b	.	2a	2a	2b	1b	1a	1b	.	.	.	2m	+b	+b	.	+a	2b	3b	2a	2a
<i>Parietaria lusitanaica</i>	+a	.	1a	+p	2m	+a	1b	.	1a	.	+a	+b	.	.	+p	2m	.	+b	1a	1a	+a	.
<i>P. judaica</i>	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Umbilicium rupestris</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Mycelis muralis</i>	.	.	+p	+p	.	+b	+b	+p	+b	.	.	.	.	.	.	.	.	.	.	.	.	+b
<i>Parietaria officinalis</i>	.	.	.	.	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1a
<i>Tortula muralis</i>	.	.	.	.	.	+b	+b	2m	.	2m	.	.	.	.	.	.	.	.	.	.	.	+b
<i>Veronica cymbalaria</i>	.	.	.	.	.	.	+p	+p	2a	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Asplenium adiantum-nigrum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+b
<i>Cymbalaria muralis</i>	2a

Differential species of Variant

<i>Polypodium vulgare</i>	3b	4a	2a
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Differential species of sub-ass. southbyetosum

<i>Southbya tophacea</i>
<i>Aloina aloides</i>
<i>Gymnostomum calcareum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tortella nitida</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Differential species of sub-ass. targionietosum

<i>Targionia hypophylla</i>
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Companion species

<i>Scorpiurium circinatum</i>	+b	2a	.	+b	.	+b	2a	.	3b	.	2b	3a	2a	+b	.	2a	2b
<i>Poa nemoralis</i>	1b	.	1b	+b	1b	+a	+p	.	+p	.	+p
<i>Geranium robertianum</i>	+r	+b	+p	.	.	.	+b	.	+b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Fossombronia angulosa</i>	.	.	.	+b	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cardamine hirsuta</i>	.	.	.	.	.	+p	+r	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lunularia cruciata</i>	.	.	.	.	2a	.	.	.	+p	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Barbula cylindrica</i>	2a	.	.	.	2a	.	2m	.	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sonchus asper</i>	.	+r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Arisarum vulgare</i>	.	.	.	.	.	+a	+r	.	+r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Quercus coccifera</i>	.	.	.	.	.	+r	.	.	3b	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sherardia arvensis</i>	.	.	.	.	.	+r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Anthemis chia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Euphorbia peplus</i>	+r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Thalictrum minus</i>	+b	.	.	.	2a	+b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Smilax aspera</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sonchus oleraceus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Brachythecium rutabulum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Camptothecium sericeum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Leiocolea turbinata</i>	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Geranium rotundifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Brachypodium sylvaticum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Vicia ervilia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Ornithogalum montanum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Clematis flammula</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Barbula unguiculata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Bryum capillare</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Fissidens taxifolius</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>P. adiantoides</i>	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Ditrichum subulatum</i>	+p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cyclamen hederifolium</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Also in Relevé: (1) *Rubia perigrina* 2a, *Tortula muralis aestiva* +p; (2) *Allium roseum* +r; (4) *Holcus lanatus* +p, *Carthamus lanatus* +r; *Helicrysum siculum* +p, *Barbula tophacea* 2a; (5) *Dryopteris carthusiana* +p, *Geranium lucidum* +a, *Catapodium rigidum* +r; (6) *Hyosoton aquaticum* 2a, *Arabis verna* +r; (9) *Stachys sylvatica* +p, (10) *Leontodon taraxacoides* +r, *Cledonia* sp. +a; (11) *Lapsana communis* +r, *Hypericum montbretii* +r, *Carex* sp. +a, *Anemone pavonina* +p, *Hypnum cupressiforme* 2a; (15) *Fossombronia foveolata* +b; (16) *Erigeron mucronatus* +r, *Poa annua* +b, *Senecio vulgaris* +r, *Stellaria media* +b; (17) *Phagnalon rupestre* +r, *Antirrhinum* sp. +r; (19) *Saxifraga tridactylites* +p.

Nomenclature: Phanerogams - TUTIN, T.G. et al. 1964-76. *Flora Europaea*. Vols. 1-4, Cambridge University Press.

Mosses - WARBURG, E.F. 1963. *Census Catalogue of British Mosses*. BBS Publ., Ipswich.

Liverworts - PATON, J.A. 1965. *Census Catalogue of British Hepatics*. BBS Publ., Ipswich.

3. The most xeric of the three sub-associations is found mainly on SE and SW (140-310°)- facing walls in open situations that receive direct sunlight for at least part of the day. The thallose liverwort *Targionia hypophylla* acts as a differential species, *Ceterach officinarum* assumes greater importance in terms of cover, and weeds of cultivation such as *Sonchus asper*, *Vicia ervilia* and *Anthemis chia* are more common. This sub-association is known as **targionietosum**.

THE PLANT GEOGRAPHICAL AND SOCIOLOGICAL AFFINITIES OF THE
ASSOCIATION SELAGINELLO-ANOGRAMMETUM

In his numerical analysis of the geographical distribution of European pteridophytes, Birks (1976) recognises a '*Selaginella denticulata* element', a group of ten species which includes *Anogramma leptophylla*, *Asplenium onopteris* and *A. petrachae*. It has a distribution which is centred on the central and western Mediterranean and Lusitanian regions. The predominantly coastal distribution pattern of *S. denticulata* as mapped by Jalas & Suominen (1972), ranging from Crete and the Greek Islands, along the Adriatic coasts of Albania and Yugoslavia, western Italy and southern France, and with concentrations in Corsica, Sardinia and Portugal provides a good indication of the main centres of distribution of the species group. The majority of the species favour a series of humid microclimates such as those provided by the narrow-sided valleys beneath *Platanus*, *Castanea* and *Cupressus* woodlands in Crete (Brownsey & Jermy 1973), *Olea* and *Quercus coccifera* in Corfu to moderately open situations in the Azores and Madeira where the annual precipitation is in the range 2000–3000mm (Wilmanns & Rasbach 1971; Benl 1971). But of the ten species, only *Anogramma* and *Selaginella* commonly occur together, especially in calcareous, coastal localities throughout the region (Molinier 1937, Braun-Blanquet 1966, Segal 1969, Terretaz 1964). In most of the reported localities, the *Anogramma* and *Selaginella* are accompanied by *Parietaria lusitanica*, *Umbilicus rupestris*, *Scorpiurium circinatum* and *Targionia hypophylla*.

Because of the general lack of research on fern-dominated wall communities, there is considerable confusion in the plant sociological classification of such vegetation types. All researchers are in agreement that the majority of rock and mural vegetation types should be classified in the Class Asplenieta rupestris (Braun-Blanquet 1948). But beyond this, opinions on the naming of orders and alliances vary widely (cf. Rivas Martinez 1960, Oberdorfer *et al.* 1967, Segal 1969), and there is no universally accepted system for the classification of associations. The popular trend is to refer wall and chasmophyte vegetation in which species of *Asplenium* and *Parietaria* are predominant to the Order Parietarietalia muralis (Rivas Martinez 1960). But Segal (1969), in his extensive overview of European wall vegetation prefers to erect the Order Tortulo-Cymbalarietalia and the Alliance Parietarion judaicae to include all *Parietaria judaica* wall vegetation of the Mediterranean region and the Selaginello-Anogrammetum. This is probably a more preferable classificatory position for the association than either of those given by Braun-Blanquet (1966) or Rivas Martinez (1960).

The various Mediterranean and Lusitanian communities of rock and wall vegetation in which pteridophytes are predominant may be classified in the following system whose taxa unite communities that are primarily similar in floristic characteristics but which also have similar ecological and geographical distribution patterns.

1. Class **Asplenieta rupestris** Br.-Bl. 1934.
 - 1.1 Order **Androsacetalia vandellii** Br.-Bl. 1926 — chasmophytic vegetation of siliceous rocks in the sub-alpine and alpine regions of central Europe, the Pyrenees and Sierra Nevada. The order is named for the uncommon calcifuge, *Androsace vandellii*, and Braun-Blanquet (1948) considers *Woodsia ilvensis* and *Asplenium septentrionale* as good regional character species. In view of the wider distribution of the latter species, Oberdorfer *et al.* (1967) suggest that *Asplenieta septentrionalis* is a better name.
 - 1.11 Alliance **Asplenium septentrionalis** Gams 1927 (*Androsacion vandellii* Br.-Bl. 1926) — an alliance containing two main associations, *Asplenium septentrionali-adianti-nigri* Oberd. 1938 and *Woodsia-Asplenium septentrionalis* R.Tx.1937, which are recorded in the mountain regions of central Europe and are probably to be found in the Lusitanian region.
 - 1.12 Alliance **Cheilanthion hispanicae** Rivas God. 1955 — the most oceanic alliance in the order,

- found on shallow soils over siliceous rocks in the Sierra Morena, Spain and in eastern Portugal. *Cheilanthes hispanica* is a good character species.
- 1.13 Alliance **Anogrammion leptophyllae** Bellot & Casaseca 1959 — described by Rivas Martinez from the western mountains of Spain and of doubtful status; *Anogramma* communities of natural rock-crevice sites).
- 1.2 Order **Asplenietalia glandulosi** Br.-Bl. & Maier 1934.
- 1.21 Alliance **Asplenion glandulosi** Br.-Bl. 1926. The most interesting fern-dominated association in this group of Mediterranean calcicolous vegetation types is probably Phagnalo-Asplenietum glandulosi Br.-Bl. (1931) 1952, named for the occurrence of *Asplenium petrarchae* (syn. *A. glandulosum*) and *Phagnalon sordidum*. The association is described by Sutter (1973) mainly from south-facing calcareous rocks in lower Languedoc and probably occurs throughout the range of *A. petrarchae*. *Cheilanthes fragrans* is the only other rare fern found in the association and communities in which the calcicole *Asplenium fontanum* dominates and probably also belong to this alliance.
- 1.22 (Alliance **Asplenion fissi** — vegetation of fissures and crevices in montane calcareous rocks of SE Europe in which *Asplenium fissum* and *A. lepidum* are common may form an eastern vicariant of *Asplenion glandulosi*).
- 1.3 Order **Tortulo-Cymbalarietalia** Segal 1969.
- 1.31 Alliance **Parietarium judaicae**.
Association **Selginello-Anogrammetum leptophyllae** Molinier 1937.
- 1.32 Alliance **Tortulo-Asplenion** — includes two associations which are widespread in Europe — the ubiquitous *Asplenium trichomanes-rutae-murariae* R.Tx. 1937 and *Asplenium-Cystopteridetum* Oberd. (1936) 1947, a sub-montane and montane association characterised by the presence of *Asplenium viride* and *Cystopteris fragilis*.
2. Class **Adiantetia** Br.-Bl. 1947.
- 2.1 Order **Adiantetalia** Br.-Bl. 1931.
- 2.11 Alliance **Adiantion** Br.-Bl. 1931 — communities dominated by *Adiantum capillus-veneris*, occurring on moist, shaded, often tufaceous, limestone rocks, or in humid caves in the Mediterranean region and on the southern Atlantic coast of Europe. The most common association, *Eucladio-Adiantetum* is named for the fern and the small, tufa-forming bryophyte, *Eucladium verticillatum*.

The above classification is by no means complete. It is simply a contribution to a better understanding of the sociology and ecology of fern-dominated vegetation of rocks and walls. There is a great need for further research by plant sociologists and peridologists and this paper presents a standard method and classificatory framework as stimuli for such studies.

REFERENCES

- ADAM, P., BIRKS, H.J.B. & WALTERS S.M. 1972. A contribution to the study of the flora and vegetation of the Budva area, Montenegro. *Glas. Republ. Zav. Zast. Privode*. 4: 41-72.
- BENL, G. 1971. Fern hunting in Madeira. *Brit. Fern Gaz.* 10: 165-174.
- BIRKS, H.J.B. 1976. The distribution of European pteridophytes: a numerical analysis. *New Phytol.* 77: 257-287.
- BRAUN-BLANQUET, J. 1948. Übersicht der Pflanzengesellschaften Rätens. I. *Vegetatio*. 1: 29-41.
- BRAUN-BLANQUET, J. 1966. Vegetationsskizzen aus dem Baskenland mit Ausblicken auf das weitere Ibero-Atlantikum. I. Teil. *Vegetatio* 13: 117-147.
- BROWNSEY, P.J. & JERMY A.C. 1973. A fern collecting expedition to Crete. *Brit. Fern Gaz.* 10: 331-348.
- DE JONCHEERE, G.J. 1963. Ferns of Sardinia. *Brit. Fern. Gaz.* 9: 114-116.
- JALAS, J. & SUOMINEN, J. 1972. *Atlas Florae Europaeae I. Pteridophyta*. Helsinki, 121 pp.
- KAYSER, B. & THOMPSON, K. 1964 *Economic and Social Atlas of Greece*. National Statistical Service of Greece, Athens.
- MOLINIER, R. 1937. Les Iles d'Hyères; étude phytosociologique, *Ann. Soc. Hist. Nat. Toulon*. Nr. 21.
- MORAVEC, J. 1968. Zu den Problemen der pflanzensoziologischen Nomenklatur. In TÜXEN, R. 1968 (ed.) *Pflanzensoziologische Systematik* Ber. Int. Symp. 1964, Stolzenau/Weser. Springer Verlag.
- OBBERDORFER, E. et al. 1967. Systematische Übersicht der westdeutschen Phanerogamen — und Gefasskryptogamen — Gesellschaften. *Schrift. Vegetationskunde* 2: 7-62.

- RIVAS MARTINEZ, S. 1960. Roca, clima y comunidades rupícolas; sinopsis de las alianzas hispanas de *Asplenietea rupestris*. *Annales Real Acad. Farm.* 1960: 153-168.
- SEGAL, S. 1969. *Ecological notes on wall vegetation*. Junk. The Hague. 325 pp.
- SHIMWELL, D.W. 1971. *Description and Classification of Vegetation*. Sidgwick & Jackson, London.
- SUTTER, R. 1973. Über Vorkommen und Verbreitung von *Asplenium petrarchae* (Guerin) DC. und die Assoziationen Phagnalo-*Asplenietum petrarchae*. *Bot. Jahrb. Syst.* 93: 568-602.
- TERRATAZ, J.-L. 1964. *Anogramma leptophylla* en Valais et en Ossola. *Trav. Soc. Bot. Geneve.* 7: 20-30.
- WILMANN, O. & RASBACH, H. 1973. Observations on the Pteridophyta of Sao Miguel, Acores. *Brit. Fern. Gaz.* 10: 315-329.
- ZAFFRAN, J. 1970. Les Pteridophyte Cretoises. *Israel J. Bot.* 19: 236-244.

REVIEW

OVERLAYS OF ENVIRONMENTAL AND OTHER FACTORS FOR USE WITH BIOLOGICAL RECORDS CENTRE DISTRIBUTION MAPS. Published by the Institute of Terrestrial Ecology, 68 Hills Road, Cambridge CB2 1LA, England. 1978. 390 x 212 mm. Price £2.00. (Available, by post, from the Publications Officer at the above address.)

When I had the pleasant task of reviewing the "Atlas of Ferns of the British Isles" (see Fern Gaz. vol. 11 p.399-400, 1978), I mentioned that there were no overlays which could be used to compare fern species ranges with environmental factors. Since then, I have been sent a set of transparent overlays which can be used in conjunction with the Atlas. It must be added that these overlays are not an *exact* fit on the Fern Atlas maps as they are not designed specifically for this purpose. But they are sufficiently near in size to be useful, for, with a bit of manipulation, appropriate areas can be brought into reasonably close superposition (overall the overlays are about 3 mm longer top to bottom, than the scale of the Atlas maps).

The set comes flat in a card folder which contains some information about the features used on each overlay. There are 12 overlays. These include: altitude, geology (chalk and limestone), rivers, upland moorland, western oakwoods, February minimum temperature, January mean temperature, July mean temperature, annual rainfall, wet days, vice-county boundaries, county boundaries.

Despite the slight discrepancy in map size, this seems a very useful set of overlays to use in conjunction with the Fern Atlas.

C.N. PAGE

FERNS OF NAINITAL (WESTERN HIMALAYAS): AN UPDATED LIST

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ABSTRACT

Nainital, situated about the easternmost limit of the western Himalayas, is one of the most beautiful hill stations in the Himalayas (India). It abounds in fern species. This account endeavours to list all the species of ferns which occur in and around Nainital. The list, largely based on our own collections, includes 96 species distributed over 33 genera.

INTRODUCTION

During the monsoons, ferns are commonplace at every hill station in the Himalayas. Nainital is a beautiful hill-station of the Kumaon hills (India), deriving its name from the large 'eye-shaped' lake (Naini = eye, Tal = lake) which it surrounds at an altitude of 1850 m. It is located at 29°23 N, 79°30 E and forms the easternmost limit of the western Himalayas. In addition to the main lake, the area includes several lakes at lower altitudes, such as Sariya-Tal (1770 m), Khurpa-Tal (1635 m), Bhim-Tal (1371 m), Naukhuchia-Tal (nine-cornered, 1219 m) and Sat-Tal (a complex of seven lakes, 1371 m). It also includes several types of forest formations covering an altitudinal range from 900 m (below Bhujia Ghat) to 2611 m (Cheena peak or Naini peak).

Duthie (1918) was the first to catalogue the ferns of Nainital, together with those of the Kumaon region and the adjacent frontiers of Garhwal and Tibet, covering a total area of 11,500 sq. miles. From this vast area, a total of 185 species in 30 fern genera, and 15 species of fern-allies in 6 genera were recorded. But only 24 species of ferns, based on collections made by Strachey and Winterbottom between the years 1846-1849, were referred to Naintal. Loyal and Verma (1960) made fresh collections and recorded a total of 61 species for Nainital. Subsequently more collections were made by S.C. Verma (in 1962 and 1975), S.P. Khullar (in 1965, 1967, 1972 and 1975), R.P. Nagpal (in 1970) and Vijay Bala (in 1974), all from the Department of Botany, Panjab University. We feel that these much more complete collections justify an updated list of the ferns of Nainital. The present updated list brings the total number of ferns for the Nainital area to 96 species in 33 genera.

LOCATIONS VISITED

With headquarters at Nainital, field trips to most surrounding different types of vegetation can be made. Ferns are particularly abundant in the oak forests and especially in the very humid ravines and streams within them. Notably rich areas are (i) the pony road to Kilbury, (ii) Naintital to Dhobi Khad (towards the Laria Kanta side) following the old Nainital-Almora pony road, (iii) the area between Bhujia Ghat and Jeolikote, and (iv) along the path passing through the forest from Land's End to Dorothy's Seat (Tiffin Top) (see fig. 1).

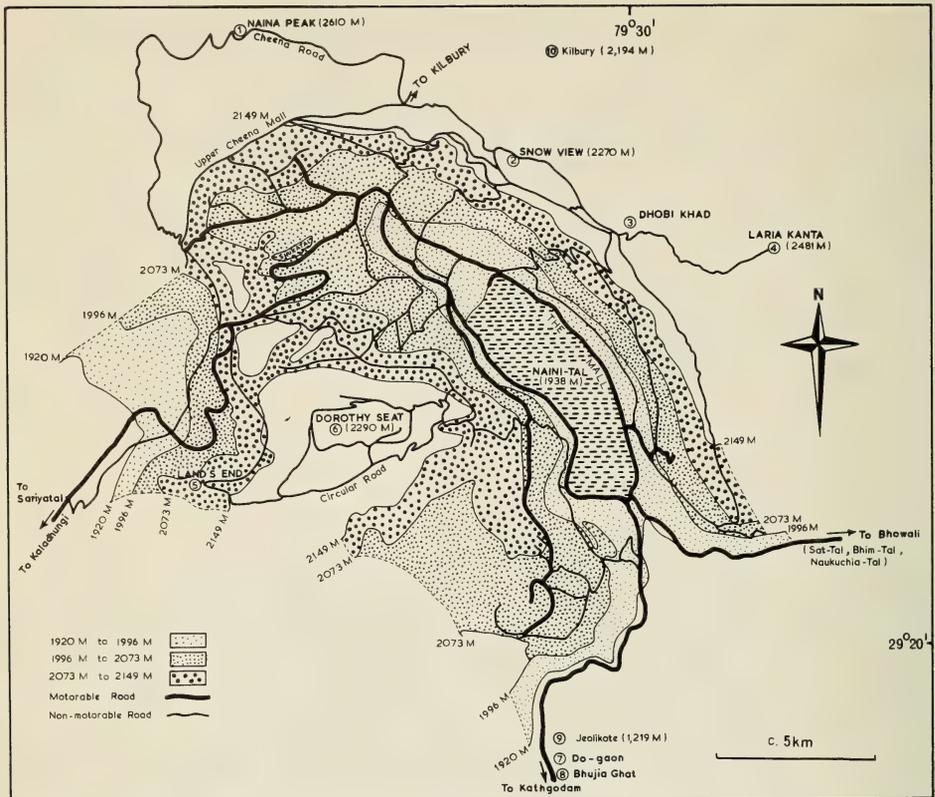


FIGURE 1. Map of Nainital area showing relief, roads and main localities mentioned in the text.
THE LIST OF FERNS

Species are arranged in families following the system proposed by Mehra (1961). For convenience, the genera and species within families are listed alphabetically. Eleven species, based solely on Duthie's catalogue are included (marked "D"), and these need to be located afresh.

While listing the ferns, the principal localities of only those species considered relatively restricted in distribution are stated, and such localities are numbered on the map (fig. 1). All other species are more or less common around Nainital. Preparation of a fully illustrated and keyed fern flora of Nainital is in progress.

Botrychium lanuginosum Wall. ex Hook. & Grev. var. *lanuginosum*. Fairly common throughout Nainital, usually on exposed sloping surfaces in the forest and road sides, highly variable in size and pubescence.

B. ternatum (Thunb.) Sw. Collected by Prof. P.N. Mehra in 1949 from Laria Kanta side, also reported by Duthie (1918).

Ophioglossum petiolatum Hk. Restricted to grassy slopes, above Khurpatal, grows in patches protected and concealed under small shrubs (fig. 8), very variable.

O. vulgatum L. (s.l.). Rare, found with difficulty in the grassy open land below Tiffin Top. A larger form, more near to *O. reticulatum* L., occurs in abundance about the Kalika temple (Ranikhet, near Nainital, fig. 9).

Lygodium flexuosum (L.) Sw. Fairly common below Bhujia Ghat, about the edges of broad-leaved forests, climbing on shrubs, in relatively open places.

Adiantum capillus-veneris L. The cosmopolitan Venus-hair fern occurs 'everywhere' near water, particularly along stony drainage courses, variable.

A. edgeworthii Hk. Restricted, found behind Kainchi temple, about Bhowali and Bhim Tal — Sat Tal area.

A. incisum Forsk. Abundant at low altitudes. Occurs in at least two forms: an erect or semi-erect one with large dark-green fronds and a smaller prostrate form (usually more hairy) often completely matting sloping forest margins and the masonry work. Both forms are diploid ($n=30$), unlike the African *A. incisum*, which is tetraploid.

A. lunulatum Burm. More often called *A. philippense*, but the name *A. lunulatum* is preferred (Verma, 1961). Common at low altitudes on shady and moist slopes. Variable in frond size, pinnule form and size, and at least the Bhujia Ghat population seems to be uniformly triploid apogamous ($n=2n=90$) (cf. Mehra and Verma, 1963).

A. venustum Don. Abundant on very humid shaded slopes, usually in the forests, between 1800-2400 m.

Onychium contiguum Hope. Abundant, covering large areas in both shaded and open localities between 1800-2400 m (fig. 3). The possibility of the occurrence of *O. lucidum* and *O. siliculosum*, which are met with in the adjoining regions eastwards, needs to be explored. *O. siliculosum* has been collected from Thal, a place 140 miles from Nainital, in the interior of Kumaon hills.

**Cheilanthes albomarginata* Clarke (= *Aleuritopteris*). The most common and the most variable fern, along roadsides and forest margins in and around Nainital, descending to 1300 m. Fronds scaly all over (stipe, primary and secondary rachises and costae).

C. anceps Blanford. Rather rare, collected near Jeolikote along the roadside.

C. anceps Blanford. var. *brevifrons* Khullar. Shares with *C. anceps* only the extension of scales on the stipe and the principal rachis and better treated as a distinct species. Common in humid and shady or protected niches. Very common near Bhowali, slopes around Khurpa Tal, Do-Gaon-Jeolikote, and Bhim Tal.

C. anceps aff. Locally common in Bhim Tal area, possibly hybrids between 12 and 13. The entire *anceps* group needs careful study.

C. dalhousiae Hk. Very frequent at higher altitudes, particularly en-route to Cheena peak, Dhobi Khud and Kilbury. a non-farinose species of the *Aleuritopteris* group.

C. farinosa sens. lat. An extremely common fern up to 1500 m altitude, uniformly diploid ($n=30$), and a taxonomically a confused species. Most forms agree with *C. farinosa* sensu Blanford, but true *C. farinosa* of Yemen is triploid and apogamous. This is a complex group needing further study.

C. subrufa Desv. Very common in crevices of slate rocks and masonry work between Dogaon and Bhujia Ghat (850 m).

Anogramma leptophylla (L.) Link. A small annual fern, restricted to humid niches and concealed among mosses and liverworts (1900-2400 m), but by no means common; collected several times on way to Cheena peak and Dhobi Khud.

Coniogramme affinis Hieron. Infrequent, gathered only in the Kilbury forest area.

C. caudata (Wall.) Ching. Not common, found along the ravine about Dhobi Khud in the forest.

Gymnopteris vestita (Wall.) Underw. Rather infrequent, found in the crevices along the road to Kilbury (fig. 2).

Pteris cretica L. Extremely common (1600-1900 m) in both open and shaded locations on forest margins and inside the forests (fig. 5); very variable in overall size, serration on the margin, and fertility.

P. excelsa Gaud. Local, in deep ravines, mostly in Dhobi Khud area.

P. quadriaurita s.l. Common polymorphic fern of forest floor and margin, at least three forms distinguishable, probably none equivalent to *P. quadriaurita* Retz. sensu stricto (see Verma and Khullar, 1965).

P. vittata L. Common at low altitudes. Two forms occur, both tetraploid ($n=58$); one with a very long terminal pinna, which inhabits open roadsides and forest margins, and another with a small terminal pinna but fronds often very large, which inhabits shaded and damp habitats. The latter is closer to the Linnean type. A third form, which is infrequent, collected by S.C. Verma once below Bhujia Ghat, differs in having narrower pinnae and broader indusial flaps and is diploid ($n=29$). Further study is needed.

*We follow Manton *et al.* (1966: Kew Bull. 18(3): 553-565) in recognising the genus *Cheilanthes* as many of the characters mentioned by Ching are not shared by all the species in the Himalayas. Excepting *C. dalhousiae*, other species (farinose on the under surface) could be placed under *Aleuritopteris*.

A. foliolosum (Wall. ex Clarke) Bedd. Found only near a streamlet on the pony track to Kilbury, particularly about the grove shown in fig. 16.

A. oxyphyllum (Hook.) Diels. Recorded by Duthie (1918). Collected from the Thal-Didihat forest (150 miles from Nainital) in Kumaon hills.

A. pectinatum (Wall.) Presl. A low-level fern, locally common on the slopes above Khurpa Tal, Jeolikote, Bhowali road, Kainchi, Bhim Tal—Sat Tal area; near Kalika temple (Ranikhet).

A. proliferum Moore. Recorded only from Ranikhet, can be expected in Nainital.

A. drepanopterum (Kze.) A.Br. Infrequent, along the Kilbury road.

A. rupicola (Hope) C. Chr. Common at higher levels, particularly along the Kilbury road.

A. schimperi Moug. ex Fée. Exceedingly common on the forest floor.

Athyrium nigripes (Blume) Moore. Recorded by Duthie (1918).

Lunathyrium japonicum sens. lat. Recorded by Duthie (1918).

Diplazium lobulosum Wall. ex Pr. Recorded by Duthie (1918).

D. polypodioides Blume. Common near ravines, on Bhowali road, Kainchi, Bhim Tal—Sat Tal forest, and Kalika (Ranikhet).

D. spectabile (Wall. ex Mett.) Ching. Not common, collected from the ravine near Dhobi Khud.

Goniopteris prolifera (Retz.) Presl (*Ampelopteris prolifera* (Retz.) Copel.). Common along the streamlets in the Naukuchia—Bhim Tal area.

Christella dentata (Forsk.) Brownsey & Jermy (*Cyclosorus dentatus* (Forsk.) Ching). Common along ravines, water channels in Khurpa Tal, Dogaon—Jeolikote and Sat Tal areas.

Macrothelypteris bukoensis (Tagawa) Pic. Ser. (*Thelypteris brunnea* (Wall.) Ching). Locally common, near water channels and humid areas, particularly Kilbury, about the place in fig. 16.

Glaphyropteridopsis erubescens (Wall. ex Hook.) Ching (*Thelypteris erubescens* (Wall.) Ching). Common along ravines at lower elevations, particularly along the Bhowali road.

Pseudocyclosorus repens (Hope) Ching (*Thelypteris repens* (Hope) Ching). Common along ravines and 'swampy' areas of Dogaon, Bhowali—Jeolikote area.

Cyclogramma auriculata (J. Sm.) Ching (*Thelypteris subvillosa* (Moore) Ching). Recorded by Duthie (1918).

Pseudocyclosorus tylodes (Kunze) Ching (*T. xylodes* (Kunze) Ching). Recorded by Duthie (1918).

Asplenium dalhousiae Hook. The most common fern, extending from low altitudes (Kathgodam area) to Cheena peak; very variable in form and size.

A. ensiforme Wall. ex Hook. & Grev. Not common, lithophyte in very humid localities, collected on way to Kilbury and from Dhobi Khud ravine.

A. exiguum Bedd. Rare, on moist shady rocks in the Kilbury area.

A. indicum Sledge. Belongs to *A. laciniatum* complex, not infrequent, in quantity opposite Sanatorium Bhowali, towards Kilbury, and near Rattighat.

A. unilaterale Lamk. Recorded by Duthie (1918).

A. varians Hook. et Grev. Abundant all around Nainital, on moist shaded rocks, and along roadsides.

Arthromeris wallichiana (Spr.) Ching. Infrequent, found in Dhobi Khud area.

Drynaria mollis Bedd. Common epiphyte in the Cheena peak area, Kilbury, towards Land's End, Dorothy's Seat and Laria Kanta.

Lepisorus excavatus (Bory) Ching (= *Pleopeltis excavata* (Willd.) Sledge). An abundant epiphyte/lithophyte all around Nainital (fig. 18).

L. aff. *excavatus*. A larger form from Cheena peak area, needs further study.

L. kashyapii (Mehra) Mehra (= *Pleopeltis kashyapii* (Mehra) Alston). Common epiphyte around Nainital, (fig. 14).

L. kuchanensis (Wu) Ching. Common epiphyte, particularly in the Tiffin Top area.

L. nudus (Hk.) Ching. Fairly common epiphyte, about Tiffin Top, en route to Snow View, Nainital lake-side, and Nainital-Ranikhet road.

Lepisorus aff. *nudus* (Hook.) Ching. A very characteristic fern, and the most common epiphyte at lower altitudes, particularly Khurpa Tal, Saria Tal, and below Jeolikote (fig. 12). Also occurs about Dhobi Khud and Tiffin Top. It is characterised by simple leathery fronds (subcoriaceous), yellowish-green colour and scales over the undersurface. R.R. Stewart has placed similar material from Mussoorie, at Kew, under *L. nudus* (Hook.) Ching. The material differs from the description of *L. nudus* provided by Bir and Trikha (1969) in possessing the scaly undersurface. Further studies are necessary.

L. scolopendrium (Don) Mehra and Bir (= *Pleopeltis scolopendrium* (D. Don) Alston & Bonner). Infrequent, found towards Cheena peak and Kilbury.

Loxogramme involuta (Don) Presl. Rather rare, gathered on Nainital-Saria Tal road below Cheena peak road, and from Dhobi Khud.

Microsorium membranaceum (Don) Ching. Fairly common on moist shady rocks, locally abundant below Jeolikote (fig. 6).

Phymatodes oxyloba (Wall. ex Kunze) Presl. Infrequent lithophyte, found near Bhowali Sanatorium and beyond, Bhim Tal — Sat Tal area, on the way to Rattighat, and beyond Bhowali towards Kainchi.

P. stracheyi Ching. Rare lithophyte, found in large numbers on the pony track to Kilbury (locally common, fig. 13).

Polypodium amoenum Wall. ex Mett. A common epiphyte or lithophyte of Nainital.

P. argutum Wall. ex Hook. Infrequent, found as epiphyte on way to Kilbury, Tiffin Top, and Dhobi Khud (fig. 19).

P. lachnopus Wall. ex Hook. Common epiphyte/lithophyte of Nainital, characterised by black 'hairs' on rhizomes.

P. microrhizoma Clarke ex Bak. Epiphyte/lithophyte, very common all around Nainital.

P. subamoenum Clarke. Epiphyte/lithophyte, common all around Nainital.

Pyrrosia beddomeana (Gies) Ching. Common epiphyte near Bhim Tal.

P. flocculosa (Don) Ching. Frequent to common epiphyte/lithophyte, particularly about Khurpa Tal and below Jeolikote.

P. stictica (Kunze) Holtt. Common about Dogaon, Bhujia Ghat, and on way to Rattighat.

REFERENCES

- BEDDOME, R.H. 1892. *A Handbook to the Ferns of British India, Ceylon and Malaya Peninsula (with Supplement)*. Thacker Spink & Co., Calcutta (India).
- BIR, S.S. and TRIKHA, C.K. 1969. Taxonomic revision of the polypodiaceous genera of India-IV. *Polypodium lineare* complex and allied species. *Bull. Bot. Surv. India*. 11: 260–276.
- DUTHIE, J.F. 1918. *Catalogue of the Plants of Kumaon and the Adjacent Portions of Garhwal and Tibet*. (Catalogue originally prepared by Strachey in 1852 on collections made by Strachey and Winterbottom between the years 1846–1849), Lovell Reeve & Co. Ltd., London.
- KHULLAR, S.P. and GUPTA, S.C. 1977. On the occurrence of *Polystichum aculeatum* in the Himalayas. *Symp. Recent Res. Pl. Sci. (Punjabi University), Patiala, Abstr. (sect. 2): 11–12*.
- LÖVE, A., LÖVE, D. & PICHI-SERMOLLI, R.E.G. 1977. *Cytotaxonomical Atlas of the Pteridophyta*. J. Cramer, Vaduz.
- LOYAL, D.S. and VERMA, S.C. 1960. Ferns of Nainital. *J. Bombay Nat. Hist. Soc.* 57: 479–490.
- MEHRA, P.N. 1961. Cytological evolution of ferns with particular reference to Himalayan ferns. (Presidential address). *Proc. Indian Sci. Congr. (Roorkee) part II: 130–153*.
- MEHRA, P.N. and VERMA, S.C. 1963. Polymorphicity and cytogenetics of *Adiantum lunulatum* complex. Maheshwari Comm. Vol., *J. Indian Bot. Soc.* 42A: 110–121.
- VERMA, S.C. 1961. Taxonomic status of *Adiantum lunulatum* Burm. *Nova Hedwigia* 3: 463–468.
- VERMA, S.C. and KHULLAR, S.P. 1965. Cytogenetics of the western Himalayan *Pteris cretica* complex. *Ann. Bot. (n.s.)* 29: 673–681.



FIGURE 2. *Gymnopteris vestita*, Kilbury road area (c. 1/7 natural size).



FIGURE 3. *Onychium contiguum*, towards Cheena peak (c. 1/20 natural size).



FIGURE 4. *Pteridium aquilinum* var. *wightianum*, Kilbury road area (c. 1/20 natural size).



FIGURE 5. *Pteris cretica*, Kilbury road area (c. 1/12 natural size).

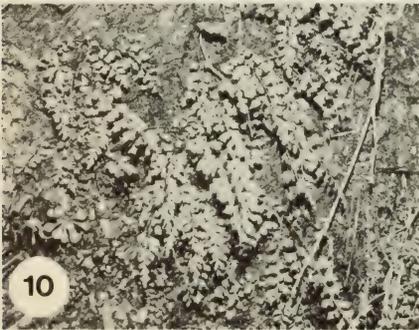


FIGURE 6. *Microsorium membranaceum*, Saria-Tal road (c. 1/7 natural size).

FIGURE 7. *Dryopteris marginata*, near Kilbury (c. 1/7 natural size).

FIGURE 8. *Ophioglossum petiolatum*, above Khurpa-Tal (c. 1/7 natural size).

FIGURE 9. *Ophioglossum vulgatum* (large form), near Kalika temple, Ranikhet (c. 1/10 natural size).

FIGURE 10. *Asplenium varians*, Lakeside, Nainital (c. 1/7 natural size).

FIGURE 11. *Dryopteris odontoloma*, Laria Kanta (c. 1/20 natural size).

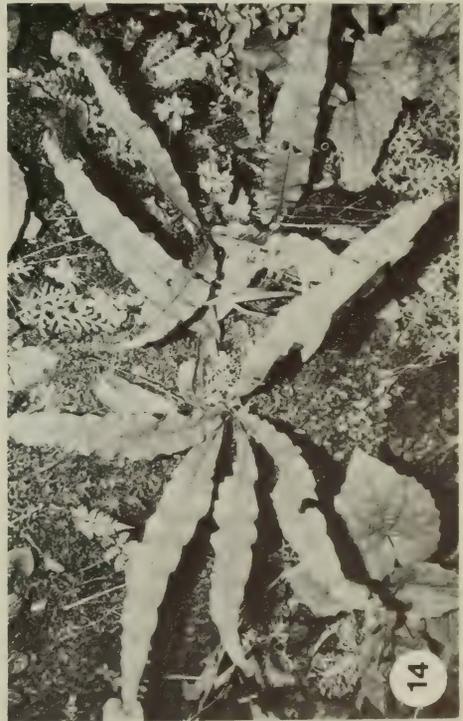


FIGURE 12. *Lepisorus amaurolepida*, midway to Saria-Tal (c. 1/5 natural size).

FIGURE 13. *Phymatodes stracheyi*, beside pony road to Kilbury (c. 1/10 natural size).

FIGURE 14. *Lepisorus kashypaii*, near Kilbury road (c. 1/8 natural size).

FIGURE 15. *Polypodium microrhizoma* with *Athyrium anisopterum* beneath, beside Kilbury road (c. 1/10 natural size).

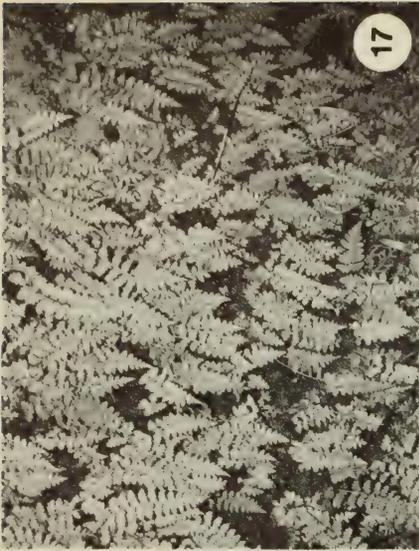


FIGURE 16. A typical fern grove on the pony track to Kilbury, showing mainly *Thelypteris brunnea* (in front) (c. 1/50 natural size).

FIGURE 17. *Athyrium anisopterum*, Kilbury road area (c. 1/8 natural size).

FIGURE 18. *Lepisorus excavatus*, Tiffin Top forest (c. 1/8 natural size).

FIGURE 19. A branch full of epiphytes with many fronds of *Polypodium argutum* (c. 1/20 natural size).

THE FERN FLORA OF OILPALM PLANTATIONS IN WEST MALAYSIA

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ABSTRACT

The environment of scientifically-controlled commercial plantations of *Elaeis guineensis* on the Malaysian peninsula is described and discussed as a habitat for ferns.

INTRODUCTION

Elaeis guineensis Jacquin, a palm of the sub-family Cocoideae, is a native of West Tropical Africa and has long been exploited there on a village scale for its oil. The tall, stout, upright trunk bears a crown of pinnate leaves which have spines along the edges of their leaf-stalks. Male and female inflorescences are produced on short stalks amongst the leaf bases of the crown, as subsequently are bunches of fruit. Edible oils are manufactured from both the pericarp and the kernel.

Large plantations of this species are cultivated in wet tropical lowlands throughout the world, within about 16° of the equator. By 1968, there were over 120,000 ha of oilpalms in Malaysia alone.

The natural vegetation in Malaysia is tropical rain forest. Annual rainfall in the lowlands is about 2,500 mm, with precipitation more or less throughout the year. Humidity is high. Palms and ferns contribute significantly to the natural flora, and wild palms which retain their leaf-bases often support epiphytes, most commonly ferns. Scientific plantation agriculture has produced a new habitat for these, extending their previously limited distribution.

The author has long had associations with the palmoil industry, and this article is compiled from personal field observations. Pteridophyte nomenclature is based on Holttum (1966), with some revisions. Further useful information on palms in general is given in Corner (1966) and Whitmore (1977), and oilpalms by Hartley (1977). Fern specimens have been deposited at Kew (K), and duplicates of Malaysian specimens in Singapore (SING).

YOUNG OILPALMS

High quality oilpalm seed is germinated under laboratory conditions and, after careful selection, planted in nurseries. Seedlings develop until they are of sufficient size for planting in the field. By this stage, the palms have not produced trunks and there are no epiphytes.

In the field, the young palms are at first surrounded by leguminous cover crops. Clean circles are maintained around each palm, either manually or by use of herbicides, and the cover crop itself is weeded. Then ferns begin to grow. *Nephrolepis biserrata* often establishes on the now-developing trunks, but such plants are continually removed during plantation maintenance operations. After about 30 months the first palm fruit crop is taken. The short trunk is now recognisable and the leaf-bases are beginning to accumulate debris. *N. biserrata* is still cleaned away regularly, but some of the rhizomes have become so well-established by this stage that fronds soon reappear. Where wetter conditions prevail and *Stenochlaena palustris* occurs in the surrounding areas, it too may make its appearance early. Conditions

within the plantation are still fairly open, but as the palm canopy closes and the cover crops die out, and terrestrial ferns gradually appear. Although the trunk is regularly cleaned until it is 6 or more years old, larger numbers and more species of epiphytic ferns then establish on it.

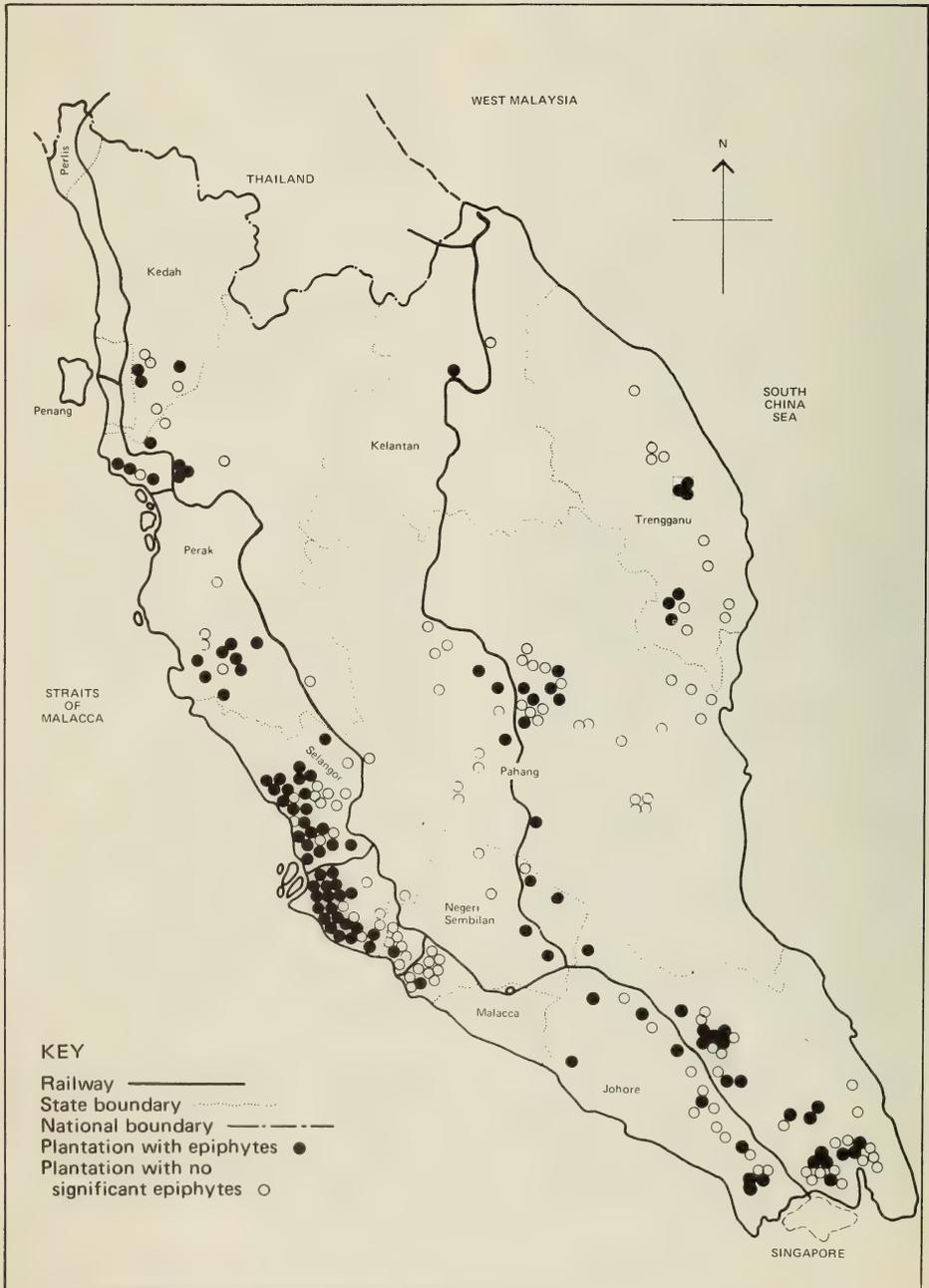


FIGURE 1. Map of West Malaysia showing the distribution of oilpalm plantations and small-holdings where the fern flora was recorded.

MATURE OILPALMS

Rank upon rank of oilpalms with their neatly tailored trunks cover large areas of the Malaysian lowlands (fig. 2). The canopy meets overhead giving shade and cooler, but more humid, conditions. The ground is often covered with a moderate grassy undergrowth, not permitted to grow out of control. Around the base of each trunk, the cleared circles are maintained. Epiphytic growth on the lower part of each trunk is kept to a minimum, but above this is often a profuse epiphytic flora, mostly ferns (fig. 4). Such plants cause no harm to the oilpalms themselves, although they may reduce the crop by concealing loose ripe fruit. Long-climbing plants are discouraged, since they may reach into the crowns and interfere with pollination. Figs and other woody plants are removed to prevent loss of vigour in the host palm.



FIGURE 2. Plantation of oilpalms, nine years old, in Johore, showing pruned leaf-bases.

Most of the ferns begin growth in the pockets of debris and humus accumulated in the palm leaf-bases (fig. 3) and which retain sufficient moisture for their continued growth except during unusually dry periods. Once established, those species with creeping rhizomes or runners soon spread. The small-fronded epiphytes with long-creeping rhizomes appear around the tenth year, by which time spores from terrestrial species on the floor of the plantation have also begun to grow epiphytically on the trunks.

After 18-20 years rotten leaf-bases begin to fall, revealing patches of the surface of the trunk. By 23-25 years large expanses of bare trunk surface can be seen (fig. 5) or the trunk may be smooth for the greater part of its length. Long-creeping rhizomes tend to bind the leaf-bases and prevent them falling, often leaving masses of vegetation suspended. The flora of the trunk changes as the leaf-bases fall. Many epiphytes drop to the ground — some continue to grow there, others do so where they had been thrown on heaps of decaying matter in the inter-rows.



FIGURE 3. Trunk of mature oilpalm with an abundant growth of epiphytes, predominantly *Davallia denticulata* and *Nephrolepis biserrata*.

Some of the oldest of the original oilpalm plantings, dating from 1917-20, in Johore and Selangor were visited in 1976. The trunks of these palms varied, presumably with the planting material used. Some were quite smooth up to the crown, whilst others had retained all their leaf-bases which were not pruned as short as present-day standards demand. The smooth trunks had very few epiphytes growing on them but had retained some suspended tangled masses. Growth on the trunks with the longer leaf-bases was not luxuriant.

Over a period of three years, 271 plantations and small-holdings, varying from recent plantings, to ones of 59 years old, were visited in West Malaysia (fig. 1). Of these 139 supported a significant flora of well-grown epiphytic ferns, 54 had trunks still being regularly cleaned of epiphytes, and the remainder were too young to have developed a significant fern flora. Most plantations cultivated palms of a range of ages, each block consisting of palms of the same age, and ground conditions varied from place to place in the plantation. The epiphytic ferns of groups of ten or more adjacent oilpalms, situated well within the boundary of the plantation, were recorded at each site and notes made of the terrestrial fern flora there. The total of 55 ferns and two fern-allies recorded in mature oilpalm plantations and small-holdings are listed in table 1.

DEVELOPMENT OF THE EPIPHYTIC FERNS WITH OILPALM AGE

The trunk of a mature oilpalm elongates at the rate of 30-60 cm per annum and can attain a height of more than 24 m. The surface of the trunk is not immediately exposed because the dying leaves are unable to form a clean abscission layer and they break off some distance above the base of the stalk. Under natural conditions these long leaf-bases remain attached to the trunk, slowing rotting until, about 20 years later, they fall and expose the trunk surface. In commercial plantations, trunks are tidily trimmed until they resemble elongated pineapples. Debris from the crowns of



FIGURE 6. *Cyathea latebrosa* growing epiphytically on an oilpalm trunk in Trengganu.



FIGURE 5. Oilpalm from which rotten leaf-bases have fallen, exposing the trunk surface. The main fern epiphyte is *Asplenium nidus*.



FIGURE 4. Immature plants of *Nephrolepis biserrata* growing in the humus accumulated in the short leaf-bases of an oilpalm trunk.

the palms accumulates in the short leaf-bases, gradually rotting to form humus. The pinnate leaves allow rain to penetrate the canopy and their bases channel it towards the trunk. Many ferns and small climbing plants, some figs and occasionally orchids develop as epiphytes in this habitat. Rats, snakes and other small animals frequently make their homes there too.

Carefully calculated quantities of fertiliser are regularly applied to the palms to ensure optimum growth and maximum yield. In the early years of the industry the

TABLE 1: TOTAL NUMBERS OF FERNS AND FERN-ALLIES RECORDED

GROWTH		GROWTH	
HABIT	SPECIES	HABIT	SPECIES
T	<i>Acrostichum aureum</i> L.	E T	<i>N. biserrata</i> (Sw.) Schott
t	<i>A. speciosum</i> Willd.	E	<i>N. radicans</i> (Burm. f.) Kuhn
e T	<i>Adiantum latifolium</i> Lam.	E	<i>Ophioglossum pendulum</i> L.
e T	<i>Amphineuron opulentum</i> (Kauf.) Holtt.	e	<i>Phymatodes longissima</i> (Bl.) J.Sm.
E	<i>Asplenium glaucophyllum</i> v.A.v.R.	e	<i>P. nigrescens</i> (Bl.) J.Sm.
E t	<i>A. longissimum</i> Bl.	E	<i>P. scolopendria</i> (Burm.) Ching
E t	<i>A. nidus</i> L.	e t	<i>Pityrogramma calomelanos</i> (L.) Link
e	<i>A. pellucidum</i> Lam.	e T	<i>Pleocnemia irregularis</i> (Presl) Holtt.
T	<i>Blechnum indicum</i> Burm. f.	e T	<i>Pronephrium triphyllum</i> (Sw.) Holtt.
T	<i>B. orientale</i> L.	t	<i>Pteridium caudatum</i> (L.) Maxon var. <i>yarrabense</i> Domin
e T	<i>Christella arida</i> (Don) Holtt.	T	<i>Pteris biaurita</i> L.
e T	<i>C. dentata</i> (Forsk.) Brownsey & Jermy.	e t	<i>P. ensiformis</i> Burm.
e T	<i>C. parasitica</i> (L.) Lev.	e t	<i>P. longipinnula</i> Wall.
e T	<i>C. subpubescens</i> (Bl.) Holtt.	T	<i>P. semipinnata</i> L.
e T	<i>Cyathea latebrosa</i> (Wall.) Copel.	e T	<i>P. tripartita</i> Sw.
T	<i>Cyclosorus gongyloides</i> (Schkur) Link	e T	<i>P. vittata</i> L.
E	<i>Davallia denticulata</i> (Burm.) Mett.	e	<i>Pyrosia angustata</i> (Sw.) Ching
t	<i>Dicranopteris linearis</i> (Burm.) Underwood var. <i>subpectinata</i> (Chr.) Holtt.	e	<i>P. longifolia</i> (Burm.) Morton
e t	<i>Diplazium asperum</i> Bl.	t	<i>Schizoloma ensifolia</i> (Sw.) J.Sm.
e T	<i>D. esculentum</i> (Retz.) Sw.	e T	<i>Sphaerostephanos heterocarpus</i> (Bl.) Holtt.
E	<i>Drymoglossum piloselloides</i> (L.) Pr.	E T	<i>S. polycarpus</i> (Bl.) Holtt.
e	<i>Drynaria sparsisora</i> (Desv.) Moore	E T	<i>Stenochlaena palustris</i> (Burm.) Bedd.
E	<i>Goniophlebium verrucosum</i> (Hook.) J.Sm.	e T	<i>Taenitis blechnoides</i> (Willd.) Sw.
e T	<i>Lygodium flexuosum</i> (L.) Sw.	t	<i>Tectaria vasta</i> (Bl.) Copel.
e T	<i>L. longifolium</i> (Willd.) Sw.	E	<i>Vittaria elongata</i> Sw.
e T	<i>L. microphyllum</i> (Cav.) R.Br.	E	<i>V. ensiformis</i> Sw.
E T	<i>Microlepia speluncae</i> (L.) Moore	FERN ALLIES	
E	<i>Microsorium punctatum</i> (L.) Copel.	e	<i>Psilotum flaccidum</i> Wall.
E	<i>Nephrolepis acutifolia</i> (Desv.) Chr.	E	<i>P. nudum</i> (L.) Beauv.

'E' denotes the species as a common epiphyte on oilpalm trunks: abundant, locally abundant or of frequent occurrence. 'e' denotes an epiphyte of less frequent occurrence. 'T' denotes a terrestrial fern common on the floor of the plantation: abundant, locally abundant or frequent. 't' denotes a terrestrial fern of less frequent occurrence. Epiphytes which had obviously recently fallen from older palms were discounted.



FIGURE 7. *Goniophlebium verrucosum* growing abundantly on an oilpalm in Johore.



FIGURE 8. Fertile plant of *Pityrogramma calomelanos* growing as an epiphyte on an oilpalm.



FIGURE 9. *Vittaria elongata* and *V. ensiformis* concealing an oilpalm trunk.

palms were cultivated until they were too tall to harvest, but today it is considered economic to replant when the palms are about 25 years old.

The debris in the leaf-bases of very young palms consists almost entirely of soil-splash. As humus, mostly derived from the inflorescences, accumulates and as the habitat becomes shadier, the number of fern species growing there increases. At first they are the ferns commonly recognised to be epiphytic. Then some normally terrestrial species appear, growing in the lowest leaf-bases first. When the palms are about ten years old, the distribution of species is fairly uniform on all trunks. *Nephrolepis biserrata*, *Goniophlebium verrucosum* and *Davallia denticulata* are, however, more abundant than other species. Then the lower trunks often become mossy and the number of plants of *Vittaria* spp. increases. *N. radicans*, *N. acutifolia*, *Asplenium longissimum*, *Microsorium punctatum* and *Phymatodes scolopendria* become conspicuous and the distribution of species changes. Some trunks support a wide variety of ferns, whilst others support few. The normally terrestrial species begin to disappear.

By the eighteenth year, many of the leafbases have become rotten. Slow at first, they begin to fall away. The process accelerates and the trunk surface becomes exposed. The long rhizomes of some epiphytes are so tightly bound round the trunks that they remain, others are displaced and fall to the ground. *Stenochlaena palustris*, if present, and *N. biserrata* usually continue to grow in and near the crown of the palm. *G. verrucosum* and *D. denticulata* frequently remain high on the trunks too. *Pyrrosia* spp., *Phymatodes* spp. and *M. punctatum* may continue to climb on the smooth surface. In some areas *Drymoglossum piloselloides* adheres patchily. *Vittaria* spp. continue to grow amongst mosses near ground-level.

Small young plants of *A. nidus* are common on oilpalms. In well-maintained plantations they are removed before they reach any appreciable size, as large 'nests' would trap too much loose fruit and reduce the crop. Similarly, well-grown plants of *Drynaria sparsisora* are rarely seen.

Ophioglossum pendulum could be more common than has been recorded here. The limp fronds hang beneath the stiffer fronds of other ferns and are not easily seen. They are particularly difficult to detect when growing amongst the ribbon-shaped fronds of *Vittaria* spp.

Table 2 gives ages of palms when epiphytic fern species were recorded.

A characteristic of the genus *Nephrolepis* is its ability to reproduce vegetatively by means of runners and spreads rapidly. Both *N. biserrata* and *N. acutifolia* were recorded on oilpalms long after the leaf-bases had fallen. The oldest palms on which *N. radicans* was recorded were still losing their leaf-bases. Further observations are needed to determine if this species remains on palms with smooth trunks.

With the exception of three species, all the fern epiphytes on old palms with smooth trunks possess runners or long-creeping rhizomes which carry them into the crown of the tall palm or bind them to the trunk. The exceptions are *A. nidus*, which has a very tenacious growth habit, and the two *Vittaria* spp., which root in the mosses growing on the lower part of the palm trunk.

ORNAMENTAL OILPALMS AND 'ESCAPES'

Specimens of *Elaeis guineensis* are grown in many botanical gardens, out-of-doors in the tropics and in hot-houses in temperate climates. They are also common as ornamentals, often under conditions which would horrify a professional planter. Others have appeared on roadsides, where fruit has fallen as the crop was being taken to the factory.

Such palms may grow well, but they are not subject to the strict regime of the plantations. In gardens the dead and dying leaves are not removed unless they become too overtly, and the 'escapes' receive no attention at all. Often the base of the trunk is overgrown with terrestrial plants. *Stenochlaena palustris*, *Dicranopteris linearis*, *Lygodium flexuosum* and *L. microphyllum* scramble and climb on the trunks, sometimes reach into the crowns. Debris and humus do accumulate, but in the deep shade of the long, broken leaf-bases. Few epiphytes find this an ideal habitat and only *N. biserrata*, *Goniophlebium verrucosum*, *Davallia denticulata* and *Microsorium punctatum* have been recorded.

TABLE 2: DISTRIBUTION OF EPIPHYTIC FERN SPECIES IN RELATION TO AGE OF OILPALM

Species	Age of palm in years			Occurrence (%) in mature plantations visited
	Earliest record	Commonly recorded	Latest record	
<i>Nephrolepis biserrata</i>	5	5	59	99.3
<i>Stenochlaena palustris</i>	5	5	40+	60
<i>Asplenium nidus</i>	5	8	59	58
<i>A. longissimum</i>	5	8	26	50
<i>Goniophlebium verrucosum</i>	5	6	59	77
<i>Vittaria elongata</i>	5	10	40+	54
<i>Davallia denticulata</i>	6	7	59	80
<i>Pityrogramma calomelanos</i>	6	7	12	20
<i>Sphaerostephanos polycarpus</i>	6	7	15	12
<i>Microlepia speluncae</i>	6	8	23	23
<i>Phymatodes</i> spp.	6	10	59	43
<i>Nephrolepis radicans</i>	6	8	25	7
<i>Pteris</i> spp.	7	9	13	8
<i>Asplenium glaucophyllum</i>	7	12	20+	9
<i>Drymoglossum piloselloides</i>	7	12	30+	12
<i>Drynaria sparsisora</i>	7	12	40+	8
<i>Vittaria ensiformis</i>	8	12	40+	29
<i>Microsorium punctatum</i>	9	16	30+	11
<i>Nephrolepis acutifolia</i>	10	12	40+	11
<i>Pyrrhosia</i> spp.	10	16	40+	11
<i>Ophioglossum pendulum</i>	10	15	25	4
<i>Asplenium pellucidum</i>	—	12	—	0.7
Other Thelypteridaceae	5	7	15	18
Other 'terrestrial' spp.	5	8	15	14
<i>Psilotum flaccidum</i>	—	20	—	0.7
<i>P. nudum</i>	15	25	—	2

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REFERENCES

- CORNER, E.J.H. 1966. The Natural History of Palms. Wiedenfeld and Nicolson, London.
 HARTLEY, C.W.S. 1977. The Oil Palm. Longman, London.
 HOLTUM, R.E. 1966. Ferns of Malaya (Revised Flora of Malaya, Vol. II) 2 ed. Govt. Print. Office, Singapore.
 WHITMORE, T.C. 1977. Palms of Malaya, 2 ed. Oxford University Press, Kuala Lumpur.

REVIEW

THE PTERIDOPHYTES OF SURINAME by K.U. Kramer, 1978. *Naturwetenschappelijke Studiekring voor Suriname en de Nederlandse Antillen*, No. 93. Utrecht. 24 x 16 cm, 198pp.

This work includes over 300 species, subspecies and varieties in 63 genera of which about one quarter are described as being rare. Although there are no specific descriptions as the subtitle indicates (An Enumeration with Keys of the Ferns and Fern Allies) each entry is a rich source of references to the literature.

The genera are keyed out in one of two ways: by a general key which distinguishes nine of the most distinctive groups such as the lycopods, aquatics, filmies and the gleicheniaceous members, whilst the great majority are treated by a multi-access key which is an innovation in fern literature. Every genus has 7 or 8 alternate characters each represented by a letter of the alphabet, thus giving a letter formula. This has the advantage that it very clearly brings out the features in common or separating genera. However, the convention used is not sufficient to characterize every genus by a different formula and in such cases an additional note is given to distinguish the components. For example, *Asplenium* and *Blechnum* both have the same letter formula ACGIQSWX but are finally separated from one another by the presence of the sorus on a free vein in the former case or on a commissure parallel to the costa in the latter. The keys to the species are of a conventional type.

Recent important literature published on a genus is quoted and in a number of cases where full monographic work is not available genera such as *Polypodium*, *Thelypteris*, *Hymenophyllum* and *Trichomanes* are treated in the broad sense.

For each taxon, in addition to relevant literature and synonymy, the geographical distribution is given, together with a sentence on its ecology in Suriname and an indication of its abundance. A valuable feature which should help to stimulate collectors is the inclusion of several taxa which have not yet been found in Suriname but whose presence may be reasonably expected from the geographical distribution.

T.G. WALKER

ON THE REPORTED OCCURRENCE OF *ASPLENIUM CUNEIFOLIUM* AND *A. ADIANTUM-NIGRUM* IN THE BRITISH ISLES

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ABSTRACT

Preliminary experimental evidence is presented which shows that British serpentine populations of "*A. cuneifolium*" are allotetraploid.

In Europe, the *Asplenium adiantum-nigrum* aggregate consists of a complex of three closely-related taxa, two diploid species, *A. onopteris* L. and *A. cuneifolium* Viv. (with $n = 36$), and an associated allotetraploid, *A. adiantum-nigrum* L. ($n = 72$), which has been shown by Shivas (1969) to be derived from a cross between these two diploid taxa followed by chromosome doubling. *A. adiantum-nigrum* is a very variable species and it is found throughout most of Europe except the east and the extreme north (Jalas & Suominen, 1972). *A. onopteris* is a Mediterranean species with an outlier in south-west Ireland, while *A. cuneifolium*, which occurs in central and eastern Europe, has particular edaphic requirements, being found exclusively on serpentine and other ultrabasic rocks.

Although it has been pointed out in the past that *A. cuneifolium* could possibly occur in suitable habitats in Britain, the first confident claim of its occurrence in this country was by Roberts & Stirling in 1974. These authors collected material of the *Asplenium adiantum-nigrum* aggregate from 11 Scottish serpentine localities; three plants from two of these sites (Glen Lochay, v.c.88 and Glendaruel, v.c.98) were examined cytologically and were said to have given diploid counts of $n = 36$. Plants from other serpentine localities in Scotland were reported to be morphologically identical with these two populations, and were therefore assumed to be diploid also. Roberts & Stirling pointed out the morphological similarity between all of their material and plants of *A. cuneifolium* from Europe, and, despite the inadequacies of their cytological data, unhesitatingly referred all the material from the Scottish serpentine localities to *Asplenium cuneifolium* Viv.

Subsequently, at the request of these authors, chromosome counts were made in Leeds on material collected by Stirling from the Scottish localities listed in his joint paper. The diploid counts previously reported by them could not be corroborated; tetraploid counts of $n = 72$ were consistently obtained (Sleep et al., 1978). To date, no diploid counts of the *Asplenium adiantum-nigrum* aggregate from Scottish serpentine localities have been recorded. Counts have now been made from 8 of Roberts & Stirling's listed sites (including the two populations from which diploid counts were previously reported) and all have been clearly tetraploid.

Concurrently, a plant of the *A. adiantum-nigrum* aggregate from Corsica, which on morphological grounds one would have no hesitation in referring to *A. cuneifolium* Viv., was reported to be tetraploid by Deschatres, Schneller & Reichstein (1978). This plant was so close to the central European populations of *A. cuneifolium* Viv. in general appearance that it was suggested that the Corsican plant could be an autotetraploid derivative of *A. cuneifolium*.

In gross morphology, spore size and chromosome number the Scottish plants corresponded well with material of this Corsican tetraploid, and it was thought possible that the Scottish material could also be regarded as an autotetraploid form of *A. cuneifolium*. However, without further evidence, it could equally well be

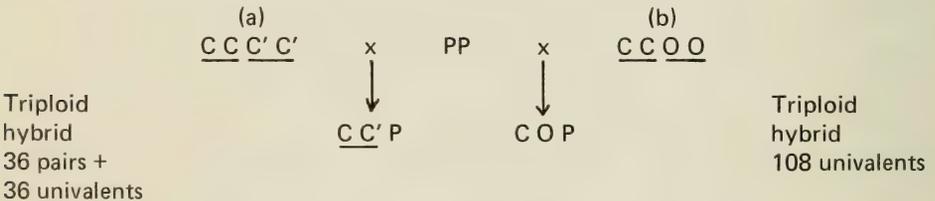
interpreted as a form of *A. adiantum-nigrum* which, on serpentine, could produce a type of morphology closely resembling *A. cuneifolium* (Sleep et al., 1978). In order to determine which of these two possibilities is correct, a hybridization programme was set up at Leeds using material of putative autotetraploid *A. cuneifolium* from Scotland and Corsica. Preliminary results from this experimental investigation are now available and are reported below.

In order to determine if a plant is *allotetraploid* (i.e. derived by hybridization between two distinct diploid species, followed by chromosome doubling) or *autotetraploid* (i.e. derived by chromosome doubling from a single diploid species), attempts are made to synthesize "wide hybrids", i.e. a hybrid between the tetraploid under investigation and either an unrelated diploid (e.g. *Phyllitis scolopendrium*) or an unrelated allotetraploid species of known parentage. If the Scottish serpentine material is indeed an autotetraploid derivative of *A. cuneifolium*, it can be expected to show at meiosis chromosome pairing between its constituent genomes (autosyndesis), and this pairing can be expected to be constant in any hybrid between it and another unrelated species. If, however, the material under investigation is an allopolyploid which has arisen as a result of hybridization between two cytologically distinct diploid species, then it can be expected to show complete failure of chromosome pairing in any hybrid which involves a species with which it is unrelated. This is shown diagrammatically below:

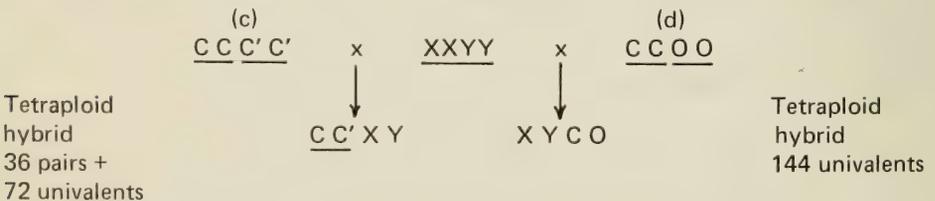
The genomes (chromosome sets) involved can be represented by letters, as follows:

- CC = *A. cuneifolium*
- CC' C' = autotetraploid *A. cuneifolium*
- OO = *A. onopteris*
- CCOO = *A. adiantum-nigrum*
- Base number in *Asplenium* = 36.

A. Comparative behaviour shown by crosses between (a) an autotetraploid and (b) an allotetraploid and an unrelated diploid species (PP).



B. Comparative behaviour shown by crosses between (c) an autotetraploid and (d) an allotetraploid and an unrelated allotetraploid species (XXYY).



The underlining bars indicate the constitution of bivalents formed at meiosis.

The chromosome pairing behaviour in wide hybrids can thus be used with a high degree of certainty in determining if a given tetraploid is auto- or allopolyploid. Attempts were therefore made to cross cultures of putative autotetraploid *A. cuneifolium* and *A. adiantum-nigrum* with unrelated species. Several different hybrid

combinations have been synthesized, but the crosses which specifically concern us here involve *A. kobayashii*, a rare Japanese allotetraploid that is derived from a cross between *Camptosorus sibiricus* Rupr. and *Asplenium incisum* Thunb. This species has already proved itself to be a valuable standard since, in investigations of this kind (Lovis, Brownsey, Sleep & Shivas, 1972), it both hybridises easily with other unrelated species and, because of its spectacular inter-generic origin, shows no homology between its constituent genomes. This preliminary report concerns hybrids which were synthesized between *A. kobayashii* and tetraploid plants identified as *A. cuneifolium* from the upper Deveron valley, Bridgend, on the Banff/Aberdeenshire border (the 7th locality listed by Roberts & Stirling, 1974). This cross proved easy to produce, and 91 hybrid plants were obtained. The hybridization technique used is now standard at Leeds and was described in detail by Lovis (1968). In the cytological investigation, developing sporangia were fixed, stained, and the preparations made permanent according to Manton (1950).

Meiosis has been examined in the nine of these hybrids which have so far become fertile. These plants incorporate two different stocks of *A. kobayashii*, and three different parental plants of "*A. cuneifolium*", although all from the single locality mentioned above. Material attributed to *A. cuneifolium* from different places has been incorporated into other hybrids which have not yet become fertile. All of the hybrid plants studied have proved to be tetraploid (as was expected) and show almost complete failure of pairing at meiosis, most of the chromosomes (132-144) appearing as univalents. The number of bivalents observed ranges from 0 to a maximum of 6 per cell. There is thus no effective homology between any of the four genomes present in this hybrid (two from the "*cuneifolium*" parent and two contributed by *A. kobayashii*), from which it follows that both parents must be of allopolyploid origin. This result, besides confirming allopolyploidy in *A. kobayashii*, shows unequivocally that the culture of "*A. cuneifolium*" investigated must be an allotetraploid. The number of bivalents observed (0-6, out of a possible maximum of 36) is too few to invalidate this conclusion.

The evidence presented here from the chromosome pairing behaviour in synthetic hybrids thus demonstrates clearly that one of the Scottish serpentine populations which has been claimed to be *A. cuneifolium* by Roberts & Stirling (1974) is not, as had been suggested, autotetraploid, but is allotetraploid in origin. This observation has obvious relevance to the several recent references to the occurrence of *A. cuneifolium* in the British Isles (Roberts, 1979(a) and (b); Scannell, 1978).

For example, *A. cuneifolium* has now been claimed to occur also on serpentine outcrops at the Lizard in Cornwall (Page & Bennell, 1979). Plants from these Cornish serpentine populations have not been examined cytologically, but the spore measurements given in this paper (range 37-51 μ) agree very well with those published by Roberts & Stirling (range 36-46 μ) for their material from the Scottish serpentine localities which is now known to be tetraploid. It therefore seems highly probable that these Cornish plants from Kynance Cove will also prove to be tetraploid. Additional evidence, albeit indirect, is available which suggests very strongly that these populations are in fact allotetraploid. Lovis & Vida (1969), in their elegant experimental resynthesis of *X Asplenophyllitis jacksonii*, used material of the *A. adiantum-nigrum* aggregate from Kynance Cove in their hybridization programme. I have had the opportunity to study Professor Lovis' collections of *A. adiantum-nigrum* from this locality; his specimens bear a striking resemblance to the plants from Kynance Cove described by Page & Bennell as being attributable to *A. cuneifolium*, as well as to Scottish serpentine material attributed to the same taxon, and, although it has not yet been possible to trace the Lovis voucher specimen, it seems very likely that he

incorporated into his hybridization programme a specimen of the same material which Page & Bennell are now referring to *A. cuneifolium*. In order to check this, one of Professor Lovis' specimens was sent to Dr. Page, who confirmed the similarity of the material. Lovis & Vida obtained two hybrids between *A. adiantum-nigrum* from Kynance Cove and *Phyllitis scolopendrium*, both of which show almost complete failure of chromosome pairing at meiosis. There is clearly no homology between either of the genomes contributed by the *Asplenium* parent, which must therefore be an allotetraploid.

What, then, is the nature of this allotetraploid? In view of its morphology, there seems little doubt that it is an extreme form of *Asplenium adiantum-nigrum* L. Evidence for this view may be obtained by crossing the material suspected of being *A. adiantum-nigrum* with the typical form of that species. If the two are in fact the same, the hybrid between them can be expected to show complete pairing of the chromosomes at meiosis. Material of the plants identified as *A. cuneifolium* from the serpentine at Bridgend (which had already been incorporated into the hybrids with *A. kobayashii*) was crossed with *A. adiantum-nigrum* from Guernsey. Hybrids proved very easy to obtain, and no less than 104 were produced from the same number of inseminations. In this type of cross, it can be very difficult to determine if the plants obtained from a hybridization attempt are in fact hybrids, or just selfed progeny arising from self-fertilisation of the female parent. In this case, the parental stocks were of distinctive morphology, and hybrids between them could be recognised by their intermediate appearance as well as by hybrid vigour. Some specimens also showed a small amount of spore abortion, although others, despite their intermediate morphology, produced uniformly good spores. A full report of this investigation, with photographs, will appear elsewhere, but the preliminary results, since they are clearly pertinent to the problem under discussion, can be presented here. Two hybrids have so far been analysed: both yielded several cells which showed virtually complete chromosome pairing at meiosis, a result which is completely in agreement with the belief that the Scottish serpentine populations are neither *A. cuneifolium* nor an autotetraploid derivative of that species, but a form of *A. adiantum-nigrum*.

The evidence presented above clearly shows that the serpentine populations from Scotland and Cornwall which have been identified as *A. cuneifolium* are not that species, but are *Asplenium adiantum-nigrum* L. These populations do appear to show a remarkable degree of morphological homogeneity, and it seems most likely that they represent a specialised serpentine form of *A. adiantum-nigrum*. How far they merit taxonomic recognition (perhaps at the varietal level) is a vexed question which is currently under review. *A. adiantum-nigrum* is an exceedingly adaptable species. It is of wide distribution, occurring also in North America and in the mountains of central and southern Africa, and it may be found in a wide range of habitats, both natural and man-made. As may be expected of a vigorous allotetraploid, it shows a wide spectrum of morphological variation, completely overlapping with the typical forms of both its parents. I have experienced great difficulty in separating plants of *A. adiantum-nigrum* and *A. onopteris* in the Mediterranean region because of their similar appearance. Without a detailed and quantitative morphological study to determine the precise range of variation in *A. adiantum-nigrum* and its progenitors, it seems premature to make a decision to separate the British serpentine populations of this species as a distinct taxon. It is hoped that further work in progress at Leeds will help to resolve this question.

In the meantime, however, it is clear from the present study that the name of *A. cuneifolium* has been erroneously applied to serpentine populations of *A. adiantum-nigrum* in the British Isles. All records of *A. cuneifolium* from Britain

should therefore be treated as suspect.

I am indebted to Dr. Janet Souter for her help in making the cytological preparations used in this investigation.

REFERENCES

- DESCHATRES, R., SCHNELLER, J.J. & REICHSTEIN, T. 1978. A tetraploid cytotype of *Asplenium cuneifolium* Viv. in Corsica. *Fern Gaz.* 11: 343-44.
- JALAS, J. & SUOMINEN, J. (Eds.). 1972. *Atlas Florae Europaeae 1. Pteridophyta*. Helsinki.
- LOVIS, J.D., 1968. Fern hybridists and fern hybridising II. Fern hybridising at the University of Leeds. *Fern Gaz.* 10: 13-20.
- LOVIS, J.D., BROWNSEY, P.J., SLEEP, A. & SHIVAS, M.G., 1972. The origin of *Asplenium balearicum*. *Fern Gaz.* 10: 263-68.
- LOVIS, J.D. & VIDA, G. 1969. The resynthesis and cytogenetic investigation of X *Asplenophyllitis microdon* and X *A. Jacksonii*. *Fern Gaz.* 10: 53-67.
- MANTON, I. 1950. *Problems of cytology and evolution in the Pteridophyta*. Cambridge.
- PAGE, C.N. & BENNELL, F.M. 1979. Preliminary investigation of two south-west England populations of the *Asplenium adiantum-nigrum* aggregate and the addition of *A. cuneifolium* to the English flora. *Fern Gaz.* 12: 5-8.
- ROBERTS, R.H. 1979a. Spore size in *Asplenium adiantum-nigrum* L. and *A. onopteris* L. *Watsonia* 12: 233-238.
- ROBERTS, R.H. 1979b. The serpentine Black Spleenwort in Norway. *Br. Pterid. Soc. Bull.* 2: 22.
- ROBERTS, R.H. & STIRLING, A. McG. 1974. *Asplenium cuneifolium* Viv. in Scotland. *Fern Gaz.* 11: 7-14.
- SCANNELL, M.J.P. 1978. *Asplenium cuneifolium* Viv. in West Galway. *Irish Nat. Journ.* 19: 245.
- SHIVAS, M.G. 1969. A cytotaxonomic study of the *Asplenium adiantum-nigrum* complex. *Fern Gaz.* 10: 68-79.
- SLEEP, A., ROBERTS, R.H., SOUTER, JANET I. & STIRLING, A. McG. 1978. Further investigations on *Asplenium cuneifolium* in the British Isles. *Fern Gaz.* 11: 345-48.

REVIEWS

EXPERIMENTAL BIOLOGY OF FERNS, Edited by A.F. Dyer, 1979, 657. 157 x 234 mm, Academic Press, London. Price £37.50.

As Adrian Dyer says in his introduction this is the first review of the experimental investigation of the structure, function, development and evolution of ferns for 40 years. The book has two main aims: to make more botanists aware of work already done; and to encourage further experimental work by drawing attention to problems in fern biology. There is no doubt that these aims are achieved.

The book begins with a chapter on the Diversity of Ferns: An Ecological perspective (C.N. Page). There is nothing experimental about this — experimental aspects of ecology are dealt with later, by the same author; it is an interesting account of ferns in different habitats throughout the world. Physiologists and other experimentalists, I suspect, would have liked more details about the adaptive biology and morphology seen in the many genera mentioned in this text. P.R. Bell follows giving a stimulating comparison of Fern and Vascular Plant Life Cycles and T.G. Walker in reviewing the Cytogenetics of Ferns, gives a readable account from 160 references tempered with his considerable experience of tropical studies. E.J. Klekowski in Genetics and Reproduction brings the reader into more experimental studies with a bang and plenty of jargon.

Ultrastructure has its place: in gametophyte cells (G.D. Cran); and spore wall morphogenesis (J.M. Pettitt) — an account which, like Walker's above, is contributing

substantially to fern phylogeny. The next six chapters deal with aspects of the gametophyte which as one might expect lends itself to experimental studies. The Culture of Gametophytes (A.F. Dyer) is dealt with clearly and in depth. Cell division in Protonemata (A.F. Dyer and M.A.L. King), Gametophyte Differentiation and Development (D.L. Smith), Gametophyte Photomorphogenesis (G.P. Howland and M.E. Edwards) and Antheridiogens and Antheridial Development (U.Naf) are highly specialised topics and unavoidably overlap in marginal areas. Some fundamental features of Gametogenesis and Fertilisation are put over in a second paper by P.R. Bell where these processes are reviewed again ultrastructurally. R.A. White's account of Sporophyte Development is traditional and clear. Apart from a chapter on the Biology and Control of the Bracken Fern (W.W. Fletcher and R.C. Kirkwood), that seems superfluous and out of context, C.N. Page has the closing words on Experimental Aspects of Fern Ecology. It is a very difficult chapter to write and one thing becomes clear — that much "experimental" (i.e. observational?) ecology was done over 50 years ago. If ever there was a field for experimental research it is in the biology of ferns in relation to their environment.

This book was a mammoth task to edit and Adrian Dyer is to be congratulated on having the courage to take it on. From the dates of the bibliographies it took over two years to get through the press, possibly too long for some actively working authors. Sometimes I felt 'experimental' meant looking in more detail with modern equipment such as the EM. It would have been worth having perhaps two parts to the book — description and synthesis, the latter possibly discussing subjects like 'apogamy' from several angles. Many must feel a lack of descriptive background; for instance I can see no references to Atkinson and Stokey's life-long studies on gametophytes. On the whole, however, authors have done their homework. I estimate in the region of 1750 references are quoted and even allowing 10% duplicity this is still a lot. Aimed, it is said, at senior undergraduates, postgraduates and established botanists, (all underpaid sectors of the community!) this book may seem expensive but it is really good value and some libraries may need two copies.

A.C. JERMY

SYSTEMATICS OF POLYSTICHUM IN WESTERN NORTH AMERICA, NORTH OF MEXICO by David Wagner. *Pteridologia* 1, 64 pp.; 1979. (American Fern Society Special Publication.)

In the pteridological world, it has been customary to publish monographs and the longer detailed studies based on theses in either a general journal, or, as in the U.S.A. and Japan, in the publication of the institution where the work has been carried out. Now, for the first time, a new journal, *Pteridologia*, issued by the American Fern Society, is to be devoted to a broad range of topics specifically concerned with ferns and fern-allies. The "Systematics of Polystichum in Western North America North of Mexico" by David Wagner constitutes the first number of this new journal.

This article is derived from the author's Ph.D. dissertation, submitted to Washing State University in 1976; it sets out very clearly the results of a thorough and detailed morphological study, based on the examination of more than 5,000

herbarium specimens, of the *Polystichum* species of western North America as delimited above. Some interesting conclusions are reached, two new taxonomic combinations made, a hitherto-forgotten taxon rediscovered, and a species new to North America postulated. The present study is an extension of the preliminary work of Professor W.H. Wagner on reticulate evolution in the Holly Ferns of the western United States and adjacent Canada, published in 1973.

Dr. Wagner begins by giving us his reasons for splitting the western American Sword Fern into two distinct species as *P. munitum* and *P. imbricans*. Despite some deficiencies, both in the quantitative measurements and in the presentation of the data, there still seems to be a strong case for his treatment of these two simply-pinnate polystichums; their separation as distinct species is further supported by the virtually complete failure of chromosome pairing shown by a wild hybrid between them, as well as by their occurrence in contrasting ecological habitats.

Polystichum andersonii is a tetraploid species bearing a characteristic proliferous bud and it occurs only in western North America; according to W.H. Wagner, it could be interpreted either as an autopolyploid or as an allopolyploid having *P. munitum* as one parent. David Wagner postulates a bipinnate second parent for his species and claims to have found a herbarium specimen representing it; it should be noted, however, that allopolyploidy still has to be proved for this species.

Polystichum andersonii is a tetraploid species bearing a characteristic proliferous bud and it occurs only in western North America, and according to W.H. Wagner, could be interpreted either as an autopolyploid or as an allopolyploid having *P. munitum* as one parent. David Wagner postulates a bipinnate second parent for this species and claims to have found a herbarium specimen representing it, although allopolyploidy has still not been proved.

Some confusion in the past about the nature and relationships of the large, divided polystichums of the *P. braunii*/*P. andersonii* group has been resolved by Dr. Wagner's discovery of the existence of *P. setigerum* (= *P. alaskense* Maxon), a species which was described by Presl in 1825 but which has remained un-noticed by generations of pteridologists until now. Living material corresponding to this species was collected and cytological investigation showed 123 regular paired chromosomes at meiosis. *P. setigerum* is the first sexually-reproducing hexaploid to be reported in *Polystichum* (although an octoploid, *P. falcinellum*, occurs in Madeira), and Dr. Wagner is to be congratulated on its discovery. It is considered possible that *P. setigerum* arose as a cross between the bipinnate *P. braunii* and *P. munitum*, followed by chromosome doubling; my own studies on the synthetic hybrid between these two species and on herbarium specimens of *P. alaskense* confirm this suggestion. It is, however, surprising to find that no wild hybrids within this group have ever been collected. I would expect the triploid hybrid between *P. munitum* and *P. braunii* to occur in nature, particularly in view of the ease with which it can be synthesized in the laboratory. Presumably routine spore examination to detect possible hybridity has been carried out on all the thirty specimens of *P. setigerum* cited as good species. It would also be interesting to know if spore characters can provide a useful indication of the level of ploidy, or confirm the suggested origin from *P. braunii* and *P. munitum*.

The proposed ancestry of three western North American amphidiploid species is discussed in detail, and the conclusions regarding the phylogeny and relationships of the five diploid and five tetraploid species under consideration are then summarised; a brief survey of their ecology and phytogeography is also given. The work concludes with a usable key to *Polystichum* in western North America, followed by a detailed account of the taxonomy of the thirteen species within the area studied. Useful maps showing the American distribution of these species are included, as well as a list of

representative specimens of each taxon.

This is a very carefully executed and detailed taxonomic study, and many of the problems which caused confusion in the western American polystichums have now been unravelled. I would, however, like to see some experimental hybridization work and genome analysis carried out on this fascinating and closely-related group of species. It could confirm many of the findings presented here as well as clarify some of the points which at present must remain uncertain.

ANNE SLEEP

THE PTERIDOPHYTES OF KANSAS, NEBRASKA, SOUTH DAKOTA AND NORTH DAKOTA by Aleta Jo Petrik-Ott, *Beihefte zur Nova Hedwigia* 61:5-332; 1979. J. Cramer, Vaduz, Price DM100,- (£25.00).

This book is a local Flora of four States in central USA and its aim is to collate information on the distribution of all pteridophytes (some 90 taxa) in those States from 24 major works and many smaller papers (listed in the bibliography, pp. 299-309). The author, herself, has contributed much in field-work in recent years and maps of the States, showing presence on a county basis is an effective method of presenting the data. Hopefully this will stimulate local botanists to fill in many new localities and in the reviewer's opinion this is the gist of, and the most useful part of the book. The distribution of each species is also given on a map of the N. American continent but as this is on a State for State basis, the maps are misleading often showing a continuous distribution from east to west for example, when there is really a disjunction caused by the Mississippi valley. Each species is well-drawn (by the author). The text gives verbose and not always clear descriptions of each species; genera are not described so many generic characters are repeated. This aspect has been covered of course in several recent books and much better. The text also includes detailed localities of all specimens seen which to my mind are totally unnecessary.

This is a clearly printed, well bound book and although much of the cost will be absorbed by subscribers who will get the book in the Series, whether they want it or not, it is still expensive to the individual purchaser.

THE PTERIDOPHYTA OF FERNANDO PO (Contributions to a Flora of the island) 1 by G. Benl in *Acta Bot. Barcinonensia* 31:1-31; 1978 (publ. 1979).

The first part of this work covering Lycopodiaceae, Selaginellaceae, Psilotaceae, Schizaeaceae, Gleicheniaceae, Osmundaceae, Cyatheaceae contains often detailed ecological notes resulting from the author's own field work.

A.C. JERMY

FLORA OF THAILAND Vol. 3 Part 1 Pteridophytes by M. Tagawa and K. Iwatsuki, pp. 128; June 1979. Obtainable from Thai National Documentation Centre, Thailand Institute of Scientific and Technological Research, 196 Phahongothin Road, Bangkok 9; price U\$ 8.00.

This volume covers all families up to and including Dennstaedtiaceae of the 31 families listed for Thailand by the authors in Mem. Fac. Sci. Kyoto Univ. Biol. 5: 67-88; 1972.

A key to all families is given with keys to genera and species of the families dealt with in this volume. The work continues the high standard of this international project giving regional synonymy, clear and concise descriptions, detailed distribution in Thailand and briefly of the complete range. The ecological notes are often based on field experience of the authors in Thailand and elsewhere in S.E. Asia.

CAPE PENINSULA FERNS by J.P. Roux, 66pp., 1979. Published and available from the National Botanic Gardens of South Africa, Kirstenbosch, Newlands, Cape Province S.A., price R.2.50 (about £1.50) [please remit in S.A. currency.]

This is a well produced guide to the fern species of the Cape Peninsula, with line drawings and identification keys to all recognised species (56), by a horticulturist who has himself drawn the plates; most of which are very convincing. The text is clear, giving references to standard works, concise descriptions and a selected list of the few specimens examined. Hopefully this little book will encourage more local fern enthusiasts and as many of the species mentioned are sold as houseplants in Western Europe it should have a good sale here.

FLORA DE LA PROVINCIA DE JUJUY, REPUBLICA ARGENTINA (ed. Angel L. Cabrera) Part II Pteridopitas by Elias R. de la Sota, 275 pp., 1977. Coleccion Cientifica del Instituto Nacional de Tecnologia Agropecuaria (INTA) Vol. 13, Buenos Aires; price not quoted.

This Flora covers the Andean Province of Jujuy in N.W. Argentina in country ranging from 500 to 6000 m altitude. 161 species of ferns and allies in 50 genera (and 23 families) are dealt with with good keys and full descriptions which are supplemented by excellent illustrations often to species not hitherto illustrated before. This book is worth obtaining for its illustrations alone, although the Spanish text is easy to get to grips with. Part I of this series gives the background and phytogeography of the area; the rest of the 3,500 vascular plants of the Province will be dealt with in eight future parts.

A.C. JERMY

SHORT NOTES

ADDITIONAL FIELD CHARACTERS SEPARATING THE SUBSPECIES OF *ASPLENIUM TRICHOMANES* IN BRITAIN

Habit differences observed by the authors between specimens of the *Asplenium trichomanes* group in a number of Scottish stations provide a useful guide to the separation of the two subspecies in the field. Opportunity to discuss these observations with P.M. Benoit and J.W. Dyce and compare them with North Wales plants in the field (see Jermy in Dyce, 1979 : 17) showed similar differences to occur at Welsh sites known to contain the two subspecies. These differences are additional to those which can usually be seen in herbarium material, summarised by Lovis (in Jermy et al., 1978 : 58-60).

When growing from steep or vertical rock faces (the most usual situation for both subspecies), specimens which morphologically can be referred to subsp. *trichomanes*, usually have a habit in which the fronds arch upwards and outwards, away from the rock face. In luxuriant specimens in deep shade they may also arch downwards, in a cascading fashion. By contrast, plants of subsp. *quadrivalens*, unless growing in very deep shade, usually adopt a habit in which the fronds are closely adpressed to the rock-face, over which they spread in all directions (but especially upwards) in a rather sinuous manner. In both subspecies, stipes and rachides on *newly emerged* fronds are normally coloured a glossy, deep blackish-brown. In subsp. *trichomanes*, this colour usually changes rapidly during the first season to a glossy coppery or bronze-red colouration throughout, whilst the blackish-brown colour persists much more permanently in rachides of subsp. *quadrivalens*. As fronds age, a third difference appears. In subsp. *trichomanes*, in most specimens the pinnae become particularly readily *shed from their rachides* (usually during their first autumn and winter), whilst remaining largely leafless, rachides are retained on the plants in sheltered places, apparently for several seasons. By contrast, in most specimens of subsp. *quadrivalens*, pinnae are *retained on their rachides* very much longer (usually at least throughout the first winter, except in very exposed situations), and are rarely completely shed before the rachides themselves eventually break away. Differences in environment can cause some modifications to these differences, plants of subsp. *quadrivalens*, for example, readily shedding their pinnae under conditions of severe drought. Plants of the rarer subsp. *trichomanes* thus give the overall appearance in the field, in addition to their greater delicacy of structure, of having a gracefully arching frond habit, with the current year's fronds arising over persistent masses of thin, bronze-red stipes. At a distance, the habit of such plants can look very different from the spreading sinuous or sinusoidal habit of subsp. *quadrivalens*, and more closely resembles that of *Asplenium viride*.

Another field character which is worthy of observation is the plane of the pinna lamina. In subsp. *trichomanes* this pinna-blade is ridged or striate longitudinally often curling under along the side whilst turning up at the tip. Subsp. *quadrivalens*, on the other hand, has a flatter lamina without such ridges or raised tip (P. Benoit, pers. comm.). Although these differences do not form an infallible guide, they can be of help in separating plants of the two subspecies growing in most typical, broadly similar situations. They are also features which we recommend should be recorded as field annotations on herbarium specimens.

REFERENCES

- DYCE, J.W. 1979. [B.P.S.] Meetings in 1979: Criccieth, North Wales. *B.P.S. Bulletin* 2: 13-18.
 JERMY, A.C., ARNOLD H.R., FARRELL, L., & PERRING, F.H. 1978. *Atlas of ferns of the British Isles*. London.

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A NEW FIND OF *EQUISETUM* X *TRACHYODON* IN NORTH-WEST SCOTLAND

In July 1978, Mr. J. Grant Roger and the author found a horsetail on the western shore of Loch Hope, W. Sutherland (VC108), which was assumed to be *Equisetum variegatum* Schleich. ex Web. & Mohr. Subsequently, a voucher specimen was sent to Dr. C.N. Page, who determined it as *Equisetum* x *trachyodon* A. Br. This record is therefore of some interest since it indicates a further extension in the known range of this hybrid. In Scotland, in addition to its original station in Kincardineshire (Matthews, 1940), it occurs on the Isle of Harris, Isle of Rhum and Isle of Skye (Page, 1979), and recently, *Equisetum* x *trachyodon* has also been found in England, on the Wirral coast (Barker, 1979). The present locality is about 150 km NW of the Skye station and it could well occur elsewhere in Northern Scotland. With regard to the local distribution of the putative parents of this hybrid, *Equisetum variegatum* is not known north of the Assynt district, but *E. hyemale* L. occurs on the north side of Ben Hope (Ferreira, 1958), about 8 km SE of the present site.

The site was revisited in July 1979, when the present observations were made. The general habitat is a SE-facing shore of Loch Hope (located at the level of full flood), which is irrigated by seepage water originating from calcareous rocks associated with the Moine Thrust Plane that crop out within Arnaboll Wood. The site is about 20 x 4 m in size and over 200 shoots of *Equisetum* x *trachyodon* (14 of which had produced cones) were seen, originating from about 60 separate rhizomes.

The horsetail occurs here within two distinct plant communities (a) *Carex panicea*-*Campyllum stellatum* flush and (b) *Molinia* - *Myrica* mire. Both communities are described by McVean and Ratcliffe (1962).

(a) *Carex panicea* - *Campyllum stellatum* flush

This open flush vegetation has a cover of about 15% and grows amongst small stones up to 7 cm diameter. The sand/silt substrate is permanently moistened by the seepage water from the adjacent wood. The floristic composition of this flush was:

<i>*Equisetum</i> x <i>trachyodon</i>	(f) †	<i>Ranunculus flammula</i>	(o)
<i>Molinia caerulea</i>	(f)	<i>Succisa pratensis</i>	(o)
<i>Carex demissa</i>	(f)	<i>Campyllum stellatum</i>	(o)
<i>Nardus stricta</i>	(o)	<i>Agrostis tenuis</i>	(l)
<i>Leontodon autumnalis</i>	(o)	<i>Carex panicea</i>	(l)
<i>Pinguicula vulgaris</i>	(o)	<i>Eleocharis quinqueflora</i>	(l)
<i>Plantago maritima</i>	(o)	<i>Prunella vulgaris</i>	(r)

(b) *Molinia* - *Myrica* mire

Eroded tussocks of this dense mire vegetation occur within the area of *Carex panicea* - *Campyllum stellatum* flush, on the shoreline. Here, the cover is 90-100% and a thin layer of peat overlies the sand/silt substrate. This community is flushed by the same water as in the previous one, but, in this case, by capillary action. The

floristic composition of the mire was:

<i>*Erica tetralix</i>	(a) †	<i>Nardus stricta</i>	(o)
<i>Molinia caerulea</i>	(a)	<i>Pinguicula vulgaris</i>	(o)
<i>Calluna vulgaris</i>	(f)	<i>Selaginella selaginoides</i>	(l)
<i>Myrica gale</i>	(f)	<i>Carex pulicaris</i>	(l)
<i>Carex panicea</i>	(f)	<i>Eleocharis quinqueflora</i>	(l)
<i>Narthecium ossifragum</i>	(f)	<i>Juncus squarrosus</i>	(l)
<i>Potentilla erecta</i>	(f)	<i>Alnus glutinosa</i> (seedlings)	(r)
<i>Succisa pratensis</i>	(f)	<i>Plantago lanceolata</i>	(r)
<i>Equisetum x trachyodon</i>	(o)		

A detailed search of the shoreline for a kilometre both to the north and south of the site failed to locate any additional material of this horsetail.

*Nomenclature of the Flowering Plants & Pteridophytes according to Clapham, Tutin & Warburg (1962).

†(a) = abundant, (f) = frequent, (o) = occasional, (l) = local and (r) = rare.

ACKNOWLEDGEMENTS

I am much indebted to Dr. C.N. Page for the determination of *Equisetum x trachyodon* and for the stimulating discussions on the ecology and distribution of this hybrid in Britain.

REFERENCES

- BARKER, M. 1979. *Equisetum x trachyodon* in Cheshire, new to the English flora. *Fern. Gaz.* 12: 59-60.
- CLAPHAM, A.R., TUTIN, T.G. & WARBURG, E.F. 1962. *Flora of the British Isles*. Cambridge.
- FERREIRA, R.E.C. 1957. *Equisetum hyemale* L. in West Sutherland. *Trans. Bot. Soc. Edinb.* 37: 220.
- MCVEAN, D.N. & RATCLIFFE, D.A. 1962. *Plant Communities of the Scottish Highlands*, HMSO, London.
- MATTHEWS, J.R. 1940. *Equisetum trachyodon* as a Scottish plant. *Trans. & Proc. Bot. Soc. Edinb.* 33: 29-32.
- PAGE, C.N. 1979. *Equisetum x trachyodon* in Western Scotland. *Fern. Gaz.* 12: 57-59.

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PTERIS CRETICA AND SELAGINELLA KRAUSSIANA NATURALISED IN SCOTLAND

Boturich Castle, Dunbartonshire, is situated at the south end of Loch Lomond, ¾ mile (1.2 km) north of Balloch and approximately 400 metres from the shore of the Loch. Below the Castle is a large kitchen garden and orchard (now disused), derelict greenhouses, coldframes and a potting shed. Recently, two alien pteridophytes, *Pteris cretica* L. and *Selaginella kraussiana* (Kze.) A. Br., were found to have become sufficiently well-established here that they can be considered to be naturalised. Both species have been frequently cultivated as glasshouse plants in Britain, and both have presumably established here from former cultivated plants grown in the castle greenhouses, although these greenhouses have been disused for approximately 30 years.

Selaginella kraussiana, a native to the Azores and tropical West Africa, is hitherto known to have established itself in the more oceanic areas of south and west Britain and Ireland where it can successfully overwinter, but has only once been recorded to have done so in Scotland (recently in nearby Kintyre, V.C.101 — Kenneth 1979). Similarly, *Pteris cretica* has previously been recorded in scattered localities only in

southern Britain (e.g. West Kent V.C.16, South Devon V.C.3 and Staffordshire V.C.36 – A.R. Busby, personal communication).

Pteris cretica has become established on the interior mortared wall of the old potting shed at Boturich, in dense shade together with *Phyllitis scolopendrium*. The only sources of light are through the open doorway and through a skylight in the roof. Moisture supply within the shed is limited to that which can enter through the leaking roof.

Selaginella kraussiana grows as a prostrate mat in dense shade below the staging of a lean-to greenhouse (back wall facing east). A tall overgrown beech hedge and naturally regenerating alder, sycamore, ash and hazel saplings shade the greenhouse itself. Glass missing from about half of the roof permits a constant supply of rain water to enter during wet weather (annual rainfall is circa 60 inches) and a water tank sunken into the floor in the corner below the staging helps retain humidity during dry conditions.

The only other plants growing under the staging and associated with the *Selaginella* are *Phyllitis scolopendrium*, *Dryopteris dilatata* (one small plant) and the bryophytes *Brachythecium velutinum*, *Amblystegium serpens*, *Ceratodon purpureus* and *Lophocolea bidentata*. All these species have colonized pockets of soil in crumbling walls and in soil and detritus on the floor and amongst broken flower pots. Success of the *Selaginella* has been followed over three seasons and it appears to thrive, although restricted to the shaded area below the staging in the lean-to. It occurs in none of the other buildings. The *Pteris* seems to have a much more tenuous hold, and only three individual clumps, none looking particularly healthy, have been found.

Both aliens suffered considerably in vigour following the particularly severe winter of 1978. One plant of the *Pteris* nevertheless survived, and the *Selaginella* recovered health again by the following summer.

Voucher herbarium specimens are to be deposited at R.B.G. Edinburgh (E).

REFERENCE

KENNETH, A. 1979. Plant Records. *Watsonia* 12: 347.

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NEW RECORDS OF ASPLENIOUM AND EQUISETUM HYBRIDS IN FRANCE

Asplenium x *ticinense* D.E. Meyer (Meyer, 1961), the hybrid between *A. adiantum-nigrum* and *A. onopteris*, has only recently been shown to be a member of the French flora, having been identified (Roberts, 1974) from two herbarium fronds gathered at Vernet-les Bains (Pyrenees-Orientales).

On September 1977 R. Prelli found *A.* x *ticinense* in northern Brittany near Trecelin, 5 km south of Cap Frehel (Côtes-du-Nord) with the parent species under the cover of *Fraxinus excelsior* and *Quercus pendunculata*. Two stocks have been discovered on a slope facing westward. Growing with them were *Asplenium scolopendrium*, *Polystichum setiferum*, *Hedera helix*, *Ruscus aculeatus*, *Iris foetidissima*, *Rubia peregrina*, *Brachypodium silvaticum*.

It seems likely that this hybrid might occur in other places where the altitudinal ranges of the two parent species overlap. In 1978 we identified two mature fronds of *A.* x *ticinense* found at La Blanche, between Saint-Etienne-de-Tinee and Isola (Alpes-Maritimes), at an altitude of c. 900 m, and between Col de Sorba and Ghisoni (Corsica). These specimens were respectively collected by A. Borel and G. Dutartre to

whom we are indebted for these new records.

Specimens from the three sites are large, having a total length up to 60 cm, with the blade up to 27 cm long. The blade is tripinnate with the pinna segments long and acuminate. These segments are curved towards the apex of leaf, except in the specimen from Corsica. Mature sporangia contain only misshapen, defective spores.

It is worth noting that records of *A. onopteris* in the western part of France are questionable (most being misidentification of *A. adiantum-nigrum*). Near Trecelin, spore size was also studied in the parent species. A random sample of 100 spores from each plant was measured, excluding the perispore. The spores of *A. adiantum-nigrum* are longer (mean values 32µm to 38µm) than those of *A. onopteris* (mean value 26µm to 32µm).

Asplenium x *sarniense* Sleep (*A. adiantum-nigrum* x *A. billotii*), described from Guernsey (Sleep, 1971), has since been found by the authors (March 1978) in the southern coast of Brittany, at Kersicot, 2 km east of La Foret-Fouesnant (Finistre). The habitat of *A. x sarniense* at Kersicot is a wall partly covered with *Hedera helix* in the shade of a row of *Castanea sativa* trees. The parent species grow very near to the hybrid and occur widely in the neighbourhood. Associated species noted include *Melandrium diurnum*, *Dactylis glomerata*, *Rubus* sp., and *Polypodium interjectum*, all of which are regularly cut in the course of roadside trimming.

As noted by Sleep, the hybrid and *A. adiantum-nigrum* have similar triangular, bi- to tripinnate blades, and triangular pinnae in which the proximal pinnules are large and subdivided. But the pinnules of the upper part of the blade, which are shortly but distinctly stalked, even towards the end of the pinnae, show the influence of *A. billotii*. These pinnules are oval in shape, rounded at the tips and bear short, mucronate teeth. Spores are abortive.

It is interesting to point out that Litardière (1924) described *Asplenium trojanii* from Corsica. He suggested that the plant may be a hybrid between *A. billotii* and *A. adiantum-nigrum*. Although the locality has been visited, a more thorough investigation of the site is needed. Even if the first parent is *A. billotii* the possibility of another species of the *A. adiantum-nigrum* complex being one parent cannot be overlooked.

Equisetum x *font-queri* Rothm., the hybrid between *E. palustre* and *E. telmateia*, has been identified as a member of the French flora (Hauke, 1966; Page, 1973) from herbarium specimens gathered by Burnat at "entre le pont du Var et la mer; sables des alluvions du Var" (Alpes-Maritimes) on the 20th May 1872. Specimens from this locality can also be seen in herb. Burnat (G-BU !) at Paris (P !), at Lyon (LY !), at Kew (K) and at Stockholm (S-PA). Unfortunately the site has very probably been destroyed, but R. Prelli found the hybrid in April 1977, at Cagnes-sur-Mer, west of the river Var (Alpes-Maritimes). The plant occupies about 150 sq m of a railway embankment near its junction with the river La Cagne. The *Equisetum* predominates amongst other horsetails (*E. arvense*, *E. ramosissimum*, *E. telmateia*). Flowering plants noted included *Hordeum murinum*, *Urtica dioica*, *Polygonum aviculare*. The river side was in the past marshy, but today the stream has been confined by banks. *E. palustre* has not been recorded in the site, but might have been there in the past. However it still grows 3-4 km away from this site.

Another specimen of *E. x font-queri* from Pyrenees-Orientales is at Montpellier (MPU !). The labels read as follows: "abonde au rivage du Tech a Elne".

All the *E. x font-queri* specimens agree completely with the descriptions given by Page (1973) and Roberts & Page (1979) for the two British stations, and are intermediate in size and morphology between the parent species. As noted by Page, a proportion of the spores are small, misshapen, lack good elaters and are obviously abortive.

REFERENCES

- HAUKE, R.L. 1966. A systematic study of *Equisetum arvense*. *Nova Hedw.* 13: 81-109.
- LITARDIERE, 1924. *Ann. Soc. Linn. Lyon. n.s.* 70: 131-133.
- MEYER, D.E. 1960. Sw Zytologie der Asplenien Mitteleuropas (XXIV-XXVIII). *Ber. Deutsch. Bot. Ges.* 73: 86-394.
- PAGE, C.N. 1973. Two hybrids in *Equisetum* new to the British Flora. *Watsonia* 9: 229-237.
- ROBERTS, R.H. 1974. *Asplenium* × *ticinense* D.E. Meyer from a French locality *Fern. Gaz.* 11: 55.
- ROBERTS, R.H. & PAGE, C.N. 1979. A second British record for *Equisetum* × *font-queri*, and its addition to the English flora. *Fern Gaz.* 12: 61-62.
- SLEEP, A. 1971. A new hybrid fern from Channel Islands. *Brit. Fern Gaz.* 10: 209-211.

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EQUISETUM X ROTHMALERI NEW TO JAPAN

A herbarium specimen of *Equisetum* × *rothmaleri* C.N. Page (the very rare hybrid between *E. arvense* L. and *E. palustre* L.) has been recently confirmed, collected from "environs de Sapporo" in the northern Japanese Island of Hokkaido. The specimen, at Paris (P), was collected by M. l'Abbe Faurie, on 26 May 1891 (Faurie 6850).

Despite the abundance of the two parent species around the north temperate zone, this is only the second known station for this cross. The first (type) locality is on the Isle of Skye, western Scotland (Page 1973), and the Skye and Japanese plants match very closely. Separated by such a great distance, the two must clearly have originated independently.

REFERENCE

- PAGE, C.N. 1973. Two hybrids in *Equisetum* new to the British Flora. *Watsonia* 9: 229-237.

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MACROTHELYPTERIS, A FERN GENUS NEW TO MAINLAND AFRICA

While collecting ferns in August 1979 on Ian Garland's farm 'Twinstreams' at Mtunzini, Natal, South Africa, *Macrothelypteris torresiana* (Gaud.) Ching was found to be locally common on the sides of ditches at the margin of swamp forest and sugarcane fields not far above sea-level. Schelpe (1969) does not list this fern for southern Africa, nor does Holttum (1974) mention its presence in mainland Africa. (Both these authors have confirmed my identification.)

Macrothelypteris torresiana is a wide-ranging species native to the Old World Tropics from the Mascarene Islands to Queensland and Hawaii, which has also become naturalised in the tropics of the New World. It is capable of growth in a wide variety of

habitats, some unmodified, e.g. limestone screes in light shade, others of a secondary nature following man's disturbance, e.g. roadside banks in forest and areas of forest clearance following logging. Although the nearest known localities are in Madagascar and Reunion it seems reasonable to assume that it is of natural occurrence in a secondary habitat at Mtunzini (which lies at approx. lat. 29° 57' S and 32° 45' E, in the subtropical summer rainfall belt of South Africa) and that it probably occurs elsewhere along the coast of northern Natal and further north in Africa also.

REFERENCES

- HOLTUM, R.E. 1974. Thelypteridaceae of Africa and adjacent islands. *Jour. S. Afr. Bot.* 40: 123-168.
 SCHELPE, E.A.C.L.E. 1969. A revised checklist of the pteridophyta of southern Africa. *Jour. S. Afr. Bot.* 35: 127-140.

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NEW COMBINATIONS IN SOUTH-EAST ASIAN FERNS

Preparation of an account of Grammitidaceae for Flora Malesiana and of ecological papers based upon my recent fieldwork in Borneo, New Guinea and the Philippines necessitate the publication of the following new combinations.

- Crypsinus stenopteris* (Baker) Parris **comb. nov.**
 Basionym: *Polypodium stenopteris* Baker, *Jour. Bot.* 17: 43 (1879).
Ctenopteris barathrophylla (Baker) Parris **comb. nov.**
 Basionym: *Polypodium barathrophyllum* Baker, *Jour. Bot.* 29: 107 (1891).
Ctenopteris rufidula (C. Chr.) Parris **comb. nov.**
 Basionym: *Polypodium rufidulum* C. Chr., *Ind. Fil. Suppl.* 3: 157 (1934) (*nom. nov.* for *P. rufescens* Brause (1912) non Bl. (1829)).
Diplazium angustisquamatum Holtum Parris **comb. nov.**
 Basionym: *Athyrium angustisquamatum* Holtum, *Gardens' Bull. (Singapore)* 11: 273 (1947).
Diplazium latilobum (Copel.) Parris **comb. nov.** *Ken Herb. (1966) nom. illeg.*
 Basionym: *Athyrium latilobum* Copel., *Univ. Calif. Publ. Bot.* 18: 222 (1942).
Diplazium megistophyllum (Copel.) Parris **comb. nov.** *Jag. Acta Phytobot. Indon.* 25: 186, 1973.
 Basionym: *Athyrium megistophyllum* Copel., *Philipp. Journ. Sci.* 56: 475, t.7 (1935).
Goniophlebium mehipitense (C. Chr.) Parris **comb. nov.**
 Basionym: *Polypodium mehipitense* C. Chr., *Mitt. aus d. Inst. allgem. Bot. Hamburg* 7: 159 (1928).
Goniophlebium rajaense (C. Chr.) Parris **comb. nov.**
 Basionym: *Polypodium rajaense* C. Chr., *Mitt. aus d. Inst. allgem. Bot. Hamburg* 7: 159 (1928).
Grammitis clemensiae (Copel.) Parris **comb. nov.**
 Basionym: *Oreogrammitis clemensiae* Copel., *Philipp. Journ. Sci.* 12C: 64 (1917).
Grammitis maxwellii (Baker) Parris **comb. nov.**
 Basionym: *Polypodium maxwellii* Baker, *Kew Bull.* 1893: 211 (1893).
Grammitis papuensis (v.A.v.R.) Parris **comb. nov.**
 Basionym: *Polypodium papuense* v.A.v.R., *Malayan Ferns Suppl.* 521 (1917).
Grammitis sparsipila (Copel.) Parris, **comb. nov.**
 Basionym: *Polypodium sparsipilum* Copel., *Philipp. Journ. Sci.* 6C: 139 (1911).
Grammitis sucklingiana (Baker) Parris, **comb. nov.**
 Basionym: *Polypodium sucklingianum* Baker, *Annals Bot.* 8: 128 (1894).
Grammitis viridula (v.A.v.R.) Parris, **comb. nov.**
 Basionym: *Polypodium viridulum* v.A.v.R., *Nova Guinea* 14: 41 (1924).
Grammitis vittariifolia (C. Chr.) Parris **comb. nov.**
 Basionym: *Polypodium vittariifolium* C. Chr., *Ind. Fil.* 574 (1906) (*nom. nov.* for *P. minimum* Baker (1879) non Aublet (1775) nec Brack. (1854) nec Moore (1857)).
Humata subvestita (C. Chr.) Parris **comb. nov.**
 Basionym: *Humata kinabaluensis* var. *subvestita* C. Chr., *Gardens' Bull. (Singapore)* 7: 232 (1934).

Phymatopteris glauca (J. Sm. ex Brack.) Parris **comb. nov.**

Basionym: *Drynaria glauca* J. Sm. ex Brack., *Expl. Exped.* **16**: 54 (1854).

Phymatopteris taeniata var. *borneensis* (Christ) Parris **comb. nov.**

Basionym: *Polypodium griffithianum* var. *borneense* Christ. *Ann. Jard. Bot. Buit.* **20**: 122 (1906).

Pyrrosia dimorpha (Copel.) Parris **comb. nov.**

Basionym: *Cyclophorus dimorphus* Copel., *Journ. Arnold Arb.* **10**: 180 (1929).

Pyrrosia stellata (Copel.) Parris **comb. nov.**

Basionym: *Cyclophorus stellatus* Copel., *Journ. Arnold Arb.* **10**: 179 (1929).

Selliguea bellisquamata (C. Chr.) Parris **comb. nov.**

Basionym: *Polypodium bellisquamatum* C. Chr., *Brittonia* **2**: 313 (1937).

Selliguea gibbsiae (v.A.v.R.) Parris **comb. nov.**

Basionym: *Pleopeltis gibbsiae* v.A.v.R., *Bull. Buit.* **11**: 37 (1918).

Xiphopteris bryophylla (v.A.v.R.) Parris **comb. nov.**

Basionym: *Polypodium bryophyllum* v.A.v.R., *Bull. Jard. Bot. Buit.* **2**: 16: 35 (1914).

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THE FIRST SYMPOSIUM ON CHINESE PTERIDOLOGY

The first Symposium on Chinese Pteridology which was organised by the Botanical Society of China was held from 19-23 October 1979, in West Tian-Mu Shan near Hangchow in Chekiang Province. There were thirty-seven delegates from botanical institutes, universities and natural history museums in fourteen provinces attending the meeting. Previous to the meeting an executive committee of five was elected: they are Chiu Pei-Shi, Shing Kung-Shar, Kung Shien-Shu, Wang Chu-Hao and Zhang Chao-Fang.

The meeting was opened by executive chairman Shing Kung-Shar reading a speech by Professor Ching Ren-Chang, the Honorary chairman of the Botanical Society of China. After reviewing the history of research work carried out in Chinese pteridology in the past fifty years, Prof. Ching said: "Although we have made considerable headway in the past this is only the first step in our long march. We must make great effort to enlarge our team, undertake more thorough field exploration for ferns, and with the help of studies of anatomy, cytology and chemistry, gradually raise the level of Chinese pteridology until almost reaching the molecular level, thereby expounding the origin, evolution and systematic relationships of Chinese ferns, and also their economical uses, for the purpose of the "Four Modernizations" as proposed by our Central Government". These are the most inspiring and glorious tasks before us. I hope each of us will steadily march from victory to victory.

Twenty-seven papers including taxonomy, ecology, spore morphology, cytology and chemistry of ferns were read and a warm discussion ensued in the following two days. From this it became clear that studies in Chinese ferns and the preparation for an all-embracing Chinese Fern Flora are in active progress. Taxonomists in several Provinces have been already collecting fern specimens and writing regional fern Floras, among which Fukien, Kwantung, Szechuan, Yunnan and Kiangsi are taking the lead in the work. From the papers read at the symposium one also can see that Chinese pteridologists are using new approaches, such as the SEM, in their work.

Everybody present felt the symposium was successful. It has not only offered a chance to exchange scientific views and strengthen mutual connections, it also has laid a better foundation for closer co-operation between pteridologists. We also discussed ways and means of training young workers, popularising fern knowledge among the general public, and introducing wild ferns into cultivation for scientific

study and as ornamentals in gardens. Delegates also exchanged opinions as to where and when the second symposium would be held.

Two excursions were arranged after the meeting for the delegates to collect and observe ferns in nearby mountains, when an altitude of 1506 m was reached, and to visit the herbarium and fernery at the Botanical Garden, Hangchow.

SHING KUNG-SHAR

THE FERN GAZETTE

Original papers, articles, or notes of any length on any aspect of pteridology will be considered for publication. Contributions will be particularly welcomed on floristic, biogeographical and ecological aspects of ferns and their allies, worldwide. Members are especially encouraged to make use of short notes for reporting pteridophyte field observations and records. All may be illustrated with black and white photographs of good technical quality and line drawings. Short papers can usually be incorporated more quickly than longer ones.

Contributions should be sent to:

C.N. Page, Royal Botanic Garden, Edinburgh, U.K.

The *last date* for receiving notes and articles to make the following early summer number is:

30 November each year

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Manuscripts: Copy should be in English and submitted in double-spaced type with adequate margins, on one side of the paper only.

Abstract: All papers, other than short notes, should include a short abstract, to be set at the head of the main text, indicating the scope of the topic and main conclusions.

Headings and sub-headings: *These should follow the style of this number.* (Primary sub-headings are centred capitals. Secondary sub-headings U and L case side roman. Tertiary sub-headings, if necessary, are U and L case side italic.) Numbering of sub-headings should be avoided.

Latin names: Quote the authority at (usually) the first mention only, in the main text but, unless unavoidable for clarity, not in the title. All latin names should be underlined throughout the typed copy.

Illustrations: Any number and combination of line and half-tone illustrations (original drawings or diagrams in ink, or black and white photographs of good technical quality) can be included with a manuscript where these help to augment or amplify the text. Photographs should be of the required magnification or larger and need not be made up into full page plates. Each drawing or photograph should be marked on the back with details of author and figure number, and the top edge clearly marked "top".

Figure numbering: Grouped illustrations should follow the numbering system, fig 1a, fig 1b, fig 2a, fig 2b, fig 3, etc. Figure numbers should be applied to illustrations *in pencil only or on a transparent overlay*. Final lettering will be added by the editor in a style and size consistent with the journal.

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Books for review in the *Fern Gazette* or *B.P.S. Bulletin* should be sent to A.C. Jermy, Botany Department, British Museum (Natural History), Cromwell Road, London SW7 5BD.

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DROUGHT TOLERANCE IN CHEILANTHES WITH SPECIAL REFERENCE TO THE GAMETOPHYTE

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ABSTRACT

The gametophytes of a range of Australian species of *Cheilanthes* are shown, in comparison with other more mesic genera of ferns, to have the remarkable capacity to withstand severe water deficits and survive after drying and continued exposure to periods of low humidity. This ability to withstand severe desiccation is considered to be important in the establishment and survival of the genus in ecological niches not otherwise colonized by ferns.

INTRODUCTION

Only a few genera of ferns are noted for their drought tolerance and their ability to survive in habitats usually not colonized by pteridophytes. Some genera are able to survive over extensive areas of open country otherwise hostile to most species of ferns. The almost cosmopolitan *Pteridium* is a good example of such a species as is *Paesia scaberula* in New Zealand. Such plants have become serious weeds of pasture country. To what extent the invasion by these species is associated with the biological adaptation of the gametophyte as against the adaptations of the rhizome of the sporophyte is not fully understood. Only a few of the genera of the lower vascular plants are able to extend into much more arid habitats than are these two examples; *Pellaea* and *Cheilanthes* are notable examples from the Leptosporangiate ferns; the resurrection plants *Selaginella lepidophylla* and *S. rupestris* are well known examples from the Lycopsidea.

In Australia we have observed that the sporophyte of some species of *Cheilanthes* perennates during the summer months by means of a rhizome while the fronds completely die down e.g. *C. tenuifolia* and *C. sieberi*. Other species which extend even further into the arid parts of Australia maintain at least a few of their leaves in an extremely dehydrated but living state e.g. *C. vellea* and *C. lasiophylla*. There are a few species of *Cheilanthes* which grow in the cooler coastal regions of Australia. But even in these regions they are never found in the moist, sheltered, constantly humid environments of most other ferns but rather they prefer rock crevices and shallow soil pockets in dry rocky hillsides e.g. *C. distans*. These species in these habitats sometimes perennate in the hot summer months by means of their rhizome, but under less severe conditions they may remain with some green fronds throughout the growing season. Hevly (1963) has described several adaptations of cheilanthoid fern genera of Arizona to their harsh desert environments. Many of these features are certainly also characteristic of the Australian species of *Cheilanthes* in their sporophytic state. The sporophytic stages of Australian species exhibit microphyllly and some have a dense indument of hairs and/or scales; the plants are small (generally below 30 cm in height) and either have narrow fronds (*C. sieberi*, *C. lasiophylla*) or if with ovate fronds then these are finely dissected (*C. tenuifolia*) or they may have very narrow pinnules (*C. caudata*). Hevly suggests that the dissection is a reduction in leaf size which may reduce water loss by reduction of total leaf surface. The rhizomes of all species of *Cheilanthes* in Australia are densely scaly and a cover of hairs and/or scales is found on the stipe and lamina of *C. lasiophylla*, *C. distans*, *C. vellea*, *C. hirsuta*, *C. contigua* and an as yet undescribed sub-species of *C. sieberi*.

That this thick indument is an inbuilt genetic feature of the plant is demonstrated in the observation that species of *C. lasiophylla* and *C. distans* taken from the field and

grown under glasshouse conditions protected from harsh light and severe water stress, show no lessening in the thickness of the scale cover on the new fronds which developed, even after more than a year in cultivation. Also, sporophytic plants of some of these species raised from gametophytes in cultivation showed the same thick scale covering as did their wild parents. It seems likely that these scales and hairs may reduce water loss through transpiration by creating still air zones near to the plant surface in which the air remains at a relatively high humidity and through which diffusion from the interior of the plant to the exterior would be slow. It is also possible that the scales and hairs reflect significant amounts of solar radiation especially in species growing exposed on desert rocks, e.g. *C. vellea* and *C. lasiophylla*. Certainly those species which genetically have the most dense indument (*C. lasiophylla*, *C. vellea*) are found in the more arid regions of Australia. However, the more common form of *C. sieberi* is unusual in having a glabrous stipe and lamina and yet it is often found growing in the same arid localities as *C. lasiophylla*. Leaves of the Mediterranean cheilanthoid fern *Notholaena marantae* R.Br. were reported by Iljin (1931) to tolerate desiccation to relative humidities of less than 50%. This tolerance was attributed to the low leaf surface-to-volume ratio which Iljin suggested reduced the change in volume of the cells on de- and rehydration. In addition he reported the presence of a non-drying substance in the cells, a stable body or "fester Körper" which could be differentially stained from the cytoplasm.

The fronds of the Australian *C. sieberi*, *C. tenuifolia*, and *C. "austrotenuifolia"** wilt and die under hot conditions and low humidity. On rehydration, after a sustained dry period, completely new fronds are produced from the rhizome. This seasonal drying off may be at least partly a response to high summer temperatures and longer day length rather than summer water deficit. Evidence supporting this view is obtained from glasshouse-grown specimens of this species which die off each summer despite regular watering and sprout new fronds from the rhizome in autumn.

On the other hand, *C. lasiophylla* in cultivation tends to die off to a lesser extent when glasshouse grown and it also does not normally produce new shoots during the hot months even if watering is maintained. We have obtained the best growth responses of these plants in cultivation by ensuring that they are subject to some water stress during the hot summer months.

It can be seen therefore, that there are a number of adaptations of the sporophyte of Australian species of *Cheilanthes* which include both stress avoidance (by reduction of moisture loss) and high temperature tolerance as seen by the ability to regenerate new fronds after what appears superficially to be death of the old plant by drought. However, these adaptations for many habitats in which these species occur would be in vain if the spores and the gametophyte generation were not also able to avoid or endure periodic xeric conditions. Such adaptations of the gametophyte could range from simple drought avoidance by rapid growth and maturation leading to early establishment of the sporophyte to either, morphologically distinctive xeromorphic features reducing water loss from the gametophyte or to truly physiological xerophytic adaptations of a cytoplasm which can withstand periodic desiccation.

Spores of *Cheilanthes* appear to be tolerant of extreme and prolonged exposure to low humidity. Working with the North American species *C. gracillima*, D.C. Eaton, Pickett (1923) reported that the spores remained viable after a period of 16 months over anhydrous calcium chloride even though the cytoplasm by this time appeared "dried and shrunken to the sides of the spore". Although we have not made a

*The name "austrotenuifolia" has no status. It is used to designate populations of a species morphologically very similar to *C. tenuifolia* and up to the present referred to that species but with most distinctive spores. It is widely distributed through the southern half of the Australian continent and we are presently investigating its correct name.

systematic study of the desiccation tolerance of the spores of the Australian species we have found it possible to germinate spores of herbarium specimens of *C. tenuifolia*, 15 months after collection and spores of herbarium specimens of *C. shirleyana*, *C. pumilio* and *C. caudata* germinated and produced typical gametophytes two years after collection from the field. It is clear, therefore, that spores can remain viable for long periods after release.

The gametophytes of those Australian species of *Cheilanthes* which we have grown lack any obvious morphological protective structures; they are one cell thick for most of their area (except the central cushion region); they have no protective hairs and lack a conspicuous cuticle. They also lack the wax secretory glands reported for *Notholaena trichomanoides* (L.) Desv. (see Bower 1923) and for *N. standleyi* Maxon (see Tryon 1947). It seems likely that the survival of the germinated spore and the gametophyte may also be assisted by two features, — first, a fairly rapid germination rate following hydration (usually within 10 days from when spores are sown in the laboratory on moist peat), and secondly by attaining sexual maturity within two months and this may be sooner under field conditions. While such development would assist the plant in avoiding drought, comparable speeds of germination and attainment of maturity have been observed in genera normally associated with more mesic conditions e.g. *Phlebodium*, *Lastreopsis* and *Doodia*.

Another factor important in some species of *Cheilanthes* is the presence of apogamy, which enables the fern to circumvent the need for free water droplets at the time of sexual maturity by avoiding the need for fertilization. Knobloch (1966) reported the occurrence of obligate apogamy in 19 species of *Cheilanthes* including *C. tenuifolia* and *C. sieberi*. We have observed apogamy to occur in at least the following 6 Australian taxa, — *C. sieberi*, *C. sieberi* sub-species "*pseudovellea*", *C. distans*, *C. lasiophylla* and *C. pumilio*.

It seems likely, therefore, that the delicate gametophyte itself might be physiologically able to endure severe water stress and so establish itself in the varied arid niches that are characteristically occupied by members of this genus. The only study we are aware of was by Pickett (1923) who studied the drought tolerance of the Central American *C. gracillima* by drying gametophytes for 5 months in the laboratory followed by 13 weeks over anhydrous calcium chloride. Despite the severe water loss by such treatment he reported that a large percentage of prothalli revived when rehydrated and those which did not survive outright sometimes generated new prothalli on their margins.

In view of the apparent complete absence of xeromorphic features associated with the gametophyte we were concerned to answer the following questions in relation to possible xerophytic adaptation:—

- (1) Are the gametophytes of selected Australian species of *Cheilanthes* drought tolerant?
- (2) If so, is drought tolerance in any way related to the stage of development at which they are dried?
- (3) How tolerant are gametophytes to drying at particular levels of relative humidity?
- (4) Are some species more tolerant than others?
- (5) Does drought tolerance vary with the climate of the area from which the specimen was collected?
- (6) Can prothalli of more mesic ferns tolerate drought in a similar way?

MATERIALS AND METHODS

Four species of *Cheilanthes* from five localities were used. These plants were in cultivation in the glasshouse and from these cultivated plants the spores were collected. The following voucher specimens have been lodged at MEL.

- (a) *C. sieberi*, Springhurst, N.E. Vict. E. Canning 4014E
- (b) *C. sieberi*, Big Desert, N.W. Vict. H. Quirk 111
- (c) *C. "austrotenuifolia"*, Springhurst, N.E. Vict. E. Canning 4014E
- (d) *C. distans*, Dargo, East Vict. H. Quirk 1
- (e) *C. distans*, Queensland, D. Gaff, s.n. (1972)
- (f) *C. lasiophylla*, Mootwingee, National Park, Far West N.S.W. I.G. Stone, s.n. (28th July, 1976) H. Quirk 108
- (g) *C. lasiophylla*, Big Desert, N.W. Victoria (MEL 515004)

In addition spores of the following more mesic species were similarly sown, *Doodia media*, R.Br., *Lastreopsis shepherdii* (Kunze ex Mett.) M.D. Tindale (from Victoria) and *Phlebodium aureum* J.Sm. (a S. American species in cultivation).

Fresh pinnules bearing mature sporangia were surface sterilized by briefly soaking in calcium hypochlorite solution, followed by washing in running water. Spores were shed between clean sheets of white paper and were sown onto moist peat in small crystallizing jars sealed with a thin film of polyethylene plastic ("Gladwrap") to reduce the risk of contamination and prevent the cultures from drying. Cultures were grown indoors near a north facing window protected from high summer sun but allowed brief periods of direct sunlight especially in the Autumn months in the late afternoon.

The humidity treatments were conducted in closed vessels using a range of concentrations of sulphuric acid following Wilson (1921) and making the assumption that the cultures would be kept in the temperature range of 25°C (in fact the temperature in this room fluctuated between 17°C and 28°C.)

%H ₂ SO ₄	70.5	58.5	50.9	43.4	36.0	27.2
RH at 25°C	5%	20%	35%	50%	65%	80%

The concentration of acid was only known within the range 95-98% which could lead to minor errors. The dilutions were made assuming the acid concentrations to be 96.5%. The above range of humidities were selected to cover and extend below those likely to be encountered by field grown material. In arid Central Australia, humidity may drop to 15% or lower in the drier months whereas in Melbourne the lowest humidities in the summer are about 60%. In the field, humidities could vary greatly through each 24 hour period. No attempt was made to simulate such changing conditions. The vessels used for the humidity changes consisted of small screwtop glass jars 8 cm high x 5 cm diameter containing 33 mls of acid solution. Aluminium foil trays were suspended on wire attached to the lid, each tray being about 3.5 cm in diameter and divided into 4 sections so that prothalli from 4 different samples could be treated in each jar simultaneously.

The gametophytes which were to be subjected to the humidity treatments were first allowed to dry slowly by taking 6 groups of prothalli (15-40 individuals) from a culture to be tested. Care was taken to see that the peat substrate remained attached to the prothalli so that damage to the rhizoides was minimal. These groups of species were placed in separate dishes of moist peat and exposed in a glasshouse for 7-10 days which allowed them to dry out gradually and reasonably naturally (the glasshouse was neither heated nor cooled but it was well ventilated). Each of the 6 groups now wilted and dried were then placed in one of the 6 humidity changes at 6 different relative humidities, sealed and wrapped in plastic and allowed to stand in the same room where they had been growing originally and where temperatures varied between 17° and 28°C.

After 10 days of such treatment the prothalli were removed and, still attached to their original substrate (peat moss) placed in petri dishes and rehydrated with a few drops of water and allowed to stand overnight. the prothalli were then replanted into moist peat under the same conditions as those in which they had originally been grown, and periodically checked to determine whether they had survived the desiccation treatment and had retained the capacity to continue to grow and develop normally. From each experimental batch a few plants were tested to check whether they were alive by placing them for 4-5 hours in a 0.1% stock solution of neutral red made up 1 : 30 with 0.1M CaCl₂ with a trace of dilute NaOH. Cells which were still alive took up the orange coloured solution while those which were permanently damaged did not.

RESULTS

Prothalli of the 7 samples of *Cheilanthes* studied were dried at 4 different stages in their development:—

Stage 1 3-4 days after germination, when prothalli are only a small filament or plate.

Stage 2 2-3 weeks later when prothalli are cordate in shape but not yet fully grown.

Stage 3 prothalli are fully mature with either antheridia or archegonia (in the case of *C. "austrotenuifolia"*) or just beginning to give rise to apogamously produced sporophytes.

Stage 4 Young sporophytes have developed 1-3 leaves. At this stage they are still very small (ca. 5mm high) and unprotected.

Our first attempts to study the drought resistance of the gametophyte failed because we dried the gametophytes at their various stages of development immediately from the fresh state over the selected acid in the humidity controlled jars. This drying proved too severe and too rapid and very few gametophytes at any stage from any species survived after such treatment. All the experimental results which follow are based on gametophytes which were dried slowly by the method described.

(a) *C. sieberi* (Springhurst)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	*	*	*	*	100	*
2	0	0	10	0	0	10
3	100	100	100	80	100	50
4	100	100	100	80	100	50

* indicates points at which, due to loss from factors other than water stress (e.g. fungal invasion) data is not available.

(b) *C. sieberi* (Big Desert)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	*	*	*	*	*	*
4	100	100	100	100	100	100

On replanting of stage 2 and 4 prothalli, all developed healthy sporophytes.

(c) *C. "austrotenuifolia"* (Springhurst)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	*	*	*	*	100	*
2	0	50	100	100	50	80
3	100	100	100	100	100	80

Replanted stage 2 prothalli were still alive 2 months later and had produced one sporophyte.

(d) *C. distans* (Dargo)

Stage	% survival at various humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	0	30	100	20	100	0
2	80	100	80	25	10	5
3	0	0	10	0	0	0
4	100	100	100	100	100	100

Of the stage 2 gametophytes replanted, those dried at 5%, 20% and 50% RH produced sporophytes. Of the stage 3 gametophytes replanted, those dried at 5% and 50% RH produced sporophytes. Of the

Of the stage 3 gametophytes replanted, those dried at 5% and 50% RH produced sporophytes. Of the stage 4 gametophytes replanted, nearly all continued to develop more leaves on the sporophyte.

(e) *C. distans* (Qld.)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	100	100	100	0	100	60
2	80	100	100	100	100	12
3	0	0	100	20	0	0
4	100	100	100	50	12	100

Of the replanted stage 2 and 3 prothalli, nearly all continued to grow and produce new sporophytes.

(f) *C. lasiophylla* (Mootwingee)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	100	*	50	*	*	*
2	5	100	100	100	100	100
3	80	75	100	100	100	20
4	100	100	100	100	100	80

Of the stage 2 and 3 prothalli replanted, all were still healthy 2 months later, but had not produced sporophytes. In contrast, those of the original culture had all produced 3-5 leafed sporophytes by this time.

(g) *C. lasiophylla* (Big Desert)

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
1	100	40	0	0	—	—
2	75	100	14	0	50	100
3	100	100	100	—	100	0

Replanted stage 2, 3 and 4 prothalli continued to grow and produce healthy sporophytes.

(h) *Doodia media* (Stage 3 only)

No prothalli survived at any of the humidities at which they were dried.

(i) *Lastreopsis* (Stage 3 only)

No prothalli survived at any of the humidities at which they were dried.

(j) *Phlebodium aureum* (Only a few at stage 3 survived and these produced antheridia but not archegonia).

Stage	% survival at various relative humidities					
	5% RH	20% RH	35% RH	50% RH	65% RH	80% RH
3	0	0	7	0	0	20

It is possible that the prothalli which did not survive after a period of desiccation were accidentally dried in the glasshouse at a faster rate than the others. It is also possible that some other unknown damage was caused to them by the nature of the experiment. It is equally possible that there is some genetically controlled variation in drought resistance of the gametophytes although we are not able to detect any definite pattern that would support such a view at this stage.

The data here answer some of the questions that were asked. First it suggests that the stage of maturity of the gametophyte has very little if any effect on drought tolerance, several species showing 100% survival rates at both very early and late stages of development. Certainly the results with the Springhurst population of *C. sieberi* suggest that it may be better adapted to survive such drought once it has reached the early sporophytic stage. In contrast the Big desert populations of the same species survived at all stages of development. The absence of data for stage 3 was due to an experimental accident, — the invasion of fungi.

It might have reasonably been expected that the less severe the lowering of humidity the less damaging it would be to cells, but the data does not really support such a view. No pattern suggesting greater survival at higher humidities was observed. Death appears, to have occurred irregularly at all humidities in fact, there does appear to be a slightly greater likelihood for prothalli which were dried and treated at relative humidity 80% not to survive. This of course, may be a reflection of continued bacterial and fungal action, which presumably could in some instances continue at this relatively high humidity. For example, stage 2 prothalli of *C. distans* (both the Dargo and Queensland populations) show much lower survival rates at high humidities. Similarly in stage 3 prothalli of *C. "austrotenuifolia"* deaths occurred only at relative humidity of 80%. It is again possible that the higher humidities here allowed continued bacterial action.

We do not have sufficient data to determine whether some species of *Cheilanthes* are more drought tolerant than others. Certainly, of the two Big Desert species studied, *C. sieberi* had a greater survival rate than did *C. lasiophylla*. However, the irregularity of the death pattern of *C. lasiophylla* (100% of stage 2 prothalli survived 20% relative humidity, while 75% and 14% survived drying to relative humidities of 5% and 35% respectively), suggested that death may be due to some unknown factor. It appears that gametophytes of the more arid zone species from the Big Desert and Mootwingee showed an overall greater survival rate than did those of *C. "austrotenuifolia"* and *C. distans* (Dargo) although some other specimens of *C. "austrotenuifolia"* and *C. distans* did exhibit some 100% survival of the very young stage 1 (prothalli) and of prothalli dried at 5% relative humidity.

Comparison of the data for *C. sieberi* cultures from the Big Desert plants, with those from specimens collected at Springhurst suggests that the prothalli from the Big Desert (the more arid areas with 210mm precipitation per annum) may be more drought tolerant than those from near Springhurst (annual precipitation 560mm). If this interpretation is correct, then the Big Desert plants are genetically better adapted to endure server periods of water stress than those of the more humid Springhurst district. However the Springhurst data is not easy to interpret in view of the 100% survival of stage 1 prothalli at 65% RH.

So far as the prothalli fo the more mesic fern species are concerned it is conclusively shown that the species of *Doodia* and *Lastreopsis* investigated are completely without tolerance to the levels of desiccation in which *Cheilanthes* can survive. The few prothalli of the epiphytic *Phlebodium aureum* which survived drying at 35% and 80% RH suggests that the species has some degree of adaptation to temporary water deficits.

DISCUSSION

The almost zero survival of prothalli subjected to sudden drying (1-5 hours) by direct introduction into the controlled humidity chambers suggests that changes which need to take place in a living cell as the cytoplasm dehydrates require a reasonable time. Given slow drying conditions (5-7 days) the physiological changes to the cytoplasm which may take place allow the cells to become adapted to a sustained period of severe moisture stress. Somewhat comparable experiments on the moss *Tortula muralis* by Gwozdz and Bewley (1975) showed that gradual drying apparently protects the cell from the injury caused by rapid drying; further they reported the fine structural changes which suggested that the slowly dried moss plant retained fewer by more active polyribosomes than did the rapidly dried plant and that the protein synthesis activity of the polyribosomes increased more rapidly on rehydration in these slowly dried plants.

When gametophytes were treated with neutral red dye to determine which cells remained alive, we found that those parts most crucial to the survival of the plant, — the rhizoids, meristem, reproductive organs and the very young sporophyte had a greater capacity to survive rapid severe drying than did the remaining vegetative cells.

The experiments reported in detail in this paper all involved slow drying of the gametophyte prior to treatment and the data undoubtedly demonstrates that the species of *Cheilanthes* studied have the ability to tolerate and survive drying to humidities well below those which would normally be encountered in the natural environment. Under these conditions of drying the gametophytes retain their chlorophyll pigment but otherwise appear shrivelled and severely damaged. At the lower humidities they become brittle to the touch. On rehydration those which survived appeared healthy again and indistinguishable from those which had never been dried. Most of the prothalli which survived the drying went on developing to produce healthy sporophytes, growth being merely interrupted during the period of drought.

It may be significant that the dehydrated prothalli although shrivelled and brittle remained green. It has been reported for other plant groups (Gaff & Hallam 1974) that those which retain their chlorophyll during desiccation (as does *Cheilanthes*) suffer less change of structure than those plants which do not retain their green pigments. Comparative fine structural analysis of the cytoplasm of the gametophytes of *Cheilanthes* with drought intolerant species during both dehydration and rehydration could possible explain some of the events taking place during water stress.

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We are grateful for the advice of Dr. D. Gaff of the Botany Department of Monash University who pointed out the requirement of slow drying in experimental studies of drought tolerance. One of us (HQ) acknowledges the support for this study of a Melbourne University Post-Graduate Award.

REFERENCES

- BOWER, F.O., 1923. *The Ferns* Vol 1. Cambridge Univ. Press, Cambridge.
- GAFF, D.F. and HALLAM N.D., 1974. Resurrecting desiccated plants. *R. Soc. N.Z. Bull.* 12: 389-393.
- GWOZDZ, E.A. and BEWLEY, J.D., 1975. Plant desiccation and protein synthesis. *Plant Physiol.* 55: 340-345.
- HEVLY, R.H., 1963. Adaptations of cheilanthoid ferns to desert environments. *J. Arizona Acad. Sci.* 2: 164-175.
- ILJIN, W.S., 1931. Austrocknungsresistenz des Farnes *Notochlaena marantae* R.Br. *Protoplasma* 13: 322-330.
- KNOBLOCH, I.W., 1966. A preliminary review of spore number and apogamy within the genus *Cheilanthes*. *Am. Fern J.* 56: 163-167.
- PICKETT, F.L., 1923. An ecological study of *Cheilanthes gracillima*. *Bull. Torrey. Bot. Cl.* 50: 329-338.
- TRYON, A., 1947. Glandular prothalli of *Notholaena standleyi*. *Am. Fern J.* 37: 88-89.
- WILSON, R.E., 1921. Humidity control by means of sulfuric acid solutions, with critical compilation of vapour pressure data. *J. Indus. and Engin. Chem.* 13: 326-333.

REVIEWS

SELECTED PTERIDOLOGICAL PAPERS 1952-1978 OF PROFESSOR S. KURATA. Edited by T. Nakaike. Supplement No. 1 to the Journal of the Nippon Fernist Club Volume 2 1979. 190 x 265 mm. No price stated.

Sataru Kurata was born in 1922. He died in the latter part of 1978 having published over 65 papers on the taxonomy, ecology, distribution and nomenclature of Japanese ferns particularly on what has been generally called Aspidaceae although one substantial paper is on *Lepisorus* in Japan. For much of this time Kurata was Professor in the Institute of Forest Botany, Faculty of Agriculture, University of Tokyo.

The papers appeared in the *Hokuriku J. Bot.* (latterly the *J. Geobot.*): Notes on Japanese Ferns (1) — (50) (1952-1970). Other major papers are from *Sci. Rep. Yokosuka City Mus.* and the *Sci. Rep. Tôhoku Univ. Ser. IV (Biol.)*. Other major papers are from *Sci. Rep. Yokosuka City Mus.* All are facimile reproductions excluding pagination but the collected work is additionally paginated to accommodate the index to Japanese and Latin names. There are substantial keys, in English, for *Cyrtomium*, *Lepisorus* and the *Polystichum polyblepharum* group. Two other keys, to *Arachniodes* and the *Athyrium otophorum* group are in Japanese. Perhaps Dr Nakarke, who saw this through the press will one day translate these so they may have greater use.

A.C. JERMY

FERNS OF FLORIDA - AN ILLUSTRATED MANUAL AND IDENTIFICATION GUIDE by Olga Lakela and Robert W. Long ix + 78pp. Banyan Books, Miami, Florida, 1976. ISBN 0-91 6224-08-2. Price \$13.

This book is intended as a field guide with identification keys and descriptions of the 135 species of native and naturalised ferns. 115 are illustrated, nearly all as photographs of herbarium specimens. The photographs are generally good although some additional detailed drawings would be very acceptable. There is a short introduction attempting to summarise the local ecology of ferns, pteridophyte classification, taxonomic characters of ferns, polyploidy in ferns, and even growing ferns from spores. There is also a glossary of nearly two hundred terms.

Apart from people contemplating a visit to Florida, it is essentially a flora for those who are interested in sub-tropical and tropical ferns. Although a few species have wide distributions in North America, the vast majority are restricted to the south-eastern States or even Florida while also being common in the Caribbean and tropical Central and South America. These readers would appreciate having more notes on the distribution and ecology of the Florida species together with additional information on the local climate and geology.

B.A. THOMAS

TROPISMS IN REGNELLIDIUM DIPHYLLUM

LUIS D. GÓMEZ

Herbario Nacional, Museo Nacional de Costa Rica, C.A.

ABSTRACT

Diaphoto- and paraheliotropisms are reported from plants of *Regnellidium diphyllum* under cultivation. The possible significance of these physiological reactions on the ecology and distribution of this fern is briefly discussed.

OBSERVATIONS

The movement of plants or their parts attracted the attention of Darwin (1880) and many others after him. Nevertheless, with the exception of occasional mentions, the movements of ferns has remained a rather void aspect of pteridophyte physiology, the last detailed account of them is that of Du Buy & Nuernbergk (1938).

The expansion and contraction of the leaflets of *Marsilea* has been recently observed by Piggott (1979) who also mentions the heliotropic movement of its fronds. Another genus in the Marsileaceae, *Regnellidium*, shows a remarkable diaphototropism or light-tracking ability. Plants cultivated in tanks at 20°C and placed near a light source (75 Watt at 3 feet) will turn all the fronds towards the light in 90-120 minutes, the curvature taking place near midlength of the petioles. The same plant, turned around 180° will initiate reorientation towards the light in 15-30 minutes until all leaf surfaces are perpendicular to the light source.

If a plant is exposed to light sources of equal intensity, one at each side of the tank, some fronds will face in one way while the rest face the other, except for the young unexpanded ones which will remain more or less straight and oblique to the path of light.

The shoot apex of *Regnellidium* is also light sensitive. Developing rhizomes are directed to the light source but their reaction to changes of position of the light is not as rapid as that of the leaves. The movement of the apical portion of the rhizome and of the leaves is interdependent: if a portion of the rhizome is placed in such a manner that some of its fronds are directed to one light source, and the rest to another, the shoot apex is still able to track a third source of light, even if it is of lower intensity.

In *Marsilea*, a decreased illumination causes a closing-up of its leaflets (cupping or paraheliotropism). In *Regnellidium* this reaction is almost insignificant. Submerged plants do not exhibit cupping during the night or in artificial darkness but aerial leaves show very reduced paraheliotropism. This type of movement is only observed in fully expanded leaflets, never in the immature ones. The maximum width of the leaves is attained approximately 14-20 hours after the maximum petiole elongation is achieved, until then the leaflets remain appressed upwards, total divergence of the leaflets takes from 180-270 minutes.

ECOLOGICAL INTERPRETATION

The rare *Regnellidium diphyllum* Lindm. is restricted to few localities in southern Brazil with one relictual population in Argentina (Schultz, 1949; de la Sota & Mitchell, 1970). It usually grows in shallow ponds of slightly acid (pH 6.0) water in association with grasses, aquatic phanerogams and *Salvinia*. In crowded conditions, a not uncommon situation in marginal lotic environments, effective sun-tracking mechanisms clearly allow for a maximum illumination since planar leaves would be continuously exposed to the maximum levels of incident energy. This, coupled to the fast petiolar growth (average rate is 0.73mm/hour of light in our plants) increases the

potentiality of the plant to compete with other natant and emergent water plants. The cupping of the leaves in *Marsilea* and *Regnellidium* suggest a mechanism for the reduction of energy absorption via a decrease in the angle of incidence of the source of radiation. In their natural environment the Marsileales are subjected to intermittent wet and dry periods. The stress resulting from such intervals of drought is counteracted through paraheliotropism, by a reduction of the energy levels, thus becoming a very significant adaptation for the survival of the plants. This is particularly the case in the species of *Marsilea*, often found in xeric and sub-xeric habitats and whose sporocarps are quite adapted to a thorough drying and exposure to heat before dehiscence. The weak paraheliotropic reaction observed in *Regnellidium* suggests this plant requires longer periods of pronounced moisture and could, in all probability, account for its sparse highly localized distribution (Gaudet, 1963).

Whether the phototropisms of *Regnellidium* and other hydropterides are dependent on a phytochrome-mediated K-ion transfer as in other "sensitive" plants or not, remains to be studied as well as the possible role of the latex of this plant, and offers a fascinating field for exploration in the much-needed branch of fern sporophyte eco-physiology.

ACKNOWLEDGEMENTS

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REFERENCES

- DARWIN, C., 1880. The power of movements in plants. 1st Ed. John Murray, London.
- DU BUY, H.G., NUERNBERGK, E.L., 1938. Growth, tropisms and other movements. In Fr. Verdoorn (Ed.) Manual of Pteridology. M. Nijhoff, The Hague. pp. 303-346.
- GAUDET, J.J., 1963. *Marsilea vestita*: Conversion of the water form to the land form by darkness and by far-red light. Science 140: 975-976.
- PIGGOTT, A.G., 1979. Observations on light response in *Marsilea crenata*. Fern Gaz. 62-64.
- SCHULTZ, A.R., 1949. Contribuciones ao cohecimiento de *Regnellidium diphyllum* Lindm. Lilloa 17: 139-144.
- SOTA, E. de la, MITCHELL, D.S., 1970. Sobre la presencia de *Regnellidium diphyllum* Lindm. (Marsileaceae-Pteridophyta) en Argentina. Darwiniana 16(1-2): 408-409.

AN ECOLOGICAL SURVEY OF THE FERNS OF BERWICKSHIRE, SCOTLAND

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ABSTRACT

A systematic list of the ferns and fern allies of Berwickshire (v.-c. 81), south-eastern Scotland, is given, based mainly on records made in 1979 by the author. This includes notes on the distribution, abundance and habitats of the taxa. The list includes 32 species and 3 hybrids as recently recorded. The records for *Equisetum x litorale* and *Dryopteris x deweveri* are first county records. The status of species for which only pre-1950 records exist is discussed and two species accepted as native (*Osmunda regalis* and *Asplenium ceterach*) though only as casuals. The distribution of the commoner 18 species is shown by maps. Species lists are given for moorland, walls and deciduous woodland. Three species are suggested as primary woodland indicators in the area (*Equisetum sylvaticum*, *Gymnocarpium dryopteris* and *Polystichum setiferum*). The phytogeographical affinity of the flora on a European basis is described by dividing it amongst the floristic elements of Birks (1976). The majority of species belong to his widespread and Mediterranean/Atlantic elements and three species to upland or northern elements. The geographical distribution of species within the area is described and three major patterns of distribution are recognised: widespread; coastal plateau and northern-central; and eastern or coastal.

INTRODUCTION

Berwickshire is the south-easternmost vice-county (v.-c. 81) in Scotland, situated on the eastern end of the Southern Uplands, which are smooth rounded hills mostly between 450 and 600m in height (Whittow, 1979). However, the county is atypical of the Southern Uplands in that there are extensive areas of lowlands

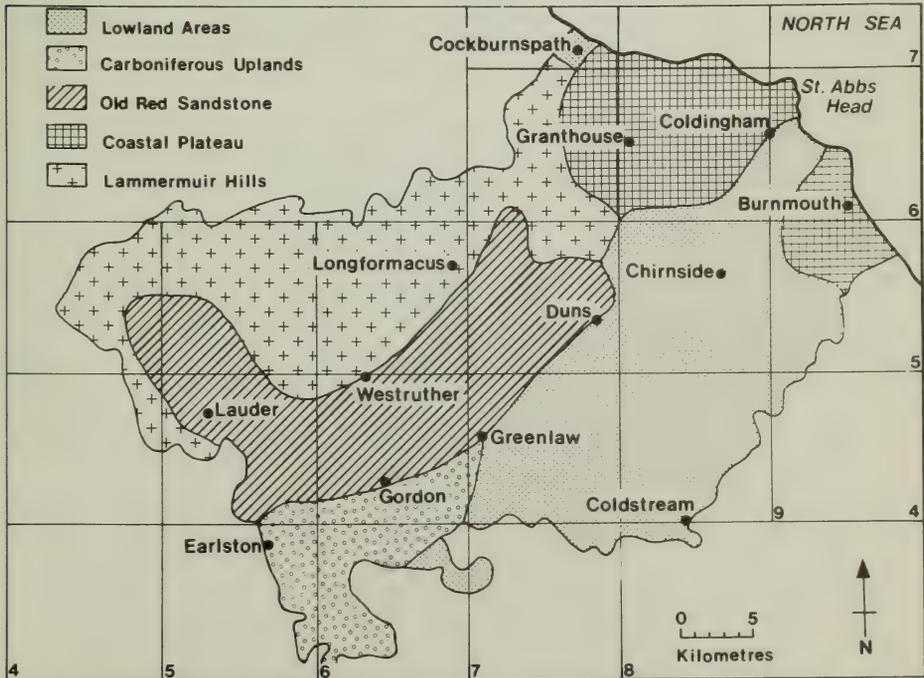


FIGURE 1. Map of Berwickshire (v.-c. 81) showing the five topographical regions and the 10 km grid squares of the National Grid of the Ordnance Survey.

(Sissons, 1976). The county is bounded to the north by the Lammermuir Hills, to the east by the North Sea, to the south by the River Tweed and to the west by the Moorfoot Hills. It is one of the smaller vice-counties, extending at most only 40km north/south and 60km east/west. Botanically it has no particular claim to fame, having no concentrations of rarities or nationally rare habitats, though it has a wide range of habitats and species to match.

Sissons (1976) divides the area into five topographical units (Fig. 1). In the north is the highest ground (400-500m), which is part of the Lammermuir Hills. These produce typical Southern Upland scenery of rounded hills and smooth slopes with few outcrops of rocks. The solid geology (Greig, 1971) is mostly Silurian, sedimentary rocks which weather to produce poor, acid soils. To the south is the Tweed Basin which consists of three morphological units related to the geology of the region. The lowest ground, which is mostly below 100m, is in the south east. This is known as the Merse and is underlain by Carboniferous sedimentary rocks, concealed by a thick layer of strongly drumlinised drift, which produces high quality farmland. The Merse is separated from the Lammermuir Hills by low uplands of Old Red Sandstone interrupted by a series of igneous intrusions that form conspicuous hills. In the extreme south of the county is a small area of Carboniferous lavas that also form low uplands. The fifth topographical unit is a plateau of Ordovician and Silurian rocks (200-240m), which occurs along most of the short coastline of the county forming steep, grassy sea-cliffs with numerous outcrops. The last three topographical units all have acidic soils that produce farmland intermediate in quality between the high quality farmlands of the Merse and the low quality ones of the Lammermuir Hills that mostly bear rough upland grazing.

The climate of the area is described in Gregory (1976) who places most of the area in his BD2 category along with Midland England and the eastern coast of northern England and Scotland. This region has a growing season of 7 to 8 months and less than 750mm of rain which falls mostly in the second half of the year. Inland the climate becomes colder in winter and merges into category BM2 on the hills, which have a higher average rainfall.

Lacking rare species and unusual habitats the area has been botanically under-recorded. The only complete floras for the county being in the work of Johnston in the first half of the 19th century (Johnston, 1829 & 1853), though these both cover areas larger than the vice-county. New records for the county and species lists for the better known sites then occur fairly commonly in the *History of the Berwickshire Naturalists' Club* up until about 1940. After this date botanical activity in the county seems to have almost ceased, as judged by the number of records published in this and other journals. This cessation is so complete that during the Botanical Society of the British Isles' field week to the county in July 1979 no one who actually lived in the county attended. This lack of activity is a shame as the county has many interesting sites that are in danger of being destroyed without even a proper record of what they contained.

The lack of activity in the study of the modern flora of Berwickshire also extends to the study of the plant remains that must exist in the numerous Quaternary deposits in the area. Newey (1968) in his account of pollen analyses from south-east Scotland does not include a site from the area and the only account of Quaternary plant fossils in the area seems to be the note by Mitchell (1948) on Whitrig Bog. This records spores of *Selaginella selaginoides** from late-glacial deposits. Despite the lack of records for the county itself Birks (1977) has reconstructed a preliminary picture of the natural vegetation of the area before man cleared it for agriculture. He places the county in his "Oak forest with birch" region and considers these woods had *Ulmus glabra* and *Fraxinus excelsior* on better soils and *Corylus avellana* in more open areas. Surviving

*Nomenclature follows Clapham *et al* (1962) for angiosperms and Jermy *et al* (1978) for ferns.

fragments of these woods on acid soils have a ground flora of *Pteridium aquilinum* and *Deschampsia flexuosa* when heavily grazed, and a richer flora including *Dryopteris aemula*, *D. pseudomas* and *Blechnum spicant* when ungrazed. These woods before they were cleared would have covered all but the highest parts of the Lammermuir Hills with the only other open areas being on cliffs, bogs and flood plains in the lowlands.



FIGURE 2. View looking down into Pease Dean from the bridge (36/791.700), the classic locality for *Polystichum setiferum* in Berwickshire.

The best sites for ferns in the area at present are steep, rocky hillsides which, because they are unsuitable for grazing, have retained remnants of the native oak/birch woods described above. These occur mostly in cloughs (narrow, steep-sided valleys) around Duns and Abbey St. Bathans and in deans near the sea, for example Dowlaw and Pease Dean (Fig. 2). Otherwise the distribution of ferns is determined by the layout of the topographical units, which provide markedly different opportunities for the occurrence of ferns. The lowland of the Merse with its intensively-cultivated, large fields, planted copses and shelterbelts provides habitats for only the commoner lowland ferns. Walls in this area, however, provide a habitat for ferns that would otherwise not occur. The uplands of the Lammermuir Hills provides habitats for the more upland and heathland ferns, particularly along the rocky banks of streams that flow through the large areas of undulating moorland. The rather lower Coastal Plateau contains areas of similar moorland alongside areas of more intensive agriculture and forestry. In this region the coastal cliffs with their rocky outcrops and grassy flushes provide suitable sites for some of the more interesting fern species. The low uplands of Old Red Sandstone and of Carboniferous lavas provide a mixture of the habitats that occur in the Merse and the Lammermuirs, and being less intensively-farmed provide more semi-natural areas in the form of marshy fields and boggy areas.

This brief summary of the area provides rather too good a picture of the suitability of the area for ferns as changes in the form of farming are occurring that threaten to markedly alter the picture over large areas. These changes are part of the national

trend from traditional methods of farming to modern more intensive methods that leave very little room for wildlife in crops and very few odd corners uncultivated. In the Merse these changes are virtually complete. In the low uplands and Coastal Plateau they are proceeding rapidly, such that orange coils of plastic drainage-pipe are a common site. In these areas, if the changes continue at the speed they are, in a few years there will be as few areas for wildlife as in the Merse. In the Coastal Plateau the changes appear to be a more abrupt and recent phenomenon with improved farmland directly replacing the moorland recorded by Johnston (1829 & 1853) leaving in many places only thin, roadside strips of moorland. The changeover is virtually complete in the southern section of the Plateau and proceeding fast in the northern section. Only the Lammermuir Hills, which because of their altitude do not provide the opportunities for agriculture that the other parts of the county do, are free from extensive improvement at present.

METHODS

The records (Table 1) made by the author given in the following sections were all made during July 1979 and refer to the vice county (v.-c. 81) as given in Dandy (1969). They were gathered on the basis that two to three examples of each major habitat type (Table 2) were visited in each 10 km grid square. At each habitat visited a subjective estimate of the abundance of each fern present was recorded on the Dafor scale. If a habitat spread over more than one one-kilometer square (referred to here as a monad), a separate record was made for each. If during the course of visiting one habitat other major habitat types were encountered, separate records were made for these. Habitats were selected either because there were old records for the sites or because they looked promising on maps or on the ground. No attempt was made to record habitats which contained no

TABLE 1: FERN TAXA RECORDED FOR BERWICKSHIRE

(Taxa recorded in present survey are marked ! and taxa, for which only doubtful or pre-1950 exist, are enclosed in brackets. Numbers in brackets refer to floristic elements in Table 3.)

<i>Lycopodium clavatum</i> ! (1)	<i>Oreopteris limbosperma</i> ! (3)
<i>Huperzia selago</i> (1)	<i>Asplenium scolopendrium</i> ! (3)
<i>Diphasiastrum alpinum</i> (5)	<i>A. adiantum-nigrum</i> ! (3)
(<i>D. x issleri</i>) (7)	<i>A. marinum</i> ! (4)
<i>Selaginella selaginoides</i> ! (5)	<i>A. trichomanes</i> agg. ! (2)
(<i>Equisetum hyemale</i>) (1)	<i>A. trichomanes</i> subsp. <i>quadrialeans</i>
<i>E. fluviatile</i> ! (1)	<i>A. ruta-muraria</i> ! (2)
<i>E. arvense</i> ! (1)	(<i>A. ceterach</i>) (3)
<i>E. x litorale</i> !	<i>Athyrium filix-femina</i> ! (1)
<i>E. sylvaticum</i> ! (1)	<i>Gymnocarpium dryopteris</i> ! (1)
<i>E. palustre</i> ! (1)	<i>Cystopteris fragilis</i> ! (1)
<i>E. telmateia</i> ! (3)	(<i>Polystichum lonchitis</i>) (6)
<i>Botrychium lunaria</i> (1)	<i>P. aculeatum</i> ! (3)
<i>Ophioglossum vulgatum</i> (2)	<i>P. setiferum</i> ! (4)
(<i>Osmunda regalis</i>) (3)	<i>Dryopteris filix-mas</i> ! (2)
<i>Cryptogramma crispera</i> ! (6)	<i>D. pseudomas</i> ! (3)
<i>Polypodium vulgare</i> ! (2)	(<i>D. aemula</i>) (8)
<i>P. interjectum</i> ! (3)	<i>D. carthusiana</i> ! (1)
<i>P. x mantoniae</i>	<i>D. austriaca</i> ! (3)
<i>Pteridium aquilinum</i> ! (2)	<i>D. x deweveri</i> !
<i>Phegopteris connectilis</i> ! (1)	<i>Blechnum spicant</i> ! (3)

ferns. In all, records were obtained from 160 monads but due to the non-systematic nature of the survey there are a number of forms of bias in the results. The three major ones are: a bias towards monads near roads; a bias to monads below 250m; and a bias to monads in the eastern half of the county. Where the ecological or geographical distribution of taxa is discussed below, attempts have been made to correct for these forms of bias.

TABLE 2:
FREQUENCY OF THE COMMONER SPECIES IN THE MAJOR HABITATS

(Figures in the body of the table refer to the number of monads in which a species occurred in the particular habitat. Heath includes moorland dominated by ericaceous shrubs and grasses while tall herb includes tall grasslands).

SPECIES	MAJOR HABITAT TYPES									No. of Monads with Species
	Marsh	D. Wood	C. Wood	Scrub	Hedge	Heath	Tall Herb	Bare Rock	Walls	
<i>Equisetum fluviatile</i>	6	1	—	—	—	—	—	—	—	9
<i>E. arvense</i>	8	6	1	1	5	3	35	—	—	60
<i>E. palustre</i>	15	—	—	—	—	—	9	—	—	24
<i>Polypodium vulgare</i> agg.	—	2	—	—	—	—	—	18	23	43
<i>Pteridium aquilinum</i>	1	27	9	6	—	17	21	3	1	63
<i>Oreopteris limbosperma</i>	—	6	1	1	—	11	—	—	—	18
<i>Asplenium scolopendrium</i>	—	6	—	—	—	—	1	6	15	24
<i>A. adiantum-nigrum</i>	—	—	—	—	—	—	—	1	7	8
<i>A. trichomanes</i> agg.	—	—	—	—	—	—	—	4	25	27
<i>A. ruta-muraria</i>	—	—	—	—	—	—	—	1	28	29
<i>Athyrium filix-femina</i>	7	66	13	7	1	13	9	5	11	100
<i>Cystopteris fragilis</i>	—	—	—	—	—	—	—	1	8	9
<i>Polystichum aculeatum</i>	—	13	—	—	1	—	1	5	1	16
<i>Dryopteris filix-mas</i>	3	74	20	15	16	8	37	13	45	132
<i>D. pseudomas</i>	—	46	7	7	3	8	7	4	1	76
<i>D. carthusiana</i>	1	6	1	—	—	1	—	—	—	7
<i>D. austriaca</i>	2	72	19	8	3	17	10	9	10	107
<i>Blechnum spicant</i>	—	12	2	1	1	16	1	—	—	27
No. of Monads with habitat	20	79	24	16	18	25	58	26	70	

D. Wood = Deciduous C. Wood = Coniferous

A survey was also made of the main works and data banks which contain fern records for the area; these included Jermy *et al* (1978), the History of the Berwickshire Naturalists' Club 1-40 (1834-1974); Johnston (1829-1853) and the Biological Records Centre, Monk's Wood. As Jermy *et al* (1978) is based on 10 km grid squares and many of these on the borders of the area cross two or more vice-counties, a record from Jermy *et al* (1978) was only accepted as from the vice-county if there was a record at Monk's Wood for the grid squares in the vice-county.

RESULTS

Results are presented in four ways. The systematic list describes the status, ecology and distribution of all fern taxa ever recorded for the vice-county, while the remaining three ways refer only to records from this survey. Table 2 summarises the frequency of the commoner species in the more frequent habitats. Figures 3, 5 and 7 give distribution maps for the commoner species on a tetrad basis; and the habitat lists detail the occurrence of ferns in selected habitats.

SYSTEMATIC LIST OF TAXA

Each taxon recorded during the survey is given with notes on (a) its geographical distribution, (b) its habitats and (c) its altitudinal range, as recorded in the survey. Where a taxon was recorded in only a few monads, an entry is given in the form (a-c) followed by notes on the individual occurrences. Reference in these notes to abundance in habitats refers only to abundance in examples of the habitat where the species occurred, how often the species occurred in the habitat type can be seen from Table 2. Notes are also given (d) for significant extensions to (a), (b) and (c) from other sources, particularly post-1950 10 km grid square records not reconfirmed here, and selected pre-1950 records that have not been reconfirmed recently. Taxa that have not been reconfirmed in this survey are given only type (d) notes.

Grid references prefixed with *circa* are my interpretation of localities originally given without a reference. Numbering of taxa follows Jermy *et al* (1978). Abundance is recorded on the Dafor scale where D = dominant, A = abundant, F = frequent, O = occasional, R = rare and L = locally.

1.2 *Lycopodium clavatum* (Stag's-horn clubmoss)

- (a-c) Recorded only once for Duns Castle reserve but at two localities. In both it occurred as a sparse patch about one metre in diameter, at 150m. At 36/779.553 it bore cones and grew amongst short acid grass below beech trees (*Fagus sylvatica*), while at 36/779.558 it was sterile and grew below heather bushes (*Calluna vulgaris*) in heathland.
- (d) Recorded at BRC post-1950 for the 10 km grid squares 36/44, 45, 53, 54, 55, 64, 65, 74, 76 & 86.

3.1 *Huperzia selago* (Fir clubmoss)

- (d) Only post-1950 record is record at BRC for Earlston c. 36/56.38. There are, however, older records for Lamberton Moor c. 36/95.58, Durrington Law c. 36/69.54 and Penmanshiel Moor c. 36/81.67 in Johnston (1853); and for Buncle Edge near the forts c. 36/80.60 and old roads on Coldingham Moor c. 36/86.67 (Lynn, 1895). The species therefore seems to be much less wide-spread than it was a hundred years ago.

4.1 *Diphasiastrum alpinum* (Alpine clubmoss)

- (d) Only post-1950 records are records at BRC for 36/64 & 65. There are, however, older records for Lamberton Moor c. 36/95.58 (Johnston, 1853); moor on ridge between Kyle Hill and Dogden Moss c. 36/70.50 (Anon, 1886); and Buncle Edge c. 36/80.60 and old roads on Coldingham Moor c. 36/86.67 (Lynn, 1895). The species therefore seems to be less wide-spread than it was one hundred years ago.

4.1xc *D. x issleri*

- (d) There is a record for *Lycopodium alpinum* var. *decipiens* at Cattleshiel Moor near the Lesser Durrington Law c. 36/68.53 (Anderson, 1915), however, no specimen from this locality has been traced and so the record must remain unconfirmed.

5.1 *Selaginella selaginoides* (Lesser clubmoss)

- (a-c) Recorded only once as rare but with cones in a grassy flush in heather (*Calluna vulgaris*) moorland on Greenlaw Moor 36/721.485 at 210m.
- (d) Recorded at BRC for the 10 km grid squares 36/66 & 75 post-1950 and in Jermy *et al* (1978) for 36/64 pre-1950. There are also older records for Lamberton Moor c. 36/95.59 (Johnston, 1829), Penmanshiel Moor c. 36/81.67 (Johnston, 1853) and Ross Links c. 36/96.60 (Brown, 1939). Records therefore suggest species was previously more widely distributed, however, although some old sites have probably been lost due to land reclamation the species has probably been overlooked in other sites in recent years.

7.1 *Equisetum hyemale* (Rough horsetail)

- (d) There is a record in BRC for Westruther 36/56 dated 1956 but as this is unconfirmed it is not included in Jermy *et al* (1978), but they do record the species as having been recorded pre-1950 for 36/95 & 96. The record for 36/95 is based on Johnston (1829) where it is recorded as plentiful on Lamberton Moor c. 36/95.58. However, this record is omitted by him in his later flora of the area (Johnston, 1853) which suggests that it too should be treated with suspicion. While the record for 36/96 appears to be based on a record for "36/96 half a mile south west of Burnmouth". The authority for this record is given as Johnston (1853) but the record does not appear in this work. It is therefore very much an open question as to whether or not this species has ever been recorded for the country.

7.3 *E. fluviatile* Fig. 4a (Water horsetail)

- (a) Widespread but local throughout the county.
 (b) Locally abundant as an emergent at the side of ponds and rivers; frequent to occasional in marshes dominated by various species of monocotyledenous plants; recorded once as occasional in a sedge (*Carex* sp.) swamp at Lithtillum 36/803.409 and once as locally frequent in old peat workings overgrown by birch (*Betula* sp.) wood at Gordon Moss nature reserve 36/63.42.
 (c) 0-400m though more common below 200m.
 (d) Recorded post-1950 at BRC for 36/53, 54, 63, 65, 76, 77, 83, 86 and 95.

7.4 *E. arvense* Fig. 4b (Field horsetail)

- (a) Widespread and common throughout the county though less common in the west of the county.
 (b) The commonest habitat for the species was tall grass or herb communities, where it was occasional to locally abundant. Also occurred in marshes, hedges and deciduous woods, where it was less common and less abundant. Occurred finally as a casual in a range of habitats (Table 2) including arable and bare ground.
 (c) 0-450m but less common above 100m and decreasing in abundance with altitude being only recorded as rare above 300m.
 (d) Recorded post-1950 at BRC for 36/44, 54, 63, 73 & 94. Johnston (1829) records the species as "moist cultivated fields, too common". The apparent reduction from this level to that in the present survey, where it was found on only a few occasions in fields, is probably a real decrease due to the intensive farming in much of the area.

7.4x3 *E. x litorale*

- (a-c) Recorded for only one monad. It occurred occasionally in a reed marsh (*Phragmites communis*) at 36/910.689 on the nature reserve at St Abb's Head at 20m with both parents and *E. palustre*. This record, which was confirmed by C.N. Page, is the first for the vice-county.

7.6 *E. sylvaticum* (Wood horsetail)

- (a-c) Recorded for only three monads, in each case in damp areas of deciduous woods on steep slopes either in a dean as at Raecleugh Head 36/740.527 (200m) or on the slope of a hill as below Edins Hall Brock 36/769.608 & 36/778.603 (170m). At each site the species occurred as small isolated patches a few metres in diameter.
 (d) Recorded post-1950 at BRC for 36/54, 65, 74, 84 & 86 with older records for 36/53 (BRC), Newton Don c. 36/70.37 (Shaw, 1894) and Edington Hill Moor 36/90.56 (Henderson, 1875).

7.7 *E. palustre* Fig. 4c (Marsh horsetail)

- (a) Widespread but local throughout the county.
 (b) Major habitat was marshes mostly dominated by rushes (*Juncus* spp.) where it was occasional to locally frequent and also occurred, but much less commonly, in tall grass and herbaceous communities where it tended to be more local picking out the wetter areas.
 (c) 0-450m but commoner above 300m, though records were scarcer here. The increased frequency of the species at higher altitudes may be due to the prevalence of moorland with marshy areas here.
 (d) Recorded post-1950 at BRC for 36/44, 56 & 94.

7.8 *E. telmateia* (Great horsetail)

- (a-c) Recorded for four monads, these were all within a kilometer of the sea and below 50m. Occurred in two distinct habitats, one was damp areas of deciduous woods in narrow, rocky valleys (Dunglass Dean 36/770.721 and Pease Dean 36/792.701) and the other damp areas in tall herbaceous communities on slopes overlooking the sea (Pease Bay 36/794.707, Catcairn Bushes 36/967.597 & Ross Point

36/962.606). At most sites the species occurred in small dense patches a few metres in diameter.

(d) Recorded pre-1950 Jermy *et al* (1978) for 36/76 & 86.

8.1 *Botrychium lunaria* (Moonwort)

(d) Recorded post-1950 Jermy *et al* (1978) for 36/64, 65 & 75 and pre-1950 for 36/76, 95 & 96. There are also older records for Bemerside Hill c. 36/59.34 (Johnston, 1829), Lauder Common c. 36/50.46 (Kelly, 1874), and Penmanshiel Moor c. 36/81.68 (Johnston, 1853). Overall records indicate species has occurred widely but locally throughout county in grassland and moorland habitats.

9.1 *Ophioglossum vulgatum* (Adder's-tongue)

(d) Recorded post-1950 in Jermy *et al* (1978) for 36/65 & 86 and pre-1950 at BRC for 36/77 & 85. There are also older records for "field above Wellrig Duns" c. 36/76.53 (Falconer, 1932), "wood near Milne-Graden Mains" c. 36/87.44 (Donaldson, 1842), "near ruined church of St. Helens" c. 36/804.707 (Anon., 1932), Ross Links c. 36/96.60 (Brown, 1939) and Lauder Common c. 36/50.46 (Kelly, 1874). Records therefore indicate that the species has occurred throughout the county but only locally. They further suggest the species is now more restricted in distribution than a hundred years ago but this may be because the plant has been overlooked.

10.1 *Osmunda regalis* (Royal fern)

(d) There are only three records for this species all well pre-1950. The first record is for a plant at Coldingham Moor c. 36/86.67 (Shaw, 1872) and this is recorded by Kelly (1875) as having been taken away. Kelly (1875) also records the plant as rare in a moist boggy spot, at the side of a natural wood near Spottiswoode c. 36/60.49 and Hardy (1886) records three old plants railed at Flass Old Wood near Wedderlie House c. 36/62.51. These two records may refer to same site, in any case Shaw (1904) states the plants in the latter locations are thought to have been planted. The evidence for the species having occurred naturally in the county therefore is minimal.

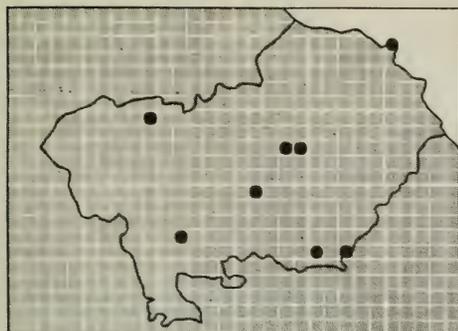
11.1 *Cryptogramma crispum* (Parsley fern)

(a-c) Recorded only for the Black Hill of Earlston Fig. 3 (36/585.373). Here the species occurred in unshaded screes on the north side of the hill at 230m. The species was frequent in the habitat with fertile and sterile fronds present.

(d) This site for the species has been known since at least 1853 (Johnston 1853) and is the only site where it has been seen since 1950. There are, however, pre-1950 records at BRC for 36/54, 36/64 (record dated 1930 for Houndslaw) and 36/76. This last record refers to that which is given in Johnston (1829) as south bank of the Whiteadder half a mile above Abbey St. Bathans (c. 36/74.61).



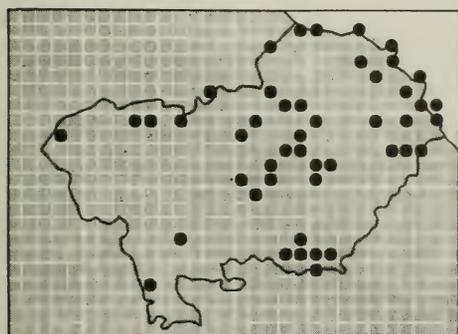
FIGURE 3. *Cryptogramma crispum* growing in the screes on the northern side of the Black Hill of Earlston (36/585.373) in 1979.



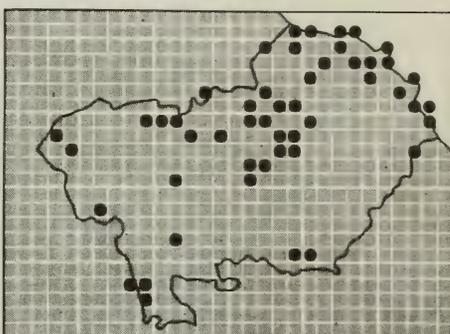
(a)



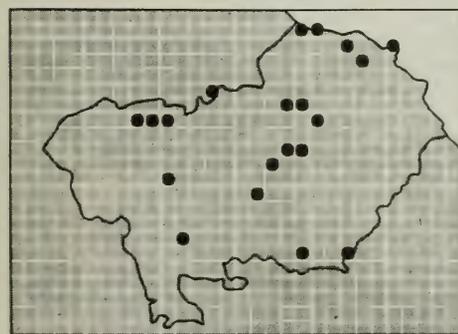
(d)



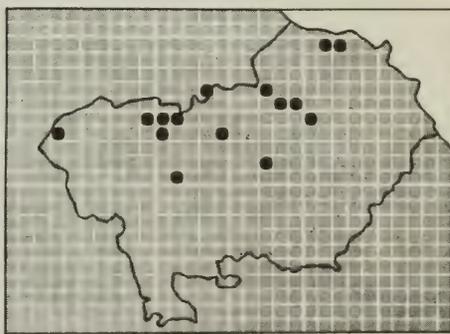
(b)



(e)



(c)



(f)

FIGURE 4. The distribution of the following in Berwickshire as recorded in the present survey: a, *Equisetum fluviatile*; b, *E. arvense*; c, *E. palustre*; d, *Polypodium vulgare* agg.; e, *Pteridium aquilinum* and f, *Oreopteris limbosperma*.

16.1-3 *Polypodium vulgare* agg. Fig. 4d (Polypody)

- (a) Widespread throughout the county except the Merse where it was more local.
- (b) Rare to frequent on exposed and sheltered rock outcrops; occasional to locally abundant on drystone walls especially those with an earth capping or fill between the stones, but less common and less abundant (R) on mortared walls. A particular habitat was the top of beech (*Fagus sylvatica*) banks, which are field boundaries made of linear mounds of earth and stones planted along their tops with beech trees, where the species was locally abundant among the beech roots. Minor habitats were unshaded screes where the species was occasional and as an epiphyte where the species was recorded once on a rowan (*Sorbus aucuparia*) tree.
- (c) 0-400m but uncommon above 250m.
- (d) Recorded post-1950 at BRC at 36/45 & 84.

16.1 *P. vulgare*

- (a) Recorded throughout the area, this is the common segregate of the species complex in the area. Fifteen specimens were critically determined of these fourteen were this segregate.
- (b) Rare to frequent on shaded and unshaded rock outcrops; frequent or locally abundant on drystone walls, particularly those capped with earth and beech banks but not recorded for mortared walls; and twice recorded for unshaded screes as occasional to frequent.
- (c) 0-400m.
- (d) Recorded in Jermy *et al* (1978) post-1950 for 36/85 and in Long (1974) for "steep bank of Tweed below Bemersyde Hill 36/53".

16.2 *P. interjectum*

- (a-c) Recorded only once as frequent on damp, shaded outcrops for the deciduous wood in Pease Dean (36/79.70) altitude 20m.
- (d) Only other records are in Long (1974) for "36/53 steep bank of Tweed below Bemersyde Hill" and a herbarium specimen dated 1960 at BM for humus on drystone wall at Howpark Burn (c. 36/81.65) collected by Bangerter & Hall.

16.2x1 *P. x mantoniae*

- (d) There is a pre-1950 record for 36/86 in Jermy *et al* (1978) and a herbarium specimen in BM dated 1960 for humus on drystone wall at Howpark Burn (c. 36/81.65) collected by Bangerter & Hall.

17.1 *Pteridium aquilinum* Fig. 4e (Braken)

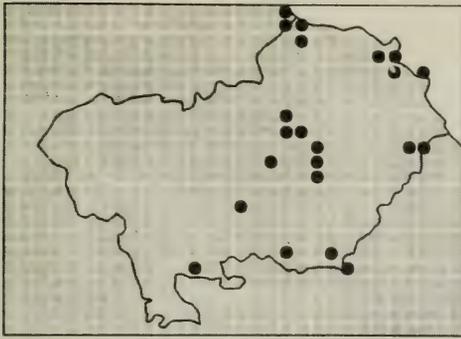
- (a) Widespread and common throughout the county except the Merse where the species was more local, probably due to the lack of habitats in this area of intensive farming.
- (b) Most important habitat was moorland where it was dominant over large areas forming almost pure stands; less common and less abundant (LF-LA) but more widespread in tall herbaceous communities; and also widespread but less common and less abundant (O-F) in woods and scrub. Also recorded once or twice for the following habitats short grass, scree, rock outcrops and mortared walls.
- (c) 0-400m but slightly rarer below 200m probably due to lack of habitats in lowland areas.
- (d) Recorded at BRC post-1950 for 36/44, 55, 63 & 83.

19.1 *Phegopteris connectilis* (Beech fern)

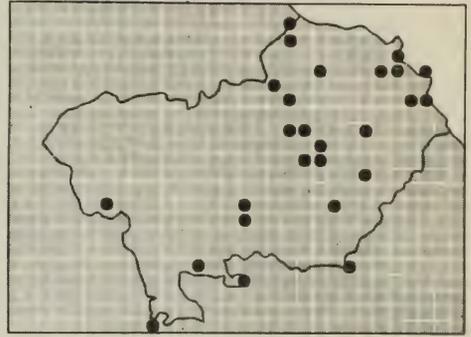
- (a-c) Recorded only once as occasional over a small area (c. 5m diameter) of rocky outcrops in ash/hazel (*Fraxinus excelsior*/*Corylus avellana*) wood on banks of the Whiteadder below Edin' Hall Broch (36/772.604) at 170m (Fig. 6).
- (d) Recorded at BRC post-1950 for 36/74, 75 & 77 and pre-1950 for 36/85. The species is therefore restricted to the centre of the county. The record for 36/85 probably refers to Hardy (1865) who recorded the species for Buncle Wood (c. 36/81.58), as this wood was being reclaimed for agriculture in 1979 it seems likely this site has been lost.

20.1 *Oreopteris limbosperma* Fig. 4f (Mountain fern)

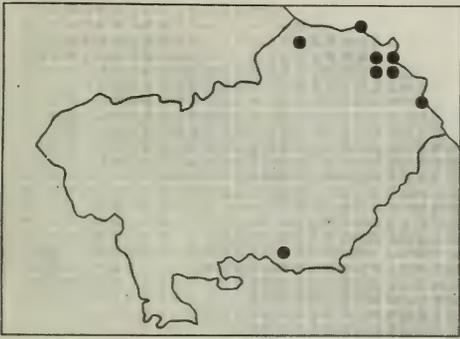
- (a) Virtually confined to the Lammermuir Hills and the northern half of the Coastal Plateau where the species is widespread but local.
- (b) Occurred most commonly and abundantly (O-F) in heather (*Calluna vulgaris*) moorland, especially along the rocky banks of small valleys, and less commonly and less abundantly (R-O) in deciduous woodland often with a high abundance of Birch (*Betula* spp.). Also recorded once each for coniferous woodland and scrub.
- (c) 100-400m but more common and abundant in higher half of this range probably due



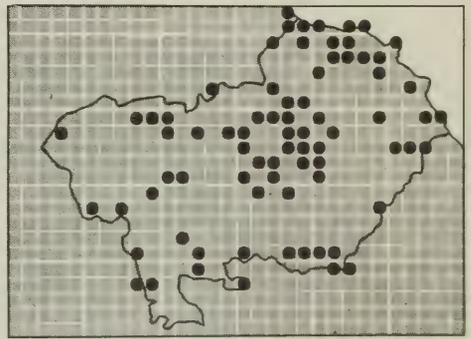
(a)



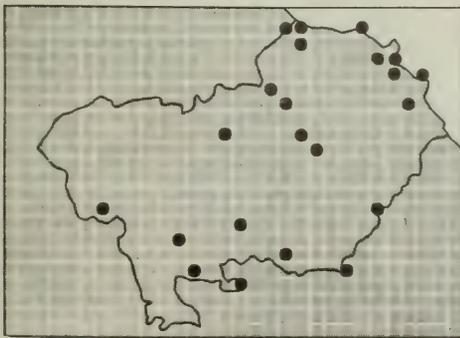
(d)



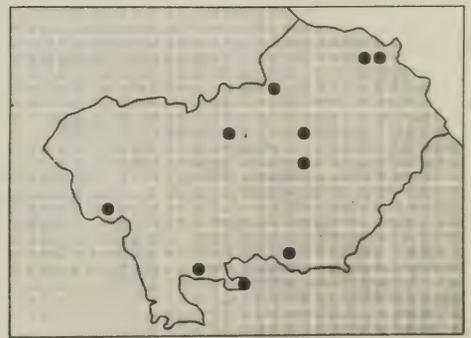
(b)



(e)



(c)



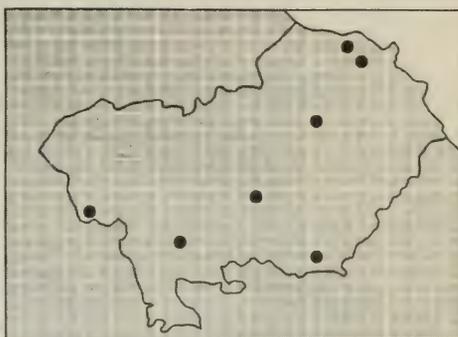
(f)

FIGURE 5. The distribution of the following in Berwickshire as recorded in the present survey: a, *Asplenium scolopendrium*; b, *A. adiantum-nigrum*; c, *A. trichomanes* agg.; d, *A. ruta-muraria*; e, *Athyrium filix-femina* and f, *Cystopteris fragilis*.

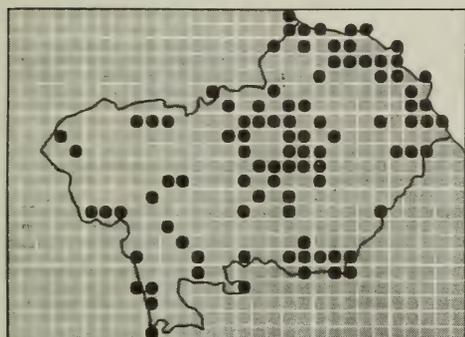
- to the restriction of its preferred habitat to higher altitudes.
- (d) Recorded post-1950 at BRC for 36/44 & 74 and pre-1950 for 36/54 & 77.
- 21.1 *Asplenium scolopendrium* Fig. 5a (Hart's-tongue)
- (a) Widespread but local to the east of a line from Cocksburnspath to Greenlaw, with only isolated occurrences to the south-west of this line.
- (b) Recorded for two distinct habitats, mortared walls and woods. In the former the species was generally rare and occurred mostly in unshaded situations. In the latter the species was more abundant (R-F) and grew in damp, shaded situations. The woods in which it grew were all mixed deciduous woods on steep, rocky slopes and the plants grew either on the rock outcrops or on the woodland floor. Also recorded once each for earthed drystone wall and for tall grass habitats, though probably planted in the latter.
- (c) 0-200m though more common below 100m.
- (d) Recorded post-1950 at BRC for 36/53 & 73 and pre-1950 for 36/54. There is also a pre-1950 record in Johnston (1829) for "cave between Fast-Castle and Redheugh by sea shore" (c. 36/86.71).
- 21.2 *A. adiantum-nigrum* Fig. 5b (Black spleenwort)
- (a) Widespread but local in eastern half of county, being commoner near the sea.
- (b) Recorded as rare to frequent on unshaded, mortared, stone walls and once as occasional on unshaded, natural rock outcrops on sides of Dowlaw Dean (36/868.707).
- (c) 0-100m.
- (d) M. Braithwaite (Pers. comm., 1979) considers the species more common on natural rock outcrops than the above records suggest and this is borne out by an analysis of the published records for the species (Jerdon, 1866; Stuart, 1897 & Long, 1973). Recorded at BRC for 36/85 & 95 post-1950 and 36/54, 75 & 77 pre-1950. There is also a recent record in Long (1973) for "Tweed bank opposite Old Melrose and below Gledswood, 36/53".
- 21.6 *A. marinum* (Sea spleenwort)
- (a-c) Recorded only once as rare on unshaded rocks by sea at Cove Harbour (36/789.716) at 5m.
- (d) Recorded post-1950 at BRC for 36/86, 87, 95 & 96 which are all coastal squares, the only record away from the coast is in Johnston (1853) "sandstone rocks by the Tweed above Ladykirk house — 7 miles from sea" (c. 36/89.46).
- 21.7 *A. trichomanes* agg. Fig. 5c (Maidenhair spleenwort)
- (a) Widespread but local throughout the area.
- (b) Most common on mortared walls where it was rare to frequent. It also occurred in the more natural habitats of natural rock outcrops in mixed deciduous woods at Stichill Linn (36/706.375) and Pease Dean (36/791.699 & 36/793.702) and unshaded natural outcrops in Dowlaw Dean (36/868.707). In these more natural habitats the species was only ever rare and below 60m.
- (c) 0-200m but commoner below 100m.
- (d) Recorded post-1950 at BRC for 36/55 & 95 and pre-1950 for 36/53.
- 21.7b *A. trichomanes* subsp. *quadrialeans*
- (d) Recorded post-1950 at BRC for 36/74, pre-1950 for 36/75, 77 & 85 all specimens checked by J.D. Lovis (Jermy *et al.*, 1978). The specimen for 36/74 came from an "old wall" which is a typical habitat of this subspecies. It would be interesting to check the records from the more natural habitats mentioned above to see if they represented the other subspecies.
- 21.9 *A. ruta-muraria* Fig. 5d (Wall-rue)
- (a) Widespread but local throughout the area except the western half of the Lammermuir Hills.
- (b) Occasional to frequent on mortared walls with one occurrence on a dry, unshaded rock outcrop in a quarry at Grantshouse (36/81.65) where it was occasional.
- (c) 0-200m.
- (d) Recorded at BRC post-1950 for 36/55 & 95. Older records suggest the species occurs more commonly on rock outcrops: Johnston (1853) "sandstone rocks by Tweed below Ladykirk House" (c. 36/88.45) and Stuart (1897) "large boulder at the Fastcastle side of Dowlaw Dean" (c. 36/86.71).
- 21.11 *A. ceterach* (Rustyback)
- (d) Recorded in Jermy *et al.* (1978) for 36/86 as pre-1950, this appears to be based on a record at BRC for "Renton near Cocksburnspath source C.O. Sonntag Flora of



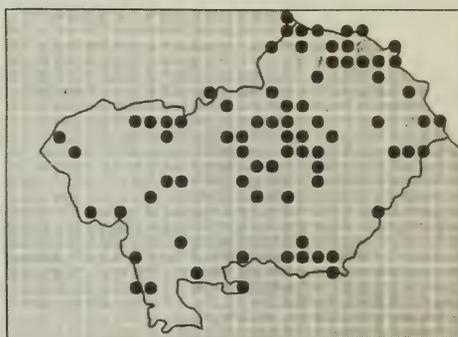
(a)



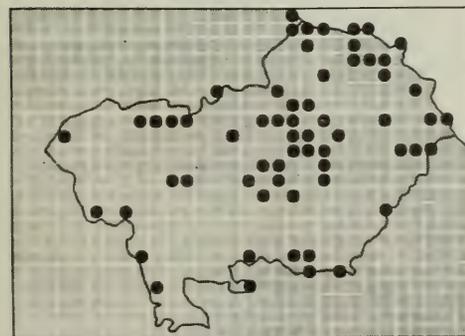
(d)



(b)



(e)



(c)



(f)

FIGURE 6. The distribution of the following in Berwickshire as recorded in the present survey; a, *Polystichum aculeatum*; b, *Dryopteris filix-mas*; c, *D. pseudomas*; d, *D. carthusiana*; e, *D. austriaca* and f, *Blechnum spicant*.

Edinburgh". The species is also recorded in Martin (1934) and Brown (1937) for Cocksburnspath (c. 36/77.71) and Evans (1917) for Renton House (c. 36/82.65) planted. It seems therefore that the species has been only seen in one locality in the area where it may be native.

22.1 *Athyrium filix-femina* Fig. 5e (Lady-fern)

- (a) Widespread and common throughout the county.
- (b) The commonest habitat of the species was deciduous woods, where it was frequent to locally abundant. It was less common and less abundant (O) in coniferous woods, moorlands marshes and scrub. It also occurred sporadically, often as isolated plants, in tall herb, scree and hedge communities, as well as on mortared walls and shaded outcrops.
- (c) 0-450m though slightly more common above 100m.
- (d) Recorded post-1950 at BRC for 36/44 & 94.

23.1 *Gymnocarpium dryopteris* (Oak fern)

- (a-c) Recorded five times. Four records were for mixed deciduous woodland on the side of a small rocky valley just above a stream — south bank of Dye above Longformacus (36/685.571), Eller Burn (36/768.612), bank of Whiteadder below Edin's Hall Broch (36/772.604) and Drakemire Strips (36/794.608). The fifth record was for birch wood on a sphagnum bog at Coldingham Common (36/853.687). All localities were at about 200m and consisted of a single patch a few metres in diameter.
- (d) Other records suggest a sparse distribution throughout the county except for the Merse. Recorded at BRC post-1950 for 36/45, 53, 64, 74 & 75 and in Long (1973) for Chester Hill screes 36/54. There are also older records for 36/77 BRC pre-1950, Edington Hill Moor (c. 36/90.56) in Henderson (1875) and Ale near Eyemouth (c. 36/91.63) in Hardy (1867).

24.1 *Cystopteris fragilis* Fig. 5f (Brittle bladder-fern)

- (a) Widespread but local throughout the county though avoiding the south east and north west.
- (b) Occurred most commonly on mortared, stone walls that were dry and unshaded, though only a few plants in each locality. Recorded once for a natural, rock outcrop in mixed deciduous wood at Stichill Linn (36/706.375) where it was occasional and once as rare on the stoney bank of a ditch in a garden at Silverwells (36/879.664).
- (c) 50-200m.
- (d) Other records record plants in the south east of the county, thus there are post-1950 records at BRC for 36/84 & 95 and older records for near Mains (c. 36/88.55) Johnston (1829) and for banks of the Leader Carolside (c. 36/56.39) Kelly (1874).

26.1 *Polystichum lonchitis* (Holly fern)

- (d) There is a pre-1950 record in BRC for 36/76 which may refer to the other record for the county which is in Hardy (1885). Here the species is recorded for "the side of the Whiteadder at the base of Moonjee very dwarf but true", which sounds rather more like depauperate *P. aculeatum* than *P. lonchitis*. Evans (1917) regards the species as an escapee in the Borders. The evidence is therefore minimal that the species ever occurred in the county.

26.2 *P. aculeatum* Fig. 6a (Hard shield-fern)

- (a) Widely distributed but local in the east of the county.
- (b) Occurred most commonly in deciduous wood (O-LF), often in narrow rocky valleys and on natural, rock outcrops (F) in such woods. There were single occurrences in tall grass, a hedge and on a drystone wall.
- (c) 0-250m but commoner at lower altitudes particularly below 50m.
- (d) Other records fill in the species occurrence in the east of the county and extend its range to the south west. Recorded post-1950 at BRC for 36/54, 64 & 86 and as locally common on the steep bank of the Tweed below Bemersyde Hill 36/53 Long (1974). A number of old records refer to *P. lobatum* as distinct from *P. aculeatum* and *P. setiferum*, thus Hardy (1879) records the three species for Pease Dean near the bridge (c. 36/79.70) and Stuart (1897) for Dowlaw Dean (c. 36/86.70). *Polystichum lobatum* is nowadays considered a form or variety of *P. aculeatum* with narrower, less-divided fronds.

26.3 *P. setiferum* (Soft shield-fern)

- (a-c) Frequent to locally abundant on the floor of the mixed deciduous woodlands in Tower Dean (36/78.69) and Pease Dean (36/79.69 & 36/79.70), and frequent in a hedge nearby (36/793.701). Also occurred twice on walls. Once at Mellerstain (36/651.384) where there is a small colony on a damp, mortared wall and once at

Manderston (36/810.547), where there was a single plant on a drystone wall. This latter plant probably arose from cultivated plants nearby. Altitudinal range was 0-150m.

- (d) Other records are all for sites within a few kilometers of the sea or coastal 10 km grid squares. Thus there is a post-1950 record at BRC for St. Abbs and area 36/96 and a pre-1950 record for 36/86. There are also older records for Dunglass Dean (c. 36/76.71) (Johnston, 1853) and for Dowlaw Dean (c. 36/86.70) (Stuart, 1897).

27.2 *Dryopteris filix-mas* Fig. 6b (Male-fern)

- (a) Widespread and common throughout the area.
 (b) There were three major habitats for this species in the area: woods and scrub including hedges; tall grass; and walls and outcrops. It was commonest and most abundant (F) in deciduous woods; equally common but less abundant (F-O) in scrub and hedges; and both less common and less abundant (O) in conifer plantations. It was the only fern that was at all common or abundant (O) in stands of tall grass and herbaceous vegetation. It was about as common on walls and outcrops as in tall grass communities but less abundant (O-R). It was noticeably less common and less abundant (R) in heath communities and there were odd records for marsh, scree and short grass communities.
 (c) 0-450m. It was equally common at all altitudes but became less abundant above 200m and only recorded as rare above 300m.
 (d) Recorded post-1950 at BRC for 36/44 & 56.

27.3 *D. pseudomas* Fig. 6c (Scaly male-fern)

- (a) Widespread and common in the Lammermuir Hills, Coastal plateau and the east of the Low Uplands of Old Red Sandstone; and widespread but more local in the rest of the county.
 (b) The habitat in which the species was most common was deciduous woods, though it was only occasionally in abundance here. It was less common in heathlands but more abundant (F) in this habitat. It was also less common in coniferous plantations and scrub where it was rare in abundance. There were also odd occurrences in hedge, tall herb, scree, outcrop and mortared wall communities, where it was only recorded as rare in abundance.
 (c) 0-450m but commoner and more abundant above 150m.
 (d) Recorded post-1950 at BRC for 36/56, 64 & 94.

27.5 *D. aemula* (Hay-scented buckler-fern)

- (d) Johnston 1853 comments under *Lastrea foenicicii*, which is a synonym for this species (Dyce, 1978), "I suspect it to be frequent in area" but gives no localities. There is also a pre-1950 record at BRC for Dirrington Law 36/65 but the card states this record to be an error.

27.8 *D. carthusiana* Fig. 6d (Narrow buckler-fern)

- (a) Widespread but local throughout the south and east of the county.
 (b) Recorded most commonly for deciduous woods especially those dominated by birch (*Betula* spp.) for example Buncle Wood (36/813.585) and Silverwells (36/878.665). However, it was only more abundant than rare where there was a birch wood on a sphagnum bog, as at Coldingham Common (36/853.687) and Gordon Moss (36/63.42) where the species was occasional and frequent respectively. Also recorded as rare in a conifer plantation (Lauder Common 36/504.467), a rush marsh (Coldingham Common) and a gorse heath (Buncle Wood).
 (c) 50-300m.
 (d) Recorded post-1950 at BRC for 36/45, 53 & 75 and in Henderson (1875) for Edington Hill Moor (c. 36/90.56).

27.9 *D. austriaca* Fig. 6e (Broad buckler-fern)

- (a) Widespread and common throughout the area.
 (b) The habitat in which the species most commonly occurred was deciduous woodland, where it was frequent in abundance. It also occurred commonly but less abundantly (F-O) in coniferous plantations and heaths. It occurred less commonly and less abundantly (O) in scrub and on drystone walls and outcrops; and there were odd occurrences in marsh, tall herb, short grass, scree, hedge and mortared wall communities. A particular habitat of the species was amongst the roots of beech (*Fagus sylvatica*) trees on banks and it was recorded twice as an epiphyte, once on oak (*Quercus* spp.) and once on alder (*Alnus glutinosa*).
 (c) 0-450m but gradually more common with increasing altitude.

27.9x8 *D. x deweveri*

(a-c) Recorded twice, once for Gordon Moss (36/63.42) as rare in a birch (*Betula* spp.) wood on a peat moss at 140m with both parents; and once for Duns Castle grounds (36/77.55) as rare in a mixed deciduous wood at 170m. At the latter site *D. carthusiana* was not recorded. Both records were determined by M. Gibby.

(d) No previous records.

28.1 *Blechnum spicant* Fig. 6f (Hard fern)

(a) Widespread but local in the Lammermuir Hills, the north section of the Coastal Plateau and the east of the Low Uplands of Old Red Sandstone.

(b) Recorded as commonest and most abundant (F-O) in heaths, and less common and abundant (O-R) in deciduous woods especially those dominated by birch (*Betula* spp.) and/or on steep slopes. There were also odd records for conifer plantations, scrub, tall herb and hedge communities.

(c) 100-450m but becoming commoner at higher altitudes.

(d) Recorded at BRC post-1950 for 36/44, 54, 64, 77, 84, 87 & 96.

HABITAT LISTS

Species lists and notes are given for selected habitats. Abundance only refers to abundance in examples of the habitat in which the species in question occurred, and is recorded on the Dafor scale. How often the species occurred in the habitat is given as a percentage frequency, rounded to the nearest ten percent.

Moors

This habitat includes all areas dominated by ericaceous undershrubs, and upland areas dominated by grasses used as open grazing. It was evident in the field that rocky areas of moorland along the sides of the small streams had a greater abundance of ferns than areas of general moorland. These two habitats were therefore recorded separately. The list refers to six examples of rocky moorland and twenty-two of general moorland.

Species	Abundance		Frequency (%)	
	General	Rocky	General	Rocky
<i>Equisetum arvense</i>	O	R	10	20
<i>Polypodium vulgare</i> agg.	—	R	—	30
<i>Pteridium aquilinum</i>	LA	F	70	50
<i>Oreopteris limbosperma</i>	O-F	F	30	70
<i>Athyrium filix-femina</i>	O	O	40	70
<i>Dryopteris filix-mas</i>	R-O	R	20	70
<i>D. pseudomas</i>	F	F	10	80
<i>D. carthusiana</i>	R	—	10	0
<i>D. austriaca</i>	O-F	R-F	50	100
<i>Blechnum spicant</i>	O-F	O	60	50

The most important ferns of moorlands in the area were *Pteridium aquilinum*, *Dryopteris austriaca* and *Blechnum spicant*. The greater abundance of ferns in rocky areas was due to a greater abundance and frequency of the ferns present in the general areas. The only significant exceptions to this latter point were *Polypodium vulgare* agg. which did not occur in the general areas and *Pteridium aquilinum* which was less important in the rocky areas. The greater occurrence of ferns in the rocky areas was possibly due to crevices at the base of rocks providing habitats for prothalli. Although in the case of *Polypodium vulgare* agg. the provision of thin, dry, organic soils

over a solid substrate, which is the preferred habitat of the sporophyte, was probably more important. The reason for the lesser occurrence of *Pteridium aquilinum* in the rocky areas is less obvious, though it may be that as these areas were near streams the water table was higher and the soils therefore too water-logged.

Walls

There are few outcrops of limestone or base-rich rocks in the county, the stone walls of the area are therefore made of siliceous rocks. The major source of variation in these walls was the presence or absence of mortar/cement between the stones. The few brickwalls surveyed are included with the mortared walls in the list and dry stone-faced earthbanks with the drystone walls. The list refers to twenty examples of drystone walls and fifty-three examples of mortared walls.

Species	Abundance		Frequency (%)	
	Drystone	Mortared	Drystone	Mortared
<i>Polypodium vulgare</i> agg.	O-F	R-O	70	20
<i>Pteridium aquilinum</i>	—	R	0	10*
<i>Asplenium scolopendrium</i>	O	R	10*	30
<i>A. adiantum-nigrum</i>	—	R	0	10
<i>A. trichomanes</i> agg.	O	R-F	30	40
<i>A. ruta-muraria</i>	O	O-F	0	50
<i>Athyrium filix-femina</i>	R	R-O	10*	20
<i>Cystopteris fragilis</i>	—	R	0	20
<i>Polystichum aculeatum</i>	R	—	10*	0
<i>P. setiferum</i>	R	R	10*	10*
<i>Dryopteris filix-mas</i>	R-O	R-O	60	60
<i>D. pseudomas</i>	—	R	0	10*
<i>D. austriaca</i>	0	R	40	10

* Represents only one record

The two most important ferns on walls were *Dryopteris filix-mas* and *Asplenium trichomanes* agg. Also important were *Polypodium vulgare* agg. and *Dryopteris austriaca* on drystone walls, and *Asplenium ruta-muraria* on mortared walls. No other species were seen more than once on drystone walls but mortared walls had six other species which occurred more than once. The major reason for the greater species richness of the mortared walls was probably their relative base richness due to the mortar, though the presence of smaller crevices in mortared walls may favour colonization by ferns.

One particularly noticeable feature of the ecology of wall ferns was the preference of *Cystopteris fragilis* and *Asplenium scolopendrium* for drier, less shaded habitats than these species prefer in other areas of Great Britain, for example the Burren (Willmot, 1979) and Derbyshire (Willmot, 1977). Although the records for *A. scolopendrium* were mostly for small, sterile isolated plants. This change in preference may be due to the relative coolness of the area, compared to the areas in Willmot (1977 & 1979), compensating for the drier nature of the habitats. It is also worth noticing the importance of walls for the existence of certain species in the county. Although no species were confined to walls, *Asplenium adiantum-nigrum*, *A. trichomanes* agg., *A. ruta-muraria* and *Cystopteris fragilis* were much more frequent (Table 2) on walls than on their natural habitat of outcrops.

Deciduous Woods

It was noticeable during the survey that the fern flora of the deciduous woods varied greatly, with woods on steep slopes having a richer flora than woods and plantations of flatter ground. The list refers to thirty-four examples of wood on steep slopes and forty-five on flatter ground.

	Abundance		Frequency (%)	
	Flat	Steep	Flat	Steep
<i>Equisetum fluviatile</i>	O	—	10*	—
<i>E. arvense</i>	R-O	O	10	10
<i>E. sylvaticum</i>	—	R-O	0	10
<i>E. palustre</i>	O	—	10	0
<i>E. telmateia</i>	—	R	0	10*
<i>Polypodium vulgare</i> agg.	—	R-O	0	10
<i>Pteridium aquilinum</i>	O-F	O-F	30	50
<i>Phegopteris connectilis</i>	—	R	0	10*
<i>Oreopteris limbosperma</i>	R-O	O	10	10
<i>Asplenium scolopendrium</i>	R	R-F	10*	20
<i>Athyrium filix-femina</i>	R-F	O-F	80	90
<i>Gymnocarpium dryopteris</i>	R	R-O	10*	10
<i>Polystichum aculeatum</i>	—	R-O	0	40
<i>P. setiferum</i>	—	F	0	10
<i>Dryopteris filix-mas</i>	O-F	O-F	100	100
<i>D. pseudomas</i>	R-O	R-F	40	90
<i>D. carthusiana</i>	R	—	10	0
<i>D. austriaca</i>	O-F	O-F	80	100
<i>D. x deweveri</i>	R	—	10*	0
<i>Blechnum spicant</i>	O	R-O	10	20

* Represents only one record

Ignoring *Equisetum arvense* and *E. palustre*, as casual species in woods and the four taxa recorded only once, there are fourteen species whose preference between the two types of wood can be judged. Three species (*Athyrium filix-femina*, *Dryopteris filix-mas* and *D. austriaca*) are very common in both sorts of wood. Amongst the remaining eleven rarer species nine show a preference for woods on steep slopes, one (*D. carthusiana*) a preference for woods on the flat, and one (*Oreopteris limbosperma*) no preference. To understand these preferences it is necessary to examine more closely the differences between the two groups of woods.

Many of the woods on the flat were obviously plantations, as the tree species in them were introductions (e.g. *Fagus sylvatica*) or because their layouts showed they were shelter-belts. The woods on steep slopes, on the other hand, often had very rocky floors. This suggests that they could never have been cleared for agriculture and therefore that they might be remnants of the "Oak forest with birch" which Birks (1977) considers the natural vegetation of the area. In fact many of these woods contained high proportions of *Quercus* sp. and *Betula* sp., along with *Ulmus glabra*, *Fraxinus excelsior* and *Corylus avellana* which Birks (1977) considers were associates of the oak and birch. If the major difference between these two groups of woods is that those on the flat are plantations on cleared land and those on the slopes are woods on sites never cleared, there are two explanations for the preference of a species for the woods or slopes. The first explanation is that a species was once more widespread in the area and has been unable to recolonise the new woods. The second is that a

species was always commoner in the sites not cleared and has not spread to the newer woods because the conditions there are not suitable for it. Three species appear to fall into the second category (*Polypodium vulgare* agg., *Asplenium scolopendrium* and *Polystichum aculeatum*), as they have a preference for rocky outcrops which are only common in the woods on slopes. This leaves six species that might fall into the first category. Three of these species (*Pteridium aquilinum*, *Dryopteris pseudomas* and *Blechnum spicant*) show only a quantitative preference but three species (*Equisetum sylvaticum*, *Gymnocarpium dryopteris* and *Polystichum setiferum*) are virtually confined to woods on slopes. These latter three species should therefore be considered as possible primary woodland indicators, in the sense of Peterken (1974), in the area.

The species with a preference for the woods on the flat (*Dryopteris carthusiana*) illustrates the fact that these woods were not a homogeneous group. The majority occurred on mineral soils but a few occurred on wet, peaty soils and this species occurred in the woods with this soil type, which is its preferred habit elsewhere. These soils do not develop on steep slopes in the area which explains the absence of the species from the woods on slopes.

SUMMARY OF THE FLORA

Thirty-two species and three hybrids have been recorded in the area since 1950 and six taxa before 1950 but not since (Table 1). The thirty-two species is an accurate reflection of the true fern flora of the area, as there are no species common in adjacent vice-counties which are absent from Berwickshire. However, hybrids are probably under-recorded due to the lack of study of them, and *Dryopteris x tavelii* and *Polystichum x bicknellii* could no doubt be added to the list if suitable habitats were examined.

Division of the species into the floristic elements of Birks (1976) (Table 3) demonstrates the general biogeographic affinities of the flora. Eighteen species belong to elements widespread in Europe and a further eleven to elements that though more restricted in Europe (Mediterranean/Atlantic) are still widespread in the British Isles. The eighteen species represent 80% of the former elements in the British Isles while the eleven only 50% of the latter elements. This lower percentage of the Mediterranean/Atlantic elements is to be expected as many of the species have a

TABLE 3:
THE PHYTOGEOGRAPHICAL AFFINITIES
OF THE FERN FLORA OF BERWICKSHIRE

(Based on the floristic elements of Birks (1976))

Floristic Element	Distribution in Europe	Number of Species in Element in:		
		(a) Berwickshire post-1950 (pre-1950)	(b) British Isles	(c) Europe
1. <i>Cystopteris fragilis</i>	Widespread	12(1)	14	14
2. <i>Pteridium aquilinum</i>	Widespread	6	8	8
3. <i>Asplenium scolopendrium</i>	Mediterranean/Atlantic	9(2)	14	14
4. <i>Adiantum capillus-veneris</i>	Mediterranean/Atlantic	2	6	6
5. <i>Woodsia alpina</i>	Arctic-alpine	2	6	6
6. <i>Polystichum lonchitis</i>	Widespread montane and sub-montane	1(1)	9	11
7. <i>Selaginella helvetica</i>	Alps, Pyrennes and lowlands of mainland	(1)	3	11
8. <i>Hymenophyllum wilsonii</i>	Western seaboard	(1)	4	4

western distribution in the British Isles, and Berwickshire is on the eastern coast. The remaining three species (*Diphasiastrum alpinum*, *Selaginella selaginoides* and *Cryptogramma crispera*) are all rare in the county and belong to northern and/or upland elements. Thus overall the flora consists of species widespread in the British Isles with the absence of species showing a marked western distribution, and the presence of a few northern and/or upland species.

The distribution of the six taxa for which only pre-1950 and often questionable records exist among the elements shed further light on the status of these species in the area. Three species (*Equisetum hyemale*, *Osmunda regalis* and *Asplenium ceterach*) belong to elements well-represented in the flora. There are no reasons to doubt the records for the latter two species, so these species at least were native in the area. However, the paucity of records for these species and their marked western distribution in the British Isles suggests they were only casual species. The remaining three taxa (*Diphasiastrum x issleri*, *Polystichum lonchitis* and *Dryopteris aemula*) all belong to elements represented poorly or not at all in the extant flora. As the records for all three species are questionable, there is no reason to consider these species as ever having been native in the area.

Examination of all records for each species reveals five patterns of geographical distribution for those species where sufficient records exist to construct a distribution. The ten species in the list below occur throughout the area:

<i>Equisetum fluviatile</i>	<i>Asplenium trichomanes</i> agg.
<i>E. arvense</i>	<i>Athyrium filix-femina</i>
<i>E. palustre</i>	<i>Dryopteris filix-mas</i>
<i>Polypodium vulgare</i> agg.	<i>D. pseudomas</i>
<i>Pteridium aquilinum</i>	<i>D. austriaca</i>

Two species (*Asplenium ruta-muraria* and *Dryopteris carthusiana*) occur throughout the area except for the north-west, and three species (*Lycopodium clavatum*, *Oreopteris limbosperma* and *Blechnum spicant*) throughout the area except for the lower ground in the south and east. A further seven species, given in the list below, also avoid the lower ground in the south and east but are more restricted in their distribution on higher ground:

<i>Huperzia selago</i>	<i>Botrychium lunaria</i>
<i>Diphasiastrum alpinum</i>	<i>Phegopteris connectilis</i>
<i>Selaginella selaginoides</i>	<i>Gymnocarpium dryopteris</i>
<i>Equisetum sylvaticum</i>	

These species occur in the Coastal Plateau and the northern-central part of the area, that is the eastern half of the Lammermuir Hills and of the low uplands of Old Red Sandstone. *Phegopteris connectilis* is rather anomalous here as it only occurs in the northern-central part. The final pattern of distribution is shown by the seven species below which are restricted to the eastern half of the area or to areas near the coast

<i>Equisetum telmateia</i>	<i>Cystopteris fragilis</i>
<i>Asplenium scolopendrium</i>	<i>Polystichum aculeatum</i>
<i>A. adiantum-nigrum</i>	<i>P. setiferum</i>
<i>A. marinum</i>	

These distribution patterns are demonstrated by the following figures: widespread *Dryopteris filix-mas* (Fig. 7b), widespread except north-west *Asplenium ruta-muraria* (Fig. 5d), widespread except south and east *Blechnum spicant* (Fig. 7f), Coastal Plateau and northern-central is not shown well in the distribution maps here as they only refer to records from this survey, and eastern *Polystichum aculeatum* (Fig. 7a).

The widespread species are all of broad ecological tolerance or species whose habitats are common throughout the area. The "widespread except south and east", and "Coastal Plateau and northern-central region" species are all species with well known preferences for upland environments. However, why the latter group are more

restricted in distribution is less obvious. The eastern species belong mostly to the Mediterranean/Atlantic elements of Birks (1976) and are probably restricted to the east of the area due to the milder climate there. Reasons for the apparent avoidance of the north-west by *Asplenium ruta-muraria* and *Dryopteris carthusiana* are unclear.

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REFERENCES

- ANDERSON, A., 1915. List of the less common plants in the area of the club. *Hist. Berwicks. Nats. Club* 22: 227-272.
- ANON., 1894. Reports of meetings for 1892. *Hist. Berwicks. Nats. Club* 14: 9-86.
- ANON., 1932. Reports of meetings 1931. *Hist. Berwicks. Nats. Club* 27: 294-326.
- BIRKS, H.J.B., 1976. The distribution of European pteridophytes: A numerical analysis. *New Phytol.* 77: 257-287.
- BIRKS, H.J.B., 1977. The Flandrian forest history of Scotland: a preliminary synthesis. In F.W. Shotton (Ed), *British Quaternary Studies: Recent Advances*: 119-135. Oxford.
- BROWN, J., 1937. Some plants found during 1937. *Hist. Berwicks. Nats. Club* 29: 294-296.
- BROWN, J., 1939. Some plants found during 1939. *Hist. Berwicks. Nats. Club* 30: 199-203.
- CLAPHAM, A.R., TUTIN, T.G., & WARBURG, E.F., 1962. *Flora of the British Isles*. Cambridge.
- DANDY, J.E., 1969. *Watsonian vice-counties of Great Britain*. London.
- DONALDSON, J.S., 1842. Selby address. *Hist. Berwicks. Nats. Club* 2: 261-269.
- DYCE, J.W., 1978. Fern nomenclature — old and new. *Bulletin of the Brit. Pterido. Soc.* 1: 261-263.
- EVANS, A.H., 1917. Notes on plants found in the district worked by the Berwickshire Naturalists' Club. *Hist. Berwicks. Nats. Club* 23: 217-235.
- FALCONER, A.A., 1932. Botanical notes. *Hist. Berwicks. Nats. Club* 27: 393-396.
- GREGORY, S., 1976. Regional Climates. In T.J. Chandler & S. Gregory (Eds), *The Climate of the British Isles*: 330-342. London.
- GRIEG, D.C., 1971. *British Regional Geology: The South of Scotland*. Edinburgh.
- HARDY, J., 1865. Plant notes. *Hist. Berwicks. Nats. Club* 5: 232-236.
- HARDY, J., 1867. Anniversary address. *Hist. Berwicks. Nats. Club* 5: 371-406.
- HARDY, J., 1879. Reports of meetings. *Hist. Berwicks. Nats. Club* 9: 425-497.
- HARDY, J., (1885). Miscellaneous. *Hist. Berwicks. Nats. Club* 10: 607-610.
- HARDY, J., 1886. Report of meetings for 1885. *Hist. Berwicks. Nats. Club* 11: 10-93.
- HENDERSON, G., 1875. On Chirnside parish: the estate of Edington. *Hist. Berwicks. Nats. Club* 7: 95-104.
- JERDON, A., 1866. Annual address. *Hist. Berwicks. Nats. Club* 5: 241-248.
- JERMY, A.C., ARNOLD, H.R., FARRELL, L. & PERRING, F.H., 1978. *Atlas of Ferns of the British Isles*. London.
- JOHNSTON, G., 1829. *Flora of Berwick-upon-Tweed*. Vol. 2. Edinburgh.
- JOHNSTON, G., 1853. *The Natural History of the Eastern Borders*. Vol. 1. London.
- KELLY, A., 1874. Habitats for some Berwickshire plants. *Hist. Berwicks. Nats. Club* 7: 125-126.
- KELLY, A., 1875. Localities for some border plants. *Hist. Berwicks. Nats. Club* 7: 327.
- LONG, A.G., 1973. Natural history observations during 1973. *Hist. Berwicks. Nats. Club* 39: 204-209.
- LONG, A.G., 1974. Natural history observations during 1973-74. *Hist. Berwicks. Nats. Club* 40: 62-63.
- LYNN, F., 1895. Buncle Edge forts. *Hist. Berwicks. Nats. Club* 15: 365-376.

- MARTIN, I.H., 1934. *Field-club Flora of the Lothians*. Edinburgh.
- MITCHELL, G.F., 1948. Late-glacial deposits in Berwickshire. *New Phytol* 47: 262-264.
- NEWHEY, W.W., 1968. Pollen analyses from south-east Scotland. *Trans. Proc. Bot. Soc. Edinburgh* 40: 424-434.
- PETERKEN, G.F., 1974. A method for assessing woodland flora for conservation using indicator species. *Biol. Cons.* 6: 239-245.
- SHAW, W., 1872. Botanical notices. *Hist. Berwicks. Nats. Club* 6: 282-283
- SHAW, W., 1894. Notes on some rarer plants. *Hist. Berwicks. Nats. Club* 14: 401-404.
- SHAW, W., 1904. Reports of meetings for 1901. *Hist. Berwicks. Nats. Club* 18: 17-122.
- SISSONS, J.B., 1976. *The Geomorphology of the British Isles: Scotland*. London.
- STUART, C., 1897. Lists of plants gathered in Dowlaw Dean. *Hist. Berwicks. Nats. Club* 16: 165-166.
- WHITTOW, J.B., 1979. *Geology and Scenery in Scotland*. Harmondsworth.
- WILLMOT, A., 1977. A pteridophyte flora of the Derbyshire dales national nature reserve. *Fern. Gaz.* 11: 279-284.
- WILLMOT, A., 1979. An ecological survey of the ferns of the Burren, Co. Clare, Eire. *Fern Gaz.* 12: 9-28.

CHEILANTHES CORIACEA, AN AFRO-ARABIAN FERN SPECIES NEW TO IRAN

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ABSTRACT

Cheilanthes coriacea Decne. is reported for the first time from Iran, in the south-west of the country. It is the third known example of an Afro-Arabian fern species in Iran; the other species there being European elements. Some distribution patterns of western Asian species are pointed out in relation to Iran.

INTRODUCTION

A parcel of ferns was sent to Prof. K.U. Kramer at Zurich from the herbarium at Ariamehr Botanic Garden, Teheran, Iran (TARI) in connection with the account of the Pteridophyta for the Flora Iranica project. Included among them was a small unidentified specimen of *Cheilanthes*, labelled: "Iran, prov. Fars: Kazerun, Abgineh., S. slope on cliffs, hanging. In crevice of rocks. Leg. Foroughi and Assadi, no. 15098, 10 Oct. 1974." The two collectors are both at Ariamehr and have between them and also with Dr. P. Wendlebo of Göteborg, Sweden, collected a great number of useful and important specimens. Mr. Assadi specialises in ferns. Since the specimen came from Fars province, near the Persian Gulf in south-west Iran, it seemed possible that it might belong to the small Afro-Arabian element in the flora, rather than to the European one. The only other non-European fern species in Iran are *Pteris dentata* Forssk. subsp. *flabellata* (Forssk.) Runemark, known from the south Caspian coast in Mazanderan province, and *Onychium divaricatum* (Poir.) Alston (Syn.: *O. melanolepis* (Decne.) Kunze, from south-west Iran; information about both these species is given by Wendlebo (1976), who also erroneously lists the specimen under consideration here as *Cheilanthes marantae* (L.) Domin, a slightly similar Iranian species which is part of the European element. A check through the African material of *Cheilanthes* at the British Museum (Natural History), London, immediately showed that this curious specimen belongs to *Cheilanthes coriacea* Decaisne, a species hitherto known only from north-eastern Africa and south-western Arabia (Somalia, Ethiopia, Sudan, Chad (Tibesti) and the Yemen). Thus it is a third and previously overlooked Afro-Arabian species in the Iranian fern flora. Its presence in Iran suggests that other overlooked Afro-Arabian species might possibly be present there, especially in the rather little known regions of the southern Zagros mountains in Fars and adjacent provinces, though they would have to be species adapted to dry conditions.

TAXONOMY

Cheilanthes coriacea resembles *C. marantae* in being covered with closely adpressed, pale or pale-brown, lanceolate scales on the lower surface of the lamina, but may be readily distinguished by being a smaller plant in all its parts, with a long, thin, nearly glabrous stipe, usually as long as the lamina. The lamina is short, broadly ovate-lanceolate and widest towards the base; the pinnules are markedly narrower than in *C. marantae* and the basiscopic ones are lengthened towards the base of the lower pinnae. The fronds are normally up to c.10 cm tall.

PHYTOGEOGRAPHY

Phytogeographical connections between the Iranian fern flora and that of north-eastern Africa and Arabia are few, involving only the three examples mentioned. But the rest of the Iranian fern flora is European in nature, with close connections to the Caucasus and Turkey. It is noticeable though that it is considerably impoverished compared to those areas, probably due to a combination of the present climate and the lack of a direct high mountain connection between them. There are 31 species of ferns and fern-allies in Iran that are common to Europe. Further afield, there are several European ferns that have spread into the West and Central Himalayas and are also common to Iran. All are species that are tolerant of a rather high degree of drought, though, apart from a few more highly xeromorphic exceptions (*Cheilanthes persica* (Bory) Mett. ex Kuhn, *C. pteridioides* (Reich.) C.Ch., *Cystopteris fragilis* (L.) Bernh. etc.), they are not now present in the desert gap of eastern Iran and western Afghanistan. A few species, such as *Polystichum lonchitis* (L.) Roth, occur in the Caucasus and West Himalayas (and Tien Shan), but apparently not in Iran. There are no examples known of extant Himalayan fern species spreading westwards to Europe and Iran, but there are some indirect connections between the two regions, for example the probable relationship between the European and Iranian *Dryopteris affinis* (Lowe) Fras.-Jenk. complex and the Himalayan species *D. paleacea* (Swartz) Hand.-Mazz. (syn.: *D. wallichiana* (Spreng.) Hyl.) outlined by Fraser-Jenkins (1980), which suggests that there may have been connections during the Tertiary period. There are also some important connections between the Himalayan and African fern floras with some species or groups in common, for example *Athyrium schimperi* Moug. ex Fée, which occurs in the Himalayas, Rajasthan and West and East Africa, *Polystichum luctuosum* (Kunze) J. Smith, from South Africa, Madagascar and the West Himalayas, with the very closely related *P. tsus-simense* (Hook.) J. Smith in south-east Tibet, China, Taiwan and Japan, or *Adiantum reniforme* agg. from Macaronesia, Madagascar, Réunion and Szechuan, West China (Lin, 1980). Several other species aggregates are common to Africa and the Himalayas.

Unfortunately, in tentatively recording the existence in Iran of various species, Parsa (1950) and Parsa and Maleki (1978) did not take phytogeographical considerations into account and did not allow for the Iranian fern flora being considerably impoverished compared to Turkey and the Caucasus. Hence many of their records are spurious and misleading and they also make a number of erroneous records due to misidentification. An earlier work by Fedtchenko (1946) is more accurate, though it also over-records a few species, mainly those in complexes which were not fully elucidated at the time as no modern cytological investigations had then been carried out. An account by Wendlebo (1976) is in general the most reliable and accurate.

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REFERENCES

- FEDTCHENKO, B.A., 1946. Ferns of Iran. *Sborn. Nauch. Rabot. Bot. Inst. Komarov. Akad. Nauk S.S.S.R.* 1945: 63-74.
- FRASER-JENKINS, C.R., 1980. *Dryopteris affinis*: a new treatment for a complex species in the European Pteridophyte flora. *Willdenowia* 10: 107-115.
- LIN, You-Xin, 1980. New taxa of *Adiantum* L. in China. *Acta Phytotax. Sinica* 18: 101-105.
- PARSA, A., 1950. *Flore de l'Iran*. Teheran.
- PARSA, A., & MALEKI, Z., 1978. *Flora of Iran* (2 edn). Teheran.
- WENDLEBO, P., 1976. An annotated check-list of the ferns of Iran. *J. Bot.* 1: 11-17.

A CHROMOSOME COUNT FOR *ASPLENIUM ANCEPS* FROM THE CANARY ISLANDS

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ABSTRACT

A chromosome count for *Asplenium anceps* Lowe ex Hooker & Grev., is given for the first time from the Canary Islands.

ASPLENIUM ANCEPS

Asplenium anceps Lowe ex Hooker & Grev., a member of the *Asplenium trichomanes* group, is a species endemic to the Macaronesian islands (Azores, Madeira, Canary Islands).

It was in the last century that the species was recognised (Lowe 1831, Bolle 1866). Recently Benl & Sventenius (1970), Page (1971, 1977) and Lovis et al. (1977) have published various localities for this fern. Apart from Madeira, where the plant shows a wider distribution, only few localities are known, and from the Azores only two specimens of *A. anceps* have so far been reported.

In the field *A. anceps* can easily be recognised by its rachis, which shows, in addition to the two adaxial wings present on *A. trichomanes*, a third abaxial wing (for further details see Lovis et al. 1977).

All previously cytologically examined plants originated from Madeira and the Azores. They were all diploid with $n = 36$ pairs of chromosomes at meiosis (Lovis in Meyer 1969, Lovis et al. 1977, Lovis unpubl.). It was thus of interest to see if the plants from the Canary Islands showed the same ploidy level. In the course of an excursion to the western part of the Canary Islands, H. and K. Rasbach visited the great Barrancos in the northern part of La Palma to west of Barlovento, an area particularly exposed to the northern trade wind (Page 1971). On May 21st and 22nd 1979 they found approximately 60 specimens of *A. anceps* in the Barranco Franceses at 1050-1110 m altitude (fig. 1). On 23rd May a further 12 plants were discovered in Barranco Gallegos at about 850 m.

A. anceps grows on small ledges and steep slopes between high rock faces. Even here it is usually exposed to the north and growing in the shade of trees and bushes. The fern occurs in the moist, misty zone which is characterised by drizzle during summer. The plant grows in loose humus soil and it can be regarded as an element of the "Laurisilva" which is shown also by the species it is associated with.

One plant taken from the Barranco Franceses (Ras-65) is now being cultivated in Basle by Prof. Dr. T. Reichstein (TR-5072). One frond of this plant was fixed in the field (absolute ethanol : acetic acid 3:1), the solution was changed after 24 hours and after 4 days the fixed material was brought into 70% ethanol and kept in a refrigerator.

The chromosome count was made in Zürich by J.J. Schneller. Meiosis is regular and at metaphase I, 36 chromosome pairs can be distinguished (fig. 1, b and c). The chromosome numbers thus correspond to those already found in plants from the Azores and Madeira. All these plants are thus diploid.

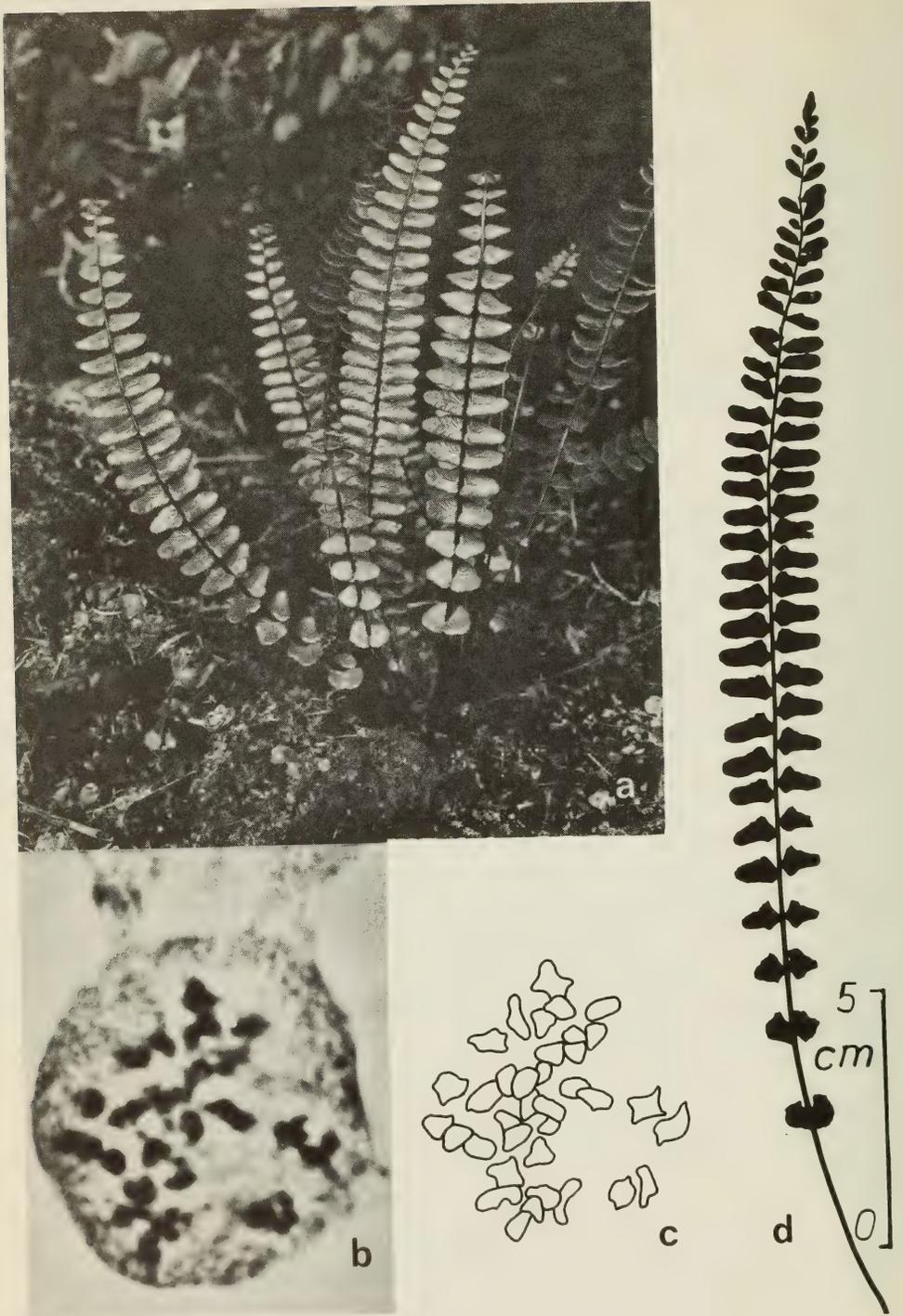


FIGURE 1. a, *Asplenium anceps* Lowe ex Hook. & Grev. from Canary Islands, La Palma, Barranco Franceses (Photo: H. & K. Rasbach); b, meiosis in *A. anceps* from Barranco Franceses, La Palma (Ras-65), show 36 bivalents (not all in the same plane) (Photo: J.J. Schneller); c, explanatory diagram of same cell; d, silhouette of whole frond.

ACKNOWLEDGEMENT

We thank Prof. Dr. T. Reichstein very much for his stimulation and interest.

REFERENCES

- BENL, G. & SVENTENIUS, E. R., 1970. Beiträge zur Kenntnis der Pteridophyten-Vegetation und -Flora in der Kanarischen Westprovinz. *Nova Hedwigia* 20: 413-462.
- BOLLE, C., 1866. Die Standorte der Farnn auf den canarischen Inseln, pflanzentopographisch geschildert. *Zeitschr. Ges. Erdk.* 1: 209-238, 273-287.
- LOVIS, J. D., HELGA RASBACH, RASBACH, K. & REICHSTEIN, T., 1977. *Asplenium azoricum* and other ferns of the *A. trichomanes* group from the Azores. *Am. Fern Journ.* 67: 81-93.
- LOWE, R. T., 1831. Primitiae faunae et floriae Maderae et Portus Sancti. *Trans. Cambridge Phil. Soc.* 4: 1-70.
- MEYER, D. E., 1969. *Asplenium newmani* Bolle von den Kanarischen Inseln ist ein X *Asplenoceterach*. *Willdenowia* 5: 221-229.
- PAGE, C. N., 1971. Three pteridophytes new to the Canary Islands. *Brit. Fern Gaz.* 10: 205-208.
- PAGE, C. N., 1977. An ecological survey of the ferns of the Canary Islands. *Fern Gaz.* 11: 297-312.

REVIEW

FERNS AND FERN ALLIES OF GUATEMALA : PART 2 POLYPODIACEAE by Robert G. Stolze. *Fieldiana, Botany New Series* no. 6, 522 pp. 1981. Published by the Field Museum of Natural History, Chicago. 235 x 155 mm.

This second part of the *Ferns and Fern Allies of Guatemala* lives up to the standard and expectations set in Part 1. Stolze deals with 69 genera of Polypodiaceae *sensu lato*; they are arranged alphabetically. Two genera, *Polypodium* and *Thelypteris*, are divided into subgenera, the first into six subgenera (*Campyloneurum*, *Microgramma*, *Niphidium*, *Phlebodium*, *Pleopeltis*, and *Polypodium*). *Thelypteris* consists of subgenera *Amauropelta*, *Cyclosorus*, *Goniopteris*, *Macrothelypteris*, *Meniscium*, *Stegnogramma*, and *Steiropteris*. Each entry consists of an ecological account, and a summary of its Guatemalan distribution followed by a general statement on its world distribution. The species is then described concisely without being pedantic, in a way which I find excellent for grasping the concept of a species that one has never seen. The entry is completed with notes on the history, taxonomy and nomenclature of the species in question. Frequently the author compares the species with close relatives, pointing out how it can be distinguished.

The typography is clear and the book is again illustrated to the extent of 80 plates by five first-rate artists of which Richard Roesener stands out for his most unusual techniques.

Bob Stolze saw fit to draw in two experts to help with this work. John Mickel (New York Botanical Garden) has contributed the account of *Elaphoglossum* (38 species) and Alan Smith (University of California at Berkeley), whose knowledge on New World Thelypteridaceae is extensive, has written up that family (59 species). There are good indented keys to all genera and to all species. This is a model fern flora and must be useful to anybody working on tropical American ferns.

A. C. JERMY

A CHROMOSOME COUNT FOR MACROGLOSSUM (MARATTIALES)

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ABSTRACT

A diploid chromosome count of $2n = 80$ has been obtained for a plant of *Macroglossum alidae* from Sarawak. This is the first record for the genus and is based on $x = 40$, characteristic of the Marattiales. A diploid representative of *Angiopteris evecta* was also found with $2n = 80$.

INTRODUCTION

Macroglossum is a small genus of Marattiales, consisting of a single, or at most two, species. It has a very limited geographical distribution, being recorded in the wild from Borneo and Sumatra under the name *M. alidae* Copel. The problematical second species, *M. smithii* (Rac.) Campbell was erected by Raciborski (as *Angiopteris smithii*) on a smaller statured plant growing at the Botanic Garden at Buitenzorg (now Bogor) in Java. The status of this latter species in the wild appears to be somewhat uncertain.

Whilst a member of the Royal Geographical Society's Expedition to Gunung Mulu, Sarawak, in 1978 I had the opportunity to examine a mature plant of *M. alidae* growing near the Expedition's base camp at Long Pala. Like *Angiopteris*, which it most resembles, it had a massive rootstock somewhat more than $\frac{1}{2}$ m high and almost as much in width. The fronds were up to $3\frac{1}{2}$ m long, inclusive of the thick stipe, and differed from those of *Angiopteris* in being simply pinnate. The pinnae were very broad — at least twice or up to three times the width of the pinnules of *Angiopteris* or *Marattia* and numbered up to 13 pairs per frond. A few of the fronds were fertile but all these, during July and August, bore only old, dehiscent sporangia. The bases of the stipes had the thick fleshy stipules characteristic of the Order and a number of young plants were growing among the roots on the surface of the rhizome. Although their origin was difficult to determine with absolute certainty, it is believed that they were produced vegetatively. Despite a careful search being made no sporelings were found on the ground in the vicinity.

ECOLOGY AND CULTIVATION

This specimen of *Macroglossum* was growing in the permanently wet silt overlying limestone at an altitude of c. 60m above sea level in dense alluvial forest which casts a deep shade. Other herbaceous plants and shrubs were rather sparse in the vicinity of the fern. One of the offshoots was sent alive to Newcastle for further study. Here it thrives in one of the glasshouses under conditions favoured by *Angiopteris*, putting on good growth in a potting mixture of coarse peat, loam and sand. Care has to be taken to avoid sudden drops in temperature and exposure to cold draughts which are anathema to many members of the Marattiales.

CYTOLOGY

It proved impossible to obtain a fixing in the field due to the lack of suitably young sporangia and the results reported here were obtained from the offshoot sent to Newcastle. This plant produced a large number of thick fleshy roots which were duly fixed in acetic alcohol.

The chromosomes stained rather lightly with aceto-carmine (as did those of *Angiopteris*) and a typical cell is shown in Fig. 1a, together with its explanatory

diagram (Fig. 2a). Several cells showed $2n=80$ unequivocally, indicating a diploid state on a basic chromosome number of $x=40$. This base number is typical of other members of Marattiales viz. *Angiopteris* (Manton and Sledge, 1954; Mehra and Singh, 1955; Ninan, 1956; Ghatak, 1962; Walker, press. comm. and unpub.), *Danaea* (Walker, 1966, 1973a), *Christensenia* (Braithwaite, 1977; Walker, 1979) and *Marattia* (Walker, in Manton, 1959; Walker, 1966 and unpub.). Other species of *Marattia* (Ninan, 1956; Brownlie, 1961) are based on $x=39$, a number which Walker (1966, 1973b) considers to be secondarily derived from that of $x=40$ found everywhere else in Marattiales from geographically widely separated areas.

A sporeling of *Angiopteris evecta* (Forst.) Hoffm. was collected in a gully in mixed dipterocarp forest at c. 750m above sea level. In cultivation in Newcastle this yielded dividing root tip cells showing $2n=80$. The plant was thus diploid, in contrast to other specimens reported from Sri Lanka (Manton and Sledge, 1954) and India (Ninan, 1956; Ghatak, 1962) which were tetraploid.

Like the chromosomes of *Macroglossum* those of *Angiopteris* did not stain deeply. A cell is shown in Fig. 1b together with an explanatory diagram (Fig. 2b). It is intended to carry out detailed karyotype analyses of members of this Order at a later date but suffice it to say that there are fairly obvious similarities in the distribution classes of chromosome lengths in the karyotypes of *Macroglossum* and *Angiopteris*.

As the closeness of affinity between *Macroglossum* and *Angiopteris* is the subject of a current investigation at the British Museum (Natural History) where comparative anatomical and morphological studies are being made it is not proposed to pursue this matter further here, except to point out that Campbell (1914a, 1914b) noted that there are marked differences in certain features despite many overall similarities between the two genera.

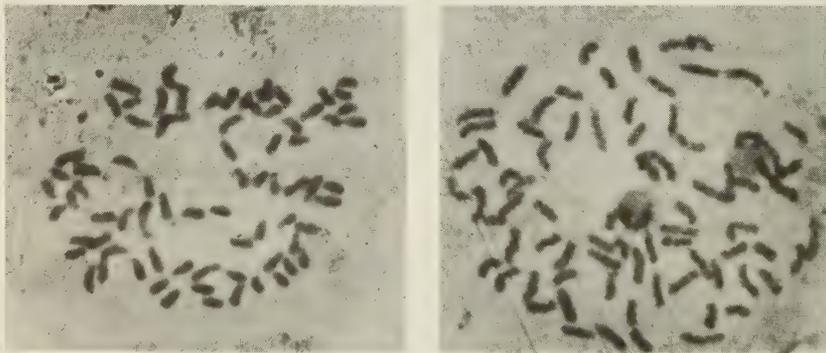


Figure 1. Root tip mitosis in (a) *Macroglossum alidae*, T13519; (b) *Angiopteris evecta*, T13401. Both $\times 1000$. Permanent acetocarmine squash preparations.

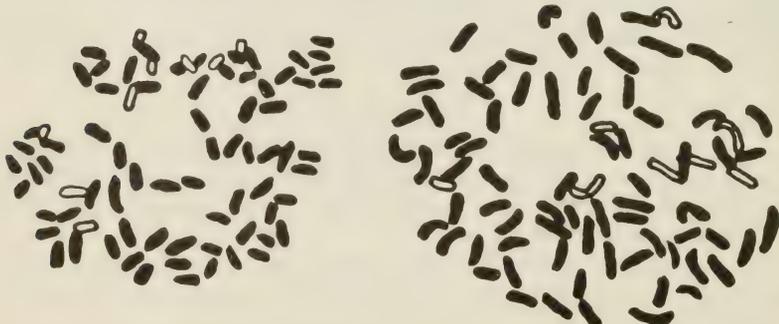


Figure 2a & b. Explanatory diagrams to Figures 1a and 1b, respectively, $\times 1000$.

ACKNOWLEDGEMENTS

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REFERENCES

- BRAITHWAITE, A.F., 1977. A chromosome count and range extension for *Christensenia* (Marattiaceae). *Amer. Fern J.* 67: 49-50.
- BROWNLIE, G., 1961. Additional chromosome numbers of New Zealand ferns. *Trans. Roy. Soc. New Zeal. Bot.* 1: 1-4.
- CAMPBELL, D.H., 1914a. The genus *Macroglossum* Copeland. *Philipp. J. Sci. C. Bot.* 9: 219-223.
- CAMPBELL, D.H., 1914b. The structure and affinities of *Macroglossum alidae* Copeland. *Ann. Bot.* 28: 651-669.
- GHATAK, J., 1962. Observations on the cytology and taxonomy of some ferns from India. *Nucleus* 5: 95-114.
- MANTON, I., 1959. Cytological information on the ferns of West Tropical Africa. In A.H.G. Alston, *The flora of West Tropical Africa*, 2nd ed.: 75-81. Crown Agents, London.
- MANTON, I., & SLEDGE, W.A., 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. *Phil. Trans. R. Soc. (B)*. 238: 127-185.
- MEHRA, P.N. & SINGH, H.P., 1955. Cytology of Cyatheaceae, Woodsiae and Marattiaceae. *Curr. Sci.* 24: 425.
- NINAN, C.A., 1956. Studies on cytology and evolution of the pteridophytes 1. Observations on the Marattiaceae. *J. Indian Bot. Soc.* 35: 233-239.
- WALKER, T.G., 1966. A cytotaxonomic survey of the pteridophytes of Jamaica. *Trans. R. Soc. Edin.* 66: 169-237.
- WALKER, T.G., 1973a. Additional cytotaxonomic notes on the pteridophytes of Jamaica. *Trans. R. Soc. Edin.* 69: 109-135.
- WALKER, T.G., 1973b. Evidence from cytology in the classification of ferns. In A.C. Jermy, J.A. Crabbe and B.A. Thomas (Eds.). *The phylogeny and classification of the ferns*. *Bot. J. Linn. Soc.* 67, Suppl. 1: 91-110.
- WALKER, T.G., 1979. A further chromosome count for *Christensenia* (Marattiales). *Fern Gaz.* 12: 51-52.

REVIEW

PALAEOBOTANY – AN INTRODUCTION TO FOSSIL PLANT BIOLOGY by Thomas N. Taylor xiii + 589 pp. McGraw-Hill Book Company, 1981. ISBN 0-07-062954-4. Price about £23 or US \$29.

The study of fossil plants is far too often thought of as an insular and over specialised field of botany by students of living plants. It can be a field that such people fear to enter because of the widely dispersed and seemingly over-detailed literature. Here, after a twenty year gap, is an up-to-date text book that should serve as an excellent introductory text for the serious reader. The book has a traditional layout in the sense that it has an introduction, dealing in general with fossils and their preservation, followed by chapters mainly devoted to major plant groups. About a quarter of the book deals with the three major groups of pteridophytes. The text is clear, the illustrations carefully chosen and each chapter has its own list of references.

The text is however largely devoted to morphological studies with interspersed ideas of evolution. There is virtually no taxonomic information of value to those readers involved with this aspect of living pteridophytes and there is also no serious attempt to give ideas of palaeoecology.

The book is clearly needed by all who are seriously interested in fossil plants. It is certainly not for the casual reader.

B.A. THOMAS

AN ANALYSIS OF THE GRAMMITIS POEPPIGIANA-G. MAGELLANICA COMPLEX IN THE SOUTH ATLANTIC AND SOUTH INDIAN OCEANS

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ABSTRACT

Grammitis poeppigiana (Mett.) Pic. Ser. and *G. magellanica* Desvaux subsp. *magellanica* are easily distinguished in part of their range (New Zealand Subantarctic islands and southern South America) but on Tristan da Cunha and Gough Island in the South Atlantic Ocean they appear more similar. However, they can be separated here and in all parts of their overlapping range by a combination of frond length and spore diameter.

INTRODUCTION

Grammitis poeppigiana (Mett.) Pic. Ser. (syn. *G. kerguelensis* Tardieu-Blot and *G. armstrongii* Tindale) is now regarded as a widely ranging circumantarctic species (Parris, 1975; Parris & Given, 1976) while *G. magellanica* Desvaux subsp. *magellanica* (hereafter referred to as *G. magellanica*) has a more restricted distribution from the subantarctic islands of New Zealand through southern South America to Tristan da Cunha and Gough Island (Parris & Given, 1976). Fig. 1 shows more precisely the distribution of the two species.

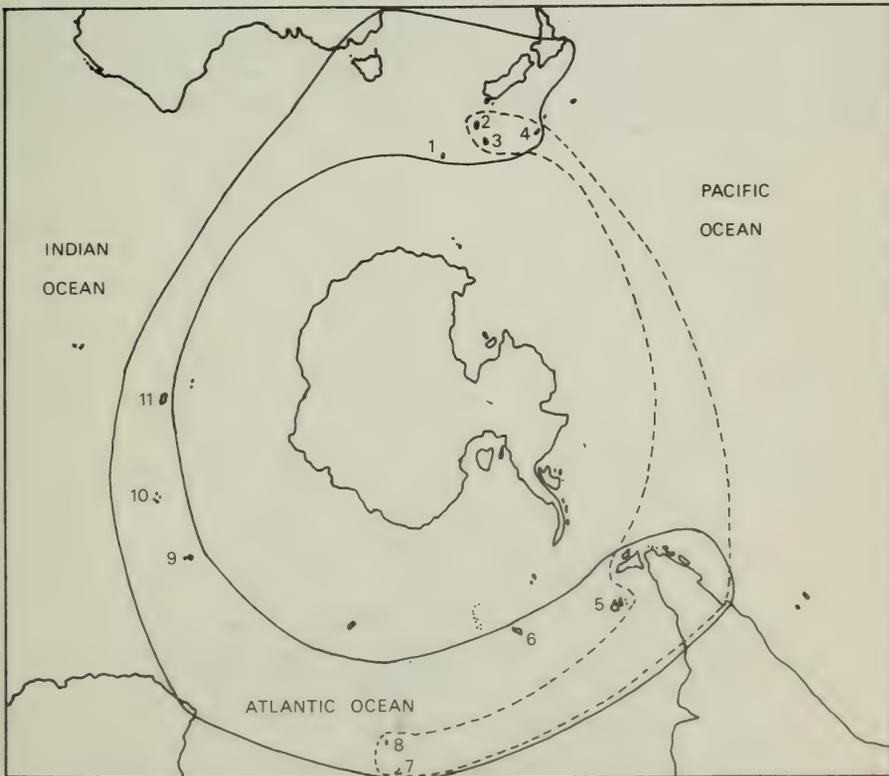


FIGURE 1. Distribution of *Grammitis poeppigiana* (solid line) and *G. magellanica* subsp. *magellanica* (dotted line): 1. Macquarie I., 2. Auckland Is., 3. Campbell I., 4. Antipodes I., 5. Falkland Is., 6. South Georgia, 7. Tristan da Cunha, Nightingale and Inaccessible Is., 8. Gough I., 9. Marion & Prince Edwards Is., 10. Crozet Is., 11. Kerguelen I.

There is no problem in distinguishing the two species in South America and New Zealand, where both occur, but on the islands of the South Atlantic and South Indian oceans discrimination on gross morphological appearance may be difficult, and judging from literature records and herbarium specimens, there has been much uncertainty as to which species occurs where throughout this region.

Accordingly a variety of measurements were made on material of both species from New Zealand and South America so that those characters giving the best specific discrimination in areas where both species occur might be applied to the resolution of the status of material from the remainder of the species' ranges.

METHODS

Wherever possible, ten fertile fronds from each collection were measured to provide the data on frond length and frond width; as the stipes of both species are indistinct and winged almost to base, frond length includes both stipe and lamina. For microscopic measurements of sporangia length and spore diameter, ten measurements of each character were made from each collection. Only mature sporangia, which had shed spores but which were closed, and spores which had not germinated were measured. Spores and sporangia were measured mounted in a glycerine solution.

RESULTS

It became apparent that the two characters of most reliable use in distinguishing *G. poeppigiana* and *G. magellanica* were frond length and spore diameter. Fig. 2 shows that with the exception of one aberrant New Zealand collection of *G. magellanica* a combination of these two characters gives absolute discrimination of the two species and this is also emphasised by the data in Table 1 which gives the range, mean and standard deviation of these characters for the South American and New Zealand populations of the two species.

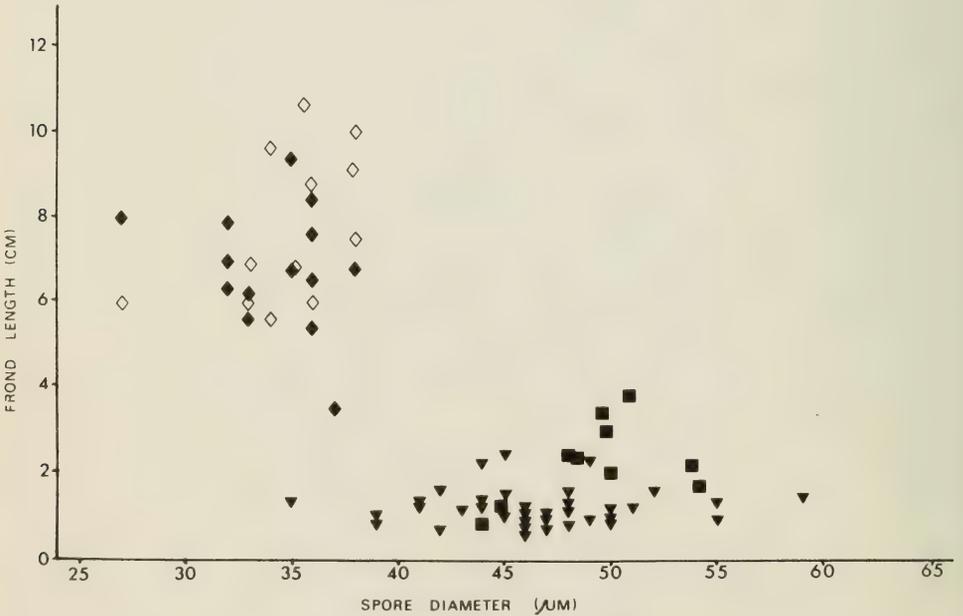


FIGURE 2. Mean of frond length and spore diameter of *G. poeppigiana* and *G. magellanica* from New Zealand and South America: ▾ *G. poeppigiana* New Zealand, ■ *G. poeppigiana* South America, ◆ *G. magellanica* New Zealand, ◇ *G. magellanica* South America.

TABLE 1:
RANGE, MEAN AND STANDARD DEVIATION OF FROND LENGTH AND
SPORE DIAMETER IN *G. POEPPIGIANA* AND *G. MAGELLANICA*:
NEW ZEALAND, SOUTH AMERICA AND
NEW ZEALAND/SOUTH AMERICA COMBINED DATA

	Frond length (cm)			Spore diameter (μm)		
	Range	mean	st.d.	Range	mean	st.d.
<i>G. poeppigiana</i>						
New Zealand	0.4-3.0	1.2	\pm 0.7	31-65	46.4	\pm 7.2
South America	0.6-2.9	1.6	\pm 0.9	35-58	46.5	\pm 7.3
combined	0.4-3.0	1.3	\pm 0.7	31-65	46.5	\pm 6.6
<i>G. magellanica</i>						
New Zealand	2.2-12.0	6.8	\pm 2.8	25-50	33.9	\pm 4.1
South America	4.3-12.1	7.3	\pm 2.4	25-50	35.0	\pm 4.4
combined	2.2-12.1	7.1	\pm 2.9	25-50	34.6	\pm 4.5

Fig. 3 superimposes on the overall values of the two characters of each species the appropriate mean measurements of all collections studied for the remainder of the species' ranges.

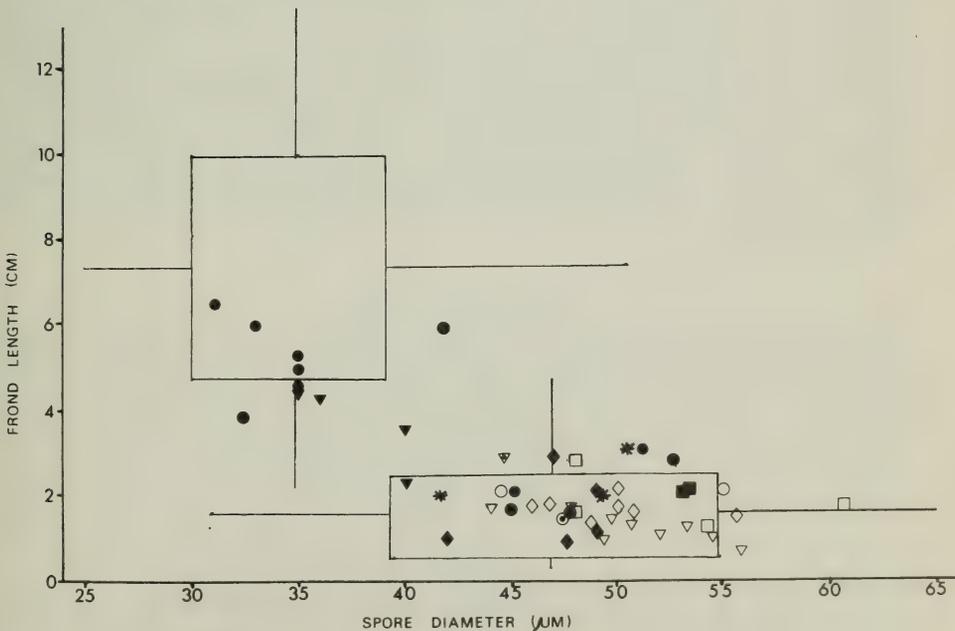


FIGURE 3. Mean of frond length and spore diameter of *G. poeppigiana* and *G. magellanica* from Atlantic and Indian Ocean superimposed on mean (± 1 standard deviation) frond length and spore diameter of combined New Zealand and South American data for *G. poeppigiana* and *G. magellanica*: \circ Falkland Is., ∇ South Georgia, \bullet Tristan da Cunha, \blacktriangledown Gough Is., $*$ South Africa, \diamond Marion Is., \square Crozet Is \blacksquare Kerguelen I., \blacklozenge Australia, \odot Nightingale Is., \blacktriangledown Inaccessible I.

This shows clearly that Falkland Islands, South Georgia, Marion Island and Kerguelen Island specimens are virtually identical with South American and New Zealand *G. poeppigiana*. Material from Inaccessible Island, Crozet Islands, Australia and South Africa, although tending to have slightly larger fronds, can only be regarded as *G. poeppigiana*.

Tristan da Cunha specimens demonstrate convincingly that both species are present on this island and, apart from an anomalous intermediate specimen which cannot be assigned reliably the same would seem to be true of the relatively nearby Gough Island.

Thus, particularly when viewed in the context of the variability of the two species in their chief 'mainland' areas of South America and New Zealand, identification of South Indian and South Atlantic Ocean specimens can be made with considerable confidence.

The important distinctions between the species are summarised below:

G. poeppigiana – rhizome usually long-creeping, sometimes short-creeping or ± ascending, fronds usually less than 4cm long, sori less than 5 (-7) pairs, spores usually larger than 40 µm diam.

G. magellanica – rhizome erect, rarely ascending, fronds usually more than 4 cm long, sori normally more than 5 pairs, spores typically smaller than 40 µm diam.

DISCUSSION

The distribution of these two species fits very well the scheme for zonation of terrestrial vegetation in southern latitudes proposed by Wace (1960, 1965). His cool temperate zone extends south to the limits of tree or woody shrub growth and in this area (including southern South America, Tierra del Fuego, Tristan da Cunha group, New Zealand Subantarctic Islands) both the epiphytic *G. magellanica* and the rupestral *G. poeppigiana* are found. Only the latter has so far been recorded from the Falkland Islands which are also placed in this zone. Wace's subantarctic zone is defined by the absence of tree or woody shrub growth and the presence of closed herbfield vegetation. Only *G. poeppigiana* occurs on the islands included in this zone (South Georgia, Marion and Prince Edward Islands, Crozet Islands, Kerguelen Island, Macquarie Island).

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REFERENCES

- PARRIS, B.S., 1975. A revision of the genus *Grammitis* Sw. (Filicales: Grammitidaceae) in Australia. *Bot. Jour. Linn. Soc.* 70: 21-43.
- PARRIS, B.S., & GIVEN, D.R., 1976. A taxonomic revision of the genus *Grammitis* Sw. (Grammitidaceae: Filicales) in New Zealand. *N.Z. Jour. Bot.* 14: 85-111.
- TARDIEU-BLOT, M.L., 1962. Sur les *Grammitis* des Iles australes. *Adansonia* 2: 111-116.
- WACE, N.M., 1960. The botany of the southern oceanic islands. *Proc. Roy. Soc. London B* 152: 475-490.
- WACE, N.M., 1965. Vascular plants, pp. 201-266 in van Miegheim, J. and van Oye, P. (Eds.) *Biogeography and Ecology in Antarctica*. W. Junk, The Hague.

TWO NEW SPECIES OF SELAGINELLA FROM THE PHILLIPINES

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ABSTRACT

Two new species of *Selaginella*, discovered by the senior author when undertaking a review of cone and spore morphology of the genus in the Philippines, are described and named as follows: *S. atimonanensis* Tan & Jermy from Luzon Island, and *S. pricei* Tan & Jermy from Samar Island.

INTRODUCTION

In the course of studying the sporangial distribution pattern and spore morphology of Philippine *Selaginella* species for a Masters thesis (Tan 1974) in botany, the senior author (B.C.T.) came across two new species of the genus, materials of which were collected from limestone areas, a habitat usually sparse in *Selaginella*.

The Philippine species of *Selaginella* were first summarized by Alston in 1935. In that paper, a total of 46 species were listed with localities and a key to the species was also included. Later, Alston (1937) made several corrections to nomenclature when he reduced *S. ascendens* v. *Anderw.v.Ros.* to synonymy of *S. intermedia* (Bl.) Spring, *S. peltata* C. Presl to *S. involvens* (Sw.) Spring and *S. springiana* v. *Anderw.v.Ros.* to *S. longiaristata* Hieron. Subsequently, *S. heterostachys* Baker and *S. uncinata* (Desv.) Spring were reported by Tan (1975) as new to the country. The latter species, which is of Chinese origin, has been observed to become naturalized in Laguna Province. In addition, *S. plana* (Desv.) Hieron. from the West Indies, and *S. willdenovii* Baker, an eastern Asian-Malasian species, have also been reported as ornamentals in many local gardens and greenhouses (Price 1974).

KEY AND DESCRIPTIONS

The two presently new species of *Selaginella* from the Philippines described below are related to the *S. intertexta* group which may be distinguished by the following key:

1. Lateral leaves broadly ovate to orbicular, less than 1.5 times as long as broad..... 2
2. Lateral leaves = contiguous and opposite; plant sparsely and openly branched *S. pricei*
2. Lateral leaves spaced, not opposite; plant often much branched and forming intertwining mats 3
3. Lateral leaves symmetrical, margins not ciliate..... *S. nummularia*
3. Lateral leaves asymmetrical, margins long-ciliate *S. atimonanensis*
1. Lateral leaves broadly elliptic to narrowly ovate, at least twice as long as broad..... 4
4. Marginal cilia of all leaves long; median leaves c. 0.2mm long *S. apoensis*
4. Marginal cilia absent or, if present, inconspicuous and short; median leaves 0.6-0.7mm long *S. intertexta*

Selaginella antimonanensis Tan & Jermy *sp. nov.* (Figs. 1-6)

Caulis primus repens, inaequaliter ramosus, tegetes laxas formans, interdum radicans, rhizophoro filiformi instructus. *Folia* omnino dimorpha; *folia lateralia* distantia, 1-1.5 x 0.8-1.3mm, late ovata vel plus minusve orbicularia, saepe asymmetrica, marginibus posterioribus ellipticis longe ciliatis, anterioribus autem hemisphaericis breviter ciliatis, apice acuto vel breviter cuspidato mucronatove, basi rotunda; *folia axillaria* ovata vel elliptica, lateralibus dimidio minora, breviter cuspidata, marginibus ubique ciliatis; *folia intermedia* circa 0.25-0.75mm longa, 0.2-0.5mm lata, ovata, ea in caulibus primis asymmetrica, ea in ramis plus minusve symmetrica, apice 0.25mm longo, acuminato vel aristato, basi cordata, marginibus ubique ciliatis. *Strobili* complanati, plerumque longi minus quam 1.0cm. *Sporophylla* dimorpha, ciliata, ea dorsalia ovata vel lanceolata, dimidio minimum minora quam folia lateralia, apice acuto-acuminato, ea ventralia lanceolata, apice acuminato. *Megasporae* in siccitate albae vel flavidae, c. 200 μ m diametro, cerebriformes, sporodermate minute papillato; *microsporae* aurantiacae, 30-34 μ m diametro, verrucatae, verrucis tenuiter spinulosis.

Typus: on limestone cliff along trail to summit, 300-400 m alt., Atimonan National Park, Quezon Province, Luzon, B.C. Tan 77-2005 (holotype, CAHP; isotypes, BM, KYO, L, US).

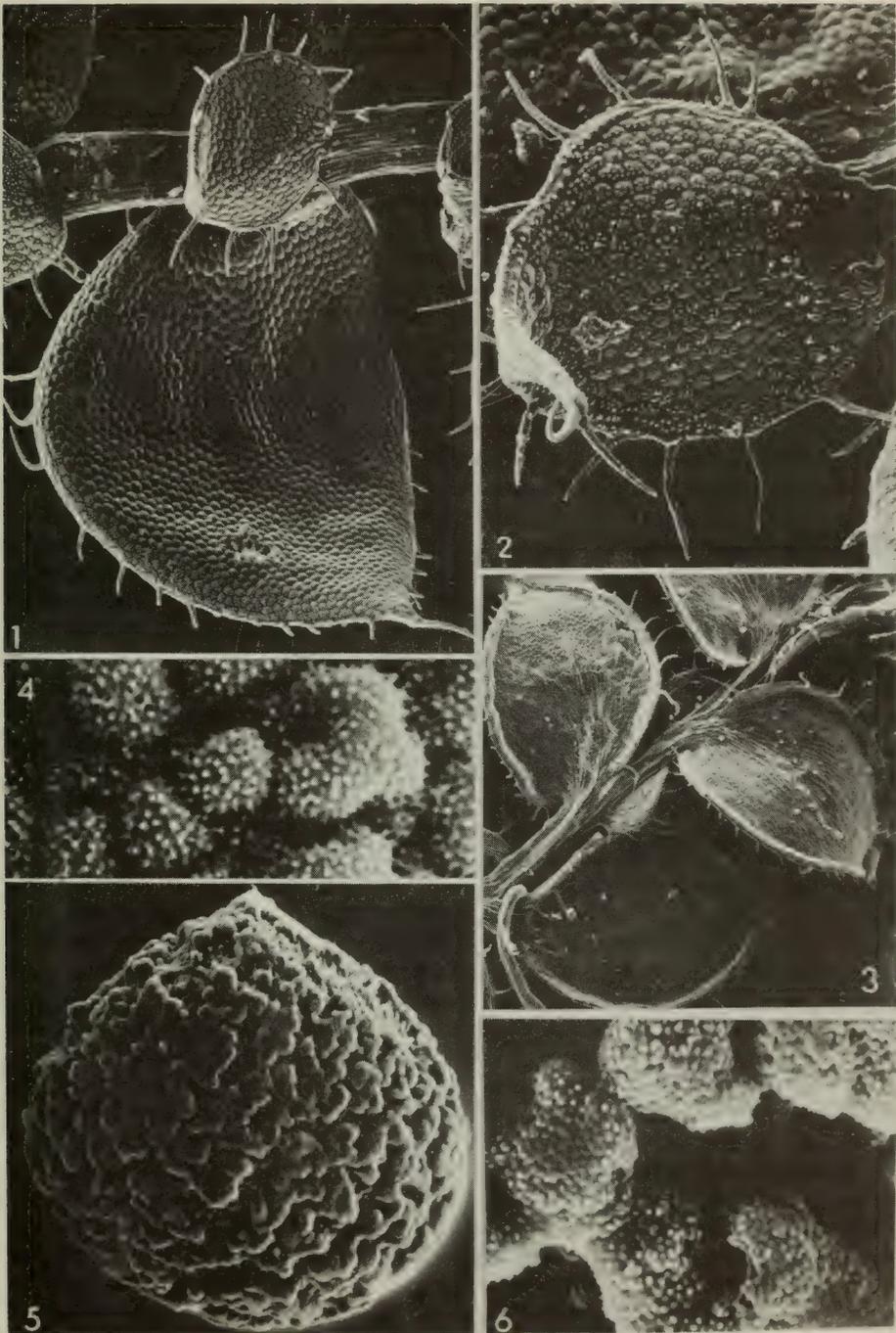
Paratypes: in limestone crevices, near summit, 428 m alt., same locality, B.C. Tan 77-2006; on moist limestone wall, near Minador Cave, Atimonan National Park, c. 250 m, B.C. Tan 77-500; 77-501.

A creeping, irregularly branched plant forming a loose mat, stems (including the lateral leaves) 2-3mm wide, rooting at intervals, rhizophores filiform. Leaves dimorphic throughout; lateral leaves 1.0-1.5 x 0.8-1.3mm, distant below, becoming more crowded towards the apex and strobili, superficially broadly ovate to almost orbicular, but asymmetric with the posterior margin elliptic and the anterior \pm hemispherical, apex acute to shortly cuspidate or mucronate, margins ciliate throughout, cilia 0.2-0.4mm and longer on the anterior margin, marginal cells papillate and conspicuous on the underside; axillary leaves ovate to elliptic approximately equal in size to the lateral leaves of the branches they subtend, apex shortly cuspidate, margin ciliate; median leaves 0.25-0.75 x 0.2-0.5mm, ovate, with long acuminate to aristate apices, those on the primary stem \pm asymmetrical, those on the branches symmetrical, bases cordate to auriculate, margins ciliate. Strobili complanate with 1-3 megasporangia near the base or occasionally almost entirely megasporangiate with 1-3 microsporangia near the apex; sporophylls of two sizes, those larger ones, dorsal and sterile, margins ciliate, those ventral and median, narrower, usually all containing sporangia. Megaspores c. 200 μ m, sporoderm minutely papillate folded into an irregular brain-like appearance, white or yellowish when dry; microspores 30-34 μ m in diameter, orange, verrucate, verrucae finely spinulose.

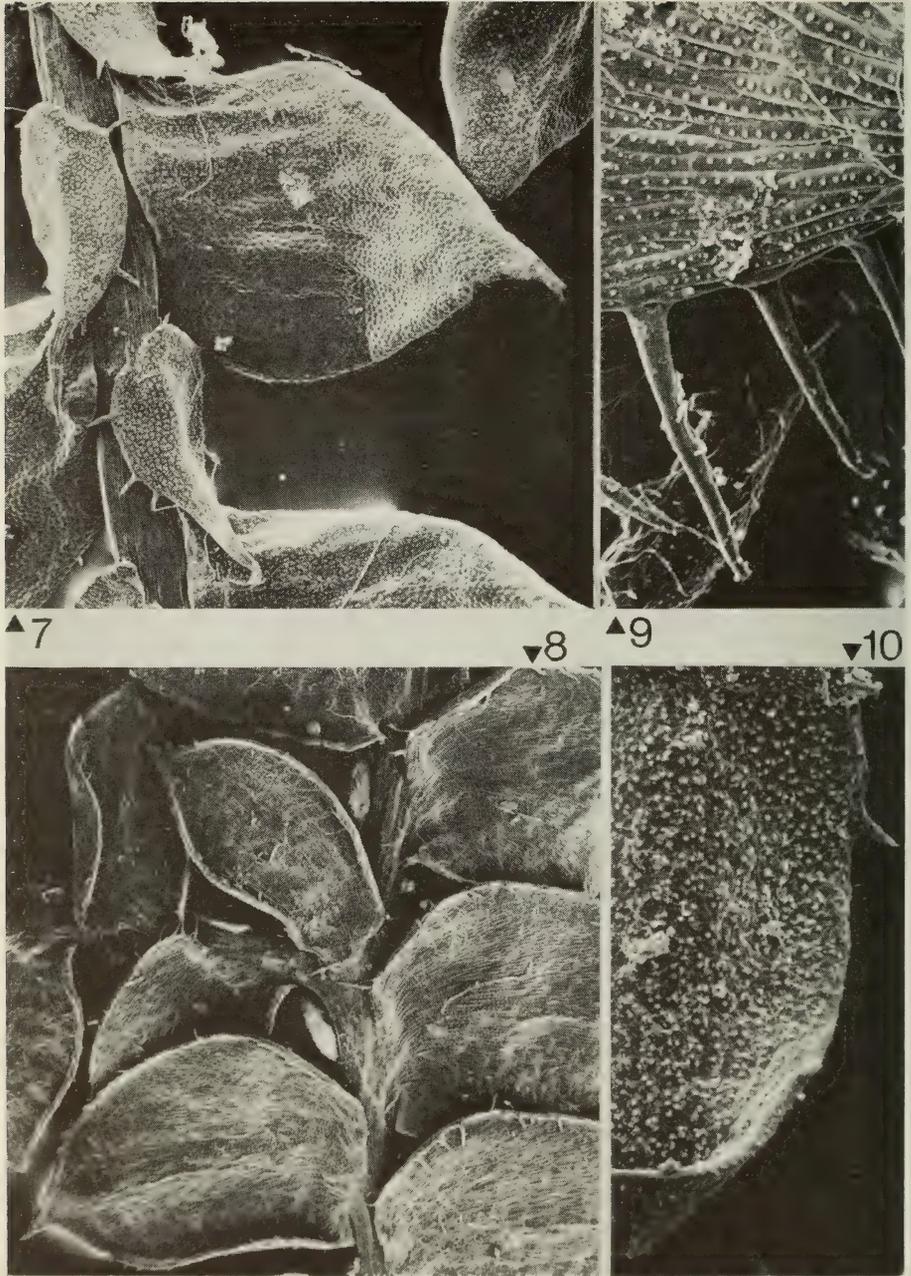
Among the local species, the new taxon is closely related to *S. intertexta* Spring and *S. nummularia* Warb. It differs from the former in being shortly creeping and having strongly ciliated vegetative leaves and sporophylls, and also in the almost suborbicular lateral leaf shape. From the latter, which it resembles closely in habit and leaf shape, it can be easily recognised by the presence of cilia on the lateral leaves which are asymmetrical. The broadly ovate to near orbicular leaf outline separates it also from the other ciliate species in the group, *S. apoensis* Hieron.

Selaginella pricei Tan & Jermy *sp. nov.* (Figs. 7-10)

Caulis primus repens, longus, tenuis, brevibus ramis distantibus, interdum radicans, rhizophoro filiformi instructus. *Folia lateralia* 1.2-1.6mm x 0.8-1.2mm in caule ramisque conferta, late elliptica, basi truncato-cordata, ad apicem breviter acutum vel acuminatum contracta, margine serrato, ciliis 0.1-0.3mm longis basi parce sparsis, secundum autem margines superiores frequentioribus et conspicuis; *folia axillaria* ovata vel elliptico-lanceolata, quam lateralia plus minusve tertia parte minora, non auriculata, apice acuto vel acuminato, in marginibus ambobus et basem versus ciliata; *folia intermedia* eis lateralibus plus minusve triplo minora, ovato-lanceolata, aristata, basi leniter cordata, asymmetrica, exterioribus lobis evidentioribus, basi ciliata et manifeste secundum margines interiores integros. *Strobili* complanati, 1-2cm longi, plus minusve 1.5mm lati. *Sporophylla* dimorpha, ciliata, ea dorsalia late lanceolata plus minusve 1.5mm longa, gradatim acuminata, non carinata, ea ventralia minora, lanceolata, acuminata, carinata. *Megasporae* non visae; *microsporae* aurantiacae 28-35 μ m diametro.



FIGURES 1-6. *Selaginella atimonanensis* Tan & Jermy : 1. portion of main branch from above, x 50. 2. median leaf, from above, x 100. 3. branchlet from below, x 20. 4. detail microspore wall, x 5500. 5. megaspore distal face, x 300. 6. detail of megaspore wall, x 2200. a = axillary, l = lateral, m = median leaves.



FIGURES 7-10. *Selaginella pricei* Tan & Jermy : 7. main branch from above, x 40. 8. branchlet from below, x 20. 9. cilia on axillary leaf, x 300. 10. upper surface of median leaf. a = axillary, l = lateral, m = median leaves.

Typus: on limestone cliff, 200 m alt., in forested trail to Concord municipality from Bagacay, Hinabangan, Western Samar, 28 June 1975, B.C. Tan 75-414 (CAHP; isotypes BM, KYO, L, US).
Paratype: creeping on limestone cliff inside primary forest, municipalities of Gandara and Matuguinao, Western Samar. *Price & Hernaez 119* (CAHP).

A species with a long slender creeping main stem with distantly spaced short branches, rooting at intervals with filiform rhizophores. Lateral leaves c. 2 x 1 mm, base truncate-cordate, broadly elliptic, those on the main branches becoming ovate-elliptic, abruptly acuminate at apex, margins sparsely serrate, ciliate around the base especially on the anterior margins; axillary leaves ovate to elliptic-lanceolate, c. $\frac{2}{3}$ the size of the lateral leaves, not auriculate, apices acute to acuminate serrate above, ciliate below; median leaves 0.8-1.2 x 0.3 mm lanceolate-ovate, aristate, weakly cordate at the asymmetric base, the outer lobes being larger, cilia sparse along inner margin. Strobilus flattened, 1-2 cm long, c. 1.5 mm broad; sporophylls dimorphic, those of the upper plane broadly lanceolate, \pm 1.5 mm long, acuminate, not keeled, ciliate throughout, those of the lower plane smaller in dimension, similar but keeled. Megaspores not seen; microspores 28-35 μ m, orange.

The species is named after Michael G. Price of UP at College, whose studies on Philippine ferns warrant special recognition.

Superficially, the taxon looks like a large form of *S. apoensis* Hieron. or a small form of *S. boninensis* Baker. The leaf sizes and the broader lateral leaves, however, distinguish it from *S. apoensis*. The fewer and shorter cilia (0.1-0.3 mm) along the leaf margins and bases, plus the laxer and more forwardly directed sporophylls of the upper plane are additional distinctive characters for the new taxon. From *S. intertexta* Spring it can be segregated by the aristate median leaves, and the long, creeping stem habit with only a few short branches.

ACKNOWLEDGEMENTS

We should like to thank Miss Alison Paul for taking the SEM micrographs and Miss Kathryn Kavanagh for help with the Latin descriptions.

REFERENCES

- ALSTON, A.H.G., 1935. The Philippine species of *Selaginella*. Philip. J. Sci. 58: 359-383.
ALSTON, A.H.G., 1937. The Selaginellae of the Malay Islands II. Sumatra. Bull. Jard. Bot. Buitenzorg, ser. 3, 14: 175-186.
PRICE, M.G., 1974. *Pteridophytes of Mount Makiling and vicinity*. M.Sc. Thesis Univ. Philippines, Los Baños (unpublished).
TAN, B.C., 1974. *Sporangial distribution and spore morphology of Philippine Selaginella*. M.Sc. Thesis Univ. Philippines, Los Baños (unpublished).
TAN, B.C., 1975. Two *Selaginella* species new to the Philippines. *Kalikasan*, 4: 42-46.

REVIEW

THE EVOLUTION OF PLANTS AND FLOWERS by Barry Thomas. 1981, 220 x 280mm, 116 pp. Peter Lowe Ltd., London. Price: £5.95.

This is a semi-popular book about the evolution of the plant kingdom. It presents not so much the theoretical side of evolution but a synopsis of the main stages of plant life on earth as known from fossil evidence. It is profusely illustrated throughout with coloured diagrams, restorations of the appearance of the fossils as whole plants, and photographs of living members of each group.

As one might expect, pteridophytes, together with conifers, are well represented, the two groups having dominated the land flora of this planet for so long a period of evolutionary time. The book gives a synopsis of the main pteridophytes present from the late Devonian period through to the Mesozoic in particular, setting them against a background of the kind of vegetation and landscape in which they grew.

The text is written in a readable and simple style which should be easy to understand by anyone without previous knowledge of the subject. An important feature of the book is certainly its illustrations, which are well-chosen, and in most cases, very well done. They greatly help in bringing the subject to life. Particularly informative are the diagrams of life-cycles, as well as the small charts showing the interrelations of the groups discussed and the period of time for which they survived.

So often, fossil plants leave the impression of dry and dusty things. I found this book a valuable stimulant in setting them in the dynamic perspective of green and living things. It is a good book for the beginner, and will probably leave him wanting to delve further.

C.N. PAGE

A FORKED VEIN AND FOLIAR FIBRES IN SELAGINELLA

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ABSTRACT

The presence and significance of a forked vein and foliar fibres is described in *Selaginella*.

INTRODUCTION

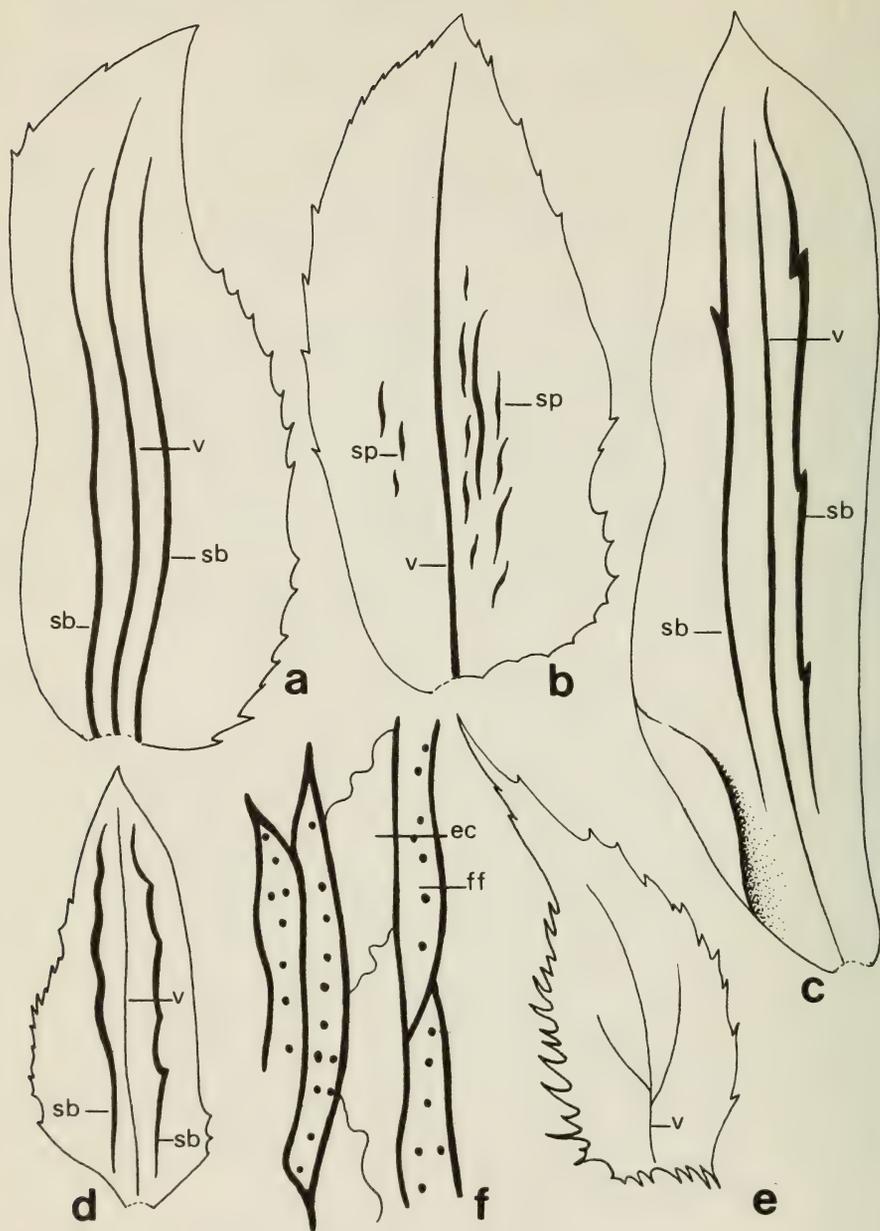
The leaves of *Selaginella* are small, scaly and provided with a single unbranched nerve. As the leaf trace is small and unbranched, its departure has no influence in the stelar cylinder, and there is no formation of a leaf gap. A survey through literature, however, reveals the existence of more than one nerve in some species of the genus. Alston (1945) noted a tri-nerved condition in *Selaginella griffithii* Spring. Panigrahi and Dixit (1967) described bi-nerved leaves in *S. involvens* (Sw.) Spring. Grambast and Rosello (1965) found forked veins in *S. willdenowii* (Desv.) Baker. The presence of more than one nerve was also reported by Webster (1970) in aberrant leaves on excised stem of *S. martensii* Spring grown in culture. These leaves differed from normal ones in having lobed tips, more stomata and sometimes more than one ligule associated with each leaf.

OBSERVATIONS

When making a systematic survey of the anatomical features of the genus, we could not confirm the occurrence of more than one vein in the normal leaves of *S. willdenowii*, *S. griffithii* and *S. involvens*. In the latter two species we found, however, a sclerenchymatous band composed of fibres with warty outgrowths on the outer periclinal surface extending along either side of the midrib on the abaxial epidermis of the lateral leaves (figs. 1a and 1f). Tracheids and sieve cells are never associated with these sclerotic bands. These two sclerotic bands together with the midrib give a deceptive tri-nerved appearance in dried leaves of *S. griffithii*. In *S. involvens* the midrib is inconspicuous and as such the two median sclerotic bands appear as two nerves of the leaves. The occurrence of similar false veins was reported in *S. caulescens* Spring from Java by Baker and Posthumus (1939). Median sclerotic bands also occur in the abaxial epidermis of the lateral leaves of *S. intermedia* (Bl.) Spring, *S. chrysocaulos* (Hook. and Grev.) Spring and *S. tenera* (Hook. and Grev.) Spring (figs. 1b-d). The foliar fibres of *S. intermedia* are so thick-walled that their lumina are almost obliterated. In *S. tenera* small patches of fibres form almost a continuous strip extending more than half the entire length of the lamina on the acroscopic side, but in the basisopic half only a few discrete patches occur (fig. 2).

Sclerotic fibres occur regularly at the margins of the lamina of the median leaves of *S. helferi* Warb., *S. intermedia*, *S. ciliaris* (Retz.) Spring, *S. chrysorrhizos* Spring, *S. denticulata* (Desv.) Alston and *S. vaginata* Spring. Similar occurrences of fibres at the margins of the leaves was also reported by Mital (1965) in many species of *Selaginella* from India.

S. adunca A.Br. ex Hieron is the only species we have come across in which the vein is really forked (fig. 1e). The leaf trace after entering the vegetative and reproductive leaves undergoes two successive dichotomies within a short distance.



Lateral leaves of *Selaginella*: a, *S. griffithii* x 50; b, *S. tenera*, x 33; c, *S. interdemia*, x 33; d, *S. chrysocaulos*, x 33; e, *S. adunca*, x 33; f, foliar fibres in the abaxial epidermis of *S. chrysocaulos*, x 450 (ec = epidermal cell, ff = foliar fibre, sb = sclerotic band, sp = sclerotic patch, v = vein).

Yet the trace creates no impact in the vascular cylinder of the stem and no incipient gap can be recognised just above the departing trace. The occurrence of a branched vein in a relatively primitive species like *S. adunca* appears significant in connection with Zimmermann's (1959) hypothesis of origin of microphyllous leaf through reduction

REFERENCES

- ALSTON, A.H.G., 1945. An enumeration of Indian species of *Selaginella*. *Proc. Nat. Inst. Sci. India, B(11)*: 211-235.
- BACKER, C.A., and POSTHUMUS, O., 1939. *Varenflora voor Java*. Java.
- GRAMBAST, L., and ROSELLO, S., 1965. Les notions de microphyllite et de mégaphylite et leur signification phylogénétique. *Compt.Rend.Acad.Sci., Paris, 261*: 5183-5186.
- MITAL, P.L., 1969. Epidermal studies in the genus *Selaginella* Beauv. *Bull.Bot.Surv.India, 11*: 150-160.
- PANIGRAHI, G., and DIXIT, R.D., 1967. Studies in the systematics of Indian *Selaginella* — II. *J. Indian Bot.Soc., 36*: 102-108.
- WEBSTER, T.R., 1970. Aberrant leaves on angle-shoots of *Selaginella martensii* Spring. *Amer. Fern J., 60*: 1-6.
- ZIMMERMAN, W., 1959. *Die Phylogenie der Pflanzen*. II. Aufl. Stuttgart.

SHORT NOTES

DRYOPTERIS X SARVELAE IN SCOTLAND; A NEW HYBRID FOR THE BRITISH ISLES

Dryopteris x sarvelae Fraser-Jenkins and Jermy is the hybrid *D. carthusiana x expansa*. Until now, the only record for this hybrid was from Espoo, Finland, where it was found by J. Sarvela (Widén, Sarvela and Ahti, 1967). In 1978 the hybrid was discovered in Argyll, Scotland (V.C. 101) by H. V. Corley, and its identification was confirmed on cytological and morphological evidence by M. Gibby in 1980. The hybrid is easily confused with *D. x deweveri* (Jansen) Jansen and Wachter and *D. x ambroseae* Fraser-Jenkins and Jermy, but it can be recognised by examination of the chromosomes during meiosis. *D. x sarvelae* is triploid ($2n = 123$); during the first metaphase of meiosis most of the chromosomes fail to pair (Gibby and Walker, 1977). This distinguishes it from *D. x ambroseae*, which is also triploid, as equal numbers of bivalents and univalents are seen in meiosis in this hybrid. *D. x deweveri* is tetraploid ($2n = 164$). *D. x sarvelae* could form wherever the two parents grow together, and it may well occur at other sites in Britain but has previously been overlooked.

REFERENCES

- GIBBY, M., & WALKER, S., 1977. Further cytogenetic studies and a reappraisal of the diploid ancestry in the *Dryopteris carthusiana* complex. *Fern Gazette* 11: 315-324.
 WIDÉN, C.-J., SARVELA, J., & AHITI, T., 1967. The *Dryopteris spinulosa* complex in Finland. *Acta Botanica Fennica* 77: 1-24.

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A NEW NAME FOR A HYBRID HORSETAIL IN SCOTLAND

The wild hybrid between the widespread horsetails *E. fluviatile* L. and *E. palustre* L. was first tentatively reported by the author from the island of Harris, Outer Hebrides, where it had been found in July 1962 (Page 1963). Further observations and finds have supported the original diagnosis of the parentage. J.G. Duckett (see Duckett & Page, 1975: 100-101) has subsequently also ably shown that this cross can, indeed, be achieved in synthetic culture, using *E. fluviatile* as the female parent, and independently has also found plants attributable to this parentage wild in Scotland (Duckett 1979).

This hybrid may well yet prove more widespread than hitherto recorded. For convenience of reference, a binominal name for it is thus proposed.

Equisetum x dycei C.N. Page *hydr. nov.* (*E. fluviatile* L. x *palustre* L.).
 lc.: C.N. Page, Brit. Fern Gaz. 9 (4): 118 (1963).

Hybrida inter *E. fluviatile* et *E. palustre* ramificationis habitu, vaginis, numero et profunditate vallicularum carinarumque, et ratione cavi centralis diametro cauli intermedia. Caules 15-45 cm alti, virides, annui; internodii endodermidibus individuis provisi. Internodii rhizomatis ut in *E. fluviatile* excavati; tubera rhizomatis ut in *E. palustre* adsunt. Strobili parvi, tenues, nigrescentes, in caulibus vegetativis terminales. Sporae abortivae.

Typus: C.N. Page No. 873: Loch-a-Mhorghain, Harris, Outer Hebrides, July 1962 (E).

Hybrid intermediate between *E. fluviatile* and *E. palustre* in branching habit, sheaths, number and depth of ridges and furrows and in the ratio of the central hollow to the diameter of the stem. Stems 15-45cm high, green, annual; stem internodes with individual endodermises. Rhizome internodes hollow as in *E. fluviatile*; rhizome tubers present as in *E. palustre*. Cones small, slender, brackish, terminal on vegetative shoots. Spores abortive.

Plants differ clearly from both parents in their strong intermediacy of structure, both in overall appearance and in proportions of the internal cavities. They resemble *E. fluviatile* in the hollow rhizomes and individual stem endodermises (both features unique in subgenus *Equisetum* to *E. fluviatile* and its hybrids), and resemble *E. palustre* in the presence of tubers and dark, slender cones. The much weaker habit of growth, fewer, more ascending branches, and black cones which are small, slender, not barrel-shaped, and much more numerous, help distinguish it from *E. x litorale* (*E. arvense* x *fluviatile*).

Plants are currently known from a small number of scattered locations in Scotland.

The plant is named in honour of J.W. Dyce, who has done much, over many years to stimulate pteridophyte recording work in Britain.

ACKNOWLEDGEMENTS

I am grateful to Dr. Robert Mill for the latinisation of the description.

REFERENCES

- DUCKETT J.C., 1979. An experimental study of the reproductive biology and hybridisation in the European and North American species of *Equisetum*. *Bot. J. Linn. Soc.* 79: 205-229.
 DUCKETT, J.G., & PAGE, C.N., 1975. *Equisetum* pp 99-103, in Stace, C.A. (Ed.) *Hybridisation in the British Flora*. Academic Press, London.
 PAGE, C.N., 1963. A hybrid horsetail from the Hebrides. *Brit. Fern Gaz.* 9: 117-119.

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EQUISETUM X TRACHYODON IN SKYE, WESTERN SCOTLAND

In November 1974, an odd-looking *Equisetum* was found in Skye, Inverness-shire, Scotland. It was growing on a lump of bank that had slipped into the Hinnisdal river, on the section of the river half-a-mile west of the bridge carrying the road between Portree and Uig, in the north end of Skye (in square 18/35). It was determined as *E. x trachyodon* (*E. hyemale* x *variegatum*) by Dr. C.N. Page, at RBG Edinburgh. At the time, the nearest known *E. hyemale* was in Geary (18/26), across Loch Snizort, or in Glen Brittle (18/41), and the only *E. variegatum* record was that shown in the 'Atlas' (18/36), for which Monkswood had no details of locality.

Succeeding winters have added some interesting facts, as we kept an eye open for *Equisetum* specimens which are evergreen. *E. hyemale* was in Trotternish, at two sites on opposite sides of the Storr ridge (two places on a river bank in 18/45 and one where a seepage area dripped over a sea-cliff in 18/55).

Drs. C.N. Page and R.E.C. Ferreira visited Skye in July 1979, found several pieces of *E. x trachyodon* upstream from the original site, and suggested that there could be yet more of it further up the glen. The river banks just east of the road bridge had been investigated soon after the 1974 discovery, but in November 1979, a search starting below Peinha (1½ miles east of road bridge) turned up dozens of little plants, where the banks were either sandy or gravelly, along a 1½ mile stretch eastwards. On a later

visit, above the join of the streams below Glenuachdarach, nothing was found.

Meanwhile, in the summer of 1978, Mr. and Mrs. J. Bowman had found the first localised record of *E. variegatum* on Skye — from a corrie below the SE end of the Cuillin ridge (18/41) — so both parents of the hybrid *are* on the island.

The winter of 1979-80 was spent walking sections of various rivers, in Trotternish and elsewhere, in search of further *Equisetum x trachyodon*, or *E. hyemale*, but without success.

The question now is: why is the *E. x trachyodon* confined to the Hinnisdal valley, and how did it get there in the first place? And the old record for *E. variegatum* in 18/36 (the neighbouring square) may well be our plants, since a similar record (same recorders) for *E. variegatum* at Nisibost in Harris (V.C. 110) has been re-determined by Dr. Page as *E. x trachyodon*. *E. x trachyodon* has also been added recently to the list for Rum.

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MORE NEW COMBINATIONS IN SOUTHEAST ASIAN FERNS

Preparation of the Flora Malesiana account of Grammitidaceae and other papers on Southeast Asian ferns necessitates publication of the following new combinations:

Ctenopteris brooksiae (v.A.v.R.) Parris, **comb.nov.**

Basionym: *Polypodium brooksiae* v.A.v.R. in *Bull.Jard.bot.Buitenzorg Ser.2*, 23: 19, t.2, f.2 (1916).

Grammitis intromissa (Christ) Parris, **comb.nov.**

Basionym: *Polypodium intromissum* Christ in *Verhandlungen der Naturforschenden Gesellschaft in Basel* 11: 440 (1896).

Grammitis plana (v.A.v.R.) Parris, **comb.nov.**

Basionym: *Polypodium planum* v.A.v.R. in *Bull.Jard.bot.Buitenzorg Ser. 2*, 16: 32 (1914).

Grammitis subdichotoma (Racib.ex v.A.v.R.) Parris, **comb.nov.**

Basionym: *Polypodium subdichotomum* Racib.ex v.A.v.R. in *Bull.Dept.Agric.Ind.Néerl.* 18: 20 (1908).

Grammitis torricelliana (Brause) Parris, **comb.nov.**

Basionym: *Polypodium torricellianum* Brause in *Bot.Jahrb.* 49: 45, f.3A (1912).

Pteridium caudatum subsp. *yarrabense* (Domin) Parris, **comb.nov.**

Basionym: *Pteridium aquilinum* var. *yarrabense* Domin in *Bibl.Bot.* 85: 161, f.32 (1916).

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THE OCCURRENCE OF A LAMINAL FLAP IN SELAGINELLA

The occurrence of a laminal flap, developed as a vertical projection on the adaxial surface of sporophylls or bracts, has been found in *Selaginella bisulcata* Spring, *S. reticulata* (Hook. and Grev.) Spring, *S. tenera* (Hook. and Grev.) Spring and *S. subdiaphana* (Wall.) Spring.

In each of these species, the laminal flap is isobilateral and is situated next to the ligule. While the ligule is a distinct structure and is embedded within the leaf tissue only at the basal region, the flap is a continuation of the lamina and extends from the base towards the distal region of the bract or the sporophyll along the midrib. The epidermal cells of the flap are elongate and resemble those of the adaxial surface of the

lamina proper. Stomata occur on both the surfaces of the flap, and are structurally similar to those on the surfaces of the sporophyll and the bract. Round cells with walls of tracheidal thickening often occur at the base of the ligule, but no tracheid enters the flap. The margin of the laminal flap in *S. subdiaphana* is markedly distinct being long ciliate, but in the other three species it resembles the margin of the sporophyll or the bract.

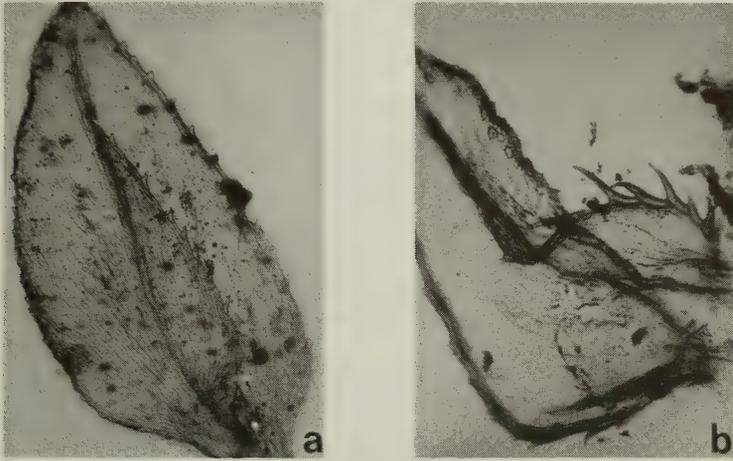


FIGURE 1: *Selaginella reticulata*, a bract with laminal flap, x 35; b, *S. subdiaphana*, a large sporophyll with laminal flap (megasporangium removed), x 70.

In *S. reticulata* the laminate flap only develops on the bracts associated with the sporophylls (fig. 1.) In *S. tenera* and *S. subdiaphana* only the larger sporophylls bear the flap (fig. 1b.).

In *S. subdiaphana* as well as in *S. reticulata*, the foliar vein extends beyond the termination of the flap, while in *St. tenera* and *S. bisulcata* the flap extends beyond the vein ending. The flap occurs on the smaller sporophylls and larger bracts. of *S. bisulcata*. No laminal flap has yet been found on the vegetative leaves of any species of *Selaginella*.

The laminal flap probably increases the photosynthetic surface of the sporophyll and the bract since chloroplasts occur within their cells. But it seems significant that it is always associated with the sporophylls or the bracts protecting the sporophylls. An alternative interpretation of its function might be that the flap with its cilia might be a contrivance for capturing spores micro- and megaspore can germinate and develop in close proximity; but clearly further observations on this are needed.

It is possible that this flap is homologous with the ensheathing velum and mass of tentacles surrounding the macrosporangium of the carboniferous genus *Miadesmia*, since the velum had its origin from a region between the ligule and the axil of the sporophyll.

As the three living species in which the flap has been found are members of the subgenus *Heterostachys* it would be interesting to see whether the occurrence of similar laminal flaps are a more extensive feature of this subgenus.

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A NEW SPECIES OF PLAGIOGYRIA FROM MALAYA

During the examination of herbarium sheets of the genus *Plagiogyria* (Kunze) Mett. present in the Central National Herbarium, Howrah (CAL), the authors have come across a new species of the genus, which is described below. The specimens had been identified earlier as *P. euphlebia* but the new species is distinct from it in the following characters:

1. Hook-like aerophores are present throughout the stipe and on the rachis at the base of insertion of the lateral pinnae
2. The lamina is leathery in texture
3. The pinna margins are strongly reflexed, the apex acute and undulate, the lower surface pale-brown, and the upper surface dark brown in colour. The present species can be readily separated from *P. tuberculata* Copel. by the presence of terminal leaflet simple like other lateral pinnae and not pinnatifid as in *P. tuberculata* Copel.

Plagiogyria malayensis R.D. Dixit & Anjali Das *sp. nov.* Fig. 1.

Aerophora unciformia prominentia praesentia in stipitibus et ad bases pinnarum, apicalibus paucis exceptis. Pinnae terminalis lateralibus similes, pinnae in 15-20 paribus, erecto-patentes, oblongolanceolatae, 12-14 x 1.8-2cm, basi cuneatae, apica acutae, undulatae, ad marginem integrae, tenues, reflexae, coriaceae, supra atro-brunneae, et infra pallido-brunneae.



FIGURE 1. Holotype of *Plagiogyria malayensis* R.D. Dixit & Anjali Das *sp. nov.*

Stipes of sterile fronds 20-30cm, dark reddish-brown, and rachis pale-brown in colour. Aerophores prominent, hook like, present throughout stipe and on rachis at the point of insertion of the lateral pinnae. Lamina 40-55 x 15-20cm pinnate, terminal leaflet simple like other lateral pinnae; lateral pinnae 15-20 pairs, alternate, 1.5-2.5cm apart, erecto-patent, shortly stalked except a few adnate pinnae in the apical region, leathery in texture, upper surface dark brown and lower surface pale brown, middle pinnae 12-14 x 1.8-2cm, oblong-lanceolate, cuneate at base, apex acute, undulate, margins thinned, entire, and strongly reflexed; midrib raised on the lower surface, obscure on the upper surface; veins free, immersed, usually simple, sometimes furcate.

Fertile pinnae present in paratype specimen, 10-14cm x 2-3mm, coiled, ascending.

Holotype: MALAYA — Gunong Batu Paleb, 6700ft., *Wray Jr. 317* (CAL).

Paratype: MALAYA — without exact location *Scortechini 397* (CAL).

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Grateful thanks are due to Dr. S.K. Jain, Director, Botanical Survey of India for the encouragement. Our thanks are also due to Dr. N.C. Majumdar, Central National Herbarium, Howrah for the Latin translation.

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NOMENCLATURAL NOTES ON DRYOPTERIS — 5

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Fraser-Jenkins (1977) described *D. x cebennae*, from the Cevennes in the Department of Ardèche, France, which was assumed on morphological grounds to be a hybrid of *D. affinis* agg. x *D. villarii* agg. and reported to be a tetraploid apomict. However it has now become clear that a mixed concept was involved and that there are two unusual species present in the area of the type locality. A fine specimen recently found in the herbarium at Toulouse (TL) labelled "*Polystichum abbreviatum. Par les falaises basaltiques (orgues des géants), Pont de Labeaume (Ardèche), vallée de l'Ardèche vers 400 m. J. Revol 998, 4/7/1907*" is clearly a specimen of *D. tyrrhena* Fraser-Jenkins & Reichstein, with characteristic sparse, wide and pale stipe-scales, highly glandular axes and lamina, somewhat deeply lobed pinnules and long-acuminate, almost slightly aristate pinnule-teeth. As this was an earlier collection by Revol, the collector of the type specimen of *D. x cebennae*, it was necessary to re-examine the type in Manchester (MANCH). On reinvestigation the Manchester specimen was found to be also *D. tyrrhena* though not quite such a well-developed specimen as the one in Toulouse. The earlier report (Fraser-Jenkins 1977) that the type had a mixture of good and abortive spores was evidently due to spore immaturity and should have referred only to the author's recent collections. *D. x cebennae* must therefore become a synonym of *D. tyrrhena* and the apomictic tetraploid taxon previously assumed to have been a hybrid is therefore without a name and is described below as *D. ardechensis*. Its description is emended to exclude *D. tyrrhena*, from which it differs in several important features (especially the scales, glandularity and pinnule teeth). It now seems highly likely that the parentage of *D. ardechensis* is not as originally thought, but *D. affinis* subsp. *affinis* (which is present in the area) crossed with *D. tyrrhena*, a far more acceptable explanation because the *D. villarii* agg. does not occur anywhere near the area and, as pointed out by Prof. C. Bange of Lyon University, (pers. comm. 1979) the

Cevennes are a range of siliceous granitic mountains where the *D. villarii* agg. is unlikely ever to have occurred, while *D. tyrrhena* would be more likely. The plant is now treated as a species and not a hybrid because rather than arising de novo, it behaves as a species in maintaining itself in several populations in the area, producing a high proportion of good spores. Prof. T. Reichstein has also found that it reproduces itself freely from spores (personal communication, 1979). It is thus the only known example of an apomictic allotetraploid species in the European fern flora. This treatment is in contrast to that of some recent American authors (Wagner 1969 & 1971, and Knobloch 1977) who have introduced a multiplication sign in front of the specific name treating as hybrids all allopolyploid species once their genomic origin has been ascertained, which is the case in almost all the known European and North American polyploid *Dryopteris* species, a treatment with which the author does not agree.

Dryopteris ardechensis Fraser-Jenkins, sp. nov.

Diagnosis: Morphologia intermedia inter *D. tyrrhena* et *D. affinis* subsp. *affinis* Frondes usque ad 50cm longae; petiolus media longitudine laminae, paleis angustis uniformibus pallide fulvis costam versus angustissimis piliformis bene obsitus; lamina triangulari-lanceolata, ad axes pauca glandulis interdum obsita, simpliciter pinnata sed par inferius pinnularum cujusque pinnae iterum pinnatum; pinnulae basi lata sessiles, pars infimo cujusque pinnae excepto quod bene petiolulatum; pinnula infima basiscopica paris infimi pinnarum longissima et ad marginem aliquanto lobata; latera pinnularum aliarum parallela parce tantum dentata nisi apicem versus, apices rotundati et dentibus aliquanto longis et acutis sed a basis latioris quam in *D. tyrrhena* nonne interdum mucronatis. Indusia cinerea, pallida fulva et fusca eanta, margine inflexo, glandulas ferrentas. Sporae partim abortivae, partim bene evolutae. Cytotypus tetraploideus, apogamus.

Type: Ex hort. T. Reichstein (sub TR 3443); coll. 26. Aug. 1979 C.R. Fraser-Jenkins No. 9784. Origin from spores coll. CRF-J (no. 3602) above Pont de Labeaume, near Aubenas, Ardèche, France 17 Jan. 1972 (Holo: BM, Iso: CANU).

Plant a tetraploid apomict (G. Vida pers. comm. 1975, and J.J. Schneller 1980, pers. comm.).

Differs from the original description of *D. x cebennae* in being well clothed with stipe and rachis scales, lamina occasionally bearing a few glands on the axes, teeth at the pinnule apices with wide bases somewhat long and acute and not tending to become aristate. Indusia grey, becoming pale-brown and then mid-brown, bearing glands. Its morphology is thus rather more intermediate between *D. affinis* subsp. *affinis* and *D. tyrrhena* than *D. affinis* and *D. submontana*, as far as can be extrapolated. Three new records have now been verified as follows:

1. Ardèche, Thins. C. Bange, 1978, nos. 78.313, 78.317, 78.319, 78.322 and 78.325 (LY!).
2. Ardèche, Gravières, bois à 1 km a val, 235 m M. Breistroffer, 30/10/1970. (GRM!).
3. Ardèche, Malarce aux Eynes, ravin ombragé. M. Breistroffer, 4/7/1970 (GRM!).

REFERENCES

- FRASER-JENKINS, C.R., 1977. Three species in the *Dryopteris villarii* aggregate. *Candollea* 32 (2): 305-319.
- KNOBLOCH, I.W., 1977. Pteridophyte hybrids. *Publ. Mus. Michigan State Univ., Biol. ser.*, 5(4): 1-352 (and addend. & corrigend.)
- WAGNER, W.H., 1969. The role and taxonomic treatment of hybrids. *Bio Science* 19(9): 785-789.
- WAGNER, W.H., 1971. Evolution of *Dryopteris* in relation to the Appalachians, in P.C. Holt (Ed.), *The Distributional History of the Biota of the Southern Appalachians II. Flora*. Research Div. Monograph 2, Virginia Polytech. Inst. & State Univ.

THE FERN GAZETTE

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THE CONTINUING NEED FOR MORE MONOGRAPHIC STUDIES OF FERNS

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In 1972 I was asked to give an opening address (published 1973) at a meeting of pteridologists in London. Though much new investigation and thought has developed since then, my attitude to the general situation is still much the same. The need still is for more monographic work on tropical species which represent the great majority of all ferns. Until we have a better knowledge of them we cannot formulate adequate generic concepts which may lead to better suprageneric ones, nor understand the findings of morphologists who study a few species. Experimental workers of all kinds, including cytogeneticists, need a good taxonomy to indicate likely subjects for fruitful work in their own disciplines and to enable them to assess its significance in relation to the whole. Such workers hitherto have largely dealt with temperate-zone species and need to be more aware of wider possibilities. Questions of nomenclature are also basic; a name must have a definite meaning, the lack of which in earlier literature has led to confusions. Monographic work, including re-examination of all types, is needed to clarify this situation.

I would like briefly to summarize the history of my own involvement with ferns. As a student I was introduced to the morphological studies of F.O. Bower and to fossil ferns and their presumed living relatives, but hardly at all to fern taxonomy in general. When I went to Singapore in 1922 I was surrounded by ferns of genera and species many of which were new to me. I soon realized that fern taxonomy was in a confused state, and I gradually came to realize that some of Bower's generalizations (summarized in his volume of 1928), based on few species, too great an emphasis on vascular anatomy and on the taxonomy of the 19th century, were untenable. Classifications of the 19th century were in most cases unnatural because they were based on rather crudely defined structures which modern understanding shows to have evolved on several different lines. For example, anastomosing veins of similar pattern were used to associate genera which are now seen not to be closely related, such as *Acrostichum* and *Lomogramma*. On the other hand, species with free and anastomosing veins, though in most other characters similar, were placed in different genera; Diels (1899) copied many such errors.

My first major investigation was on the ferns then still named *Stenochlaena* in Malaya (1932). After examining their external morphology, anatomy, scales and spores, I realized that they constituted a mixture of quite unrelated species; also that this had been recognized by Mettenius (1869) and John Smith (1875, p.140) but ignored by Diels and by Bower (1928, pp 175—177). Thus I came to understand that most 19th century taxonomists ignored important characters which need to be considered; also (like John Smith) that one can learn much from living ferns that is not clearly evident from dried specimens. I had ready access to the species of Malaya (about 500) and from them I learned a great deal. In this I was greatly helped by Carl Christensen with whom I corresponded regularly from 1925 to 1940; I also met him personally and had long talks with him in 1930 (after the Cambridge Congress), 1934 and 1938. He was the founder of modern fern taxonomy, but when I was a student I never heard his name.

* This paper is the substance of an address given by Dr Holtum on his election to the Presidency of the International Association of Pteridologists, 24 August 1981.

In the course of writing a fern flora of Malaya, which by good fortune I was able to do during the Japanese occupation of Singapore, I attempted to carry my thoughts beyond Christensen's summary of 1938; I tried to express my ideas in two papers dated 1947 and 1949 and in my book on Malayan ferns (1955). It was at this point that I came into contact with Prof. Manton's cytological studies (1950) and I began to realize the importance of this in fern taxonomy, how it confirmed some of my ideas (e.g. on Thelypteridaceae) and pointed to the need for more thought on others. I was fortunate in being able to help her to extend her studies to Malayan species, partly through fixations made in the field in Malaya and partly through plants sent to Kew for cultivation.

In 1954 I retired from my appointment in Singapore and came to work at Kew, having as my objective the preparation of a taxonomic account of the ferns in the whole Malayan region (Malesia) for Flora Malesiana. I began with Gleicheniaceae (1959) which are abundantly represented in Malaya. Here I found that Diels had followed Presl and Hooker in making a primary division, of *Eu-Gleichenia* from the rest, on the terminal or non-terminal position of sori on the veins, though Mettenius (1863) had shown that the sorus is not terminal in the former; Diels ignored the excellent subdivision made by Mettenius and so obscured the basic similarity between *Eu-Gleichenia* and *Diplopterygium* which Bower never understood. It seems to me abundantly evident that *Diplopterygium* represents the primitive element in the family as it now exists.

I proceeded to Cyatheaceae (1963) concerning which work for Flora Malesiana greatly widened my horizons. Instead of the sixteen species of *Cyathea* in Malaya, I had to deal with 190 species, for a better understanding of which I also examined the species of mainland Asia (1965) and the Pacific (1964). This acquainted me with a considerable proportion of the world total and enabled me to recognize infrageneric groups which were not so distinct in the few species of Malaya; I came to see the latter in a better perspective. I was fortunate to have the cooperation of Dr. Uday Sen while I was studying *Cyathea*. It was his anatomical study, published in a joint paper (1961) which led me to see the similarities between *Cyathea* and *Dicksonia* which, following Bower, I had previously seen as wide apart. I also saw how very different *Dicksonia* is from *Culcita*, though their sori are superficially similar.

I proceeded to look at Thelypteridaceae, a very distinct family of nearly one thousand species which was not recognized as a natural group before the work of Christensen, extended by Ching (1936, 1938) to the species of Asia. When preparing my book on the ferns of Malaya I discovered that existing subdivisions of the family were unsatisfactory (Copeland's *Lastrea* and *Cyclosorus* of 1947 are both confused mixtures) but I could see that study of a much wider range of species was necessary before I could understand the situation better. Such a study occupied twelve years, and has been extended to all species of the Old World, including Africa, where I found that two groups of species are mainly American in distribution. The family is much more diversified in the Old World than in the New, and in the Old World more diversified in Malesia than in mainland Asia, to which the studies of Ching and Iwatsuki (1964, 1965) had been almost confined. I was led to establish new genera and to re-define old ones (1971), incidentally showing that five European species of the family belong to five distinct genera when viewed on a world scale. Having done this, I tried to consider possible groupings of genera, and have set them out in a conspectus in the next part of Flora Malesiana, which I hope will be published this year. But it is evident that more observation and thought are still needed. The object of preparing such a conspectus is to show where new thought is called for.

In the course of all this work it became evident to me that in any group of ferns

there are distinctive characters whereby species and species-groups can be recognized. As noted above, such characters were mostly not described by taxonomists in the 19th century, which is the main reason why they did not arrive at an acceptable taxonomy for ferns in general. In different groups, different characters may be important; one cannot tell in advance. Such characters may appear trivial (as they did to William Hooker), but where two or three, based on different parts of a plant, are found constantly associated, one invariably finds that other, less clearly definable, characters are also associated. Christensen made this observation in his paper on *Stigmatopteris* in 1909 (p.292), but Schkuhr had already shown, a century earlier, the difference between the hairs on Thelypteroid and Tectarioid ferns.

Effective taxonomy is not a routine matter of recording a limited number of characters, but a scientific discipline requiring imaginative insight just as much as in any other field of work. This is what many botanists who are not concerned with tropical plants do not realize. New morphological characters, if recorded by the use of highly complex instruments, are considered to be of scientific importance; but the significance of such observations (e.g. SEM photographs of spores) is only evident if the object under investigation can be seen against a good taxonomic framework, and observations made by relatively simple optical equipment are still important in establishing that framework. Modern methods in cytogenetics, still little applied to tropical ferns, can only be fully exploited where taxonomy shows how to distinguish natural groups of species.

So the moral of all this may be summarized as follows. A taxonomist who wishes to attain a better understanding of genera which appear not to be well defined must examine all species (some of them may have been previously placed in other genera). A morphologist cannot do this, but his observations may indicate to taxonomists new characters which may be used in their comparative studies. Morphologists cannot understand the significance of their work without the cooperation of taxonomists, and conversely, taxonomists must take into consideration the evidence of morphologists and use it to find new characters by which to improve their systems. The two processes interact. My impression is that the greater need at present is for morphologists to try to have a better understanding of taxonomy.

As I remarked in 1973 (p.3) the Code of Nomenclature is responsible for much misunderstanding. The basic rule is that no new species can be validly named and described unless it is assigned to a genus. This implies that the correct genus is known. But the earlier taxonomists could not know how future additions to knowledge might modify generic concepts; this is especially true of ferns. The Code thus makes the impossible a necessary condition for action. Taxonomists have to make the best judgements they can, and if subsequent change of genus for a species is indicated, the Code makes rules as to how the change is to be effected. Morphologists are too apt to think that a generic name has a definite meaning and that they can take any species as representing the characters of the genus the name of which they find attached to it. In fern taxonomy name changes have been many, often uncritically made, and we have not reached finality.

There are many tropical groups which need new monographic treatment. The process should be: (1) a careful study in detail of living plants of a varied selection of species, to discover what are distinctive characters; such a study of living plants helps to understand dried specimens; (2) re-description of all type specimens for record of characters not noted by the original authors or later workers; (3) examination of all collections of specimens in the major herbaria, and as much new field work as may be possible; (4) assessment of possible new generic concepts; (5) nomenclatural problems. Note that nomenclatural problems come last in this series. There must be

rules to stabilize binomials; I am doubtful of the need for any rules beyond that.

NOTES ON SOME TROPICAL GROUPS IN NEED OF MONOGRAPHIC STUDY

Polypodiaceae sensu stricto. Nearly all species were formerly lumped in one genus *Polypodium*. Genera were split off mainly on the basis of shape and position of sori, venation and frond-form. As regards venation, it is evident that in many groups of ferns species with free and anastomosing veins can be allied, and I believe that this has not been sufficiently considered in the *Polypodium* alliance. Characters of scales are recognized to be important when distinguishing between allied species; generic characteristics of scales are not easy to define but I suggest that some may be found. It is evident that in India Copeland's definition of *Polypodium* applies mainly to species related to his *Goniophlebium* but not nearly related to *Polypodium vulgare*. I have suggested (1947, p. 128) that primitive Polypodiaceae had fronds with much-anastomosing veins; on such a view the many diverse tropical American species now in *Polypodium* are advanced and specialized.

In 1973 (p. 7) I suggested that Polypodiaceae are related to *Davallia*, though not very closely. I also think that both are in some way related to *Asplenium*. A curious character in common to the three groups is the lateral union of the adaxial vascular strands near the top of the stipe; I have never seen this in any other ferns and suggest that it may be significant.

Dennstaedtia, *Microlepia* and *Hypolepis*. I believe that these three genera are still not clearly distinguished, and that *Dennstaedtia*, as at present constituted, represents a mixture of distinct genera. R.M. Tryon (1960) has recognized eleven species of *Dennstaedtia* in the Neotropics, dividing them into two groups, but he also added a list of other names the types of which he had not seen. There are a considerably larger number of species in the Palaeotropics, mostly in the Philippines, New Guinea and the Pacific; most of them have not been adequately described or distinguished, and their large fronds are not well represented by fragments on herbarium sheets. Chromosome counts indicate diversity as between Palaeotropic and Neotropic species, also within the former. R.M. & A.F. Tryon (1980) have stated that *Dennstaedtia flaccida* (Forst.) Bernh., type species, has spores like those of *Microlepia*, but one cannot define genera on spores alone. This group of genera seems to me to have an important place in the classification of ferns as a whole. It includes *Pteridium*; I am still not convinced that *Pteris* is quite unrelated to *Pteridium*.

Asplenium. Copeland (1947, p. 164) stated that there were about 700 species of this genus. He included *Phyllitis* and *Diplora* as synonyms but expressed the opinion that the types of these two genera, though agreeing in their peculiar arrangement of opposite pairs of sori, were not closely related, and I believe he was right. He further stated that this arrangement of sori had arisen at least six times independently. Hooker had placed all ferns with this arrangement in a "suborder" Scolopendriaceae, and Bower (1928, p. 188) placed them with the Blechnoid ferns, denying their near relationship to *Asplenium* (p. 197). Dr John Mickel has recently proposed a new generic name *Sinephropteris* for one of them.

No one has yet produced a good subdivision of *Asplenium*. Until this is done the position of *Phyllitis* and others with similar soral arrangement will not be clear. In my book on Malayan ferns (1955, pp 414-415) I made suggestions for a subdivision, and I believe that the form of the rachis in relation to the attachment of pinnae provides useful evidence. But to make a good subdivision will require a study of all species. European species have been studied in great detail but without reference to their possible relationships among tropical species. In Europe there is evidence of polyploidy and hybridization; in the tropics there is high polyploidy in some groups of species. These considerations make the discrimination of individual species difficult,

but for purposes of subdivision of the genus such detailed problems need not be involved. A special problem is presented by the allied genus *Pleurosorus* which has a very peculiar distribution. In Spain there is a species *Asplenium petrarchae* (Guérin) DC which is similar in its general aspect to *Pleurosorus hispanicus* (Cosson) Morton and the two species will hybridize. It seems to me probable that they have been derived from a common ancestor, now no longer existent. The other species of *Pleurosorus* are in Australia, New Zealand and South America. I suggest that these species may have separately evolved from species of *Asplenium* in southern regions.

The Tectaria group of genera. The distinctions between *Tectaria* and *Ctenitis* appear not to be very clearly defined, and *Ctenitis*, as at present interpreted and after removal of *Lastreopsis*, appears to be an unresolved complex. The position of *Heterogonium* in relation to *Tectaria* also needs re-consideration, and the fact that natural hybrids between *Heterogonium* and *Stenosemia* have been found. I think that in this group of genera characters of scales may be important as indicators of relationships.

Athyrium, Diplazium and related genera. This is a large and complex group in the Palaeotropics. In Malesia the many species of *Diplazium* have not yet been clearly distinguished and some are undescribed. Ching's work (1964) on the genera and species of mainland Asia needs to be studied in relation to those of Malesia.

REFERENCES

- BOWER, F.O., 1928. *The Ferns*, Vol. 3. Cambridge University Press.
- CHING, R.C., 1936, 1938. A revision of the Chinese and Sikkim-Himalayan Dryopteris with reference to some species of neighbouring regions. *Bull. Fan Mem. Inst. Biol. Bot.* 6: 237-352, 8: 157-268.
- CHING, R.C., 1964. On some confused genera of the family Athyriaceae. *Acta Phytotax. Sinica* 9: 41-84.
- CHRISTENSEN, C., 1909. On Stigmatopteris, a new genus of ferns, with a review of its species. *Bot. Tidsskr.* 29: 291-304.
- CHRISTENSEN, C., 1938. Filicinae. Chapter 20 in Fr. Verdoorn (Ed.) *Manual of Pteridology*, The Hague, Nijhoff.
- COPELAND, E.B., 1947. *Genera Filicum*. Waltham, Mass. Chronica Botanica.
- DIELS, L., 1899. Cyatheaceae (pp 113-139), Polypodiaceae (pp 139-339) and Gleicheniaceae (pp 350-355) in Engler & Prantl, *Die Natürlichen Pflanzen-familien* I, Abt. 4. Leipzig, W. Engelmann.
- HOLTUM, R.E., 1932. On Stenochlaena, Lomariopsis and Teratophyllum in the Malayan region. *Gard. Bull. Str. Settl.* 7: 245-312.
- HOLTUM, R.E., 1947. A revised classification of Leptosporangiate Ferns. *J. Linn. Soc. Bot.* 53: 123-158.
- HOLTUM, R.E., 1949. The Classification of Ferns. *Biol. Reviews* 24: 267-296.
- HOLTUM, R.E., 1955. *A Revised Flora of Malaya, 2. Ferns of Malaya*. Singapore, Government Printer.
- HOLTUM, R.E., 1959. Gleicheniaceae, in *Flora Malesiana*, Ser. II Pteridophyta, 1: 1-36.
- HOLTUM, R.E., 1963. Cyatheaceae, in *Flora Malesiana* Ser. II Pteridophyta, I: 65-176.
- HOLTUM, R.E., 1964. The tree-ferns of the genus *Cyathea* in Australasia and the Pacific. *Blumea* 12: 241-274.
- HOLTUM, R.E., 1965. Tree-ferns of the genus *Cyathea* in Asia (excluding Malesia). *Kew Bull.* 19: 463-487.
- HOLTUM, R.E., 1971. Studies in the family Thelypteridaceae, III. A new system of genera in the Old World tropics. *Blumea* 19: 17-52.
- HOLTUM, R.E., 1973. Posing the Problems, (A.C. Jermy et al (Eds.) in *The Phylogeny and Classification of the Ferns*, Suppl. no. 1 to the Bot. Journ. Linn. Soc. Vol. 67.
- HOLTUM, R.E., 1978. A commentary on some Thelypteroid ferns of Eastern Asia and North America. *Acta Phytotax. Geobot.* 29: 16-17.
- HOLTUM, R.E., and SEN, U., 1961. Morphology and Classification of the Tree-ferns. *Phytomorphology* 11: 406-420.
- IWATSUKI, K., 1964. Taxonomy of the Thelypteroid ferns, with special reference to the species of Japan and adjacent islands, III, Classification, *Mem. Coll. Sci. Univ. Kyoto B*, 31: 11-40.

- IWATSUKI, K., 1965. Taxonomy of the Thelypteroid ferns, with special reference to the species of Japan and adjacent islands, IV. Enumeration of the species of Japan and adjacent islands. *Mem. Coll. Sci. Univ. Kyoto B*, 31: 125-197.
- MANTON, I., 1950. *Problems of Cytology and Evolution in the Pteridophyta*. Cambridge University Press.
- METTENIUS, G., 1863. Gleicheniaceae. *Ann. Mus. Bot. Lugd.-Bat.* 1: 46-51.
- METTENIUS, G., 1869. Lomariopsis (p. 294), Teratophyllum (p. 296) in M. Kuhn, Filices. *Ann. Mus. Bot. Lugd.-Bat.* 4: 276-300.
- MICKEL, J., 1976. Sinephropteris, a new genus of Scolopendrioid ferns. *Brittonia* 28: 326-328.
- TRYON, R.M., 1960. A review of the genus Dennstaedtia in America. *Contr. Gray Herb.* 187: 23-52.
- TRYON, R.M. and TRYON, A.F., 1980. Proposal to conserve the name Dennstaedtia T. Moore (1859) against Dennstaedtia Bernh. (1801), Sitolobium Desv. (1827), Patania Presl (1836) and Aeductum Link (1841). *Taxon* 29: 512.

REVIEW

FERNS, FERN ALLIES AND CONIFERS OF AUSTRALIA by H. T. Clifford and J. Constantine. University of Queensland Press, distributed by Prentice-hall International, London. September 1981. 246 x 186mm, 36 tables + 24 plates. Price £12.95.

This slim but valuable book provides a synopsis of the Australian non-flowering vascular plants. Botanical descriptions are given of all families and genera, with short and straightforward keys to families, genera and species. Information on the total range of taxa is provided, together with their distribution within Australia. Many of the more technical structural details of plants mentioned in the text are illustrated by good line drawings.

The choice of concentrating on generic descriptions rather than specific ones at first seems unusual. But with 387 species of Pteridophyta keyed (probably a conservative estimate) belonging to no less than 123 genera, and with a similar ratio amongst the conifers, a working knowledge of genera present in the native flora is paramount to the Australian senior schools level and university biology student, at whom the book is primarily aimed. It should, however, give a very sound generic grounding to many a fern enthusiast far outside Australia, for all but a handful of the pteridophyte genera described range far through the tropics and very many are to be found in cultivation in Europe. To anyone also interested in the wider issues of the plant geography of this fascinating continent, this book provides a valuable and highly recommended foundation.

C.N. PAGE

A PRELIMINARY SURVEY OF THE PTERIDOPHYTA OF TRANSKEI, SOUTHERN AFRICA

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ABSTRACT

The results of a preliminary survey of the pteridophytes on the Transkei coast and midlands are described. Sixty-five species of pteridophytes are recorded.

INTRODUCTION

Transkei is situated on the east coast of Southern Africa between the 29°30' and 32°S latitude and 27°30' and 30°E longitude (Fig. 1). The 250 km long coast forms the eastern border, and the southern foothills of the Drakensberg the northern and western borders.

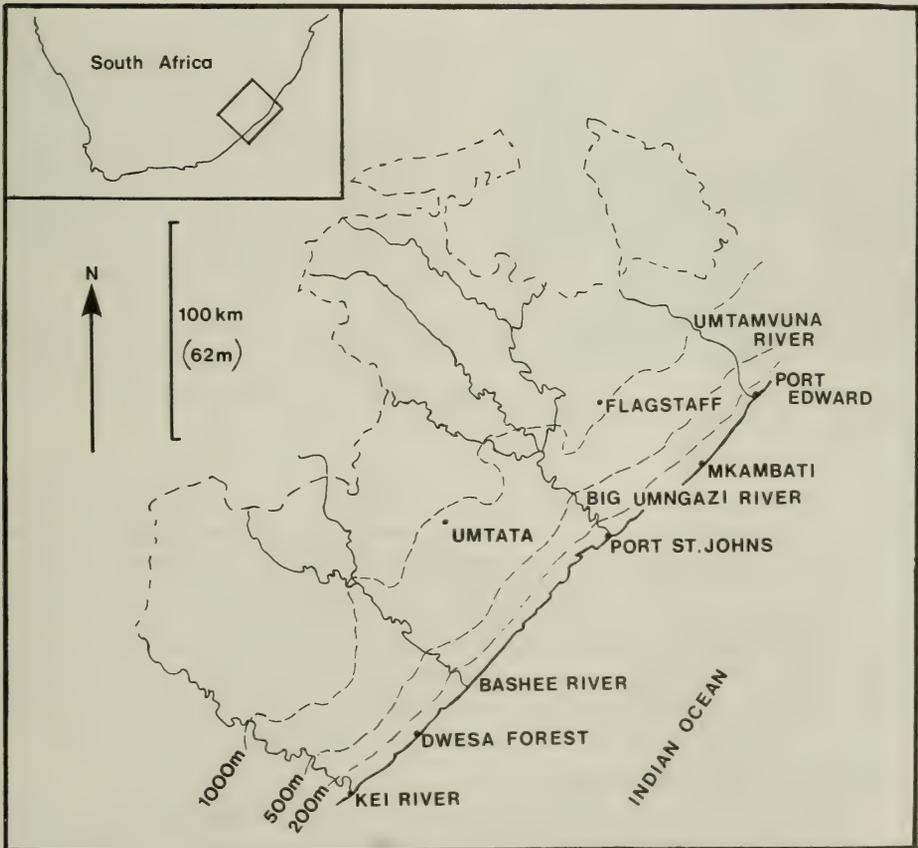


FIGURE 1. Map showing the location of Transkei, Southern Africa.

The landscape is much dissected, rising steeply from the coast to the upper plateau, and there are many short rivers.

The climate along the coast is sub-tropical but a mediterranean climate is experienced in the midlands.

The coastal belt (0-600 m) receives an average annual rainfall of 1,027-1,592mm per annum, with the main rainy season from October to March, but some rain occurs throughout the year (184mm October to March, 43mm April to September). June is the driest month.

Temperatures of the coastal regions are more constant than inland. In the south, the maximum average temperature in February (which is the warmest month) may reach 25.6°C at Bashee in the south and 26.5°C at Port Edward in the north.

July is the coldest month and temperatures may drop as low as 11.8°C in the south and 11.7°C in the north.

The midlands vary slightly from the coastal belt for here the warmest month is during January when temperatures of 27°C can be measured. Temperatures drop as low as 0.7°C in July in this region.

VEGETATION

Typical Coastal Belt Forest

This vegetation forms the major part of the coastal forests and is found in the form of riverine forests in deep dark gorges and valleys. It is usually a dense tangle near water, but becomes more open on the higher slopes. This broad-leaved evergreen forests in some instances cover vast areas. The palm *Phoenix reclinata* on stream or riverbanks is characteristic of this forest type. Trees of *Millettia grandis*, *Protorus longifolia*, *Vepris undulata* form the main canopy, *Grewia occidentalis*, *Uvaria caffra* and *Rhoicissus tomentosa* the main undergrowth and climbers and *Oplismenus hirtellus*, *Plectranthus ecklonii* and *Cyperus albostrigatus* the common forest floor vegetation.

Transitional Coastal Forest

This broad-leaved evergreen forest is more common inland in drier areas, and is confined to steep riverbanks and valleys. The forest is not as high as the typical coastal belt forests. The main trees are *Schotia* spp., *Cassine* spp., *Euphorbia grandiceps* and *Strelitzia nicolai* which is characteristic of this forest type.

Dune Forest

The dune forest occurs intermittantly in a narrow strip on the dunes running down the coast, especially around estuaries. This evergreen forest is usually stunted on the seaward side but much higher (12m) on the landward side, where protected from prevailing winds. The main canopy is formed by *Mimusops caffra*, *Euclea natalensis*, *Canthium obovatum* and *Apodytes dimidiata*. The understory is formed by *Scutia myrtina*, *Draceana hookerana* and *Eugenia capensis*. Main forest floor and margin species are *Dactyloctenium australe*, *Oplismenus hirtellus*, *Scadoxus membranaceus*. Characteristic of these forests north of Port St Johns is the abundance of *Strelitzia nicolai*.

Pondoland Coastal Plateau Sourveld

This vegetation type occupies the plateau between 300-450m above sea level. The escarpment and gorges are tropical at the coast and sub-tropical on the higher elevations and these are forest-clad. The plateau itself is of dense perennial grass veld. This is a broad-leaved evergreen forest and is higher than the coastal tropical forests with trees of *Strelitzia nicolai*, *Protorus longifolia* and *Schefflera umbellifera* forming the main canopy, with other scattered trees and shrubs of *Uvaria caffra*,

Smilax kraussiana, *Dalbergia obovata* and *Flagelaria guinensis*. Main undergrowth and margin species include *Lobelia patula*, *Cyperus albostratus* and *Setaria chevalieri*. The dense plateau consists of grasses such as *Themeda triandra*, *Tristachya hispida* and *Trachypogon spicatus*.

Zululand Thornveld

This relatively dry type of evergreen forest occupies the escarpment of lower altitudes and the higher ridges. Although not a well developed forest it includes species such as *Turaea floribunda*, *Rapanea melanophloeos* and *Apodytes dimidiata*.

THE FOREST PTERIDOPHYTES

Epiphytes

Two minor groups, the true epiphytes and the low level epiphytes, can be recognised.

The true epiphytes probably require a high rainfall and humidity. Many occur in deep shaded forests. They include *Pyrrhosia africana*, *Microsorium punctatum* and *Pleopeltis macrocarpa* which all have simple fronds and creeping rhizomes. The latter is fairly rare in the coastal forests but more common inland, where it grows with *Polypodium polypodioides* subsp. *ecklonii*, a fern with a thin slender creeping rhizome which is totally absent in the coastal forests.

Low level epiphytes include *Asplenium sandersonii*, a proliferous species, *A. rutifolium*, *A. prionitis* and *Microgramma lycopodioides*. The latter is also often a lithophyte in coastal forests.



FIGURE 3. *Microgramma lycopodioides* is a common lithophyte or low level epiphyte in broad-leaved evergreen forests.

Lithophytes

The majority of lithophytes are confined to wet coastal forest with a high humidity, and to very deep shade. Two of these species, *Asplenium rutifolium* and *Microsorium punctatum*, may also occur as epiphytes. The latter, when sheltered, can have fronds 1.6m long.

The true lithophytes are *Lycopodium gnidioides*, *L. verticilatum* with long pendulous dichotomously branched stems, *Selaginella mittenii*, *Trichomanes pyxidiferum* var. *melanotrichum*, *Microgramma lycopodioides*, *Oleandra distenta*, a deciduous species, *Asplenium gemmiferum*, *Rumohra adiantiformis* and *Vittaria isoetifolia*. The latter becomes stunted with fronds as small as 6cm long, when growing under dry conditions.

The Dry Forest Species

These occur in areas of well drained soils within the forests. Although relatively dry, there is usually some moisture available through the year. Species growing along banks of annual streams, which are dry for most of the year, are also included here.

Principal species are *Anemia dregeana*, *Cheilanthes concolor* var. *kirkii*, *C. viridis* var. *macrophylla*, *Asplenium splendens*, *Ceterach cordatum*, usually found as a

xerophyte, *Dryopteris inaequalis* and *Polystichum lucidum*. All of these are common on the forest floor and usually have short erect rhizomes with the exception of the latter two species.

Wet Forest Floor

Included here are plants from all areas where the forest floor is more or less permanently wet from seepage, including most stream bank ferns. Light intensity is often much lower than in the areas of drier forest floor. Common species include the delicate *Selaginella kraussiana*, *Marattia fraxinea* var. *salicifolia*, *Pteris bueharianii*, *P. catoptera* var. *horridula*, *Cheilanthes bergiana*, *Asplenium lunulatum*, *Thelypteris bergiana*, *Blechnum attenuatum* var. *giganteum* and *B. punctulatum* var. *krebsii*.

The Dune Forest

These are areas of forest growing on dry sandy soils, often amongst dense vegetation on the landward side of dunes. Only one species, *Microsorium scolopendria* with a long slender rhizome occurs in this forest type. It often becomes epiphytic, and is usually absent from areas facing the sea.

NON-FOREST PTERIDOPHYTES

These include all pteridophytes growing in exposed conditions including those of forest margins which are absent from within the forest itself.

Aquatic Species

These include all habitats which are at least seasonally flooded. Only one aquatic, *Marsilea macrocarpa*, was recorded in two shallow pans which were almost dry by April. This plant species continues to grow, although not as vigourously, through the winter months. In exceptionally dry years the plants will die completely. As soon as



FIGURE 2. *Davallia caryophylloides* as a non-forest lithophyte on the escarpment of the lower plateau.

water fills these pans again the sporocarps will open letting the spores free which develop rapidly into vigorous growing plants.

Lithophytic Species

These include all pteridophytes of exposed rocky situations, not shaded by trees. Such lithophytic species are more common on the escarpment of the lower plateau areas, where the rainfall is high (about 612-592mm annually). These species succeed particularly well in these habitats: *Selaginella dregei*, *Pityrogramma calomelanos* var. *aureoflava* and *Davalia caryophylloides*. Four others occur only where there is some slight protection from exposure: *Selaginella caffrorum*, *Cheilanthes inaequalis* var. *buchananii*, *Elaphoglossum macropodium* and *Blechnum punctulatum*. One remaining species, *Lycopodium gnidioides* is also a forest dweller, which occurs only on a shaded part when growing under exposed conditions.

Hygrophytic Species

Although most of these species are common on wet bank situations, some occur along forest margins. Species include: *Lycopodium clavatum* var. *inflexum*, *L. cernuum*, *L. carolinianum*, *Equisetum ramosissimum*, *Osmunda regalis*, *Todea barbara*, *Mohria caffrorum*, *Gleichenia polypodioides*, *Alsophila dregei*, *Hypolepis sparsisora*, *Pteridium aquilinum*, *Adiantum capillis-veneris*, *A. radianum*, *Pteris vittata*, *Nephrolepis exaltata*, *Thelypteris confluens*, *T. totta*, *Blechnum sylvaticum* and *B. tabulare*.

Of these species, *Mohria caffrorum* will shrivel up or the fronds may die down entirely during a dry spell.

Xerophytic Species

Only four plants come into this category. These are *Selaginella dregei*, *Schizaea pectinata*, *Cheilanthes viridis* var. *involuta* and *Pellaea calomelanos*. All are common on the upper plateau in dry, exposed conditions.

The latter species have the habit of dropping segments during long dry spells leaving the plant with a very twiggy appearance.

Introduced Species

In this study, three introduced species have been identified: *Pityrogramma calomelanos* var. *aureoflava*, *Adiantum radianum* and *Nephrolepis exaltata*. Any could rapidly develop into a threat to the local flora. *Pityrogramma calomelanos* var. *aureoflava* is spreading at a tremendous rate. Collections have been made on the Umtanvuna riverbed far from civilization. This species can develop into a pest, adapting freely to many weedy situations. *Adiantum radianum* has been recorded at only two localities (both at Port St Johns) and in both cases it was growing on wet roadbanks. The third species, *Nephrolepis exaltata*, had invaded a patch of native wet forest. Habitats that seem potentially threatened by expansion of these introduced species include those of native *Lycopodium cernuum*, *Thelypteris totta*, *Adiantum capillus-veneris* and *Microsorium punctatum* (both as a lithophyte and epiphyte).

N. exaltata is a garden escape and flourishes in the warm tropical climate of the coast. This species has spread at a tremendous rate threatening to establish itself in the deeper forest.

CONCLUSIONS

The Transkei has a rich pteridophytic flora. A range of specialized habitats is necessary to ensure the existence of these plants.

The forest dwelling species are under ever increasing pressure through the continual deforestation by the local people. These species need certain micro-

climates to survive and which only the forests can provide. Once these have been destroyed the plants will disappear entirely from these areas. Forest dwelling species cannot adapt to other conditions as can the xerophytes.

Few coastal forest reserves which are relatively rich in fern flora already exist and is at present in a good condition. A definite need for forest reserves in the midlands exists. Deforestation in these areas is at present very high.

No endemics are however restricted to this region.

Elsewhere *Davalia caryophylloides* populations can be tremendously reduced by frequent veld fires.

These potential changes in the native species populations, and the possible expansion of introduced ones, underline the importance of continued close study of pteridophytes in Southern Africa.

Much work is still needed for a complete pteridophyte survey of Southern Africa, and more intensive collecting in the southern foothills of the Drakensberg seems particularly necessary.

REFERENCES

- ACOCKS, J.P.H., 1975. Veld Types of South Africa. *Bot. Mem. S. Afr.* 40.
 HOLTUM, R.E., 1974. Thelypteridaceae of Africa and adjacent Islands. *J.I.S. Afr. Bot.* 40: 123-168.
 PALGRAVE, K.C., 1977. *Trees of Southern Africa*. Struik, Cape Town.

REVIEW

FLORA OF CHIAPAS: PART 1 INTRODUCTION by Dennis E. Breedlove; *PART 2 PTERIDOPHYTES* by Alan R. Smith, 35 + 370 pp., 82 figs. 174 x 254mm. California Academy of Sciences, San Francisco. 1981. Prices: US \$2.50; \$30.00.

Alan Smith states in his preface that pteridophytes account for 7-8 per cent of the vascular plant flora of this state in southern Mexico. He estimates that thanks to the extensive collecting carried out over the past 10 years or so possibly 95 per cent of the ferns there have been recognised. Altogether, there are 99 genera of ferns and five of fern allies known from the State, giving a total of 609 species (563 ferns and 46 allies).

This flora no doubt has its constraints imposed by the editorial committee but is comprehensive and traditional giving details of type (including synonyms) bibliographical location of illustrations, a full description (detailed and precise as we have come to expect from Alan Smith's pen) habitat, distribution and list of species seen. What is untraditional and greatly welcomed is, at the end of each genus, species to be looked for in Chiapas! and where potential new but undescribed taxa are at hand they are indicated. The end of the book contains line illustrations of 106 species (of 90 genera).

The genera of ferns are arranged alphabetically and the arrangement of species within is similar with the exception of *Grammitis*, *Thelypteris*, *Polypodium* and *Trichomanes* which are first divided into subgenera. Thus no descriptions of, or keys to, families are given and indeed mention of them at all is omitted. This is a bold, but in the reviewer's opinion, wise attitude. At 5 cents a species and the keys and generic descriptions thrown in for good measure what could be better.

DICTYMIA BROWNII (POLYPODIACEAE S.S.), AN ANCIENT AUSTRALIAN FERN

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ABSTRACT

An account of the ecology, morphology and anatomy of *Dictymia brownii* from Australia is given. The probable long-isolation of the genus within the Australasian region make its morphology and cytology of particular interest for detailed study. Chromosome counts of $n = 35$, $2n = 70$ are recorded, together with a karyotype analysis.

INTRODUCTION

Material of a relatively poorly known member of Polypodiaceae, *Dictymia brownii* (Wikstr.) Copel., was collected in Australia in 1969 by CNP and sent to TGW for cultivation in the fern collection at the Department of Plant Biology in the University of Newcastle upon Tyne. Although epiphytic in the wild these plants thrive in an ordinary fern mixture in clay pots with good drainage and are in excellent condition after 12 years of this treatment. The cytology of the plants had been worked out for some years and it was felt that a more complete account of this interesting species was desirable.



FIGURE 1. *Dictymia brownii* in the wild. A moderate-sized clump growing epiphytically on the lower part of a slender trunked rainforest tree, growing beside a stream in a light-gap at the top of a waterfall, near Kandallila Falls, south-east Queensland. (Photo: C.N. Page).

DISTRIBUTION AND ECOLOGY

Dictymia is a small genus of approximately four closely-allied species, present in Australia, New Caledonia, Fiji, and perhaps New Guinea (Domin, 1913; Copeland, 1929; Tindale, 1972; Brownlie, 1969; Jones & Clemisha, 1976). Throughout this geographic area, all the species are slow-growing epiphytes or lithophytes in humid rainforest vegetation. Beyond these few facts, very little seems to have been reported in the literature on the ecology of any one of them.



FIGURE 2. Typical Queensland rainforest, in which *Dictymia brownii* occurs epiphytically on trees high in the forest canopy, near Lake Eacham, Atherton Tableland, north-east Queensland. (Photo: C.N. Page).

Dictymia brownii of Australia is the most widely ranging of the species with the Fiji plant and one of the two New Caledonian species closely allied to it. Its ecology is thus probably fairly characteristic of that of the group. It occurs from at least the Atherton tableland area of North Queensland (lat. 17°S.) through the discontinuous areas of rainforest that follow the Great Dividing Range southward to southern New South Wales (to about lat. 34°S.). Throughout this range it is a fairly local and seldom gregarious species, growing epiphytically or on rocks. In dense rainforest it is usually confined to epiphytic sites on the uppermost parts of branches of the tallest canopy trees. In patches of more open rainforest, it extends down to the lower branches of the crowns of broadleaved trees, or occurs on the upper parts of the trunks of palms (mainly on robust, tall *Livistona australis* in south-east Queensland), which often form groves around the streams in the rainforest. *Dictymia* occurs on rocks mainly where these are tall and outcropping in the rainforest, such as on rocky cliffs, or where rocky bluffs occur in the upper rainforest margins on mountains, and there is frequent cloud and high humidity.

Nevertheless, the plant seems able to withstand a moderate amount of desiccation, at least for periods during the middle of the day, and its coriaceous frond texture is doubtless of advantage in enabling it to do this. With excessive drought the long edges of the fronds roll down and inwards, protecting the lower, stomatiferous surface of the blade. As is typical of most of the epiphytic ferns of the high rainforest

canopy (Page, 1979), *Dictymia* seems to be considerably light-demanding, and it is probably this factor which prevents it normally occurring at lower levels in the forest canopy, whilst it is probably its humidity requirement that confines it to moist forests.

In appropriate epiphytic habitats, plants eventually build up rounded, compact, intertwined rhizome masses forming collars around their supporting branches, and these give rise to many dozens of slender spreading-ascending or arching-descending fronds. In established clumps, the great majority of fronds bear abundant, large, oval, sori, although the total numbers of spores released do not seem very high. Nevertheless, established plants are probably long-lived, and the fronds are retained for lengthy periods, until they are finally cleanly shed from abscission zones a little above the rhizome surface. The developing rhizome and root masses eventually trap a certain amount of detritus, and are frequently colonised by mosses and sometimes by other epiphytic ferns and orchids, although usually the *Dictymia* remains the dominant member of such clumps. These masses probably provide something of a small reservoir of moisture for the plant during drier spells.

PHYTOGEOGRAPHIC AFFINITIES AND PROBABLE HISTORY

Endemic as a genus to the Australian-Polynesian region, Copeland (1947) suggests the taxonomic affinities of *Dictymia* lie generally with *Polypodium*, with little further comment about its origin. We feel, however, that its various morphological differences from *Polypodium* suggest that the two must have been separated for some considerable time.

In a phytogeographic and evolutionary analysis of the Australian pteridophyte flora (Page and Clifford, 1981), *Dictymia* appears to belong to that part termed the "long-resident" element, along with such other characteristically Australian or part-Australian fern genera as *Blechnum*, *Doodia*, *Culcita*, *Dicksonia*, *Leptopteris*, *Todea*, *Platyzoma*, *Neurosoria*, *Paraceterach*, and *Pleurosorus*. Indeed, *Dictymia* is the only genus of the Polypodiaceae *sensu stricto* represented in this probably ancient Australian pteridophyte assemblage.

The element contains an array of habitat-types, from streambank denizens of moist rainforest, to plants of drier forest margins and exposed rocky clefts, most of which are now confined largely to eastern Australia and adjacent larger islands.

This element seems to have long been present within the island continent of Australia during its lengthy period of separation from the rest of the Old World, since the early Cretaceous break-up of eastern Gondwanaland (Powell, Johnson & Veevers, 1981). As a whole, where links exist at all, the element has more distant and older links with New Zealand, South Africa and South America. This pteridophyte element is dominated by warm temperate members, some with species now extending well into tropical zones, perhaps adapting to warmer conditions with gradual northward migration of the continent during its plate tectonic and subsequent climatic history. It seems very likely too that the New Caldeonian-Fijian members have also been long-resident in their areas, like their equally old but much more migrationally sedentary conifer vegetation (Page & Clifford, 1981; Whitmore & Page, 1981) and more ancient angiosperm families (Johnson & Briggs, 1981; Beadle, 1981), as fragments of former more widespread Gondwanaland ferns, now present as few and isolated fragments on drifting tectonic rafts.

MORPHOLOGY AND ANATOMY

The account which follows is based on the plants growing in cultivation at Newcastle upon Tyne. We are grateful to Professor E. Hennipman, Utrecht, who kindly sent some pickled prothalli and baby sporophytes to supplement our material.

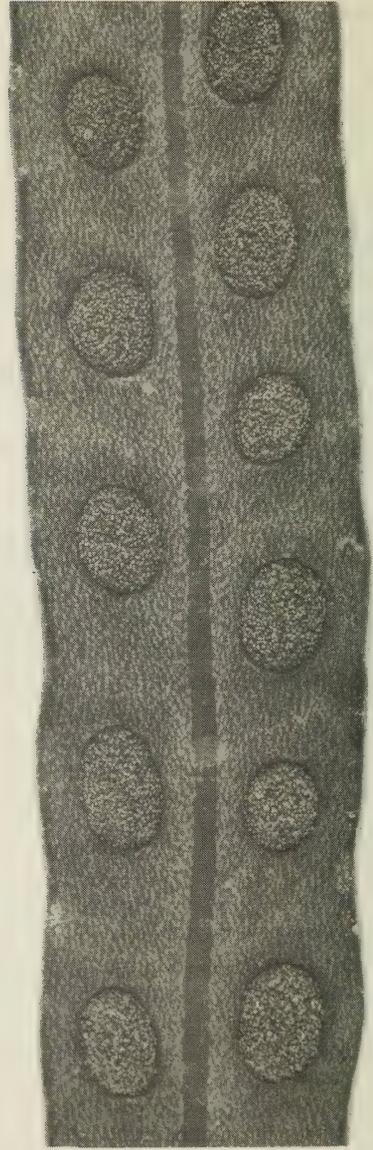
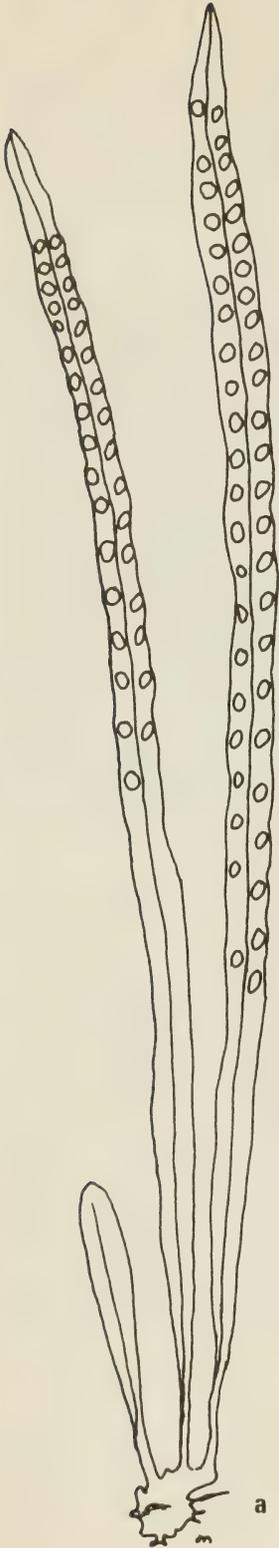


FIGURE 3. *Dictymia brownii*, a, whole fronds; b, close-up of underside showing large, orange-brown, oval sori.

1) Rhizome

The creeping, green, frequently branched rhizome bears numerous shortly-spaced fronds and is covered by abundant scales which are attached sub-basally. These measure c.5mm x 1.5mm and are light brown, with an entire margin which is only interrupted at the base by a few, for the most part, 2-celled, short hairs.

The cortex is parenchymatous only, the cells of which are conspicuously pitted, although the pits tend to be scattered over the cell wall rather than grouped into discrete pit-fields as is the case in the lamina (see below). The endodermis is very prominent with well-defined Casparian strips present on the radial walls only. No phlobaphene is present. The most noteworthy feature of the 6 or so meristeleles which are arranged in a single ring is the exceedingly prominent pericycle. This is 2 or 3 cells wide, each of the cells being several times larger than the phloem cells abutting them towards the centre and two or three times radially wider than those of the endodermis towards the outside. Fig. 4a diagrammatically depicts the rhizome in TS.

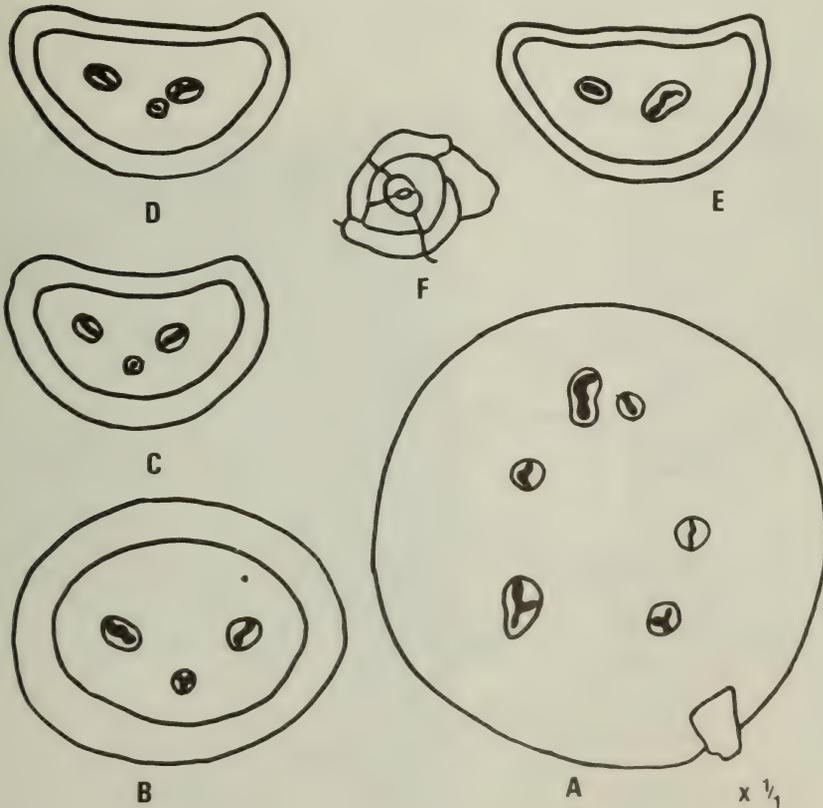


FIGURE 4. A. TS rhizome (part of root in lower portion); B. TS base of stipe; C. TS mid-stipe; D. & E. TS upper stipe, showing fusion of 2 strands; F. Cycloctytic stomium. A-E x 15 mag., F x c. 290 mag.

2) Frond

The salient features of the general appearance and habit of the fronds have already been described and Fig. 3 shows the conspicuous sori which are deeply impressed in a single row on either side of the midrib. In cultivation the fronds measure some 30cm x 1-1.5cm. In a very small number of cases the frond may fork once, as has been noted in many genera having simple fronds.

a) The Stipe

The stipe is very short, only 1-2cm long, and seated on a phyllopodium having a dehiscence layer of smaller cells. At the lower end, the stipe is approximately oval in cross-section, having an eccentrically placed vascular strand with two larger ones flanking it (Fig. 4b). Nearest the rhizome all the ground tissue is parenchymatous but a well-defined complete outer band of sclerenchyma very rapidly forms and this persists throughout the remainder of the stipe. Almost immediately above the dehiscence layer the stipe becomes more semi-circular in section (Fig. 4c). The mid strand approaches and fuses with one of the lateral strands (Figs. 4d & e) and the resultant two strands both produce small offshoots towards the base of the lamina which form the main veins.

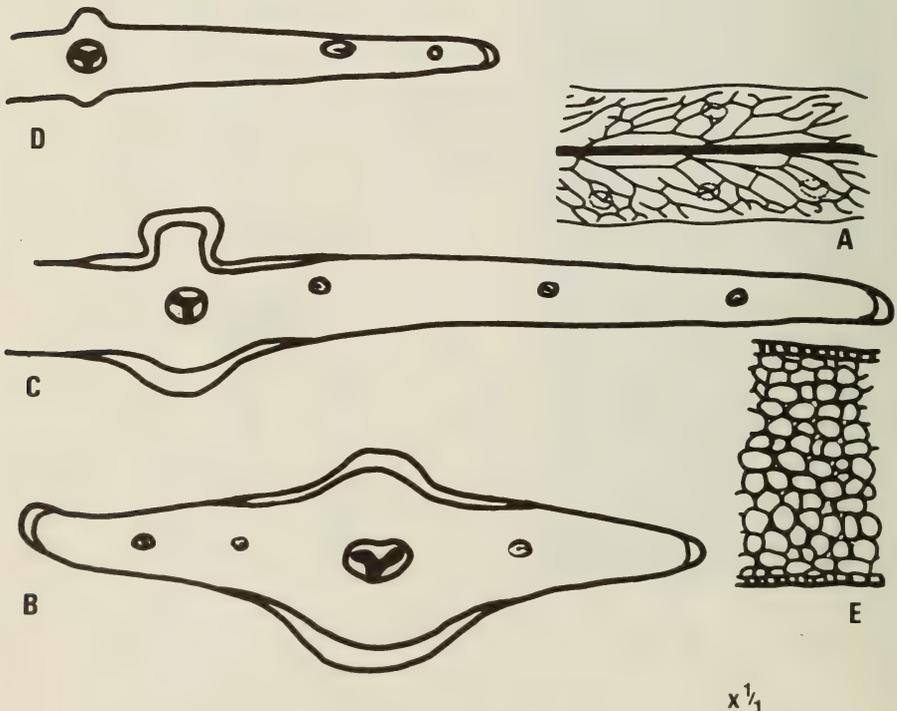


FIGURE 5. A. Venation, position of sori indicated by broken lines; B, C & D. TS frond at base, mid and upper points respectively. Limits of sclerenchyma indicated by inner unbroken line at midrib and margin; E. TS lamina showing lack of defined spongy and palisade layers. A x 1.3 mag., B-D x 15 mag., E x 50 mag.

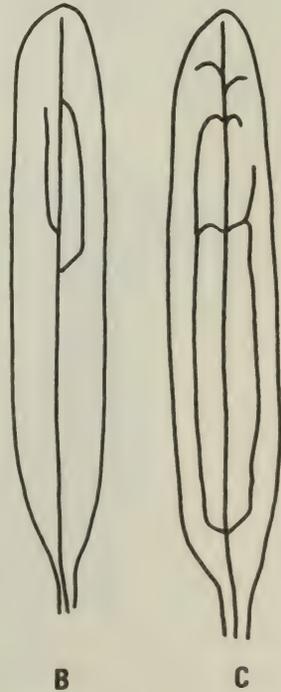
b) The Lamina

The veins form costal arches on either side of the midrib and fork and anastomose to form several rows of areolae which normally lack included veinlets. Not all the veins fuse with one another and there is an overall appearance of irregularity (Fig. 5a). In section the main vascular strand and the veins show the very prominent pericycle noted in the rhizome.

The lamina is thick and fleshy and its resistance to desiccation in the wild has already been referred to. If a frond is detached and left on a laboratory bench several days pass before there are signs of wilting and this may no doubt be correlated with the anatomical features. Transverse sections emphasise the thickness of the lamina, this being some 14-16 cells wide (Fig. 5b). The mesophyll cells are rounded with abundant intercellular spaces. They are not differentiated into spongy and palisade layers and are uniformly rich in chloroplasts. The remarkable feature of these cells is the presence of very conspicuous pit-fields in the walls (Fig. 6a). In some cases a single pit-field occupies virtually the whole of a wall as in the illustration, whilst in others two or three may be present. The epidermal cells have thick radial walls which are often heavily lignified and have prominent plasmodesmata, especially evident on the lower epidermis. Both upper and lower epidermal layers are covered with a very thick cuticle and the individual cells also show pit-fields. The surface of the lamina is devoid of appendages of any sort.



A



B

C

FIGURE 6. A. cells of the lamina mesophyll showing pit-fields; B. & C. Venation of first-formed fronds. A x 500 mag., B. & C. x 5 mag. (Photo: T. G. Walker).

A layer of sclerencyma is present on the upper and lower side of the midrib and also at the margins of the lamina, being interrupted by the presence of stomata on the lower surface. The epidermal cells are particularly heavily lignified at these parts.

The stomata are confined to the abaxial surface (Fig. 4f) and are mainly cyclocytic. They have a mean length of 40 μm (range 41 to 52.5 μm). Cyclocytic stomata were reported in only a few genera of Polypodiaceae by both van Cotthem (1970) and Sen & Hennipman (1981), these being *Lemmaphyllum*, *Paltonium*, and *Lecanopteris*. In addition, Sen & Hennipman recorded this type of stomata as being characteristic of *Dicranoglossum* (*Eschatogramme*) and *Niphidium*. By contrast the large majority of the genera of this family have polocytic or copolocytic stomata.

The sori are deeply immersed and contain numerous, long-stalked sporangia which lack glands and have a mean number of 14 indurated annular cells (range 12-18). Copeland (1947) states that paraphyses are lacking but this is an incorrect observation, probably due to examining dried specimens. In sections of fresh material small 2 or 3-celled paraphyses ending in a large colourless cell are to be seen. The spores are yellow, monolete, with a mean length of 57 μm (range 41-67 μm). The markings are very inconspicuous (Fig. 7) and consist of a shallow dimpling of the surface. If a fresh fertile frond is put in a spore packet and allowed to dry the normal thick deposit of spores which would be produced by most other ferns is absent. Microscopic examination shows that the sporangia have indeed discharged and it would appear that a very much higher than usual percentage of shed spores are trapped among the sporangia without falling free. This simple experiment has been repeated several times with the same result. We cannot say whether or not there is any biological advantage for the species in this — the net effect may be effectively to spread over a longer period the dissemination of the spores but this is pure conjecture.



x 1,1

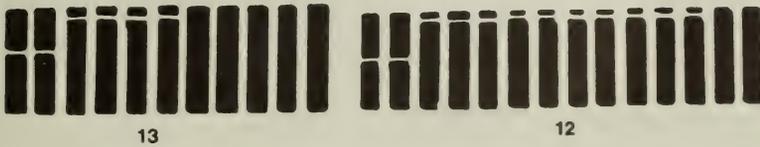
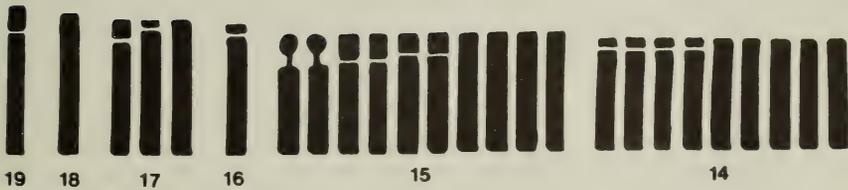
FIGURE 7. SEM of spores x 1000 mag. (Photo: T.G. Walker).

3) Prothalli

We did not follow the early stages of prothallial growth but in the mature samples available the margins of the prothalli tended to be frilly and the apical notch was frequently very shallow. No glands were seen on the margins of the prothalli unlike the situation in many other members of the family. Antheridia were produced at an earlier stage and then archegonia were also found in great abundance with their necks pointing backwards.



A



B

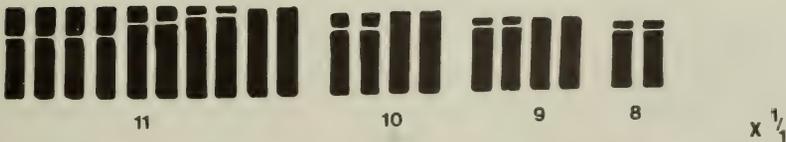


FIGURE 8. A. Root tip cell of *Dictymia brownii*, C4535, showing $2n = 70$, x 1000 mag. Permanent acetocarmine squash preparation. B. Karyogram of above cell with chromosome lengths given in units. Each unit length equals $0.33 \mu\text{m}$. (Photo: T.G. Walker).

The young sporophytes initially produce a single small frond c. 1.5cm long, the number and size increasing with age. At first the main vein produces one or two branches (Fig. 6b) and later these branches increase in number and anastomose to form the costal areoles (Fig. 6c). With increasing size the venation becomes more complex.

CYTOLOGY

Three plants, Page C4400 & C4401, collected in the Eungella Mountains, north Queensland, and C4535 collected on Mount Cordaux, south-east Queensland, each gave good preparations of root tip cells showing $2n = 70$ (Fig. 7a). Meiosis showed $n = 35$. These numbers, coupled with the direct observation of functional archegonia on the prothalli demonstrate that *Dictymia brownii* is a sexual diploid species based on $x = 35$. This basic chromosome number is not common in Polypodiaceae, having been recorded in only 5 out of the 34 genera for which cytological information is available. These are *Crypsinus*, *Pleopeltis* (including *Lepisorus* and *Microgramma*) *Marginariopsis*, *Belvisia* and *Polypodium* (including *Marginaria*). It is worth noting that apart from the monotypic *Marginariopsis* all these genera contain species with other base numbers in addition to the $x = 35$. A further point of interest is that it will be seen that none of these genera figure in the short list of those that have cyclocytic stomata.

Fig. 8b is a karyogram of the cell illustrated in Fig. 8a. The chromosomes are grouped according to length, each group differing from its immediate neighbour on either side by one unit which represents $0.33 \mu\text{m}$. The total range is from $2.67 \mu\text{m}$ to $6.33 \mu\text{m}$ with a peak at $4.0 \mu\text{m}$. The centromere positions have been calculated following the system of Levan, Fredya and Sandberg (1965). In this system when the centromere is in the exact centre of the chromosome this position is designated the median point M and when at the end, the terminal point T. The chromosome between these two points is divided into 4 equal regions, these being in order from the median point, the median region m, the submedian region sm, the subterminal region st and the terminal region t. Because it is exceedingly difficult to be sure that a centromere is actually at the terminal point T and not fractionally below it, it is probably wisest to combine the figures for the terminal region and terminal point. The analysis for *Dictymia* is shown in Table 1. It will be noted that the overwhelming majority of chromosomes (60 out of 68, excluding the satellited ones) have their centromeres located in the distal half of a chromosome arm and have only 2 at the median point. This general trend is found in some other members of *Polypodiaceae* although often not to quite such a marked extent (Walker, in preparation).

TABLE 1
Centromere position in the karyotype of *Dictymia brownii*

Centromere position	No. of chromosomes
Median point, M	2
Median region, m	2
Submedian region, sm	4
Subterminal region, st	10
Terminal region, t	26
Terminal point, T	24
Satellited	2
	70

REFERENCES

- BEADLE, N.C.W., 1981. Origin of the Australian angiosperm flora, pp. 407-426 in Keast, A. (ed.) *Ecological Biogeography of Australia*. W. Junk. The Hague.
- BROWNLIE, G., 1969. *Flore de la Nouvelle-Caledonie et Dependances No. 3. Pteridophytes*. Mus.Nat.Hist.Naturelle, Paris.
- COPELAND, E.B., 1929. Ferns of Fiji. *B.P. Bishop Museum Bull.* 59: 1-105.
- COPELAND, E.B., 1947. *Genera Filicum*. Chronica Botanica, Waltham.
- DOMIN, K., 1913. Beitrage zur Flora und Pflanzengeographie Australiens: Die farnflora Queensland. *Bibl.Bot.* 20 (85): 1-238.
- JOHNSON, L.A.S., & BRIGGS, B.G., 1981. Three old southern families — Myrtaceae, Proteaceae and Restionaceae. pp. 429-469 in Keast, A. (ed.) *Ecological Biogeography of Australia*. W. Junk. The Hague.
- JONES, D.L., & CLEMISHA, S.C., 1976. *Australian Ferns and Fern Allies*. A.H. & A.W. Reed, Sydney.
- KEMP, E.M., 1981. Tertiary palaeogeography and the evolution of the Australian climate. pp. 33-49 in Keast, A. (ed.) *Ecological Biogeography of Australia*. W. Junk. The Hague.
- LEVAN, A., FREDYA, K., & SANDBERG, A.R., 1965. Nomenclature for centromeric position on chromosomes. *Hereditas* 52: 201-220.
- PAGE, C.N., 1979. The diversity of ferns. An ecological perspective pp. 9-56 in Dyer, A.F. (ed.) *The Experimental Biology of Ferns*. Academic Press, London.
- PAGE, C.N., & CLIFFORD, H.T., 1981. Ecological Biogeography of Australian Conifers and Ferns. pp. 471-498 in Keast, A. (ed.) *Ecological Biogeography of Australia*. W. Junk. The Hague.
- POWELL, C.A., JOHNSON, B.D., & VEEVERS, J.J., 1981. The Early Cretaceous break-up of Eastern Gondwanaland, the separation of Australia and India, and their interaction with South-East Asia. pp. 17-29 in Keast, A. (ed.) *Ecological Biogeography of Australia*. W. Junk, The Hague.
- SEN, U., & HENNIPMAN, E., 1981. Structure and ontogeny of stomata in Polypodiaceae. *Blumea* 27: 175-201.
- TINDALE, M.D., 1972. Pteridophyta. pp. 38-84 in Beadle, N.C.W., Evans, O.D., & Carorin, R.C. *Handbook of the Vascular Plants of the Sydney District and Blue Mountains*, Sydney.
- VAN COTTHEM, W., 1970. Comparative morphological study of the stomata in the Filicopsida. *Bull.Jard.Bot.Nat.Belg.* 40: 81-239.
- WHITMORE, T.C., & PAGE, C.N., 1981. Evolutionary implications of the distribution and ecology of the tropical conifer *Agathis*. *New Phytol.* 84: 407-416.

REVIEW

FLORA MALESIANA SER. 2 PTERIDOPHYTA VOL 1 PART 5: THELYPTERIDACEAE by R.E. Holttum. pp. (17), 331-599. 1982. 240 x 164mm. The Hague, Martinus Nijhoff. ISBN 90 247 2652 2. Price Dfl. 145/US \$63/£

This is the result of ten years' research on the Old World species of Thelypteridaceae by the doyen of tropical fern taxonomy, Dr R.E. Holttum, whose experience in Malesian botany now extends over 50 years. In a dedicatory preface to Carl F.A. Christensen, the Holttum says, "There can be no doubt that existing ferns have originated through a process of evolution. They have therefore an inbuilt classification, and our object is to find it; the nearer we get to it the nearer we are to the practical aspect of taxonomy." This indeed is Holttum's philosophy as his publications, totalling over 100, on orchids, bamboos and gingers, and ferns in particular, show. This Dedication is an excellent account of the history of fern classification from which the reader can put not only Christensen's but also of course, Holttum's work into perspective.

Thelypteridaceae is a large family and Holttum's many papers on it over the past ten years are well known. Twenty-two genera are defined and in the taxonomic discussion, Holttum groups these into seven units of which *Trigonospora* Holtt. (3 spp.) stands out in the family in having trilate spores and *Cyclogramma* Tagawa (1 sp.) is distinct in having hooked hairs on lower surface of all axes and on the sporangia (although similar hairs are found in Sect. *Grypothrix* of *Pronephrium* Holttum thinks they are in no way related. The name *Cyclosorus* is confined to a complex of possibly three pantropic species of which *C. interruptus* (Willd.) H. Ito is the only Malesian species. *Thelypteris* similarly is restricted to the *T. palustris* Schott complex of which the Malesian representative is *T. confluens* (Thunb.) Morton. The question has been raised as to whether one blanket genus (*Thelypteris* auctores plures) can usefully and logically be divided into 22 (on a world basis) genera. Certainly it is useful, although one must recourse to checking microscopic characters (glands or hairs on sporangia; spore ornamentation; septate or unicellular hairs) to identify genera. Holttum himself admits *Nannothelypteris* (5 Philippine spp.) may be included in *Pronephrium*. The largest genus by far is *Sphaerostephanos* with 152 species in Malesia (with another 33 elsewhere); *Pneumatopteris* (54) and *Pronephrium* (57) are other big genera.

Although the author has published extensively on this family (mostly in *Blumea* or *Kew Bulletin*) I counted 100 new taxa described in this work. I think it is incredible that Eric Holttum can manually (mentally) manipulate the characters, so carefully observed, and come up with the taxonomy he has. And the value of each character is weighed with his long experience of field work in the Malesian tropics.

There are a lot of species known only from the type or a few gatherings. Obviously, as more material becomes available a reassessment will have to be made and Holttum would be the first to admit this.

This fifth part ends volume 1 and has *Corrigenda* and *Emendata* (in which 3 species of *Cyathea*, 2 *Isoetes* and one *Gleichenia* are mentioned as having been described since those genera were published in *Flora Malesiana*). To this one may add a further species of *Gleichenia* from Gunung Mulu, Sarawak (B.S. Parris, *Bot. J. Linn. Soc.*, 84: 00; 1982). Thanks to Holttum, and Hennipman and Kramer who have contributed substantially to other genera, F.M. Series II is truly underway.

A.C. JERMY

THE ECOLOGY AND CYTOLOGY OF PHANEROSORUS (MATONIACEAE)

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ABSTRACT

An illustrated account of the specialized growth and habitat of *Phanerosorus sarmentosus* (Baker) Copel. is given. A chromosome count of $n=25$ is recorded and brief comparisons are made between Matoniaceae and Gleicheniaceae.

INTRODUCTION

Baker (1887) described some plants collected by Charles Hose from the cliffs of the Niah caves in Sarawak as *Matonia sarmentosus* Baker; he later (1891) amplified this brief description with line drawings showing the branching habit of the frond and soral details. In 1908 Copeland raised this species to generic rank as *Phanerosorus sarmentosus* (Baker) Copel. on the grounds of the sympodial branching of the long pendulous fronds (see Figs. 2 & 3), the anastomosing veins around the sori and on indusial and sporangial characters. Its generic distinction is not disputed, although there is no doubt of its closeness to *Matonia*, but a further species *P. major* was described by Diels (1932) from limestone cliffs on the coast of Waigeu Island, NW New Guinea, solely on its more robust character. The present authors, as have others (e.g. Alston in herb. BM) believe this to be conspecific with the Bornean plant.

Although more familiar from herbarium material, *Phanerosorus* is little known as a living plant because of its limited distribution and its failure to become established in cultivation, no doubt due to its very demanding ecological requirements. Consequently, a brief illustrated account of the plant in the wild was felt to be of interest.

DISTRIBUTION AND ECOLOGY

It is of considerable interest that *P. sarmentosus* is found on the NW tip of New Guinea (Waigeu Is.) and then again in N Borneo. The other member of Matoniaceae (*Matonia pectinata* R. Br.) is confined to peninsula Malaysia, Sumatra and Borneo. Although *Phanerosorus* has no close fossil relatives, those of *Matonia* show possible origins in the Triassic or early Jurassic Periods and across the present Northern Hemisphere, i.e. Laurasia (Seward 1922). Both genera are plants of open places — ridge-tops or cliffs — and have a growth habit and leaf structure capable of withstanding temporary drought conditions and, although today associated with the ever-wet tropics, may not always have needed such constant moisture.

Field observations were made on spore dehiscence in Gunung Mulu N.P. in late August towards the end of the drier regime (no true dry season was experienced in this ever-wet climatic belt). Many of the mature sori had shed entire indusia leaving naked sporangia free to disperse spores into the air. At no time apparently does the indusium shrivel as in dryopteroid ferns. In many cases the entire sporangium is dropped and in material collected for the herbarium almost all sori dropped on drying leaving receptacular 'stumps' on the leaf surfaces as a sole reminder that the leaf had been fertile. It seems that dispersal of these heavier soral units (10—14 sporangia and indusium), whilst having advantages at the breeding level once gametophytes have been established, may prevent a wider dispersal of *Phanerosorus*. Similar behaviour of dropping whole mature sori in the field is seen in *Matonia pectinata*.

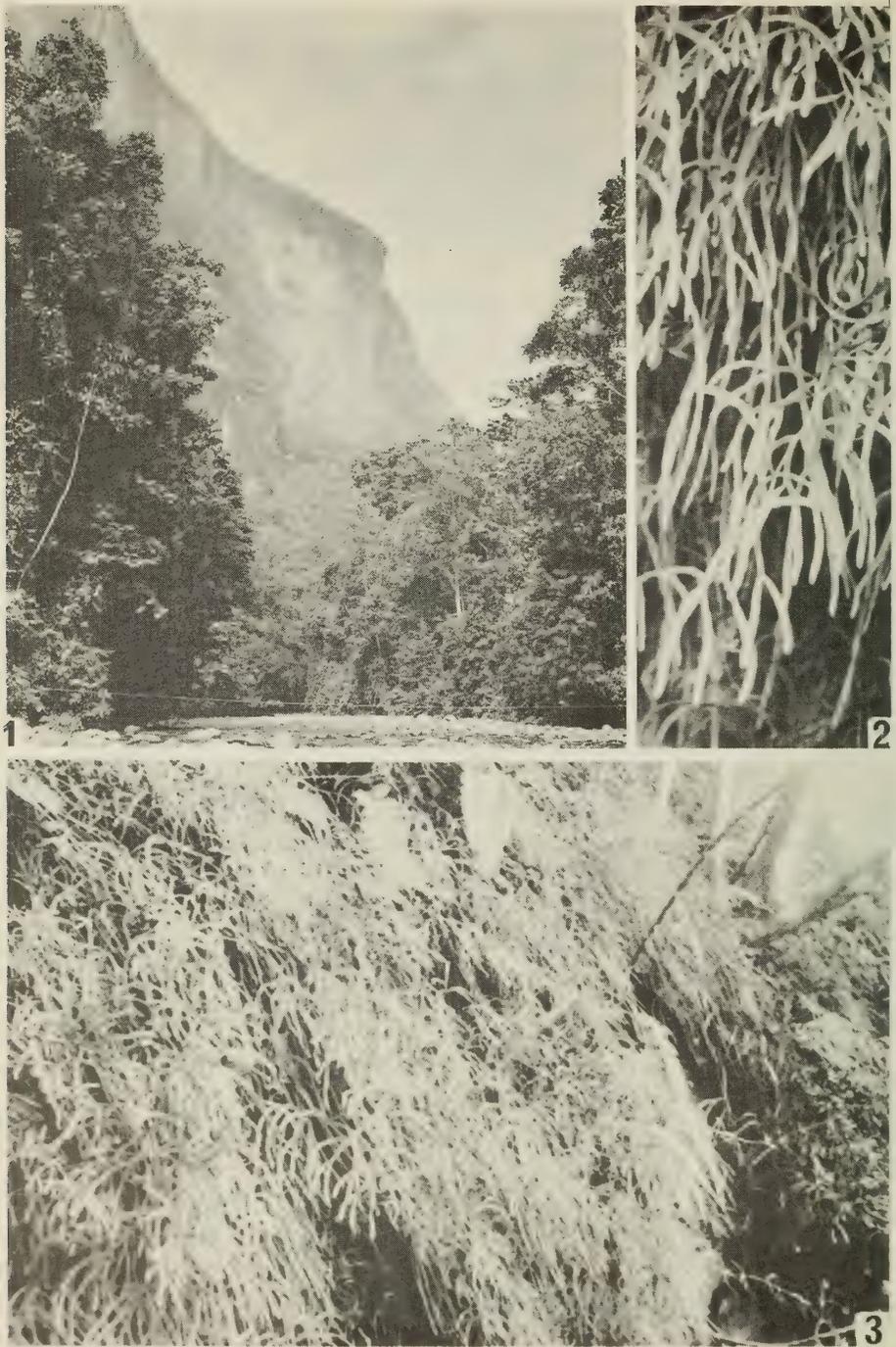


FIGURE 1. The limestone cliffs on the Melinau Gorge, G. Benarat, G. Mulu National Park, Sarawak, seen from the west.

FIGURES 2 & 3. Close up of *Phaneroglossis sarmentosus* on G. Benarat, G. Mulu National Park, Sarawak.

Within Borneo the species has been collected in Bau and at Bidi in the 1st Division, and at Niah National Park, near Miri, and in the Gunung Mulu National Park, in the 4th Division. In all of these localities as in Waigeu the plant grows on exposed limestone cliffs from 50m to 800m above sea-level. Figure 1 shows typical limestone cliffs, 400 metres high on G. Benarat in the Melinau Gorge, G. Mulu N.P. where the species was studied by the authors in 1978. The *Phanerosorus* was seen on the lower areas of cliff by the cave Lubang Rendah Harimau above the lowland forest which was growing on the limestone scree slopes.

The cliffs of G. Benarat contain a number of endemic species characteristic of limestone in Borneo, such as *Paraboea banyengiana* B.L. Burt and *P. candidissima* B.L. Burt, both Gesneriaceae, as is a related genus *Boea* of which five species have been reported on the open limestone cliffs. Other species in this habitat include *Ficus tinctoria* Forst. f. subsp. *gibbosa* (Bl.) Corner and *Fagraea auriculata* Jack subsp. *borneensis* (Scheff.) Leen. more usually as epiphytes (Anderson & Chai, 1982) and *Neonauclea peduncularis* Walp. ex G. Don. Ferns such as *Adiantum malesianum* Ghatak, *Nephrolepis hirsutula* (Forst.) C. Presl, *Pteris multifida* Poir., and *Taenitis cordata* (Gaud.) Holtt. are found here. In more shady spots *Hypodematium crenatum* (Forsk.) Kuhn, *Tectaria brooksii* Copel. and *T. devexa* (Kze.) Copel. were frequent. Another Gesneriad, *Monophyllaea*, a distinctive plant of limestone in G. Mulu N.P., occurred in similar situations. Seven species were recorded for the limestone here: *M. johannis-winkleri* Kraenl. and *M. beccarii* C.B. Clarke were those associated with *Phanerosorus*.

Phanerosorus is widespread throughout the Melinau limestone of the Benarat-Api massif and seen again in quantity on the exposed cliffs above Gua Payau in the south of the range. In almost all the localities it was difficult to reach without artificial aid. It often forms hanging thickets some five metres across in both directions.

MORPHOLOGY

The affinities of *Phanerosorus* with *Matonia* are clearly shown in the concentric vascular steles, the dichotomous or pseudodichotomous branching of the fronds, and the soral features. The sessile, or almost sessile, sporangia are grouped into circular sori which are protected by very characteristic thick, persistent, umbrella-shaped indusia to which the sporangia are frequently adherent. Compton (1909) described the branching of the fronds as being of two types; either both branches of a fork may develop more or less equally, giving rise to elongate axes which repeatedly fork, or one of the branches may develop more fully whilst the other branch after producing two pinnae ends in an aborted bud — this latter being the more usual method. These systems of branching and the production of resting and aborted buds shows great similarities to those seen in Gleicheniaceae. The similarities in gross morphology of the fronds of Matoniaceae and Gleicheniaceae also extend to stomatal details. The stomata of both *Matonia* and *Phanerosorus* are anomocytic as are those of some members of Gleicheniaceae — the others being diacytic (van Cotthem, 1970).

The gametophytes of the two families also show great similarities (Stokey and Atkinson, 1952; Atkinson and Stokey, 1964; Atkinson, 1973) although it must be confessed our knowledge depends on the study of only a very few species. The prothalli of *Matonia* closely resemble those of *Gleichenia* in being large with a very thick cushion up to 11 cells or so deep and in being long-lived with a ruffled margin. In both genera the antheridia are of the large complex type with many cells in the walls and the necks of the archegonia are much longer and straighter than in more advanced types. It was hoped to be able to supplement this information with a description of the prothalli of *Phanerosorus* and to this end spores were gathered in the field and sown

immediately on return to Newcastle a few weeks later. None germinated and this may have been due either to very limited viability or to highly specialized requirements. Similarly attempts to transport young plants and establish them on a variety of substrates in cultivation were unsuccessful. Stokey and Atkinson (1952) commented that not only were the spores of *Matonia* short-lived but that germination was poor even when the spores were still comparatively fresh.

CYTOLOGY AND GEOLOGICAL HISTORY

The first cytological record for a member of Matoniaceae was that of Stokey and Atkinson (1952) who observed in sections of a prothallus of *Matonia pectinata* that a few cells in polar view showed *c.*26 chromosomes. They also made the observation that many of the chromosomes appeared to have terminal or near terminal attachments (centromeres). This number was precisely determined by Manton (1954a, 1954b) who demonstrated the presence of 26 bivalents at meiosis in a spore mother cell of this species.

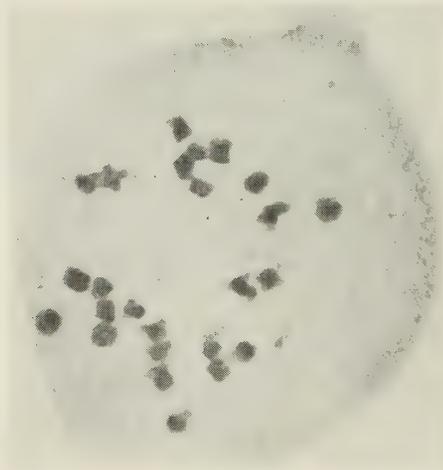


FIGURE 4. Meiosis in *Phanerosorus sarmentosus* (T13643) showing 25 bivalents, x 1000. Permanent acetocarmine squash preparation. Vouchers: Sarawak, 4th Division, Gunung Mulu National Park, G. Benarat, Lubang Rendah Harimau i 700m alt. 23 Aug. 1978, *Jermy 14466* (BM, K, L, SAR, Herb. Walker).

Fixations were made in the field in Sarawak on young plants of *Phanerosorus* collected near the entrance of one of the many caves on the south face of Gunung Benarat. Two plants gave excellent preparations of a number of cells, one of which is illustrated in Fig. 4 and showing $n=25$ without any doubt. Thus, the two genera of Matoniaceae have basic chromosome numbers which differ from one another by one, namely $x=25$ and $x=26$. It cannot, of course, be established with certainty for how long this aneuploidy has existed nor which is the original and which the derived number but there are a number of suggestive facts. According to Copeland (1947) the morphological differences seen in *Matonia* and *Phanerosorus* have been found in Matoniaceous fossil genera in the Mesozoic, suggesting a probable long history as distinct genera. Of the two genera there can be no question but that *Phanerosorus* is

the more specialized as regards habit, habitat, etc. Both Matoniaceae and Gleicheniaceae are recorded back into the Mesozoic (Boreau, 1970; Seward, 1922 and Holttum, 1954, considers that as the two families have existed together for this very long period one must go back at least to the early Mesozoic for a common ancestor.

Cytologically Gleicheniaceae shows a wide range of basic chromosome numbers, each number being characteristic of a particular genus. Table 1 lists the basic chromosome numbers found in the two families and it will be seen that the numbers reported for Matoniaceae fall in the bottom end of the range found in Gleicheniaceae.

TABLE 1:
BASIC CHROMOSOME NUMBERS IN MATONIACEAE
AND GLEICHENIACEAE

Matoniaceae	Gleicheniaceae
<i>Phaner Sorosorus</i> x=25	<i>Gleichenia</i> x=20, 22
<i>Matonia</i> x=26	<i>Diplopterygium</i> x=28? (n=56)
	<i>Sticherus</i> x=34
	<i>Dicranopteris</i> x=39
	<i>Acropterygium</i> x=43

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REFERENCES

- ANDERSON, J.A.R. & CHAI, P.K.K., 1982. The vegetation, in A.C. Jermy & K.P. Kavanagh (Eds.) Gunung Mulu National Park, Sarawak: a survey of its biota and environment *Sarawak Mus. J.* 30 (51) Special Issue no. 2 (in press).
- ATKINSON, L.R., 1973. The gametophyte and family relationships. In A.C. Jermy, J.A. Crabbe and B.A. Thomas (Eds.) The phylogeny and classification of the ferns. *Bot. J. Linn. Soc.* 67, *Suppl. 1*: 73-90.
- ATKINSON, L.R. & STOKEY, A.G., 1964. Comparative morphology of the gametophyte of homosporous ferns. *Phytomorphology* 14: 51-70.
- BAKER, J.G., 1887. On a further collection of ferns from West Borneo, made by the Bishop of Singapore and Sarawak. *J. Linn. Soc. (Bot.)* 24: 256-261.
- BAKER, J.G., 1891. A summary of the new ferns discovered or described since 1874. *Annls. Bot.* 5: 301-332.
- BOREAU, E., 1970. *Traité de Paleobotanique* IV (1) *Filicophyta*. Masson et Cie, Paris.
- COMPTON, R.H., 1909. The anatomy of *Matonia sarmentosa*, Baker. *New Phytol.*, 8: 299-310.
- COPELAND, E.B., 1908. New genera and species of Bornean ferns. *Philipp. J. Sci.* 3C: 343-349.
- COPELAND, E.B., 1947. *Genera Filicum*. Chronica Botanica, Waltham.
- HOLTUM, R.E., 1954. *Flora of Malaya, 2, Ferns*. Government Printing Office, Singapore.
- MANTON, I., 1954a. Cytology of meiosis in *Matonia*. *Nature*, 173: 453.
- MANTON, I., 1954b. Cytological notes on one hundred species of Malayan ferns. In R.E. Holttum, *Flora of Malaya, 2, Ferns*: 623-627. Government Printing Office, Singapore.
- SEWARD, A.C., 1922. A study in contrasts: The present and past distributions of certain ferns. *J. Linn. Soc. Bot.* 46: 219-240.
- STOKEY, A.G. & ATKINSON, L.R., 1952. The gametophyte and young sporophyte of *Matonia pectinata* R.Br. *Phytomorphology* 2(2,3): 138-150.
- VAN COTTHEM, W., 1970. Comparative morphological study of the stomata in the Filicopsida *Bull. Jard. Bot. Nat. Belg.* 40: 81-239.

SHORT NOTE

ASPLENIUM PULCHERRIMUM IN BORNEO

Asplenium pulcherrimum (Baker) Ching (syn. *Davallia pulcherrima* Baker, *A. billettii* Christ and *A. calcicola* Tagawa) is a small fern of limestone rocks which is known from China, Taiwan and Vietnam (DeVol & Kuo, 1975). This species has recently been discovered much further south, on Gunong Api in Gunong Mulu National Park, Sarawak, during the 1977-78 Royal Geographical Society Mulu Expedition. (Gunong Api is, at c. 1750 metres, the highest limestone mountain between northern Thailand and New Guinea (Hanbury-Tenison & Jermy, 1979). It was collected by A.C. Jermy (as No. 14115, in BM and SAR) from 'soil detritus in crevices in shade and full sun on limestone pinnacles in montane limestone forest at 1200 m'. Figure 1 shows three plants from this gathering.

A. pulcherrimum has a narrowly to broadly triangular to ovate 3- to 4-pinnatifid lamina dissected into linear segments, each with a single sorus, and dull black stipes usually as long as or longer than the lamina. It is most distinct from the other species of *Asplenium* in Borneo, but is morphologically similar to *A. coenobiale* Hance (syn. *A. fuscipes* Baker) of China and belongs to the mainland Southeast Asian element of the Bornean fern flora.



FIGURE 1. *Asplenium pulcherrimum* from Gunong Api, Sarawak, Borneo. (Jermy 14115, BM).

REFERENCES

- DEVEL, C.E., and KUO, CHEN-MENG, 1975. *Aspleniaceae*, in *Flora of Taiwan Volume 1*, Eds. Hui-lin Li, Tang-shu Liu, Tseng-chiang Huang, Tetsuo Koyama and Charles DeVol. Taipei.
- HANBURY-TENISON, R., and JERMY, A.C., 1979. The RGS Expedition to Gunong Mulu, Sarawak, 1977-78. *Geographical Jour.* 145: 175-191.

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OBSERVATIONS ON THE VENATION PATTERNS IN OPHIOGLOSSUM, BOTRYCHIUM AND HELMINTHOSTACHYS

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ABSTRACT

The Ophioglossaceae have three living genera showing two diverse types of venation patterns: (i) open dichotomous (*Botrychium* and *Helminthostachys*) and (ii) reticulate (*Ophioglossum*). The family lacks any fossil history and none of the living taxa are so far reported to have intermediate stages between the two venation types. Vein unions have been reported to occur in the open dichotomous venation of *Kingdonia*, *Circaeaster*, *Utricularia*, *Ginkgo*, *Adiantum*, *Pteris* etc., and are said to be of phylogenetic importance. A detailed study of the venation pattern in the Ophioglossaceae reveals that anastomoses are completely lacking in some species of *Botrychium*, but are of frequent occurrence in *Helminthostachys zeylanica*. In all, five different types of anastomoses leading to vein-islet formation have been observed. Other features of interest are multiple anastomoses, vein approximations, unconnected veinlets and blind vein endings of extrusive and intrusive type. It is concluded that *Botrychium*, *Helminthostachys* and *Ophioglossum* appear to form an ascending series in so far as the complexities of venation pattern are concerned.

INTRODUCTION

Foster (1952, 1969), Carlquist (1961) and Hickey (1973) have emphasized the significance of venation patterns in systematics and phylogeny. Open dichotomous venation is considered primitive and reticulate derived from it. In the last three decades various types of vein unions leading to areole formation have been described in open dichotomous venation of *Kingdonia* (Foster 1959; Foster and Arnott, 1960), *Circaeaster* (Foster, 1966, 1968), *Utricularia* (Taylor, 1964; Subramanyam, 1969), *Ginkgo* (Arnott, 1959), *Adiantum* and *Pteris* (Nair and Das 1974a, b; 1977). Venation in the family Ophioglossaceae is interesting, showing two extremes, viz., open dichotomous in *Botrychium* and *Helminthostachys*, and reticulate in *Ophioglossum*, and there has been only limited previous work on the venation patterns in this fern family (Mittal, 1968; Panigrahi and Dixit, 1969).

MATERIALS AND METHODS

A list of taxa investigated in this study is included in Table 1. Plants studied were fixed in FAA, preserved in 70% ethanol, and cleared in 5% NaOH to display the venation. In *Botrychium* and *Ophioglossum*, ten mature leaves or pinnules from each source were so treated. In *Helminthostachys*, 110 pinnae from different leaves were examined against strong light and only those portions of pinnae were cleared, where some anastomosis, approximations etc., were recognised. The terminology of Hickey (1973), with some modifications, was followed for leaf architecture in general. In *Ophioglossum*, observations on shape, size and absolute number of vein-islets, vein endings etc., were made according to Gupta (1961).

OBSERVATIONS

The sterile segment of leaf or trophophyll is simple and small in *Ophioglossum*, quite big and ternately compound in *Helminthostachys* and pinnately decompound in *Botrychium*.

In both species of *Botrychium* studied, venation is perfectly open-dichotomous. By contrast, *Helminthostachys* shows a number of vein unions, approximations, blind vein endings and detached veins. A typical reticulate venation is met within

TABLE 1:
TROPOPHYL MORPHOLOGY AND MAJOR VENATION PATTERN IN THREE GENERA

S. No. Name of taxa	Place of collection/ source	Trophophyll form	Trophophyll/ pinnule margin	General Venation of pinnule/ trophophyll	Midrib in pinnule/ trophophyll	Bundle sheath
1. <i>Botrychium ternatum</i> Thunb.	Pachmarhi	Bipinnate	Lobed-erose	Open dichotomous camptodromous	Present	Up to penultimate veinlets
2. <i>B. lanuginosum</i> Linn.	Nainital	Up to tripinnate	Lobed-serrate	" "	"	Up to ultimate veinlets sometimes
3. <i>Helminthostachys zeylanica</i> Linn.	Gorakhpur	Ternate	Sinuose with minor serrations	Open dichotomous with anastomoses camptodromous	"	Up to ultimate veinlets
4. <i>Ophioglossum costatum</i>	Khandelwal, Gwalior	Simple	Entire	campyloreticulo- dromous	Absent	Absent
5. <i>O. gramineum</i> Willd.	Pachmarhi	"	"	"	"	"
6. <i>O. lusitanicum</i> Linn.	Kaharjir, MP	"	"	"	"	"
7. <i>O. nudicaule</i> Linn.	Pachmarhi	"	"	"	"	"
8. <i>O. petiolatum</i> Hooker	Dr Imaichi, Japan	"	"	"	"	"
9. <i>O. reticulatum</i> Linn.	Dehradun	"	"	"	"	"
10. <i>O. thermale</i> Kumarov	Khandelwal, Gwalior	"	"	"	"	"

Ophioglossum. The venation is camptodromous in pinnae of *Botrychium* and *Helminthostachys* and campyloreticulodromous in *Ophioglossum* (Table 1).

An examination of 110 pinnae from different leaves of *Helminthostachys zeylanica* revealed that one or more anastomoses were present in as many as 76 (69.90%) specimens. Some interesting cases of vein approximations, blind vein endings and detached veins are described below.

Anastomoses: Based on the nature of contributing veins and their course after union, anastomoses were grouped into 5 major types and a few subtypes thereof. The frequency of different types is shown in Table 2.

Type 1 includes all the anastomoses formed by a short confluence of two veins of the same order, which separate after union. It has two subtypes. In subtype 1a the anastomosing veins are inner branches of first order dichotomy of the same costa (fig. 1d) and in 1b the anastomosing veins come from first order dichotomies of two adjacent costs (fig. 1e).

Type 2 is again characterised by the union of veins of the same order but they become confluent to the margin. The type has three subtypes. In type 2a (fig. 1f) the nature of the contributing veins is the same as in subtype 1a. Type 2b is formed by the union of inner branches of a second order dichotomy of the same costa (fig. 1g) whereas in 2c the anastomosing veins come off as outer branches of first dichotomies of adjacent costa (fig. 1h).

TABLE 2
FREQUENCY OF OCCURRENCE OF VARIOUS TYPES OF ANASTOMOSIS
IN *HELMINTHOSTACHYS ZEYLANICA*

Type	1		2			3		4		5	
Sub-types	a	b	a	b	c	a	b	a	b		Multiple anastomosis
%age of occurrence	7.5	4.5	42	9	6	21	9	33	9	1	22.5

Anastomoses Type 3 and Type 4 are formed by the union of veins of different orders (figs. 1i-l). In Type 3 the veins become separated after union but in Type 4 they proceed as a single vein. Both these types show two further subtypes. Subtype 3a is characterised by the union and subsequent separation of a branch from first order dichotomy and the contiguous acruate vein from the same costa (fig. 1i). In 3b the contributing veins come from two different costa (fig. 1j).

Type 4a (fig. 1k) is formed by the union of an arcuate vein of first order dichotomy with a branch of the contiguous vein from the same costa, whereas in 4b, the uniting veins are of next higher order (fig. 1l).

Type 5 is discernible as the areole formed by the anastomosing veins possesses a blind vieniet (fig. 1n).

In addition to the types described above, multiple anastomoses formed by the contribution of veins from a single costa (fig. 1g) or two different costae (figs. 1g, p, r). have been commonly observed.

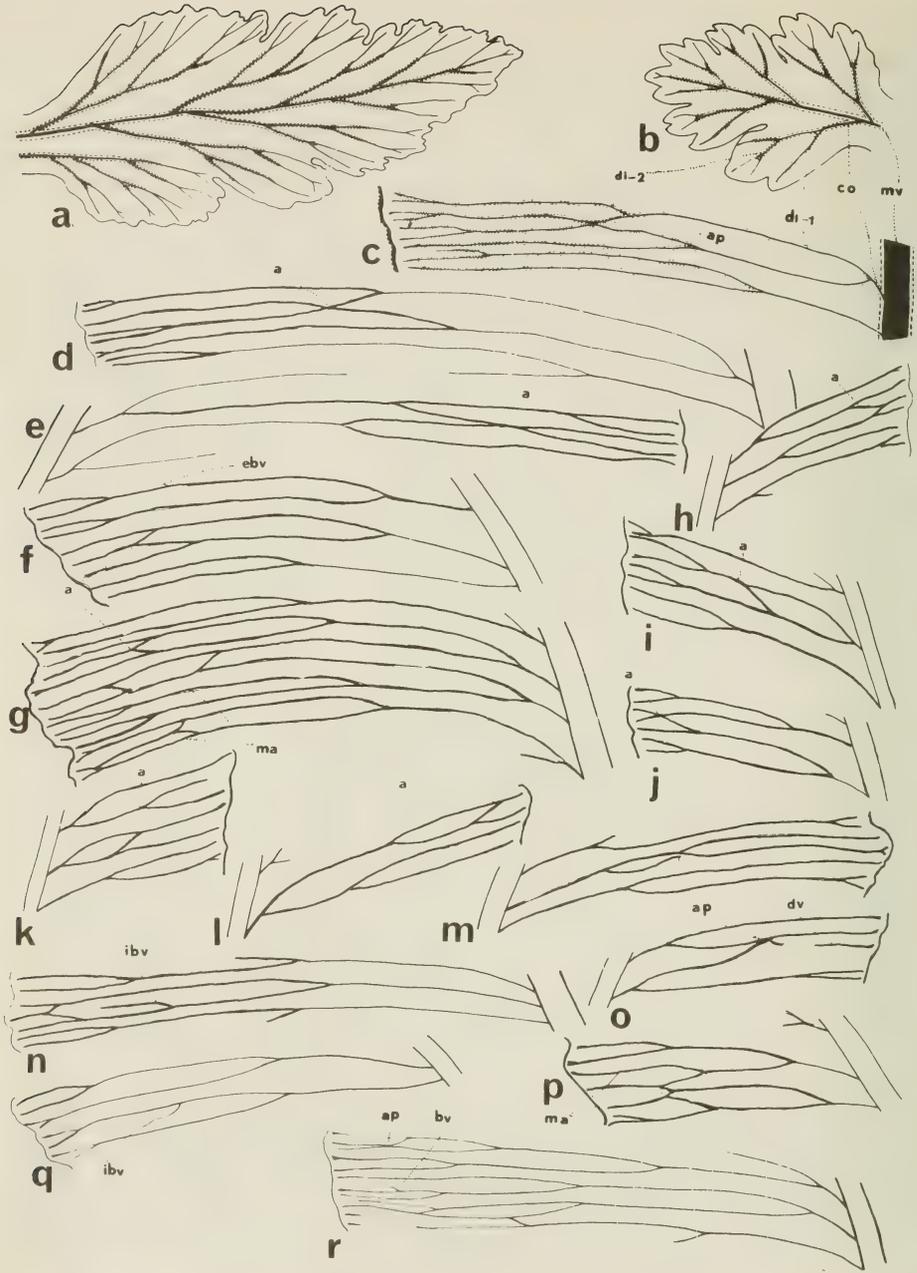


FIGURE 1, a-b, cleared pinnule of *Botrychium ternatum* and *B. lanuginosum* showing dichotomous venation; c-r, portions of pinnae from different leaves of *Helminthostachys zeylanica*: c, approximation to anastomosis type 1a; d-e, anastomosis types 1a and 1b; f, anastomosis type 2a and an extrusive blind vein ending; g, anastomosis type 2b and multiple anastomoses; h, anastomosis type 2c; i-j, anastomosis types 3a and 3b; k-l, anastomosis types 4a and 4b; m, approximation to anastomosis type 4; n, anastomosis type 5; o, an approximation and a detached vein; p, multiple anastomoses and a blind vein ending. The broken line in a-c shows the bundle sheath. Codes: a, anastomosis; ap, approximation; bv, blind vein ending; co, costa, di-1, 1st order dichotomy; di-2, second order dichotomy; dv, detached vein; ebv, extrusive blind vein ending; ibv, intrusive blind vein ending; ma, multiple anastomoses, mv, mid vein; sa, secondary areole.

Approximations: At times, two veins in open dichotomous system deflect from their path to come nearer but do not show true union. They form intermediate stages between open venation and various types of anastomoses.

An approximation leading to the anastomosis Type 1a is illustrated in fig. 1c. Approximations shown in figs. 1m and o are formed by blind veins. They represent the intermediate stages before the anastomosis Type 4. An arcuate vein of second order dichotomy and a branch from the contiguous dichotomy forming an approximation are shown in fig. 1r.

Blind Vein Endings and detached veins: Intrusive (figs. 1q, r) and extrusive (fig. 1f) blind vein endings relating to various orders of dichotomies seem not uncommon, and have twice been seen to intrude into an areole (fig. 1n). A few detached veins, mostly present near the margins of pinnae, were also observed (fig. 1p).

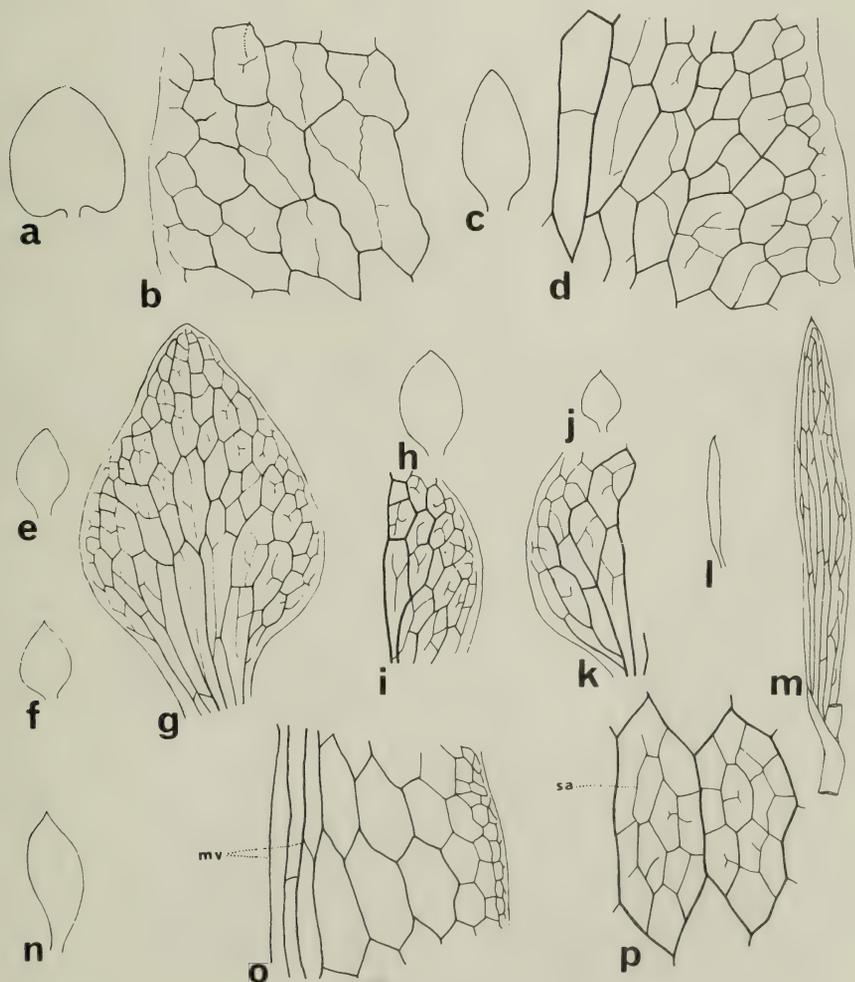


FIGURE 2. Tropophyll outlines and venation in *Ophioglossum*: a-b, *O. reticulatum*; c-d, *O. petiolatum*; e-g, *O. nudicaule*; h-i, *O. thermale*; i-k, *O. lusitanicum*; l-m, *O. oramineum*; n-o, *O. costatum* showing primary areoles only; p, *O. costatum*, two primary areoles magnified to show secondary areoles.

TABLE 3
TROPOPHYLL ARCHITECTURE IN DIFFERENT SPECIES OF
OPHIOGLOSSUM AND DIFFERENT TROPOPHYLLS OF *O. NUDICAULE*

No. Taxa	Leaf-shape	Leaf-apex	Leaf-base	Leaf area in mm ²	Average size of Areole	Areoles/ mm ²	Veinlets in Areoles /mm ²	Veinendings /mm ²	Absolute no. of veinendings	Absolute no. of veinlets
1. <i>O. costatum</i>	Ovate to Obovate	Acute to Obtuse mucronate	Cuneate	384.0	0.594	1.682	0.619	0.760	292.0	646.0
2. <i>O. graminium</i>	Narrow- Elliptic	Acute or attenuate	Slightly cuneate	20.4	0.727	1.343	0.098	0.098	2.0	27.5
3. <i>O. lusitanicum</i>	Ovate, Elliptic or Oblanceolate	Acute, acuminate	Acute cuneate	41.3	0.848	1.177	0.339	0.436	18.0	48.7
4. <i>O. petiolatum</i>	Ovate	Acute	Acute to Obtuse	526.3	3.100	0.337	0.090	0.128	67.6	169.3
5. <i>O. reticulatum</i>	Oblong to wide ovate	Acute to Obtuse- blunt	Cordate or auriculate	1166.0	5.159	0.197	0.065	0.086	100.5	226.0
6. <i>O. thermale</i>	Elliptic to lanceolate	Acute to obtuse- mucronate	Acute to obtuse	81.7	0.918	1.090	0.501	0.722	59.0	89.0
7. <i>O. nudicaule</i>	Ovate	Acute to obtuse- mucronate	Acute or slightly cuneate	73.0	1.260	0.794	0.192	0.294	20.0	58.0
8. "	"	"	"	76.0	1.270	0.790	0.233	0.329	25.0	60.0
9. "	"	"	"	78.0	1.240	0.808	0.308	0.551	43.0	63.0
10. "	"	"	"	91.0	1.320	0.758	0.187	0.230	21.0	69.0

LEAF ARCHITECTURE AND VENATION IN RELATION TO SPECIES OF OPHIOGLOSSUM

In the species of *Ophioglossum* studied, minor variation in the leaf (tropophyll) architecture occurred sufficiently consistently to suggest that this should be recorded as possibly of diagnostic use between different species.

In all seven species of *Ophioglossum* included in this survey, the leaf (tropophyll) is simple with entire margins. But it shows variations in shape and size, as well as base and apex form, from species to species (see Table 3 and figs. 2a, c, e, f, h, j, l, n). Major venation in all the species is palmate, for more than one primary vein of moderate thickness emerges from the base (figs. 2g, m). These veins follow a sinuous course and lose their identity well before the margins (figs. 2g, m) — hence they are reticulodromous. However, in *O. costatum* there are 2-4 prominent primary mid veins, one of which passes to the apex. Terminal veins just reach the margins (fig. 2o).

Primary areoles are formed by veins of 1° and 2°. Areoles formed in all the species are large, and are more or less elongated in the basal axial region and are smaller (and more tetragonal to hexagonal towards the margins — figs. 2g, i, k) except in *O. gramineum* where all the areoles are elongated (fig. 2m). The venation is double in *O. costatum* i.e., secondary areoles are regularly present (fig. 2p). Secondary areoles though formed, are also not frequent in all the other species (figs. 2b, d, g, i, k), except in *O. gramineum* where they are rarely observed (fig. 2m). Areoles are very large in *O. reticulatum* and *O. petiolatum*, large in *O. nudicaule* and smaller in the rest of the species (Hickey, 1973). The absolute number of areoles shows an approximate increase with leaf area in an individual species. The number of vein-islets per unit area of leaf however, seems fairly constant for each species (Table 3).

DISCUSSION

The importance of venation patterns on phylogenetic studies has been emphasised by Foster (1959, 1961, 1966, 1968) in the case of some Angiosperms. However, in Angiosperms there remains a controversy (Foster, 1968) whether the open, dichotomous venation is an archaic character (Lam, 1959; Subramanyam and Nair, 1972), or a result of reversion from a more complex vasculature (Foster, 1968).

Gymnosperms have retained in general, a primitive open dichotomous venation (Zimmerman, 1959). Arnott (1959) has cited various types of anastomoses in dichotomous venation of *Ginkgo* and stressed their pioneer role in reticulation.

Potonié (1912) has suggested that the predominantly reticulate venation seen in mesozoic plants has developed from the open dichotomous venation prevalent in palaeozoic floras by progressive vein unions. This view is supported by Bugnon (1925), Bower (1935) and Eames (1936), who considered open dichotomous venation to be characteristic of primitive living ferns and traced transitional stages between the dichotomous and reticulate venation in juvenile and successive adult leaves of some taxa. Foster (1961b) states that reticulate venation patterns probably originated independently from the open dichotomous venation of various lower groups of Pteropsida. Hara (1964) has traced the origin of reticulate venation in *Onoclea* by progressive vein-unions in open dichotomous venation. Bierhorst (1971) has also reported some anastomoses in dichotomous venation in the families Gleicheniaceae, Lygodiaceae, Cyatheaceae etc., and similar observations have been reported by Nair and Dass (1974a, b; 1977) in *Adiantum* and *Pteris*. These studies thus are in favour that in contrast to reticulate venation, open dichotomous venation is primitive.

The observations made here show that in *Botrychium*, which is said to be primitive, particularly regarding its sporophyte, there is an open dichotomous venation. In *Helminthostachys*, where the sterile lamina as well as fertile spike shows a step towards simplification, the presence of various types of anastomoses in nearly

70% of the leaves (with up to 12 anastomoses and 3 approximations in a single pinna and some areoles with intrusive veinlets) can be taken as signs of the initiation of reticulation. *Botrychium*, *Helminthostachys* and *Ophiglossum* thus form a progressive series with respect to their venation patterns.

Anastomoses have been differentiated as Greek alphabets (Melville, 1959), 5 types (Foster, 1966, 1968), 4 types (Arnott, 1959) and various types (Nair and Das, 1974a, b & 1977). In the present study major types 1, 2 and 3, 4 can be compared with types 1, 2 and 4, 5 of Foster. However, the fifth type where the areoles have an included blind vein ending, has not been reported so far in the open dichotomous venation of any plant. Subramanyam and Nair (1972) have even expressed doubt on the occurrence of such a type in plants possessing open dichotomous venations.

Systematic importance of the venation observed

It seems clear from this study that the venation pattern in the Ophioglossaceae differs substantially at generic level. In *Ophiglossum*, it is also of taxonomic significance even at specific level as the vein islet number in a unit area remains fairly constant for a species. Wherever venation features show some overlap between species, other characters of leaf architecture provide further specific diagnosis. In *O. thermale* and *O. lusitanicum*, for example, where there is an overlap in number of areole per unit area, the former species possesses a greater number of free veinlets which are usually bifid, compared with the latter. Thus the present study supports the views of the systematic importance of venation patterns in the Ophioglossaceae, in which other good characters are often rather few.

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- ARNOTT, H.J., 1959. Anastomoses in the venation of *Ginkgo biloba*. *Am. J. Bot.* 46: 405-411.
- BIERHORST, D.W., 1971. Morphology of vascular plants. The Macmillan Company, New York.
- BOWER, F.O., 1935. Primitive land plants. MacMillan & Co., London.
- BUGON, P., 1925. la dichotomie Cotyledonaire, caractere ancestral. *Bull. Soc. Bot. France.* 72: 1088-1094.
- CARLQUIST, S., 1961. Comparative Plant Anatomy. Hold, Rinchart and Winston, New York.
- EAMES, A.J., 1936. Morphology of Vascular Plants. MacGraw-Hill Book Company Inc. New York and London.
- FOSTER, A.S., 1952. Foliar venation in Angiosperms from an Ontogenetic standpoint. *Am. J. Bot.* 39: 752-766.
- FOSTER, A.S., 1959. The morphological and taxonomic significance of *dichotomous* venation in *Kingdonia uniflora* Balfour, F. et W.W. Smith. *Notes Roy. Bot. Gard. Edinb.* 23: 1-12.
- FOSTER, A.S., 1961. The phylogenetic significance of dichotomous venation in Angiosperms. *Recent Advances in Botany* 2: 971-975.
- FOSTER, A.S., 1966. Morphology of anastomoses in dichotomous venation of *Circaeaster*. *Am. J. Bot.* 53: 588-599.
- FOSTER, A.S., 1968. Further morphological studies on anastomoses in dichotomous venation of *Circaeaster*. *J. Arnold Arbor.* 49: 52-57.
- FOSTER, A.S., and ARNOTT, H.J., 1960. Morphology and dichotomous vasculature of the leaf of *Kingdonia uniflora*. *Am. J. Bot.* 47: 684-698.
- GUPTA, B., 1961. Correlation of tissues in leaves. 1. Absolute vein-islet number and absolute veinlet termination numbers. *Ann. Bot. (London)* 25: 65-70.
- HICKEY, L.J., 1973. Classification of the architecture of Dicotyledonous leaves. *Amer. J. Bot.* 60: 17-33.
- HARA, N., 1964. Ontogeny of the reticulate venation in the pinna of *Onoclea sensibilis*. *Bot. Mag. Tokyo.* 77: 381-387.
- LEVIN, F.A., 1929. The taxonomic value of vein-islet areas based upon a study of genera *Barsoma*, *Cassia*, *Erythroxylon* and *Digitalis*. *J. Pharm. Pharmacol.* 2: 17-43.

- MELVILLE, R., 1959. Leaf venation patterns and origin of Angiosperms. *Nature*, London 224: 121-125.
- MITTAL, P.L., 1968. Ferns and Fern allies of Rajasthan-III: Hitherto Unrecorded species of *Ophioglossum* from Rajasthan. *Bull. Bot. Surv. India*, 10: 171-176.
- NAIR, N.C., and DAS, A., 1974a. Studies on the venation pattern in ferns. I. Anastomoses in *Adiantum incisum* Forsk. (*A. caudatum* sensu Bedd. non Linn. pro parte). *Bull. Bot. Surv. Ind.* 15: 108-117.
- NAIR, N.C., and DAS, A., 1974b. Studies on the venation pattern in ferns. II. Further observations on *Adiantum incisum* Forsk. *Acta. Bot. Ind.* 6: 148-153.
- NAIR, N.C., and DAS, A., 1977. Studies on the venation pattern in Ferns IV. Additional observations on *Pteris vittata* Linn. (*P. longifolia* sensu Bedd. non Linn.). *J. Ind. Bot. Soc.* 56: 267-274.
- PANIGRAHI, G., and DIXIT, R.D., 1969. Studies in Indian Pteridophytes IV. The family Ophioglossaceae in India. *Proc. National Inst. Sci. India* 35: 230-266.
- POTONIÉ, H., 1912.* *Grundlinien der pflanzen morphologie im Litche der Palacontologie*. Jena.
- SUBRAMANYAM, K., 1969. Dichotomous venation in leaves of certain Indian Utriculariales, *Proceed. XI. International Bot. Congress Seattle (Abstracts)* 212.
- SUBRAMANYAM, K. and NAIR, N.C., 1972. Some aspects of dichotomous branching in certain Angiosperms. *Biology of Land Plant. Sarita Prakashan, Meerut (India)*: 90-99.
- TAYLOR, P., 1964. The genus *Utricularia* L. (Lentibulariaceae) in Africa (South of Sahara) and Madagascar. *Kew Bull.* 18: 1-245.
- ZIMMERMAN, W., 1959. *Die Phylogenie der Pflanzen*. Stuttgart.

* Not seen in original.

REVIEW

ILLUSTRATIONS OF PTERIDOPHYTES OF JAPAN, edited by Satoru Kurata and Toshiyuki Nakaike with the cooperation of the Nippon Fernist Club. 220 x 305mm. Vol. 1, 628 pp. (1979); Vol. 2, 646 pp. (1981). Tokyo University Press. ISBN 0 86008 289 X. Price 50 yen each vol.

These magnificent books illustrated by full page line drawings by various artists, but all to a very high standard, and a habitat photograph are something that all booklovers and fern enthusiasts will want to own. They are beautifully bound in simulated leather with a folded map of Japan in a holder on each back cover. Maps showing the dot-distribution in Japan are given for each taxon. Apart from the latin name of the species concerned all the text is in Japanese.

The drawings, which say a great deal, vary in their coverage. In some species, epidermes and stomata, T.S. of stipe and rhachis, scales and fertile leaf are drawn in close up. Some things are not drawn, however, which might have been, e.g. the sporangia and paraphyses in *Polypodium virginianum* and *P. vulgare* but as identification guides the figures say all that needs to be said. It is unfortunate that a few new nomenclatural combinations are made in this work, as they may get overlooked.

I sincerely hope the publishers will bring out an English edition; I am sure such an important work warrants it.

A.C. JERMY

SHORT NOTE

THE APPEARANCE AND DISAPPEARANCE OF A DRYOPTERIS
CARTHUSIANA COLONY

The following observations were made as part of the detailed recording (since 1965) of the flora of Perivale Wood Local Nature Reserve, Greenford, Middlesex.

Prior to 1974 no *D. carthusiana* (Vill.) H.P. Fuchs had been recorded in this 11 hectare area of ancient oak woodland & permanent pasture. In early 1972 some cans of fuel oil spilled into the feeder stream which supplied a small woodland pond and an area of wet woodland covering approximately 35 x 20 m. The vegetation of the area considered predominantly of *Salix cinerea* L., ssp. *oleifolia* Macreight, *Prunus spinosa* L., *Populus tremula* L., *Rubus fruticosus* agg., *Carex pendula* Huds., *Ajuga reptans* L., *Scutellaria galericulata* L., *Glechoma hederacea* L., *Impatiens glandulifera* Royle, *Epilobium angustifolium* L. and the moss *Plagiomnium undulatum* (Hedw.) Kop., which formed carpets to 12 cm high in places. A few *Dryopteris dilatata* (Hoffm.) A. Gray also occurred. The soil of the area was quite different from that of the rest of the wood, with no distinct A₂ horizon and much higher pH (7 surface readings in 1973 gave a range of 6.9 to 7.5; and in 1976 the range was 6.8 to 7.3). During 1974 three small but partially fertile sporophytes of *D. carthusiana* were found within the oiled area. During subsequent years more appeared within, and only within, the oil flooded area. The vegetation retained nearly all of its pre-1972 components, but all except *Plagiomnium undulatum* were somewhat reduced in vigour, and bare soil patches appeared. The extent of the flooded area and its associated thick brown oil was mapped and marked on the ground for future reference. In 1975 17 discrete individuals were located, and one of the 3 original plants had grown 25cm high x 50cm. 1976 saw an additional 10 plants, 1977, 18 more and 1978, 30 more. This total of 78 plants was not exceeded, and in fact numbers started to decline rapidly from 1979, until by 1981 just a single small individual survived for all the plants their demise followed a similar pattern, with only one or two fronds being produced after several years of apparent vigour (with 4 — 6 fronds), and these dying early, with the stock decaying visibly during the following summer. *Dryopteris dilatata* increased in numbers to 23 over this period, and to this day are healthy. The Perivale site has probably been flooded occasionally each year for decades, the only obvious difference in 1972 being the oil accompaniment. Enrichment of the site by water from an increasingly leaky canal may also have taken place, as the feeder stream runs, via a culvert under the canal. As the periphery of the area has become almost impenetrable in places since 1977, due to dense bramble and elm sucker growth, other individuals may have persisted, though some painful searches have not revealed any!

Similar oil contamination of a site 1 km away was also colonized by *D. carthusiana* from 1973 to 1979. No plants were recorded there in 1981, and the decline followed a similar pattern to that in Perivale Wood. Likewise there was only a single oil spill.

Has this rise and fall of the species been observed before? If so was any form of pollution or enrichment intimated? Perhaps a temporary competitive advantage was had by the fern? I would be pleased to hear from anyone who has observed anything similar.

REFERENCE

ROBERTS, K.A. and EDWARDS, P.J., 1974. The Flora of Perivale Wood Nature Reserve. *London Naturalist* 53: 34-51.

P.J. EDWARDS,
Royal Botanic Gardens, Kew.

A NEW CONCEPT OF DRYNARIOID FERNS

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ABSTRACT

Based on accumulated morpho-anatomical evidence, two new tribes of the subfamily Drynarioideae are proposed; Drynarieae with the genera *Drynaria*, *Photinopteris* and *Aglaomorpha* with *Aglaomorpha*, *Drynariopsis*, *Holostachyum*, *Merinthosorus*, *Pseudodrynaria*, *Thayeria*.

INTRODUCTION

The drynarioid ferns are an assemblage of large epiphytes of the Polypodiaceae family forming a taxonomically fairly discrete group. They are distributed from Africa and China to Australia and the Pacific islands. All the drynarioid ferns are distinguished by their creeping, fleshy, densely scaly rhizomes, specialisation of some of the entire fronds or bases of all fronds for collection and retention of detritus, texture and venation of the laminae, abscission of segments or pinnae from the rachises but not of stipes from the rhizomes (non-articulated fronds), and the possession of foliar nectiferous glands as translucent spots.

SYSTEMATIC POSITION OF THE DRYNARIOID FERNS

Several authors have given different treatments to the group as its systematic position is concerned. Christensen (1938) placed all the drynarioid ferns in the tribe Pleopeltideae of his subfamily Polypodiaceae under the Polypodiaceae. Ching (1940) included them in the tribe Phymatodeae of the subfamily Pleopeltioideae. Dickason (1946), Holttum (1947, 1954), Copeland (1947, 1960), Alston (1956), Pichi-Sermolli (1958, 1959, 1977), Mehra (1961) and Bierhorst (1971) amalgamated the tribes and subfamilies of Christensen (1938) and Ching (1940), and included the drynarioid ferns in the single large family Polypodiaceae near *Microsorium*. Nayar (1970, 1974) established a new subfamily Microsorioideae of the Polypodiaceae and included all the drynarioid ferns along with microsoroids in that new taxon. Recently, Crabbe *et al.* (1975) proposed a different classification in which drynarioid ferns were treated as a subfamily Drynarioideae of Polypodiaceae with out any further subdivision. Ching (1978) treated the drynarioid ferns as a very natural and distinct family Drynariaceae. In the present study, the classification of Crabbe *et al.* (1975) has been followed.

CONSTITUENT GENERA

In 1929, Copeland accepted five genera (*Aglaomorpha*, *Merinthosorus*, *Photinopteris*, *Thayeria*, *Drynaria*) and subdivided the genus *Aglaomorpha* into six subgenera (*Drynariopsis*, *Aglaomorpha*, *Psygium*, *Dryostachyum*, *Hemistachyum*, *Holostachyum*).

Later Ching (1940) recognized nine genera *Aglaomorpha*, *Drynaria*, *Drynariopsis*, *Dryostachyum*, *Merinthosorus*, *Hemistachyum*, *Holostachyum*, *Photinopteris*, *Pseudodrynaria*. Copeland (1947) and Ching (1978) accepted eight genera (*Drynariopsis*, *Pseudodrynaria*, *Aglaomorpha*, *Holostachyum*, *Thayeria*, *Merinthosorus*, *Photinopteris*, *Drynaria*). Crabbe, *et al.* (1975) accepted five genera (*Drynaria*, *Photinopteris*, *Merinthosorus*, *Aglaomorpha*, *Thayeria*). These genera are

considered to be of possible generic or subgeneric rank, but *Dryostachyum*, *Holostachyum*, *Drynariopsis*, *Pseudodrynaria* are tentatively reduced to *Aglaomorpha*. Recently, Pichi-Sermolli (1977) accepted nine genera, namely, *Drynariopsis*, *Pseudodrynaria*, *Dryostachyum*, *Holostachyum*, *Aglaomorpha*, *Thayeria*, *Merinthosorus*, *Photinopteris*, *Drynaria*. Thus, for the first time the drynarioid group was recognized as a conspicuous natural group of epiphytes (Crabbe, *et al.* 1975: p.147).

POSSIBLE GENERIC INTERRELATIONSHIPS

The drynarioid ferns are quite different from most other polypodiaceous ferns and have often been considered as one of the most controversial with regard to their interrelationship and evolution. Varied views on this have been expressed by Goebel (1928), Copeland (1929, 1960), Christensen (1938), Ching (1940), Holttum (1947, 1954), Nayar and Kachroo (1953), Nayar (1954, 1955, 1959, 1965), Zamora and Vargas (1973 a, b) and Zamora (1975).

In some cases, views expressed seem to have been based on a limited number of species or on selected morphological characters. An attempt has thus been made here to prepare a view of the interrelationships supported by a totality of evidence from as many morphological features of the plants as possible. The attributes included here are palea; rhizome; vegetative frond including epidermal cells, stomata, hypodermis, mesophyll, venation, fertile frond including sorus, sporangium and spores; and gametophyte.

The main details of several of these separate features have been published previously (see Chandra, 1978, 1979a, b, c, Chandra and Zamora, 1979), but the table attempts to draw a broad comparison between them, as a basis for the taxonomic and phylogenetic views derived (see Table 1).

On the basis of the evidence accumulated it is concluded that the contrasting combination of distinct characters and the degree of affinity (Table 1) among the drynarioid ferns supports the establishment of two natural, readily recognizable and definable groups, viz., *Drynaria* Group (*Drynaria*, *Photinopteris*) and *Aglaomorpha* Group (*Aglaomorpha*, *Drynariopsis*, *Holostachyum*, *Merinthosorus*, *Pseudodrynaria*, *Thayeria*). The affinity among some genera is clear, in others it is not so obvious consequently I prefer to limit myself to subdividing the subfamily Drynarioideae only into the tribes without any further subdivision and have adopted for them the names of Drynarieae and Aglaomorpheae. The purpose of the splitting of the drynarioid ferns was to give these two morphological groups a clearer place in the hierarchy of taxa.

Drynarieae. S. Chandra, *trib. nov.*

Rhizoma repente; frondes in dua serie alternate, stipitata; folia nidi forma typice praesens; hydathodus nullus; venatio reticulata, typice carens venulis inclusis liberis; sori typice punctiformes, totam frondem occupantes.

Typus: *Drynaria* (Bory, Pro sectione Polypodii in Ann. Sci. nat. 5; 464; 1825), J. Smith in J. Bot., London 4: 60; 1841).

Genera: *Drynaria* (Bory) J. Sm., *Photinopteris* J. Sm.

Aglaomorpheae S. Chandra, *trib. nov.*

Rhizoma repente; fronds in serie una, sessiles; folia nidi forma absentia; hydathodus typice praesens; venatio reticulata, areolae cum libra venula inclusa; sori typice non punctiformes, ad partem superiorem frondium restricti tantum.

Typus: Aglaomorpha Schott, Gen. Fil.: 20; 1834.

Genera: Aglaomorpha Schott, *Drynariopsis* (Copel.) Ching, *Holostachyum* (Copel.), Ching, *Merinthosorus* Copel., *Pseudodrynaria* (C.Chr.) Ching, *Thayeria* Copel.

These data have also helped to delineate possible lines of evolution and to comment on the relative primitiveness/advancement of the member of this alliance. These views are summarized in Fig. 1, in which the left-hand half presents an interpretation of the views of Copeland (1929, 1947) and the right-hand half the views proposed here, based on the above evidence.

TABLE 1
Distinguishing Features of the two groups of Drynarioid ferns

Attributes	Drynaria group	Aglaomorpha group
Paleae Structure	Peltate, lanceolate or shield-shaped. Marginal glandular hairs with cap-like waxy secretion	Peltate or basally attached, lanceolate or shield-shaped or ribbon-like. Marginal glandular hairs but without cap-like waxy secretion
Fronde Arrangement	Fronde in two alternating rows on the dorsal surface of the rhizome	Fronde in one row on the dorsal surface of the rhizome
Nest leaves	Present except in <i>Photinopteris</i>	Absent as a rule
Foliage leaves	Stipitate	Sessile except in <i>Aglaomorpha pilosa</i>
Hydathodes	Absent on the lamina surface except in <i>Photinopteris</i>	Present as a rule
Hypodermis	Absent in fronds except in <i>D. sparsisora</i> and <i>Photinopteris</i>	Always present
Stomatal Size	Varies from 29 μ x 38 μ to 42 μ x 54 μ	Varies from 27 μ x 32 μ to 34 μ x 42 μ
Stomatal Frequency	Varies from 39 to 79 per mm	Varies from 50 to 140 per mm
Epidermal Cell Size	Large	Smaller
Venation Pattern	Finely reticulate, free-included veinlets found only in few areoles except in <i>Photinopteris</i>	Broadly reticulate, free-included veinlets present in all the areoles
Nectary Type	Epicostular or Hypocostular	Always hypocostular
Leaf Shape	Fertile and sterile alike except in <i>Photinopteris</i>	Fertile frond more contracted than sterile one except in <i>Drynariopsis</i> and <i>Pseudodrynaria</i>
Sori Form and Distribution	Usually punctiform throughout the frond except in <i>Photinopteris</i>	Coenosoral or acrostichoid, only at the upper portion of frond except in <i>Drynariopsis</i> and <i>Pseudodrynaria</i>
Sporangial Size	Varies from 200 μ — 400 μ x 210 μ — 380 μ	Varies from 200 — 240 μ x 240 — 390 μ
Spore size	Varies from 26 — 42 μ x 40 — 70 μ	Varies from 26 — 36 μ x 42 — 56 μ

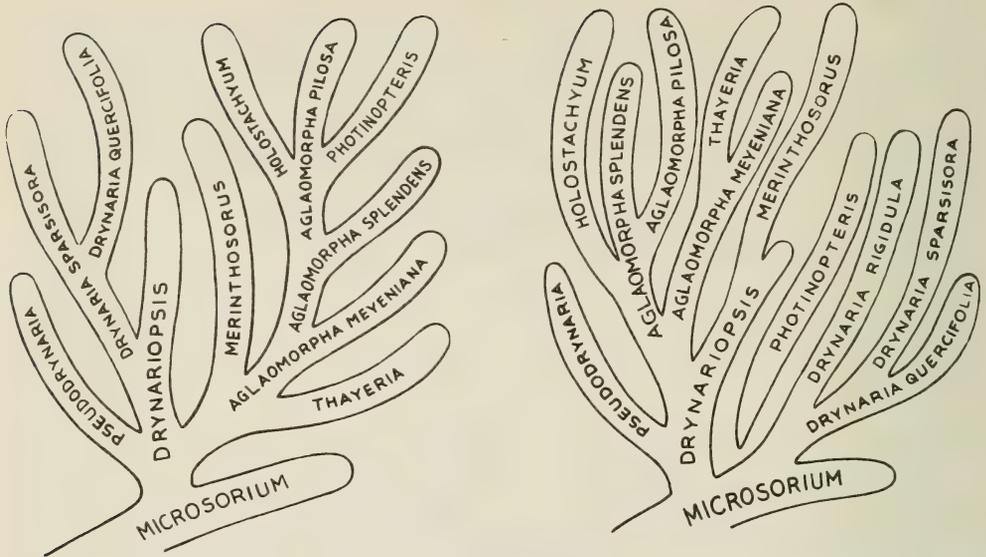


FIGURE 1. Schematic representations of the interrelationships of the drynarioid ferns; left, interpretation of the views of Copeland (1929, 1947); right, proposed revised scheme based on the evidence presented here.

ACKNOWLEDGEMENTS

It is pleasure to record here my gratitude to Dr. Prescillano M. Zamora, Professor, Department of Botany, University of the Philippines, Diliman, Quezon City, Philippines, for constant encouragement and helpful suggestions. Sincere thanks are due to Dr. Pablo K. Botor, Professor, Department of European Languages, University of the Philippines, for Latin rendering of the tribe descriptions, and to Dr. T.N. Khoshoo, Director, National Botanical Research Institute, Lucknow, India, for providing facilities.

REFERENCES

- ALSTON, A.H.G., 1956. The subdivision of the Polypodiaceae. *Taxon* 5: 23-25.
 BIERHORST, D.W., 1971. *The Morphology of Vascular Plants*. Macmillan Co., New York.
 CHANDRA, S., 1978. Morphology and Phylogeny of drynarioid ferns. Ph.D. thesis, University of the Philippines, Diliman, Quezon City (unpublished).
 CHANDRA, S., 1979a. Gametophyte morphology of the ferns genus *Drynariopsis* (Polypodiaceae). *Amer. Fern Jour.* 69: 111-118.
 CHANDRA, S., 1979b. Taxonomic use of foliar epidermis and hypodermis in drynarioid ferns. *Kalikasan: Philipp. J. Biol.* 8: 211-226.
 CHANDRA, S., 1979c. Morphological groups within the drynarioid ferns and their phylogenetic interpretation. Abstract: Third Indian Geophytological conference, Lucknow, Dec. 8-10.
 CHANDRA, S., and ZAMORA, P.M., 1979. Spore morphology in relation to taxonomy of drynarioid ferns. *Phytomorphology* 29: 252-255.
 CINGH, R.C., 1940. On the natural classification of the "Polypodiaceae". *Sunyatsenia* 5: 201-269.
 CINGH, R.C., 1978. The Chinese Fern Families and Genera: systematic arrangement and historical origin. *Acta Phytotax. Sin.* 16: 1-37.
 CHRISTENSEN, C., 1938. Filicineae, in Verdoorn, F., *Manual of Pteridology*. Martinus Nijhoff, The Hague.
 COPELAND, E.B., 1929. The Oriental Genera of Polypodiaceae. *Univ. Calif. Publ. Bot.* 16: 45-128.
 COPELAND, E.B., 1947. *Genera Filicum*. Chronica Botanica, Waltham, Mass., USA.
 COPELAND, E.B., 1960. Fern Flora of the Philippines 3: 377-555.

- CRABBE, J.A., JERMY, A.C., and MICKEL, J.T., 1975. A new generic sequence for the pteridophyte herbarium. *Fern Gaz.* 11: 141-162.
- DICKASON, F.G., 1946. A phylogenetic study of the ferns of Burma. *Ohio J. Sci.* 46: 73-108.
- GOEBEL, K., 1928. Morphologische und Biologische Studien XIII. Weitere Untersuchungen über die Gruppe der Drynariaceen. *Ann. Jard. Bot. Buitenz.* 39: 117-169.
- HOLTUM, R.E., 1947. A revised classification of leptosporangiate ferns. *J. Linn. Soc. Bot.* 53: 123-158.
- HOLTUM, R.E., 1954. *Ferns of Malaya*. Vol. II. The Ferns. Govt. Print Press, Singapore.
- MEHRA, P.N., 1961. Cytological evolution in ferns with particular reference to Himalayan forms. *Proc. 48th Indian Sci. Congr. Pt. II Section Botany*, 130-153.
- NAYAR, B.K., 1954. Studies in Polypodiaceae II: Contributions to the morphology of *Pseudodrynaria coronans* (Wall.) C. Chr. *Phytomorphology* 4: 379-390.
- NAYAR, B.K., 1955. The gymnogammoid and the pleopeltoid ferns: A summary. *J. Univ. Gauhati* 6: 47-62.
- NAYAR, B.K., 1959. Studies in Polypodiaceae VI: Further observations on the morphology of *Drynaria* Bory. *J. Univ. Gauhati* 9: 95-103.
- NAYAR, B.K., 1965. The gametophyte and juvenile leaves of the drynarioid ferns. *Bot. Gaz.* 126: 46-52.
- NAYAR, B.K., 1970. A phylogenetic classification of homosporous ferns. *Taxon* 19: 229-239.
- NAYAR, B.K., 1974. Classification of homosporous ferns Pt. II: pp. 111-201. In: B.K. Nayar and S. Kaur, Companion to R.H. Beddome's Handbook of the Ferns of British India. *Chronica Botanica*, New Delhi.
- NAYAR, B.K., and KACHROO, P., 1953. Studies in Polypodiaceae I: Contributions to the morphology of *Drynaria* Bory: *D. quercifolia* (L.) J. Sm. and *D. propinqua* (Wall.) J. Sm. *Phytomorphology* 3: 411-423.
- PICHI-SERMOLLI, R.E.G., 1958. The higher taxa of the pteridophyta and their classification, in Hedberg, O., *Systematics of Today*. Uppsala Univ. Arsskrift.
- PICHI-SERMOLLI, R.E.G., 1959. Pteridophyta, in Turrill, W.B., *Vistas in Botany*. Pergamon Press, London.
- PICHI-SERMOLLI, R.E.G., 1977. Tentamen pteridophytorum genera in taxonomicum ordinem redigendi. Appendix I et Appendix II. *Webbia* 31: 481-500.
- WAGNER, W.H., Jr., 1973. Some future challenges of fern systematics and phylogeny. *Bot. J. Linn. Soc.* 67; suppl. 1: 245-256.
- ZAMORA, P.M., 1975. Additional notes on the nectary-costule associations in drynarioid ferns. *U.S.T., J. Grad. Res.* 4: 31-33.
- ZAMORA, P.M., and VARGAS, N.S., 1973a. Notable variations in leaf forms of *Drynaria*. *Philipp. Agric.* 57: 55-71.
- ZAMORA, P.M., and VARGAS, N.S., 1973b. Nectary-costule association in Philippine drynarioid ferns. *Philipp. Agric.* 57: 72-88.

REVIEW

LIST OF THE TYPE SPECIMENS IN THE HERBARIA OF JAPAN. FERN FAMILIES by K. Iwatsuki 60 pp., 1981. Kyoto University. 257 x 180mm. Price not given.

The families listed are Lycopodiaceae, Selaginellaceae, Isoetaceae, Equisetaceae, Ophioglossaceae, Marattiaceae, Osmundaceae, Plagiogyriaceae, Gleicheniaceae, Schizaeaceae, Hymenophyllaceae, Cyatheaceae, Dicksoniaceae, Dennstaedtiaceae, Lindsaeaceae, Davalliaceae, Oleandraceae, Parkeriaceae, Vittariaceae, Pteridaceae, Aspleniaceae, Blechnaceae, Lomariopsidaceae. Full details of the type locality, collector, number and the herbaria where deposited are given. Kinds of type (syntype, isotype etc.) are given and in many cases lectotypes have been carefully chosen from among the syntypes. When the holotype appears to be lost a neotype has been selected.

A.C. JERMY

SHORT NOTE

MORPHOLOGICAL AND CYTOTAXONOMIC OBSERVATIONS ON AZOLLA PINNATA

Of the six extant species of *Azolla* (Hall and Swanson, 1968), *A. pinnata* R. Brown is distributed over large geographic areas. In a recent taxonomic revision of the *A. pinnata* complex, Sweet and Hills (1971) have segregated two varieties, *pinnata* and *imbricata*, exclusively based upon the morphological features of the vegetative organs of the sporophyte. They also observed that plants from India and Ceylon were of intermediate status between these two varieties. Thus their findings raise the question as to whether all the morphological features by which the varieties were recognized, are taxonomically reliable.

ECOLOGY

Azolla pinnata is an annual, free-floating fern. In the area under investigation, the young sporophytes, developed from embryos, can be found by October and the vegetative phase lasts for nearly 2 months. The sporocarp is formed well before the recession of water in early summer, whence the sporocarp-bearing plants undergo burrowing in dry, cracking soil, or are buried through agricultural practices in paddy fields. The total life-span of the sporophyte is thus about 5-6 months. This species has a normal sexual reproduction and, each population breeds freely for as many generations in a given locality as is permitted by inundation during the successive rainy seasons.

MORPHOLOGY

The morphological characters by which the two varieties were recognized by Sweet and Hills (1971) throughout the geographical range of the species are given in Table I. As a basis for this study, we have obtained plants from 20 different populations occurring over an area of 200 sq. miles of the Punjab Plains, northern India. From each population, 100 plants were sampled and analysed. From this large sample, the following account of the morphology of the plants was prepared:

Plants 1-2 cm wide, main axis pseudodichotomous, 2-5 leaves before the first lateral branch. Dorsal leaf lobe non-imbricate in the proximal part, slightly imbricate towards the distal part, lamina generally flat or only slightly curled, apex sub-rounded, hyaline of irregular width comprising 2-4 layers of radially-aligned, elongate cells (in sharp contrast to nearly equidimensional in var. *imbricata*), minutely serrate or undulate, pubescent in the basal half only, length-width ratio: 1.1-2.5 (Plate (1A-C)).

A comparison of this data with that of Sweet and Hills, shows that none of the populations examined, though widely separated from one another, fully resembles either of the varieties *imbricata* or *pinnata*. Also, our present data provides strong grounds for believing that most, if not all, of the features associated with the vegetative organs of the sporophyte are indeed plastic. Under experimental as well as natural conditions, we have found that plants show particular variation in having a dominant vs non-dominant main axis, dichotomous vs pinnate branch pattern, degree of leaf imbrication and flat vs curled lamina.

Each of these features can be modified by environmental factors, and especially by the degree of spacing of individuals in any population in the field. Plants around the peripheries of such populations, for example, often become more dispersed by wind currents and action of water birds, whilst those in the centres of colonies may remain densely-packed together.

We have verified this experimentally. We have found that individuals isolated from compact populations, when put into well-spaced conditions become laxer in

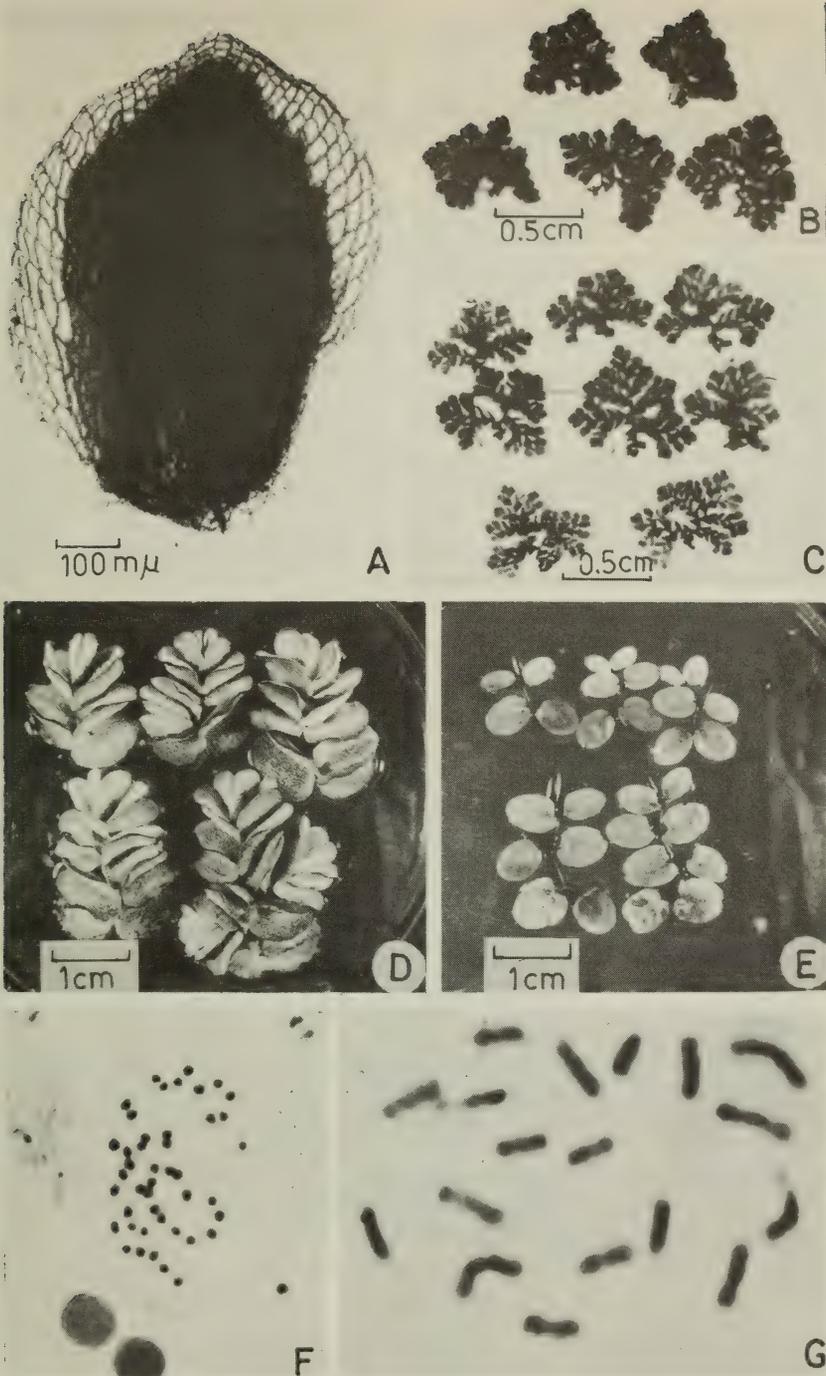


FIGURE 1. A-C, *Azolla pinnata*: A, cleared dorsal leaf lobe showing marginal features; B, C plants from compact (B) and from sparse population (C) after isolation - note the laxer branches and loss of imbrication in the latter case; D, E, *Salvinia auriculata* (= *S. molesta*), plants from compact population (D) and after isolation (E); F, *Azolla pinnata*, somatic metaphase from a leaf tip cell (fuelgen reaction stained) showing $2n=44$ chromosomes, $\times 1600$; G, *Salvinia natans*, somatic metaphase from a leaf tip cell (resorcin blue stained) showing $2n=18$ chromosomes, $\times 1900$.

TABLE I:
DISTINCTIONS BETWEEN VAR. *PINNATA* AND *IMBRICATA*

Character	Var. <i>pinnata</i>	Var. <i>imbricata</i>
1. Main axis	Dominant	Non-dominant
2. Branch pattern	Pinnate appearance	Dichotomous-like type
3. No. of leaves before the first lateral branch	4-16 (Average 8)	2-8 (Average 4-5)
4. Dorsal leaf lobe:		
a) Imbricate vs non-imbricate	Imbricate to highly imbricate	Non-imbricate to slightly imbricate
b) Length-width ratio	1.4-2.1	1.1-1.5
c) Flat vs curled	Curled	Flat
d) Apex	Acute	Rounded to sub-rounded
e) No. of hyaline cell layers	Up to 4	2-5
f) Width of hyaline margin	Irregular	Regular
g) Shape of hyaline cells	Elongate	Nearly equidimensional
h) Margin	Serrate	Smooth

growth and eventually appear pseudo-dichotomous or even pinnate. Similarly, the degree of curling of the lamina, is also markedly influenced, whilst the imbrication of the dorsal leaf lobe found in proximal portions of plants, becomes virtually absent and is only slightly expressed in distal regions (fig. 1B-C). The same is true for another free-floating fern, *Salvinia auriculata* Abul. (*S. molesta* Mitchell), examined by us (fig. 1D-E).

CYTOLOGY

Loyal (1958) reported that the gametic chromosome number of *Azolla pinnata* was $n=22$. The presence of $2n=44$ chromosomes in leaf tip cells of our material (fig. 1F) agrees with this.

A comparison of the chromosome size in *Azolla* and *Salvinia*, eg. *S. natans* (fig. 1G), seems to show a phylogenetic reduction within the Salviniaceae. Also, the correlation of reduced chromosome size with certain highly specialized features of *Azolla* eg. the megaspore apparatus, is consistent with the view of Moore (1968) that 'small chromosomes are frequently encountered in more derived plants than are large chromosomes'. The heterosporous genus *Selaginella* appears to present a remarkably similar correlation of reduced nuclear state and evolutionary specialization among the extant lycopods (Stebbins, 1966).

REFERENCES

- HALL, J.W. and SWANSON, N.P., 1968. Studies on fossil *Azolla*: *Azolla montana*, a cretaceous megaspore with many small floats. *Amer. Jour. Bot.* 55: 1055-1061.
 LOYAL, D.S., 1958. Cytology of two species of Salviniaceae. *Curr. Sci.* 27: 357-358.
 MOORE, D.M., 1968. The karyotype in taxonomy. In *Modern methods in plant taxonomy*. Edit. V.H. Heywood. Acad. Press, London and New York.
 STEBBINS, G.L., 1966. Chromosomal variation and evolution. *Science* 152: 1463-1469.
 SWEET, A. and HILLS, L.V., 1971. A study of *Azolla pinnata* R. Brown. *Amer. Fern Jour.* 61: 1-13.

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FIELD OBSERVATIONS ON THE NECTARIES OF BRACKEN, *PTERIDIUM AQUILINUM*, IN BRITAIN

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ABSTRACT

Although bracken, *Pteridium aquilinum* L., is a widespread weed of economic importance in Britain, little attention has been paid to the occurrence of nectaries upon it and their possible biological significance. Field observations are given of the structure, distribution, activity and variation of bracken nectaries as seen in Britain and some views of their possible taxonomic and ecological significance suggested.

INTRODUCTION

The presence of nectaries on the fronds of bracken, *Pteridium aquilinum* L., was recorded as long ago as 1877 by Francis Darwin. In addition to bracken, a very few other, unrelated, ferns in other habitats and parts of the world have also been reported to have nectaries (see, for example, observations and comments made by Schremmer (1969), Holttum (1968) and Paterson (1982)). These nectaries seem somewhat similar to the 'extra-floral nectaries' known more widely in flowering plants (eg Bentley, 1977). Further, Tryon (1941), Schremmer (1969) and Lawton (1976) have all also encountered the presence of arthropods, especially on young bracken fronds in association with these nectaries. However, despite these reports, remarkably little further attention seems to have been paid to their significance or their biology.

This paper reports some preliminary observations concerning the distribution of nectaries on the frond, their variation with habitat, time of functioning and morphological structure. Their occurrence on different forms of bracken has been studied on herbarium material on a world basis. Further a comparison is made between bracken nectaries and those of other members of the Hypolepidaceae and some views about the possible biological significance of these nectaries are discussed.

OBSERVATIONS

Constancy and distribution of nectaries

Examination of bracken fronds in Britain, through a wide range of localities and habitats from central Scotland to southern England, suggests that nectaries are to be found in all areas. Indeed, on all fronds, multiple nectaries of different sizes are present in the same characteristic position, but the degree to which these are developed varies somewhat with habitat (see below).

The main nectaries occur as sub-opposite pairs at the points of junction of the top of the stipe and the base of the midribs of the first pair of pinnae, on the under surface of the bracken frond. Thereafter, further sets of nectaries occur in similar positions at the junctions of each subsequent pair of pinnae with the rachis. The nectary pairs typically become progressively smaller towards the upper end of the frond, as the pinnae diminish in size.

A second set of nectaries occurs along the length of each pinna midrib, also on its underside. These occur at the junction of each pinnule midrib with the pinna midrib, thus mirroring in more reduced form, the positions in which they occur along the main frond axis. The total number of nectaries present on a single large bracken frond may thus be quite large, frequently more than fifty.

External appearance and anatomical structure of nectaries

All the nectaries seem to be of generally similar external appearance. The ones

situated on the pinna-rachis junction are usually the largest and most obvious ones, often 2-3 mm in diameter forming rounded, tear-drop or shield-shaped shining bald patches. When fresh, they are flat, slightly raised or somewhat bulging, and have a glabrous and minutely puckered, clear pale-green coloured surface, with a slightly translucent quality. They usually seem at their most conspicuous on fresh, young, expanding croziers in spring, when the rest of the surrounding areas of stipe and rachis are covered in a brownish-white pubescence (see Figs. 1 and 2). They become less distinct (though are usually still detectable) as the hairs are shed from the surrounding areas on the fully expanded frond. In spring and early summer, one or more minute, clear, colourless slightly sweet tasting droplets can often be found exuding from some of these areas. Anatomical investigations show the nectaries to be composed of small, isodiametric, parenchymatous cells, overlain by a particularly thin epidermis. These cells abut inwards on to parts of the stele, and merge into the vertically elongated cells of the cortex of the stipe and rachis. These small, parenchymatous cells, often with fairly dense protoplasmic contents, seem characteristic of secretory parenchyma as has been described in several flowering plants (eg Esau, 1965).

Variation in nectary development with habitat

Bracken colonies in Britain are typically most extensive in open areas of deep, well-drained, sandy soils, occurring through a wide range of altitude (eg Taylor 1980, Page 1982b). Less dense stands occur in a wide range of open, sandy woodlands and woodland margins, which before man's interference were probably their main original habitats (Page 1982a).

Field observations in Britain now show that although the position of nectaries is constant, their size and prominence varies with habitat. In some sites, poorly developed main nectaries can be less than 1 mm in diameter and nearly flush with the surface. In others, the main nectaries may exceed 5 mm and protrude considerably (by about 1 mm or more). Bracken in woodlands often has the least developed nectaries, whilst fronds in more open habitats frequently have the more prominent structures. The most conspicuous nectaries of all have been found in some sunny woodland margin sites, as well as in several open, sandy, habitats at low altitudes near the sea. In contrast, nectaries seem to show remarkably similar degrees of overall development in different fronds in any one site. Thus there seems to be a strong habitat correlation. It is hoped that a planned programme of transplant experiments may indicate how much of this variation is genetically determined, how much is environmentally induced, and what environmental correlations exist.

Seasonal variation in nectary activity

In the following observations, only those nectaries from which such sweet tasting droplets have been found to be exuding have been regarded as 'active'.

In all the bracken stands sampled for this purpose (principally in central and south-western Scotland and northern England), nectary activity occurs during the period of emergence of the fronds in late-spring to early summer. Such activity seems to be confined to this period, ceasing totally once the frond is fully expanded. Observations suggest that the nectaries mature and are active in succession, from the base of the frond upwards and outwards along each pinnule, with an overlap in the activity period between successive nectaries. Further, each main nectary pair appears to be active only during the period of expansion of its adjacent pair of pinnae, and to cease exudation and dry-up for good once these adjacent pinnae have become fully unrolled. Field estimates for the active life of each main nectary varied from about 6 to



FIGURE 1. Expanding fronds of Bracken, *Pteridium aquilinum*, with active nectaries. Cumberland, early June (Photo C.N. Page).



FIGURE 2. Expanding bracken fronds showing clearly the position of one of the paired nectaries adjacent to the lowermost pinnae. at this stage the nectary is about to become active. Cumberland, early June (Photo C.N. Page).

10 days, with the overall period of activity on one frond lasting probably 4 weeks or more.

Daily variation in nectary activity

There is considerable day-to-day variation. In general, the most regular nectary activity has usually been observed in the early morning, when bulging nectar droplets have sometimes been found to be present on almost every frond in a stand. These droplets have presumably accumulated slowly during the night so they are particularly apparent on cool, still, moist, dewy mornings. Their subsequent size diminishes with the increasing rate of evaporation.

Daytime observations on nectary visitors

Observations in Scotland and the north of England, made during the period of frond expansion, have shown that a considerable number of different insects are attracted to bracken nectaries. Passing insects generally seem to be most attracted to those nectaries which have obvious secretion of nectar. Very frequently, as fronds become more fully expanded, brown marks and scars can be found on the older nectary surfaces, presumably resulting from over-enthusiastic rasping or probing by insects. Ants have been observed to be very regular visitors to bracken nectaries in many sites. Additionally, small numbers of various flying insects (especially flies or beetles) have been seen flying directly to nectaries, and sometimes remaining there for many minutes.

Observations on *Pteridium* from other parts of the world

Herbarium material of *Pteridium* from most of its world range has been studied. However, as most herbarium material tends to be collected in mid to late summer after the fronds have fully expanded, the nectaries are much less distinct. This is accentuated by the necessary drying for preservation. Two other practical difficulties are encountered: *Pteridium* is usually extraordinarily poorly represented in most collections and when it is preserved, the pinna base and rachis are often absent. It is probably the combination of these factors which has made the presence of nectaries in dried *Pteridium* fronds so largely overlooked.

Nevertheless, wherever sufficiently well-preserved herbarium material has been found, it has been almost invariably possible to show that nectaries were present. Specimens from northern and central Europe, Japan, China, Himalayas, Malaya, Australia, New Zealand, central and southern Africa, eastern and western North America, West Indies, Central and South America show nectaries. Furthermore, there is also evidence of frequent physical damage to nectaries in herbarium specimens. This was presumably the work of insects while the fronds were alive.

These observations are supported for central Europe by Schremmer (1969) and for North America by Tryon (1941) and Victorin (1923). They also observed the fronds of local bracken stands to be visited in the spring by ants. It would be valuable to have further field evidence of nectary activity in expanding fronds of *Pteridium* from other parts of its range.

Observations on juvenile *Pteridium*

Fronds on most juvenile bracken plants look so totally unlike adult bracken that they could easily be mistaken for some other genus of fern. Their usually softly pubescent appearance, elongate frond shape, rounded segments and almost indefinite tip growth (see Page, 1982b), seem much more like specimens of tropical *Hypolepis* than those of adult *Pteridium*. Nevertheless even at the most early stages of sporeling development, small nectaries are regularly present in the same axillary positions as on adult plants.

Observations on other near-allies of *Pteridium*

Evidence of chromosome numbers as well as similarity of juvenile forms indicate the principal near-allies of *Pteridium* are most probably *Hypolepis* and *Paesia*, together constituting the fern family Hypolepidaceae (Page, 1976).

Examination of both living and herbarium specimens of *Hypolepis* and *Paesia* has failed to show any structures which could be regarded as nectaries. Therefore it seems likely that nectaries are confined to *Pteridium* in the Hypolepidaceae. Their presence thus seems to provide a useful diagnostic character for this genus, even in juvenile material and raises the question of their possible significance in relation to this genus' exceptional ecological success.

Comparison with cyanogenic properties of bracken stands

Research on bracken in Britain in recent years has shown that this plant can possess fronds which are cyanogenic and that stands of bracken differ in the percentage of cyanogenic and non-cyanogenic fronds present, even over quite small distances (eg Cooper-Driver & Swain, 1976; Cooper-Driver, 1978; Balick et al 1978). Field observations were made in an area of Kirkcudbright where both types of bracken were known to exist (Dyer, pers. comm.) Bracken fronds were tested for cyanogenic reaction (Jones, 1966) and for nectary activity. Nectaries were regularly found to be both present and active on cyanogenic as well as non-cyanogenic fronds.

The presence of active nectaries thus does not seem to be merely an alternative defence mechanism of young croziers which are lacking in cyanogenic properties. It seems to be a phenomenon of bracken populations generally.

POSSIBLE BIOLOGICAL SIGNIFICANCE OF NECTARIES IN BRACKEN

It is known that bracken fronds contain large numbers of toxic substances (eg Cooper-Driver, 1976). Lethal effects resulting from consumption of bracken fronds by such large herbivores as sheep, horses, pigs and cattle have been widely demonstrated by agricultural and veterinary scientists (eg I.A. Evans, 1976, 1982, W.C. Evans, 1976, Evans & Patel, 1972, Jarrett, 1982). There is evidence too, that the presence of some of these substances, eg tannins and cyanides, may actively deter grazing animals, including insects (eg Cooper-Driver & Swain, 1976, Cooper-Driver et al, 1977, Grierson, 1979).

There are indications too, from the above literature, that the levels of some of these toxic principles are greatest when the fronds are fully expanded. It has been suggested that ants attracted to the fronds by nectaries play a directly defensive role in protecting the succulent young fronds against herbivores. Lawton (1976: 205-6) summarised this as his "set a thief to catch a thief" principle, although he recorded finding no differences in average numbers of bracken-specific herbivorous arthropods on fronds with ants present compared with those on fronds without them. The observations made here also indicate that the ant numbers on fronds can frequently be few and often sporadic even at the most active nectary stages.

I want to suggest another strategy which might accrue from the presence of nectaries. By having fronds which produce such abundant nectar so early in the growing season, bracken could positively encourage ants to establish nests in its immediate vicinity. This could create frequent ground-patrols of ants throughout the whole area of bracken colonies, providing a strongly discouraging effect upon establishment of potential fern-herbivores such as slugs and snails or even against competing other plants. It seems possible that slugs and snails in particular might otherwise thrive beneath the dense, slowly-decaying litter layer of fronds that



FIGURE 3. Some insect visitors seen at bracken nectaries; and a click beetle (above) and seven-spot ladybird and a fly (below). (Photos C.N. Page & Susan Paterson).

accumulates annually. Such a strategy might help explain the particular success of bracken ecologically in warm, deep, sandy soils, so conducive to certain terrestrial ants.

It is hoped to initiate further research at Edinburgh on these biological aspects of this ecologically unusually successful fern.

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REFERENCES

- BALICK, M.J., FURTH, D.G. & COOPER-DRIVER, G., 1978. Biochemical and evolutionary aspects of arthropod predation on ferns. *Oecologia* **35**: 55-89.
- BENTLEY, B.L., 1977. Extrafloral nectaries and protection by pugnacious bodyguards. *Ann. Rev. Ecol. Syst.* **8**: 407-427.
- BRAID, K.W., 1959. Bracken — a review of the literature. Harley: Commonwealth Agricultural Bureaux.
- COOPER-DRIVER, G., 1976. Chemataxonomy and phytochemical ecology of bracken. *Bot. J. Linn. Soc.* **73**: 35-46.
- COOPER-DRIVER, G., 1978. Insect fern associations. *Ent. Exp. & Appl.* **24**: 310-316.
- COOPER-DRIVER, G. & SWAIN, A., 1976. Cyanogenic polymorphism in bracken in relation to herbivore predation. *Nature* **260**: 604.
- COOPER-DRIVER, G.A., FINCH, S., SWAIN, T. & BERNAYS, E., 1977. Seasonal variation in secondary plant compounds in relation to the palatability of *Pteridium aquilinum*. *Biochem. Syst. Ecol.* **5**: 177-193.
- DARWIN, F., 1877. On the glandular bodies on *Acacia sphaerocephala* and *Ceropia peltata* serving as food for ants, with an appendix on the nectar-glands of the common bracken fern, *Pteris aquilina*. *J. Linn. Soc. Bot.* **15**: 398-409.
- ESAU, K., 1965. *Plant Anatomy*. 2nd edition. Wiley: New York.
- EVANS, I.A., 1976. Relationship between Bracken and cancer. *Bot. J. Linn. Soc.* **73**: 105-112.
- EVANS, I.A., 1982. The carcinogenic, mutagenic and teratogenic toxicity of bracken. *Proc. Roy. Soc. Edin.* **81B**: (in press).
- EVANS, W.C., 1976. Bracken thiaminase-mediated neurotoxic syndromes. *Bot. J. Linn. Soc.* **73**: 113-131.
- EVANS, W.C., & PATEL, M.C., 1982. Acute bracken poisoning in homogastric and ruminant animals. *Proc. Roy. Soc. Edin.* **81B**: (in press).
- GERSON, U., 1979. The associations between pteridophytes and arthropods. *Fern Gaz.* **12**: 29--45.
- GLIESSMAN, S.R., 1976. Allelopathy in a broad spectrum of environments as illustrated by bracken. *Bot. J. Linn. Soc.* **23**: 95-104.
- HOLTUM, R.E., 1968. *Flora of Malaya*. Vol. II Ferns. Govt. Printer, Singapore.
- JARRETT, W.F.H., 1982. Bracken and cancer. *Proc. Roy. Soc. Edin.* (in press).
- JONES, D.A., 1966. On the polymorphism of cyanogenesis in *Lotus corniculatus* L. 1. Selection by animals. *Canad. J. Gen. & Cytol.* **8**: 556-567.
- LAWTON, J.H., 1976. The structure of the arthropod community on bracken. *Bot. J. Linn. Soc.* **23**: 187-216.
- PAGE, C.N., 1976. The Taxonomy and phytogeography of bracken — A Review. *Bot. J. Linn. Soc.* **23**: 1-34.
- PAGE, C.N., 1979a. The diversity of ferns. An ecological perspective. pp. 9-56 in Dyer, A.F. (Ed.). *The Experimental Biology of Ferns*. London: Academic Press.
- PAGE, C.N., 1979b. Experimental aspects of fern ecology. pp. 551-589 in Dyer, A.F. (Ed.). *The Experimental Biology of Ferns*. London: Academic Press.
- PAGE, C.N., 1979c. Macronesian Heathlands. pp. 117-123 in Specht, R.L. (Ed.). *Heathlands and Related Shrublands of the World*. The Hague: W. Junk.
- PAGE, C.N., 1982a. The history and spread of Bracken in Britain. *Proc. Roy. Soc. Edin.* **81B**: (in press).
- PAGE, C.N., 1982b. *The Ferns of Britain and Ireland*. Cambridge: Cambridge University Press.

- PATTERSON, S., 1982. Possible ant-involvement with several Tropical Rainforest Ferns. *Fern Gaz.* 12: 243-245.
- SCHREMMER, F., 1969. Extraruptiale Nectaries. Beobachtungen an *Salix eleagnos* Scop. und *Pteridium aquilinum* (L.) Kuhn. *Ost. bot. Z.* 117: 205-222.
- TAYLOR, J.A., 1980. Bracken: an increasing problem and a threat on health. *Outl. Agric.* 10: 298-304.
- TRYON, R.M.J., 1941. A revision of the genus *Pteridium*. *Rhodora* 43: 1-31, 32-67.
- VICTORIN, F.M., 1923. Les Filicinées on Quebec. *Contrib. Lab. Bot. Univ. Montreal* No. 2.

REVIEW

AUSTRALIAN FERNS AND FERN ALLIES by D.L. Jones and S.C. Clemesha. 232 pp., 297 figures, 60 colour photographs. 185 x 265mm. A.H. & A.W. Reed, Sydney, Wellington & London. 1980. ISBN: 589 50 26 54. Price: £13.95.

In a review in the *Fern Gazette* in 1977 (Vol. 11: 341-2) the first edition of this book was hailed as the first comprehensive guide to the whole of the Australian continent. This second edition which has benefited by the considerable interest generated by the earlier book, is even more comprehensive; some 47 new species of ferns are added bringing the total to 358 species in 108 genera. It is estimated that at least 20 species remain to be described.

The authors are good gardeners and have given us two good chapters on 'Cultivation' and 'Propagation'. Dave Jones, with whom the reviewer has had the pleasure of exploring the Queensland bush, is an acute ecologist who sums up the requirements of plants very quickly and this knowledge is given under each species throughout the book. *Dipteris conjugata* may, as Dave says, be "impossible to grow" but at least Kew has established two healthy, young plants recently. Fern allies, tree ferns, filmy ferns, 'oddities' (such as *Azolla*, Ophioglossaceae, Marsileaceae and *Schizeae*) are treated in separate chapters. The rest of the book covers genera and species alphabetically. Nomenclature is up-to-date and the majority of species are illustrated by David Jones' own line drawings and by Bruce Grey's superb colour photographs.

I found this book gave me immense pleasure to use in the field in Australia but it is also a book to browse and refer to here at home, especially when our Spore exchange contains so many of the species.

The publishers too, can be congratulated, not only on an attractive book but for printing a second edition so soon. There are a few mistakes, e.g. the legends of colour figs. 33 and 34 are switched and occasionally the authors cross-refer to synonyms instead of the correct name used in the text, when discussing closely related species under 'Confusing species' — which adds to the confusion! But these are minor points; we have a lot to thank these authors for, especially the encouragement they give to others.

A.C. JERMY

SHORT NOTES

ROOT CONNECTIONS IN A COLONY OF OPHIOGLOSSUM VULGATUM IN SOUTHERN ENGLAND

Since 1967 I have been observing *Ophioglossum vulgatum* L. in two pieces of old permanent pasture at Perivale Wood Local Nature Reserve, Greenford, Middlesex (v.c.21). The two pastures consist predominantly of *Cynosurus cristatus* L., *Alopecurus pratensis* L., *Festuca rubra* L., *Montia fontana* L. ssp. *amporitana* Senn., *Trifolium repens* L., *Ranunculus acris* L., *R. repens* L., *Lotus corniculatus* L., *Bellis perennis* L., and the moss *Calliergon cuspidatum* (Hedw.) Kindb. The pastures are 80 ft. above m.s.l. and are grazed by horses between May and October each year. They have apparently been grazed in this fashion for the last 60 years at least. The ground is often waterlogged between October and April.

The colony extends over most of the western pasture, and a smaller area of the eastern one (see Fig. 1). The number of fronds produced seems to vary widely from year to year, and in the western pasture has varied between 230 and 550, with only 1 — 2% of these being fertile in any year.

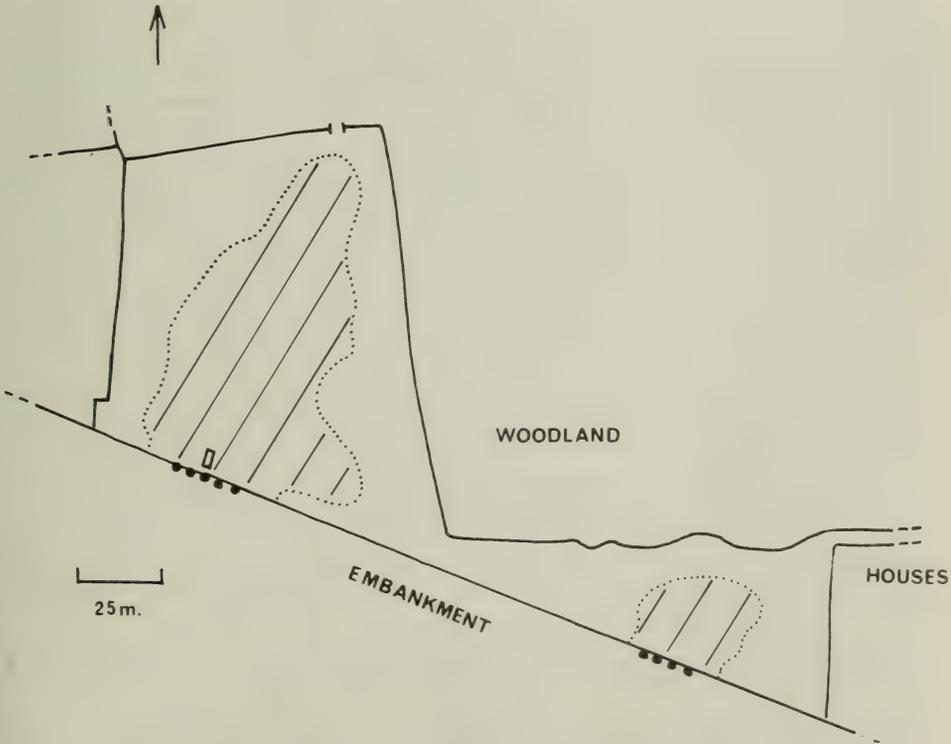


FIGURE 1. Showing the study area and extend of *Ophioglossum vulgatum* colonies. Hatched area: approximate extent of colony; large dots: groups of large fronded plants (protected from grazing).

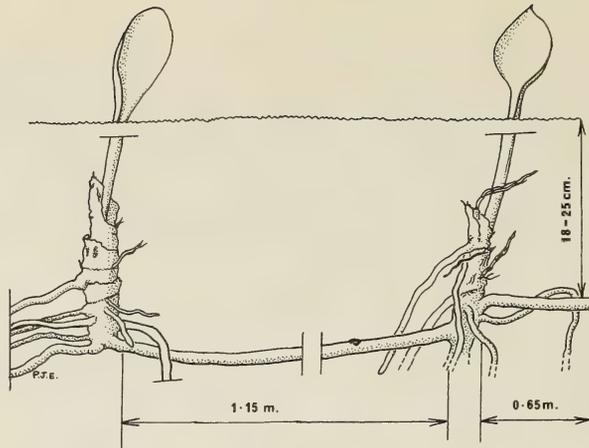


FIGURE 2. An excavated long-distance root connection between two rhizomes of *Ophioglossum vulgatum*.

During June 1978 hoof-cutting of the pasture by quarrelling horses provided a chance to gain some idea of what went on below ground as regards *O. vulgatum*. In a particularly densely cut (but not poached) part I examined some exposed rhizomes and roots of a patch of the fern occurring over an area of 2 m x 3.5 m. One of the 23 plants found was almost free of soil, and with careful teasing and turf-cutting with a knife I was able to clearly trace one of its intact yellowish-brown roots (Ogura, 1972) for 1.15 m to another rhizome with one leaf. The average diameter of this long-distance root was 2.1 mm (sample of 50 measurements using a fine micrometer, range 1.8 — 2.2 mm). No branching was found along the course of the root, but one incipient bud was. With further work I was able to follow a major root, from this second rhizome for a further 0.65 m northwards until I lost contact with it (see Fig. 2). On route, only 3 fronds were seen within 1 m either side of the "root-line". The course that the root followed was remarkably straight, and ran at a depth of 18 — 25 cm. I conjectured that there may just have been connections all the way to the seemingly isolated fronds up to 90 m north of the study area.

Further excavations of major root connections between rhizomes gave lengths of 0.2 to 0.55 m, but unambiguous contact with the roots was lost in all cases. The smaller, adventitious roots emanating from the rhizomes averaged 1.62 mm diam., in a sample of 100 (range 1.1 — 1.7 mm).

Just south of this study area of 2 m x 3.5 m is a hawthorn hedge with bramble scrub at the foot of a railway embankment. Up to 30 large fronds, mostly fertile, are found here each year. Conceivably these are connected with, and may just provide some sustenance to rhizomes in the pasture. The fronds of the latter regularly suffer full or partial decapitation each year.

As the interests of these fern colonies, and the state and composition of the turf are important considerations, I have not ventured to disturb the colony further.

REFERENCE

- OGURA, Y., 1972. *Comparative Anatomy of Vegetative Organs of the Pteridophytes*. 2 Ed. Berlin.
 ROBERTS, K.A., and EDWARDS, P.J., 1974. The flora of Perivale Wood Nature Reserve. *London Naturalist* 53: 34-51.

SHORT NOTES

OBSERVATIONS ON ANT ASSOCIATIONS WITH RAINFOREST FERNS IN BORNEO

The biology of myrmecophily, the association of ants with specialised 'ant-plants', has received considerable discussion in recent years (eg, Janzen, 1974; Huxley, 1980; Risch & Rickson, 1981). Although much of the attention has centred around flowering plant examples, these are paralleled by several ferns in which myrmecophilous associations with various species of ants are known. (eg, Yapp, 1902; Wagner, 1972; Gomez, 1974; Jermy & Walker, 1975).

Observations made during a visit to the Mt Kinabalu National Park and the Sandakan areas of Sabah, Malaysia during 1981, showed a number of possible cases of ant involvement with several other tropical ferns not normally considered to be myrmecophilous species. Ants tend to be both abundant and widespread almost everywhere within these tropical forests. However, in all the following cases particular fern species and often particular ants seemed to be associated in ways which seemed more than just accidental or casual. All concern ferns growing terrestrially or epiphytically in a variety of different types of vegetation, from altitudes just above sea level to about 5500 ft (c. 1538 m). Although these apparent ant-fern associations have been observed over a wide range of altitudes, they seem most apparent in the low altitude mixed Dipterocarp forests of Sabah.

The first case involves plants of *Platyserium*, in which ants seemed to be more or less permanently resident. The large, accumulating compost-masses of established epiphytic plants of this genus are previously known, in widely scattered places, to be the habitats of a range of animal life (including ants) and other epiphytic plants (Page 1979). Indeed it is possible, that the occurrence of ants within wild *Platyserium* specimens may be regularly the case. In Borneo, *Platyserium* normally occurs high in the rainforest canopy, but in the Sandakan area of east Borneo, specimens of *P. coronarium* (Koenig) Desv. could occasionally be found low enough on trees to be accessible for observation by climbing. Field observation showed these wild plants to regularly be the habitats of numerous small ants, each about 2.5 mm in length. A number of wild-originating *P. coronarium* clumps which had been brought into semi-cultivation low on trees at the Forest Research Centre Garden, Sepilok, near the edge of the Sandakan forest, gave opportunity for closer observation to be made of the ant-activities within these plants. Most plants (6 specimens) had been attached to garden trees in much the same condition as they had been found in the wild. These plants appeared healthy, and in all of them their ant colonies seemed still very active. In a seventh plant, attempts had previously been made to clear the clump of ants (for convenience in transportation) before being grown by brief immersion in water. Indeed, the treatment seemed to have worked, for no ants were found in this specimen, which also appeared in poor condition and, in contrast with the healthy specimens, had moss-covered basket leaves and crinkled spreading fronds, with evidence of herbivore attack. It is not possible to know if the demise in health of this particular plant was due to the lack of ants or to the treatment, but observations on the healthy ant-colonised specimens showed that one of the differences was that in these, the ants mined numerous tiny holes from the interior of each plant through the base of the clasping leaves to the outside. The ants then used the holes as entrance and exit points as well as using the gaps around the edges of the leaves. Such holes thus presumably provided better drainage to the nest and compost mass within the plant — perhaps to the plant's advantage in these areas of high and frequent rainfall. One other activity observed which relates to the morphology of the plant, was that the ants were often seen pulling their mandibles, from base to tip, over the white, stellate hairs on

the outer surface of the clasping leaves (see Holttum 1968: 139 for an illustration of these hairs), sometimes removing some of the hairs and carrying them back via the holes to the nest. The ants present in each *Platyserium* clump appeared to be a single species, and have been identified as *Pheidole* sp. (Myrmicinae).

The second case of apparent ant-involvement with a wild rainforest fern occurred in *Drynaria*. Two species of ant (*Crematogaster* sp. (Myrmicinae) and *Iridomyrmex* sp. (Dolichoderinae)) each about 3.5 mm in length, were sometimes found in more or less permanent association with plants of *Drynaria sparsisora* (Desv.) Moore, in low epiphytic sites. These two ant species also occurred widely through the Mt Kinabalu forests, as do many others, but only these species were found associating with this fern. Both seemed to form more or less passive and casual associations with *D. sparsisora* by colonising the small amounts of soil and debris collecting within its basket leaves. It is of interest to note in relation to these observations that Holttum (1968: 183) has previously recorded that *Drynaria quercifolia* and other species of this genus have nectaries on the lower surface near the base of the midrib of each lobe, seen as translucent spots in mature fronds.

A third, non-residential, type of possible ant-association was seen on occasion with mature plants of *Angiopteris* (Forst.) Hoffm. On this plant, when the spores were mature, black ants about 6 mm in length were found to be present on the fronds. Observation showed their interests to be mainly centred on dehiscing sori, from which the ants were found to be carrying away spores.

Also of interest were the activities of a large black ant, about 9 mm in length, which was found on several occasions in different places frequenting the fronds of *Nephrolepis hirsutula* (Forst.) Presl. These plants occurred mostly in roadside habitats and the ants were seen frequently on their fronds. Observations showed the ants not to pay much attention to the sporangia, but instead to be attracted to the row of small, white-coloured spots around the periphery of the pinnules of most fronds. These structures appear to be those described by Holttum (1968: 374) as hydathodes, each with a white scale, situated at a vein tip. The ants were seen here mainly at very hot times in the day.

The relationships between ants and ferns in rainforest thus seem diverse. These observations are, perhaps, not particularly exceptional, and observations elsewhere may well show other relationships between ants and ferns to exist. In each case observed here, particular species of ants seemed to associate with particular species of fern, and it is perhaps not unlikely that in the process, subtle biological advantages may be gained by each. In each case also, it seemed that the fern was providing something — a safe nesting place? food materials? nectaries? spores? hydathodes? — of immediate attraction to particular local ants. It seems not unlikely too that the fern is gaining some advantage out of these associations. Apart from the more or less physical change of having drainage holes put in the *Platyserium*, another advantage to all of the species may well be that by harbouring ant colonies or by encouraging ant visitations, additional protection from grazing animals might be gained. In the case of *Angiopteris*, or indeed, of the other species, it is not known whether the spores carried away ever germinated, and hence whether the ants might play any role in the local dispersal of the species. Such a possibility would need careful further experimentation.

Indeed the complexity of biotic inter-relationships around these ferns may not even end with ants. Observations suggest that the fern *Platyserium coronarium* also provides a home for a jumping spider, *Synemosyna formica* (Salticidae), which imitates an ant in its morphology and was seen to take the mutualistic ant as prey. Further, each *Platyserium* fern usually also had a lizard, a species of skink, associated

with it. These presumably also fed on the ants. Marking the skinks showed these animals to be highly territorial, each skink's territory associated with a particular *Platyserium* clump.

ACKNOWLEDGEMENTS

During the period of these observations, I was a member of Aberdeen University Expedition to Kinabalu, and would like to record my thanks to the expeditions sponsoring bodies, especially to the Weir Fund of Edinburgh University and Fauna & Flora Preservation Society, as well as to the Director and Deputy Director of the Sabah National Parks for supplying practical help in the field.

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REFERENCES

- GOMEZ, P.L.D., 1974. The biology of the potato-fern, *Solanopteris brunei*. *Brenesia* 4: 37-59.
 HOLTUM, R.E., 1968. *Flora of Malaya, Vol. 2, Ferns*. Singapore: Govt. Printer.
 JANZEN, D.H., 1974. Epiphytic myrmecophytes in Sarawak: mutualism through feeding of plants by ants. *Biotropica* 6: 237-259.
 JERMY, A.C., and WALKER, T.G., 1975. *Lecanopteris spinosa* — a new ant-fern from Indonesia. *Fern Gaz.* 11: 165-176.
 HUXLEY, A., 1980. *Biol. Rev.*
 PAGE, C.N., 1979. The diversity of ferns. An ecological perspective. pp 10-56 in Dyer, A.F. *The Experimental Biology of Ferns*. London: Academic Press.
 RISCH, S.J., and RICKSON, F.R., 1981. Mutualism in which ants must be present before plants produce food bodies. *Nature* 291: 149-150.
 WAGNER, W.H., 1972. *Solanopters brunei*, a little-known fern epiphyte with dimorphic fronds. *Am. Fern. J.* 62: 33-43.
 YAPP, R.H., 1902. Two Malayan myrmecophilous ferns, *Polypodium (Lecanopteris) carnosum* Blume and *Polypodium sinuosum* Wall. *Ann. Bot.* 16: 185-231.

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REVIEW

THE FLOWERING PLANTS AND FERNS OF ANGLESEY by R.H. Roberts. XV + 88 pp. 148 x 210mm. National Museum of Wales, Cardiff. CFI 3NP. 1982. Price £3.50 (£4.00 by post). ISBN 0 7200 0241 9.

R.H. Roberts, BSBI County recorder for Anglesey, and referee for *Polypodium* is no stranger to readers of the Fern Gazette. His studies in the *Polypodium vulgare* complex throughout Europe and Macronesia are well known and the Anglesey populations on the limestone of Plas Lligwy are indeed a challenge to any fern taxonomist.

The fern records up-date the BSBI/BPS *Fern Atlas* (1978) showing G. Maw's record of *Dryopteris aemula* of 1859 refound in 1979; a recent record (1976) at Mynydd Llwydiarth failed to get in the *Atlas* apparently. Both *Gymnocarpium* species and *Phegopteris connectilis* are missing — a challenge for the fern enthusiast but the stakes are high if RHR has looked already!

The author and the publishers who have kept this little book attractive but cheap, are to be congratulated.

A.C. JERMY

SHORT NOTES

ATHYRIUM GOERINGIANUM, A CONFUSED NAME

The long confused name *Athyrium goeringianum* (Kze.) Moore, has been investigated, with a view to establishing its identity. The plant concerned was described as *Aspidium goeringianum* by Kunze (1848) and was stated to have been collected in Japan by Goering, the type collection, a single frond, being in Kunze's herbarium. This was housed at Leipzig (LZ) before its complete destruction during the second world war; however a large number of duplicate types of Kunze's survive at Berlin (B), with a few at Kew (K), Geneva (G) and elsewhere. At Berlin Dr D.E. Meyer was able to establish (pers. comm. 1980) that there were no original specimens there, but that specimens of Goering numbered differently from the type number 115 and determined as *Asplenium goeringianum* by Kuhn and others, but not by Kunze, were all *Athyrium* species, which we have been able to identify as the Japanese species, *A. niponicum* (Mett.) Hance, *A. yokoscence* (Fr. & Sav.) Christ and *A. rupestre* Kodama, a somewhat widely differing selection which suggests some confusion. A similar situation exists at Kew and Leyden. But as Kuhn may have been expected to be generally familiar with Kunze's work and often made annotations on his specimens, it seemed likely that an *Athyrium* species was indeed the basis of *Aspidium goeringianum* and further information was sought in order to establish this. An illustration of *Asplenium goeringianum* (Kze.) Mett. by Mettenius (1866) was not sufficient to allow any precise identification and did not seem to fit any of the species mentioned with any degree of accuracy, though it is perhaps rather near to *A. iseanum* Ros., another Japanese species. However it is interesting that Mettenius was careful to distinguish between the true *A. goeringianum* (his fig. 11) and the *A. goeringianum* of other authors (his fig. 12). The former clearly has small, generally rounded indusia, becoming kidney-shaped and the latter has slightly more elongated indusia. The drawing of the type (but not fig. 12) would be more compatible with a *Dryopteris* than an *Athyrium* though it is impossible to be certain on the basis of this drawing. Although Mettenius had placed this species in *Asplenium*, his concept of that genus also included *Athyrium* species among other genera. Identification of *Aspidium goeringianum* as an *Athyrium* species was first put forward by Moore (1860), who made the necessary combination and, we now assume, may have been influenced by specimens sent from Berlin or elsewhere, and in all probability may not have seen Kunze's type because there was only the single frond at Leipzig. The evidence thus far in our investigation was therefore vague and indeed somewhat confusing.

We next turned our attention to Japanese fern works, the most outstanding of which, the detailed and accurate "Enumeratio Pteridophytarum Japonicarum" by Nakaike (1975), mentions the name *Athyrium goeringianum* and *Athyrium iseanum* as a name misapplied by various authors, but nowhere gives it in direct synonymy of any species or as a legitimate name. We were therefore most grateful to hear from Nakaike (pers. comm. 1980) why the name was not applied to any Japanese species. In common with other Japanese authors he was following Koidzumi (1929 and 1932), who had stated that *Aspidium goeringianum* was not a Japanese species at all, but must have been recorded from Japan in error, nor was it an *Athyrium*, but a *Dryopteris*. In his 1929 paper Koidzumi made the combination, *Dryopteris goeringiana* (Kze.) Koidz., and by great good fortune illustrated a photographic silhouette of the type in 1932, some ten years before its destruction at Leipzig. We designate this photograph as the neotype, as it is the only extant record of the single original specimen that can be accepted as certainly representing Kunze's concept. The photograph can be chosen as a type in accordance with the International Code of Botanical Nomenclature (Stafleu et al. 1978), article 9.1, and is accompanied by detailed drawings which depict the sori as

being circular and not somewhat elongated as would be expected in an *Athyrium* species such as *A. iseanum* or *A. niponicum*. Kunze himself does not mention the shape of the sori in his description, but stated that they are indusiate, a feature not drawn by Koidzumi but suggested by Mettenius' drawing; the fact that Kunze chose the genus *Aspidium* for this species implies that it had the rounded, kidney-shaped indusia characteristic of a *Dryopteris* species. On seeing Koidzumi's photograph, it was immediately possible to recognize it, not as the slightly similar *Athyrium iseanum*, but as a well-known North Chinese, East Siberian and Japanese species at present known as *Dryopteris laeta* (Kom.) C. Chr., described in 1901. This species has much coarser segments than an *Athyrium*, but has somewhat similar lowest pinnules, well developed on the basiscopic side of the pinnae, but reduced on both sides towards the bases of the lower pinnae. It was not known from Japan until 1949, well after the date of Koidzumi's publications and is rare there (see Tagawa 1949 and Hirabayashi 1974), which would explain his statement that it was an extra-Japanese species.

As Kunze's name is considerably earlier than Komarov's it now becomes necessary to refer to this *Dryopteris* species as *D. goeringiana* (Kunze) Koidz., Bot. Mag. Tokyo 43: 386 (1929) and it is clear that many earlier authors were mistaken in applying the epithet *goeringianum* to various *Athyrium* species, as confirmed by Nakaike.

This has considerable importance for British horticulturalists who have widely grown an *Athyrium* species labelled as *A. goeringianum* which contains some well-known varieties making fine and popular hardy garden-plants. Recently there has been some instability with regard to names since the Japanese rejection of the name has gradually become known, but the correct nomenclatural situation has not yet been clearly indicated. We therefore outline what we hope and expect will remain a stable situation.

The Japanese and East mainland Asian *Athyrium* commonly grown in European gardens should be known as *A. niponicum* (Mett.) Hance. The other more finely dissect species, *A. iseanum* Ros., to which the name *A. goeringianum* has been commonly applied in Japan, is seldom grown in European gardens. *A. niponicum* occurs in two varieties; first the type variety, var. *niponicum*, with a concolorous light green upper surface to the frond and a green or pink stipe and rhachis, and second the remarkable, var. *pictum* (Maxwell) Fraser-Jenkins, comb. nov. (*basionym*: *Athyrium goeringianum* var. *pictum* Maxwell, Gard. Chron. Agric. Gaz. 1867 (2): 25 (Jan. 1867); a clear description given in the editorial, by Maxwell who was the editor from 1865-1907, is sufficient to validate this name at the varietal rank, which the use of a trinomial in that periodical indicated. *Synonym*: *Athyrium niponicum* var. *metallicum* Makino, Bot. Mag. Tokyo 26: 178 (1912)). This has a rainbow effect of a pink and blue tinged central area to the upper surface of the lamina and pink costae and it appears spontaneously in an approximately 50% ratio in natural populations of the species throughout part, but not all, of its range in Japan. The varietal rank is chosen here as it is of widespread occurrence in natural populations and has some geographical distinction as well. It is neither a monstrosity, nor an unusual form. Some variation occurs in it with some plants being transitional towards var. *niponicum* and some being paler in colour than others. Nakaike (1975) also points out the existence of a cristate monstrosity grown in gardens (and doubtless there may be others), which should now be known as *A. niponicum* var. *niponicum* forma *cristato-flabellatum* (Makino) Namekata & Kurata.

It should be noted that *A. niponicum* has only one 'p', contrary to expectations.

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REFERENCES

- HIRABAYASHI, H., 1974. Cytogeographic studies on *Dryopteris* of Japan. Tokyo.
 KOIDZUMI, G., 1929. Contributiones ad cognitionem Asiae Orientalis; Bot. Mag. Tokyo 43: 386.
 KOIDZUMI, G., 1932. Plantae Japonicae Rarissimae vel Dubiae; Acta Phytotaxonomica et Geobotanica 1: 232-233.
 KUNZE, G., 1848. Pteridographia Japonica etc.; Bot. Zeit: L 1848: 557.
 METTENIUS, G., 1859. Ueber einige Farngattungen etc., VI. Asplenium: 198, n. 293, t.6, f.11-12.
 NAKAIKE, T., 1975. Enumeratio Pteridophytarum Japonicarum. Filicales: 133-134 and 138-140. Tokyo.
 STAFLEU, F., et al. (Ed.), 1978. International Code of Botanical Nomenclature; Lenigrad. Utrecht.
 TAGAWA, M., 1949. Fern Miscellany (2); J. Jap. Bot. 23: 77.

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REVIEW

SPORE FLORA OF TAIWAN by Tseng-Chieng Huang. 111 pp., 120 plates. 1981. 200 x 268mm. National Taiwan University. Obtainable from author at 24, Alley 3, Lane 30 Chou-shan Road, Tapei, 106 Taiwan. Price US \$35.

In this book the spores of 159 genera and 535 extant species are described and the locality and collector and number given for each voucher. The descriptive terms are typically those used by palynologists using light microscopy and I suspect contain descriptions of artifacts as seen under the light microscope. Their pictures are given on the plates varying from five to 17 per page. As photomicrographs go they are good but SEM micrographs could have been so much more useful. A list of the Miocene spores described from Taiwan is added. There is a very interesting illustrated glossary of terms used including a dichotomous key to sculptural patterns.

A.C. JERMY

THE FERN GAZETTE

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Back numbers of the *Gazette* and *Bulletin* are available for purchase from Dr. B.A. Thomas, (address above) from whom further details can be obtained.

AN ECOLOGICAL SURVEY OF THE FERNS OF THE KILLARNEY DISTRICT, CO. KERRY, IRELAND

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ABSTRACT

A systematic list of the ferns and fern allies of the Killarney region of Co. Kerry, Ireland (parts of v.-c. H1 and 2) is given based mainly on records made in 1980 and 1981 by the author. This includes notes on the distribution, abundance and habits of the taxa. The list includes 41 species, hybrids and subspecies. Notes are also given on all other fern taxa recorded for the area. The records made by the author include the first Irish record for *Dryopteris affinis (pseudomas) ssp. stillupensis*; the first records for the area of *D. oreades* and *Polypodium xmantoniae*; and the first records since 1950 for *Ophioglossum vulgatum* and *Oreopteris limbosperma*. The status of doubtful species in the area is discussed: *Equisetum xmoorei* and *Dryopteris expansa* are rejected as errors for other species; while no conclusion is reached about the presence of *Selaginella selaginoides* and *Gymnocarpium dryopteris* in the area. The phytogeographical affinity of the flora on a European basis is described by dividing it amongst the floristic elements of Birks (1976). The flora consists mainly of widespread species, species with southern and oceanic affinities and a few species with montane or arctic/alpine affinities.

INTRODUCTION

The Killarney district in Co. Kerry is one of the more interesting areas for ferns in the British Isles being a mountainous area on the extreme south-western seaboard. The actual area studied is shown on Figure 1, the boundaries being defined by grid-lines of the Irish national grid. This area lies approximately at latitude 52°N and longitude 10°W and includes parts of two vice-counties, H1 South Kerry and H2 North Kerry. Although Co. Kerry is a maritime county only very short stretches of coast were included in the survey area, and these were estuaries. These stretches were to the north-west of Killorglin and to the south of Kenmare.



FIGURE 1. The Killarney district surveyed. B: Barraduff, Ct: Carruntoohil, Cw: Carrigawaddra, Kg: Killorglin, Kv: Kilgarvan, MM: Mangerton Mountain, PeM: Peakeen Mountain, PM: Purple Mountain, TM: Tomies Mountain.



FIGURE 2. Killarney Woods.



FIGURE 3. Typical upland vegetation.

The topography of the area is dominated by a series of parallel ridges and valleys running east-west. These owe their origin to differential denudation of rocks thrown into anticlines and synclines by Armoracian folding (Aalen, 1978). Softer Carboniferous rocks were mostly removed to produce the valleys, leaving the older, more resistant Old Red Sandstone upstanding to form the ridges. These ridges include large areas of land over 300m (1,000 ft), a number of mountains over 600m (2,000 ft) and the Macgillycuddy's Reeks. The Reeks are the highest range of mountains in Ireland, with the highest peak in Ireland at 1,022m (3,414 ft) in Carrauntoohil. Glaciers in more recent times have accentuated this ridge and valley topography by deepening valleys and steepening cliffs. Overall this area is one of great contrasts from flat, well-wooded valley bottoms (Figure 2), at sea-level to bare, exposed mountain tops which are just shattered piles of rock. In between the majority of the area consists of rough hillsides with occasional boulders and outcrops of rock (Figure 3). Apart from this area of high ridges and low valleys, there is an area of generally lower, flatter topography in the north of the region. This area extends from north of Barraduff and Killarney to Killorglin. It drops gradually from around 210m (700 ft) in the east to near sea-level in the west. This area is covered in glacial drift and is a region of low undulating hills with large areas of poorly-drained land between. Throughout the region there are numerous lakes at all altitudes mostly due to the action of ice. Included in these are the famous lakes of Killarney.

Due no doubt to the rich fern flora of the area, the area has been better studied than most areas of Ireland. There are numerous references in the literature at the end of the last century and the beginning of the present one to the ferns of the area (Bouskell, 1905; Hind, 1857 and Rasor, 1882) culminating in Scully's (1916) flora of Kerry. In the present century there has been somewhat of a lull in references to the ferns and flora of the area until recently when there has been an upsurge of interest (O'Mahony, 1980 and Curtis and Mhic Daeid, 1981).

METHODS

The records made in this survey were all made in the summers of 1980 and 1981 for the area defined in Figure 1, with most of the recording for areas over 300m carried out in 1981. Records were collected on the basis that two or three examples of each major habitat Type (Table 1) were visited in each 10km grid square. In each habitat a subjective estimate of the abundance of every fern present was made on the Dafor scale. If a habitat extended over more than one kilometre square, a separate record was made for each. Similarly if a habitat extended over a range of more than 75m, a separate record was made for each 75m altitudinal range. If during visiting one habitat, other major habitats were encountered, records were also made for these. Habitats were selected either because there were old records for the sites or because they looked promising on maps or on the ground. Where habitats contained no ferns, no records were made. In all, records were collected from some 200 altitudinally-limited monads, but due to the non-systematic nature of the survey there are a number of forms of bias in the results. The two major ones are: a bias towards monads near roads and buildings, and a bias to monads containing old records or ones that looked superficially interesting. Where the ecological or geographical distribution of taxa is discussed below, attempts have been made to correct for these forms of bias.

A survey was also made of the major works and data banks which contain fern records for the area. These included Jermy *et al.* (1978), the Biological Records Centre, Monk's Wood, England and Scully (1916). The herbarium at the British Museum (Natural History) (BM) was also examined for specimens from the area.

Table 1 : Fern taxa recorded for the Killarney Area

Table includes all taxa recorded for the study area, those recorded in present survey are marked !, those for which only pre-1950 records exist are enclosed in round brackets () and those for which only doubtful records exist are enclosed in square brackets []. Numbers in brackets refer to floristic elements in Table 3.

<i>(Lycopodium clavatum)</i> (5)	<i>Oreopteris limbosperma</i> (3)
<i>(Lycopodiella inundata)</i> (7)	<i>Asplenium scolopendrium!</i> (3)
<i>Huperzia selago!</i> (5)	<i>(A. x confluens)</i>
<i>(Diphasiastrum alpinum)</i> (8)	<i>A. adiantum-nigrum!</i> (3)
[<i>Selaginella selaginoides</i>]	<i>A. onopteris!</i> (1)
<i>S. kraussiana!</i>	<i>A. marinum</i> (2)
<i>Isoetes lacustris!</i> (7)	<i>A. trichomanes</i> agg! (6)
<i>I. echinospora</i> (7)	<i>ssp. quadrivalens</i>
<i>Equisetum hyemale</i> (5)	<i>A viride!</i> (7)
[<i>E. x moorei</i>]	<i>A ruta-muraria!</i> (6)
<i>(E. x trachyodon)</i>	<i>A. ceterach!</i> (3)
<i>(E. variegatum)</i> (7)	<i>Athyrium filix-femina!</i> (5)
<i>E. fluviatile!</i> (5)	[<i>Gymnocarpium dryopteris</i>]
<i>E. arvense!</i> (5)	<i>Cystopteris fragilis!</i> (5)
<i>E. x litorale!</i>	<i>Polystichum lonchitis</i> (7)
<i>(E. sylvaticum)</i> (5)	<i>P. aculeatum!</i> (3)
<i>E. palustre!</i> (5)	<i>P. x bicknellii</i>
<i>E. telmateia</i> (3)	<i>P. setiferum!</i> (2)
<i>(Botrychium lunaria)</i> (5)	<i>Dryopteris oreades!</i> (3)
<i>Ophioglossum vulgatum!</i> (6)	<i>D. filix-mas!</i> (6)
<i>Osmunda regalis!</i> (3)	<i>D. affinis!</i> (3)
<i>Hymenophyllum tunbrigense!</i> (4)	<i>ssp. stillupensis!</i>
<i>H. wilsonii!</i> (4)	<i>ssp. borneri!</i>
<i>Trichomanes speciosum!</i> (4)	<i>ssp. affinis!</i>
<i>Polypodium vulgare!</i> (6)	<i>(D. remota)</i>
<i>P. interjectum!</i> (3)	<i>D. aemula!</i> (4)
<i>P. x mantoniae</i>	<i>D. carthusiana!</i> (5)
<i>P. australe!</i> (2)	<i>D. dilatata!</i> (3)
<i>Pteridium aquilinum!</i> (6)	[<i>D. expansa</i>]
<i>Thelypteris palustris</i> (6)	<i>Blechnum spicant!</i> (3)
<i>Phegopteris connectilis!</i> (5)	<i>Pilularia globulifera!</i> (3)

The bedrock of the ridge and valley area is mainly hard sandstone and conglomerates with thin occasional beds of shale of Devonian age (Wright, 1927). The only igneous rocks in this area are small areas of Felsite below Mangerton Mountain (Scully, 1916). There are also areas of glacial deposit of the same rock types, and small patches of Carboniferous Limestone in the Roughty Valley and around Lough Leane and Muckross Lake. The lowland area to the north is almost entirely covered in peat and drift derived from similar acid rocks to those that form the majority of the uplands to the south.

The upland area was sufficiently high for ice sheets to have formed on it in at least two periods during the recent ice-age (Mitchell, 1976). These ice sheets formed the glaciers that deepened the valleys and deposited the drift deposits on the lowlands to the north. In the times of these ice sheets some mountain tops protruded through the ice to form nunataks and the sea-level was much lower. These ice sheets scraped the soil from much of the upland area leaving just bare rock or shattered piles of rock fragments. Elsewhere in the area, particularly on the shallower slopes, blanket peats have formed since the ice retreated. Where mineral soils are present they are gley-podzols and brown podzolic soils (Ryan, 1963) which are poorly drained and acidic. In the lowland area to the north there are either peats, or acid brown earths (many with gleying), gleys and podzolised gleys (Ryan, 1963). These are again mostly poorly drained and acidic.

The climate of the area is described in Scully (1916) and Aalen (1978), the main features of which are dampness and mildness. The rainfall is high at about 200mm (80 inches) per annum at 18m in the upland area rising to 250mm (100 inches) per annum and more on the mountains, but falling to only 100mm (40 inches) in the lowlands to the north. This rainfall is spread through the year with about 250 raindays. The mean air temperature is 6.0-7.0°C in January and 15.0-15.5°C in July. Frosts are rare at low altitudes but become commoner at high altitudes.

The potential vegetation of the area at lower altitudes is mostly oak wood, which would have been similar to the remaining native forest vegetation in the Killarney district described by Kelly (1981). This would have covered all the lowlands except where impeded drainage allowed carr woods, dominated by alder to develop, or peat bogs. The natural altitude limit of forests in the area is uncertain but they would have given way on the hills, before clearance, to blanket peat and heather moors. These in their turn would have been replaced by open, rocky communities on the hill tops. This natural vegetation of the area has been greatly modified by man, particularly at lower altitudes. In particular the woods have been cleared to form mostly damp pastures leaving only patches of native woods around the Killarney lakes. Many of the peat bogs and blanket peats have been cut for fuel and the heather moors in many cases have been grazed to form further grasslands up to c. 450m (1,500 ft). However, the cutting of the forests has in some areas allowed blanket peats to spread (Aalen, 1978). The advent of man in the area has produced other habitats some of which are suitable for ferns, in particular, the shrub-topped hedgebanks and stone walls around fields and buildings. Man's influence has not altered the numerous lakes in the area much as yet, except by clearing the vegetation back from the banks forming stoney shores.

The vegetational history of the lowlands of the area since the last ice age has been examined in the peat bogs of the area (Jessen, 1949 and Watts, 1963). These studies have demonstrated that the vegetational history of the area has in general terms been the same as the rest of the British islands. That is open tundra type vegetation after the retreat of the ice, followed by the invasion of trees to form woodlands. These were at first dominated by birch, but this was replaced by pine which in its turn was replaced at the oak and birch of the woods we now consider the native vegetation of the area.

RESULTS

These are presented in two main ways, the systematic list described the status, ecology and distribution of all fern taxa recorded for the area, while Table 2 summarises the frequency of the commoner taxa in the commoner habitats. The possible origins of the flora and its biogeographical affinities are discussed in the

summary section at the end. Nomenclature follows Jermy *et al* (1978), but *Dryopteris pseudomas* has been changed to *D. affinis* and *D. austriaca* to *D. dilatata*; and *Thelypteris palustris* has been reinstated.

SYSTEMATIC LIST OF TAXA

Each taxon recorded during the survey is given with notes on (a) its geographical distribution, (b) its habitats, growth and ecology and (c) its altitudinal range, as recorded in the survey. Where a taxon was recorded in only a few monads, an entry is given in the form (a-c) followed by notes on the individual occurrences. Reference in this list to abundance in habitats refers only to abundance in examples of the habitat where the species occurred, how frequent the species was in the habitat type can be seen from Table 2. Notes are also given for significant extensions to (a), (b) and (c) from other sources, particularly post-1950 10km grid square records not reconfirmed here, and selected pre-1950 records that have not been reconfirmed recently, including those that have not been reconfirmed in this survey.

Grid references prefixed with *circa* are my interpretations of localities originally given without a reference. Numbering of taxa follows Jermy *et al* (1978). Abundance is recorded on the Dafor scale where D = dominant, A = abundant, F = frequent, O = occasional, R = rare and L = locally. The Biological Records Centre, Monks Wood, England, is referred to as BRC, Jermy *et al* (1978) as *Atlas*, and Scully (1916) as RS. Old and recent records refer to pre-1950 and post-1950 records respectively. Where unqualified, "grid squares" refer to 10 x 10km squares and "monads" refer to 1 x 1km squares. Reference to all grid squares refers to all grid squares shown in Figure 1.

1.2 *Lycopodium clavatum*

Only records are in RS for the Mangerton Mountain, Muckcross Lake area and in *Atlas* pre-1950 for V/9.8 no doubt based on same records.

2.1 *Lycopodiella inundata*

Only one recorded station (More, 1876 and RS) on margin of Lough Guitane covered at high water (c. W/01.84).

3.1 *Huperzia selago*

(a) Widespread but local in south and west of area due to its altitudinal requirements. Recorded for grid squares V/7.7, V/8.7, V/8.8, V/9.7 and V/9.8. (b) Most commonly on rock outcrops in upland vegetation where it was O-R, with a few records each for scree and heather moor where it was only R. It was seen to be more often producing bulbils than sporangia and was often present as broken off stem fragments which may have been acting as a means of asexual reproduction. (c) Not recorded below 240m, above, becoming more common with increasing altitude up to limit of survey at 810m.

Recorded in *Atlas* post-1950 for V/7.8. RS records the altitudinal range of the species as sea level to 3,370 ft (1011m) which is almost the highest point in the area.

4.1 *Diphasiastrum alpinum*

Only old records exist for Mangerton Mountain (Newman, 1844 and RS) V/9.8, and ridge south west of Curraghmore summit c. V/78.82 (RS). There are specimens in BM from Mangerton dated 1835 (ex herb. J.W. Curtis) and ex herb. H.T. Ryder (without date).

5.1 *Selaginella selaginoides*

According to Praeger (1934) this is a most striking absentee from Kerry. There is a specimen in BM from Killarney VC H2 dated 1930 but no mention of this or any other record in *Atlas*. Considered doubtful as this record is only one for area.

5.2 *S. kraussiana*

(a-c) Recorded once on the banks of the Roughty River at V/963 723, alt. 15m. About 10 patches, each less than one square metre, in grass at base of hedge on north side of river, all plants sterile. This site was well away from any houses or gardens, so plant was probably carried down to site by the river in flood.

Species is recorded as new county record in O'Mahony (1980) at the same locality

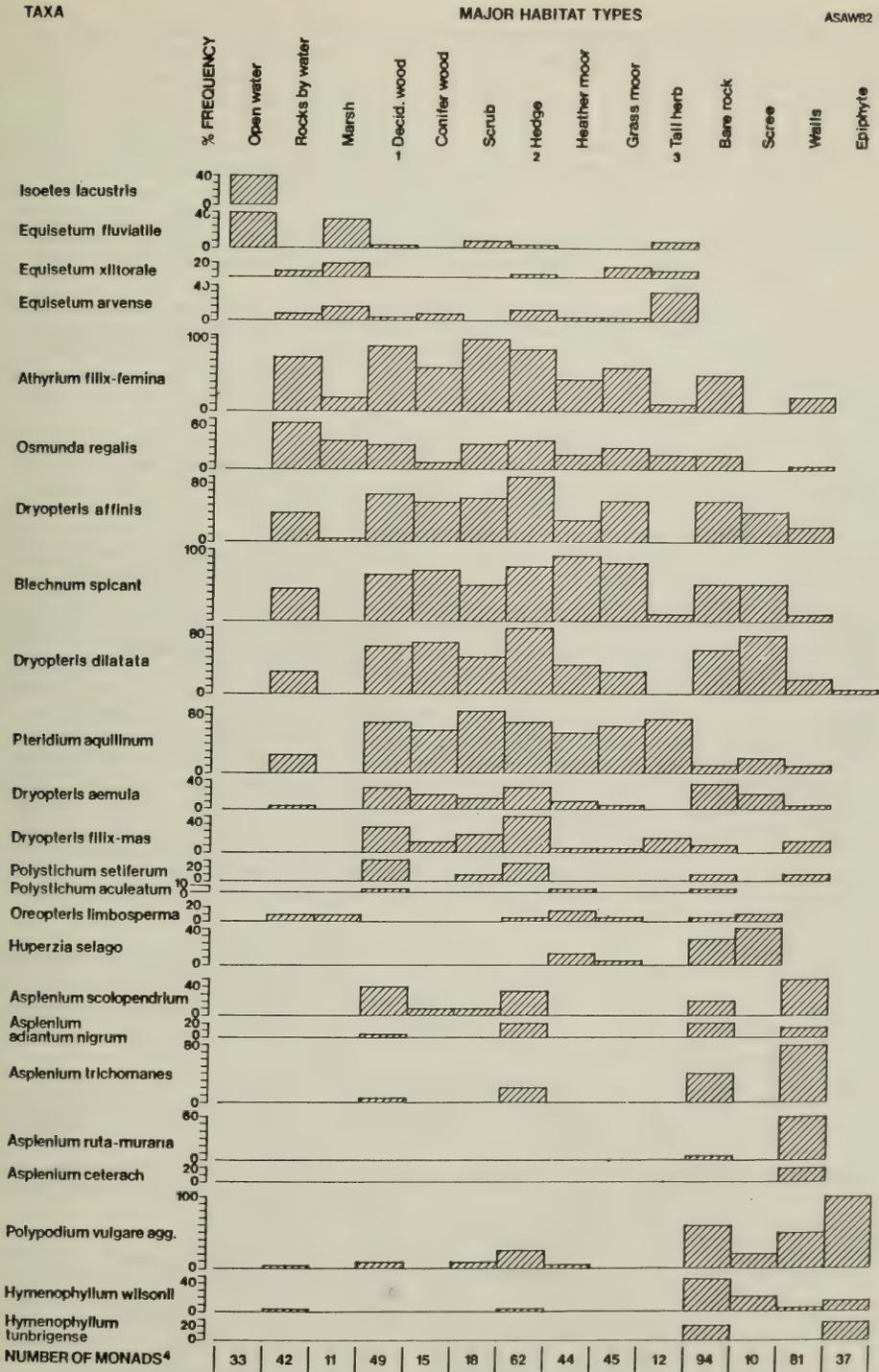


Table 2

6.1 *Isoetes lacustris*

(a) Widespread but local throughout the south and west of the area. Recorded for Cloon Lake V/70.78, Lough Caragh V/71.88, Hag's Glen V/81.84, Lough Nambrackdarrig V/94.78 and Muckcross Lake V/95.86. (b) All records mentioned in (a) are based on observation of megaspores. In all, 66 plants were examined for megaspores from 9 localities, of these 34 from 8 localities contained megaspores and were all referable to *I. lacustris*. Occurred amongst stones on the bottoms of lakes, sometimes as occasional plants, other times as extensive beds, some records based on plants or leaves washed up on shores of lakes. Plant occurred as two growth forms, one with long, straight leaves in deep water (30-90cm) and the other with shorter, curled leaves in shallower water (15cm). Both forms had *I. lacustris* type spores. (c) Occurred from sea level to 600m with equal frequency. The presence of clear lakes with stoney bottoms seems to determine its distribution rather than altitude. Recorded in RS up to 720m and in *Atlas* for V/7.9 and V/8.7.

6.2 *I. echinospora*

Not recorded in present survey despite examination of numerous megaspores; see entry for *I. lacustris* above. Recorded (RS and *Atlas*) as widespread but local, pre-1950, throughout the area. There are also specimens in BM from area mostly pre-1950 but one from Lough Guitane (c. W/02.85) dated 1977 (*A.C. Jermy* No. 13591). The dearth of recent records suggests that some older records may in fact have been *I. lacustris*.

7.1 *Equisetum hyemale*

Several old records in RS usually next to rivers. Only recent record is a specimen in BM from peninsular on west side of Caragh Lough (c. V/71.90) at edge of wood on foreshore (*Miss B. Morgan s.n.* 1952). See comments after *E. variegatum*.

7.1 x 2 *E. x trachyodon (E. hyemale x E. variegatum)*

No recent records. RS gives two records both for riversides. There are several specimens of this hybrid from the area at BM (*A.C. Jermy, pers. comm.*) but see notes after *E. variegatum*.

7.2 *E. variegatum*

No recent records but several old records in RS and several old specimens in BM. These records are all either for Lough Caragh or Muckcross Lake in the vicinity of Muckcross House, or Lough Leane in the vicinity of Ross Island. They are therefore all for altitudes below 30m and by lakes or in ditches. Several authors (*Atlas*, Newman 1844, Praeger 1934 and RS) refer specimens of this species in the area to *E. wilsonii* Newm. or *E. variegatum* var. *wilsonii* Newm. The status of these is uncertain (*Atlas*) but at present they seem best treated as a lowland, upright and unbranched form of *E. variegatum* with smoother stems. The classic locality for this form seems to be ditches near lake, Muckcross Demense, from where there is a specimen in BM, collected by W. Wilson.

The last four *Equisetum* taxa plus *E. variegatum* var. *wilsonii* form a hybrid complex which needs further investigation to determine how many taxa of what status occur in the area (*C.N. Page, pers. comm.*). In this survey two localities for plants referable to this complex were found. One was amongst stones on shore of Sugarloaf Island, Lough Caragh (G.R. V/712.887) and the other stones on shore of Kilbeg Bay, Muckcross Lake (V/958.860). These are being studied and will be reported on elsewhere.

7.3 *E. fluviatile*

(a) Recorded for all grid squares except V/9.9. Widespread but occasional in area. (b) Emergent sides of lakes and slow moving rivers, variable in abundance here from rare to locally dominant. Recorded as occasional for a few areas of marsh. (c) Sea-level to 240m with scattered records up to 600m.

Recorded in *Atlas* for V/9.9.

7.4 *E. arvense*

(a) Widespread but local throughout the area. Recorded for all grid squares except V/7.7, V/8.8 and W/O.8. (b) Occasional in tall herb communities and hedge banks with individual records for a range of other communities including cultivated ground; probably restricted in area due to the prevalence of peaty soils which it avoids (*Atlas*). (c) Sea-level to 60m with scattered occurrences up to 360m. This restriction to low altitudes is again probably due to its avoidance of organic soils.

Recorded in *Atlas* for V/8.8 and W/O.8.

7.4x3 *E. x litorale (E. arvense x fluviatile)*

(a) Recorded for 8 monads around Muckcross Lake, its inlet river, the southern shore of Lough Leane, and Ross Island plus an isolated record for Killorglin (V/78.96). (b) Occurs as O-R amongst rocks on lake shores, in damp, acid grassland (grass moor) and marshes, with individual records for tall herb and hedge communities. Occurred in same area as parents in intermediate habitats. The cluster of records round Muckcross Lake area suggests hybrid only rarely forms *de novo* from parents but can be spread by fragmentation in water. (c) Sea-level to 60m.

There are old records at BRC for Kilgarvan 1930 (c. W/O1-73) and Reen Bridge (V/870.705) 1929.

7.6 E. sylvaticum

Recorded in RS as rare but scattered in several places around Killarney, the lakes, Mangerton Mountain plus the Roughy and Slaheny valleys. No recent records traced.

7.7 E. palustre

(a-c) Recorded three times for area: frequent in *Phragmites* marsh by road from Muckcross to Dinnish cottage, alt. 27m (V/94.86); locally frequent on hedgebank at Aghadoe, alt. 90m (V/945.928); and locally frequent in marshy field near old railway station, now new school, at Kilgarvan, alt. 30m (W/009.737).

Recorded in *Atlas* post-1950 for W/0.9.

7.8 E. telmateia

Numerous old records thinly scattered through area in RS, mostly at low altitudes associated with water and/or woods. Only recent records is in BRC for roadside bank one mile west of Killorglin 1967. (c. V/76.96).

8.1 Botrychium lunaria

No recent records. Recorded in RS for a few sites scattered through area.

9.1 Ophioglossum vulgatum

(a-c) Recorded once as rare in alder/ash/birch carr by side of track from Muckcross House to Mines, alt. 25m (V/964.865).

Old records at BRC, and in RS and Bouskell (1905) record species as growing in woods and grassland at a few sites throughout the area.

10.1 Osmunda regalis

(a) Recorded for all squares in area except W/0.9. Widespread and common throughout area but becoming less so in north-eastern corner of area. (b) The two habitats where the species was most commonly encountered were hedgebanks and stones by lakes. The species was more abundant (O-R) in the latter as compared to only rare in the former. The species occurred less commonly in deciduous woods, grass moor and on rock outcrops. It was generally only rare in these three habitats. Only small, sterile plants occurred on rock outcrops without seepages. It also occurred a few times in each of a range of other habitats including peat cuttings, which it was seen to be colonising vigorously from spores. Overall appeared to prefer well-illuminated, damp habitats. (c) Sea-level to 360m with scattered records above up to limit of survey at 810m.

Recorded in *Atlas* for W/0.9.

14.1 Hymenophyllum tunbrigense

(a) Recorded mostly for the area of the Killarney Lakes (V/9.8) with scattered out-lying records for: Mullaghanattin (V/73.77), Lough Caragh (V/71.90) and Looscaunagh Lough (V/88.79). (b) The habitat the species most commonly occurred in was rock outcrops both acidic and calcareous, that were shaded and covered in moss. It also occurred as an epiphyte on a variety of trees. In both situations it was generally O-R but where it occurred it grew as dense mats. Rasor (1882) and Turner and Watt (1939) also noted this species grew more commonly on rocks than as an epiphyte. Generally, but not always, more abundant than *H. wilsonii* at lower altitudes. (c) Sea-level to 360m.

Also recently recorded in *Atlas* for V/7.8, V/8.8, V/9.9, W/0.8 and W/0.9, and latterly, at BRC, for Carrigawaddra near Kilgarvan (c. W/04.74).

14.2 H. wilsonii

(a) Thinly scattered throughout southern and central parts of area. Recorded for squares V/7.7, V/78, V/8.8, V/9.7, V/9.8 and at Crumagloun (W/02.72). (b) The two most favoured habitats for this species were rock outcrops and tree trunks. As in *H. tunbrigense* there were more sites for outcrops than tree trunks but the preference for outcrops was even stronger in this species than in *H. tunbrigense*. This contradicts Turner and Watt (1939) who recorded *H. wilsonii* as more of an epiphyte than *H. tunbrigense*. The rock outcrops were damp, shaded, moss-covered and generally acidic. This apparent preference for acidic rocks was associated with the preference of this species for high altitudes, note calcareous rocks occurred at lower ones. The species was generally O-R on rocks and tree trunks, though where it occurred it was present as dense mats. Individual records were also made for the species as rare on hedgebanks, screes, walls and rocks by water. It was commoner at higher altitudes than *H. tunbrigense*. (c) Occurred from sea-level to altitudinal limit of survey at 810m. However, it was only present in 10% of monads below 120m becoming gradually commoner at higher altitudes (70% of monads above 600m).

Recorded in *Atlas* for V/9.9, W/0.8 and W/0.9. RS records the species as extending to 990m on the Reeks.

15.1 Trichomanes speciosum

(a-c) Recorded only once during survey, shown to me by a local botanist who asked that I should not divulge the locality or give any details of it.

The species was once widespread, but local in the Killarney area on shaded, damp, acid

rocks often near waterfalls, (RS, and specimens in BM). However, it has been collected to extinction, or almost so, in many of its old localities. To discourage further depredations current localities are not published, so it is not possible to comment on its present status in the area. This species is now protected by the Irish Wildlife Act of 1976.

16.1-3 *Polypodium vulgare* agg.

(a) Widespread and common throughout the area. Recorded for all squares. (b) Recorded most commonly for rocks, walls and as an epiphyte, with a number of records for hedgebanks and isolated records for scrub, moor, heath and woodland. More abundant (F-R) on calcareous outcrops and mortared or concrete walls than (O-R) on acidic outcrops and drystone or earthed walls. Generally recorded as occasional when an epiphyte, O-R on hedgebanks, but only as rare in the remaining habitats. (c) Common from sea-level to 480m becoming less so above the limit of survey at 810m.

See also entries for segregates below, note that only some records for the aggregate were critically determined to segregate species and altitudinal limits of segregates not analysed as records too few. Overall *P. vulgare* agg. was recorded for about 100 monads, *P. vulgare*, 17, *P. interjectum* 12, *P. x mantoniae* 1, and *P. australe* 6.

16.2 *P. vulgare*

(a) Records widespread throughout area. Recorded for all squares except V/8.7. (b) Recorded only for: acid outcrops 7 records (F-R); drystone and earthed walls 3 records (R); hedgebanks 3 records (O-R) and as an epiphyte 5 records (O). This avoidance of more base-rich substrates is in accord with the ecology of the species elsewhere.

16.2 *P. interjectum*

(a) Records widespread throughout area, but less common than *P. vulgare*. Recorded for squares V/7.8, V/8.7, V/8.8, V/8.9, V/9.7, V/9.8 and W/0.7. (b) Recorded only for: rock outcrops and scree 5 records (F-R); drystone walls and hedgebanks 2 records (O); mortared wall 1 record (O); and as an epiphyte 4 records (LA-O). There was no tendency noted here for the species to require either more lime or higher humidity than *P. vulgare* as suggested in the *Atlas*.

16.2 x 1 *P. x mantoniae*

(a-c) Recorded once as rare on a hedgebank at Gearha (V/77.73) altitude 60m.

No previous records traced.

16.3 *P. australe*

(a) Restricted to areas of limestone outcrop around Muckcross and the Kenmare Valley and uncommon even there. (b) Recorded only for: limestone outcrops 3 records (LF-R); mortared walls 3 records (LF-O); and once occasional as an epiphyte on oak. Selected records: limestone outcrop Innisfallen Island (V/93.89); mortared wall Dunkerron Castle (V/88.70) and epiphyte Muckcross woods (V/95.86).

17.1 *Pteridium aquilinum*

(a) Common throughout area. Recorded for all squares. (b) The four habitats the species most commonly recorded for were: heather moor (LD-O); grass moor (LD-R); deciduous wood (LA-O) and hedgebanks (LA-F). The species formed dense stands over large areas of moorland but fronds were smaller with spaces in between in deciduous woodlands. Species sometimes occurred in a wide range of other habitats. (c) Recorded in about 80% of monads below 360m but in less than 10% above and with no records made above 600m.

18.1 *Thelypteris palustris*

(a-c) Only recorded for two adjacent monads at Muckcross (V/95.86 and V/96.86) as locally abundant to rare in damp, tall herb and grass communities, altitude 25-30m, by side of road from house to mines.

Other records record two more localities in vicinity of lakes, near western end of Ross Island (c. V/94.88) and near Cromaglen Bridge (c. V/92.82) (RS). *Atlas* gives a post-1950 record for V/9.9 but no record for this could be traced at BRC.

19.1 *Phegopteris connectilis*

(a-c) Recorded three times as rare on rock outcrops at higher altitudes near flowing water; Cloghera, alt. 120m (V/72.78); Torc Mountain, alt. 330m (V/95.84) and Horses' Glen, alt. 300m (V/99.82).

Other records give a similar picture (RS, *Atlas*, and Curtis and Mhic Daeid, 1981), but record further localities. Records for marshes at Muckcross (Newman, 1844 and RS) are probably errors for *Thelypteris palustris*.

20.1 *Oreopteris limbosperma*

(a) Widespread but local in southern and central parts of region. Recorded for squares V/7.7, V/8.8, V/9.7, V/9.8, W/0.7 and W/0.8. (b) Recorded for heather moor (F-O); hedgebanks (O-R) and rocks by rivers (R). (c) 30-480m.

21.1 *Asplenium scolopendrium*

(a) Widespread throughout area (recorded for all squares), common in lowland area, especially around the Killarney Lakes, but much less so in upland areas. (b) Occurred most commonly, in order of decreasing frequency, on walls, hedgebanks, in deciduous woods and on rock outcrops. Much more frequent and abundant on limestone outcrops and mortared walls (F-R) than acidic outcrops and drystone walls (O-R). Plants smaller in drier habitats and in mountainous areas. Less abundant on hedgebanks (O-R) than in deciduous woods (F-R). (c) Becoming less common from sea-level to tops of mountains such that is occurred in more than 50% of monads below 60m but less than 10% above 240m.

21.1x7b *A. x confluens*

Found once near Killarney in 1875 by Frazer (*Atlas*) but not recorded since. (But see Rush, this Volume, p. 301).

21.2 *A. adiantum-nigrum*

(a) Widespread but local throughout area. Recorded for all grid squares. (b) Recorded for rock outcrops, walls and hedgebanks. Commoner and more abundant on acidic outcrops (F-R) than calcareous ones (R). Equally common and abundant (O-R) on mortared and drystone walls, and on hedgebanks. Fronds larger in more sheltered habitats and stipes longer when plants growing in deeper crevices. (c) Occurred from sea-level to limit of survey at 810m but becoming less common at higher altitudes.

21.3 *A. onopteris*

(a-c) Recorded twice; once as rare on a stony hedgebank alt. 90m (Figure 4); and as rare on an exposed, acidic outcrop by side of road 30m. These specimens were determined on mean spore length (Roberts, 1979), which for ten spores from each specimen was 33µm and 32µm respectively. The mean lengths for 4 specimens of *A. adiantum-nigrum* from same area measured at the same time were 42, 37, 37 and 38µm.

Other records record that the species is more widespread in area, RS gives Loo Bridge, Glenflesk (c. W/08.81) and near the Sugarloaf, Caragh Lake (c. V/71.88) while *Atlas* gives a pre-1950 record for V/9.9 and a post-1950 record for V/7.9.

21.6 *A. marinum*

Recorded for area and figured by Newman (1844) as numerous small plants on rocks by Upper Lake (specimen in BM); and by other authors since. Still present at site in 1980 (*pers. comm.* C. Mhic Daeid, 1980). A very unusual record for species as it normally grows on sea cliffs. Jermy *et al.* (1978) consider it requires salt-spray but I consider that it grows only near the sea because it is intolerant of frost. The mild climate of the area could then allow it to grow further inland than usual.

21.7 *A. trichomanes* agg.

(a) Widespread and common throughout area. Recorded for all grid squares. (b) Occurred most commonly on mortared walls and acidic outcrops with a few records for calcareous outcrops and hedgebanks (O-R). The apparently anomalous preference of this species for both base-rich and base-poor habitats is probably explained by the presence of two subspecies in the area (*Atlas*) though only one has so far been confirmed, see below. (c) Recorded for about 50% of monads below 457m but only for 10% from 480-810m.

21.7b *A. trichomanes*, subsp. *quadrivalens*

Recorded (*Atlas*) for V/7.8, V/8.7, V/8.8, V/9.7, V/9.8 and V/9.9.

21.8 *A. viride*

(a-c) Recorded once as occasional on damp rock outcrops at base of Devil's Ladder, Carrauntoohil (V/80.83) alt. 600m with *Cyopteris fragilis*.

Old and new records indicate this is a very rare species of rock outcrops at high altitude. Curtis and Mhic Daeid (1981) record species for Mullaghanattin (c. V/73.77) and Mhic Daeid (*pers. comm.* 1989) records species in Horse's Glen (c. V/99.81). RS records Torc and Mangerton Mountains while *Atlas* vies a pre-1950 record for V/9.7.

21.9 *A. ruta-muraria*

(a) Widespread throughout area but more common in the lowlands of the north and east than the higher land of the south and west. Recorded for all grid squares. (b) Practically confined to mortared walls where species was frequent to rare, with just two records each for acidic outcrops, drystone walls and calcareous outcrops. (c) Virtually confined to areas below 240m which is no doubt due in part at least to an absence of walls above this altitude.

21.11 *A. ceterach*

(a) Records are widely but thinly scattered through the more lowland parts of the area. Recorded for grid squares V/7.7, V/7.9, V/8.9, V/9.7, V/9.9, W/0.8 and W/0.9. (b) Recorded 12 times as LF-R on mortared walls and once as abundant on a drystone wall. (c) Sea-level to 240m.

22.1 Athyrium filix-femina

(a) Widespread and common throughout area. Recorded for all grid squares. (b) Equally abundant (F-O) in a range of habitats: hedgebanks, rocks by water; scrub; deciduous woodland and acid rock outcrops. Slightly less abundant (O-R) in heather moor and grass moor. Also present, but only spasmodically, in a range of other habitats including walls and conifer plantations. Species showed a marked preference for areas of habitats that were damp. It was much more abundant on rocks and walls here than in the drier eastern areas of the British Isles, eg. Willmot (1981). No specimens with red rachises were noted. (c) Decreased slightly in frequency with altitude but was still present in 50% of monads between 600-810m, the highest altitudinal range examined.

23.1 Gymnocarpium dryopteris

Only record for area is Newman (1844) who gives Muckcross, Kerry as a locality. This record considered an error as species is rare in Ireland and it has not been refound since.

24.1 Cystopteris fragilis

(a-c) Recorded once as occasional on damp rock outcrops at base of Devil's Ladder, Carrauntoohil (V/80.83) alt. 600m with *Asplenium viride*.

Recorded elsewhere as very rare at high altitudes on rocks: Mullaghánattin c. V/73.77 (Curtis and Mhic Daeid, 1981); Horse's Glen c. V/99.80, Mangerton Mountain c. V/96.80 and one record for low altitude on rocks near Middle Lake, Muckcross (all RS).

26.1 Polystichum lonchitis

There are a few scattered old records for rocks at high altitudes in RS, *Atlas* and at BRC. These are for: Horse's Glen, Mangerton; above Lough Googh (c. V/84.83); Mullaghanattin (c. V/74.77) and cliffs south of Lough Erhagh (c. V/99.80). Recently Curtis and Mhic Daeid (1981) have reconfirmed the species in the Mullaghanattin area, and Mhic Daeid has communicated that the species is still in the Horse's Glen (*pers. comm.* 1980).

26.2 P. aculeatum

(a-c) Recorded for five monads in the region of Mangerton and Torc Mountains. Always only in small amount (R) amongst acid rock outcrops either unshaded as at Cloghfune (V/94.83) 375m, or in heather moor as at Horse's Glen (V/99.82) 300m, or in deciduous woods as at Gortracussane (V/94.84) 120m and (V/95.84) 30m and at Torc Old Bridge (V/96.83) 180m.

Recorded in RS for the Roughty Valley (V/9.7) and the Ballaghbeama Pass (c. V/76.77).

26.2x3 P. x bicknellii

Recorded once for area post-1950 in *Atlas* for square V/9.7.

26.3 P. setiferum

(a) Rare but widespread in lowland areas especially on limestone. Recorded for grid squares V/7.9, V/8.7, V/8.8, V/8.9, V/9.7, V/9.8, V/9.9, W/0.7 and W/0.9. (b) Occurred most commonly and abundantly on hedgebanks (LA-R) and in deciduous woodlands (F-O), with a few occurrences each on mortared walls and rock outcrops both acidic and calcareous. (c) Sea-level to 60m with one or two occurrences up to 240m but none above.

27.1 Dryopteris oreades

(a-c) Recorded once (this survey) as a single patch at Dromderalough alt. 600m amongst rocks on heather moor, conf. C.R. Fraser-Jenkins, specimen in BM (Figure 5).

No previous records traced for area, this is only fourth record in Ireland (*Atlas*).

27.2 D. filix-mas

(a) Widespread in lowland areas, recorded for all grid squares except V/7.7. (b) Most often encountered and most abundant in deciduous woods (O-R) and on hedgebanks (F-R), with isolated records at low altitude (R) in a range of habitats including walls, outcrops and moors. Generally less often met with than *D. affinis*, sporelings and young plants rarely seen. (c) Sea-level to 240m never recorded above.

27.3 D. affinis

(a) Widespread and common, recorded for all grid squares. (b) Most commonly met with and most abundant (F-R) in deciduous woods, on hedgebanks and on acidic rock outcrops; slightly less common and less abundant (O-R) in grass moors and amongst rocks by water; with infrequent occurrences in a further range of habitats including coniferous plantations, mortared walls and drystone walls. (c) Occurred from sea-level to limit of survey at 810m but becoming less common at higher altitudes.

Recently Fraser-Jenkins (1980) has separated the species into several subspecies; notes on specimens collected during survey and determined by him are given below.

27.3a subsp. affinis

(a-c) Recorded for 10 monads scattered throughout the area; in deciduous woods, in grass heaths on acidic rock outcrops, on hedgebanks and on an earthed, drystone wall; altitudinal range 30-375m. Selected records: occasional earthed, drystone wall Cloghera 120m (V/72.78); occasional hedgebank Gortnagan 150m (V/72.88); frequent acidic rock outcrops Boughil 240m (V/85.77); rare hedgebank Cummeenduvasig 150m (V/97.77); frequent oak wood near Torc Old Bridge 180m (V/96.83); and frequent grass heath near Loo Bridge 75m (W/07.80).

27.3b subsp. **stillupensis**

(a-c) Recorded once as rare amongst rock outcrops in Hag's Glen (V/81.83) alt. 600m; first confirmed record for Ireland.

27.3c subsp. **borreri**

(a-c) Recorded once as rare amongst rock outcrops on Mullaghanattin (V/73.77) alt. 600m.

27.4 **D. remota**

Recorded once last century for area from Glen Flesk (specimen in BM, collected G. Wager) which is in W/0.8 not W/0.9 as indicated in *Atlas*.

27.5 **D. aemula**

(a) Widespread but local throughout southern and western parts of area. Recorded for grid squares V/7.7, V/7.8, V/7.9, V/8.7, V/8.8, V/8.9, V/9.7, V/9.8 and W/0.7. (b) Most commonly found on rock outcrops, especially shaded and/or damp ones, where it was O-R in abundance, less common but equally as abundant on hedgebanks and in deciduous woods, with a few records each for moors, walls, scrub and conifer plantations. (c) Equally common from sea-level to limit of survey at 810m

Recorded in *Atlas* for V/9.9 and W/0.8 post-1950.

27.8 **D. carthusiana**

(a-c) Recorded as occasional in alder woods at eastern end of Ross Island alt. 24m (V/95.88). Records in RS, at BRC and in *Atlas* provide about another five localities for species scattered through area, eg. records at BRC include an old record for Glen Flesk (c. W/06.85) and a recent one for Reen Point, Lough Leane (c. V/94.89).

27.9 **D. dilatata**

(a) Widespread and common throughout area. Recorded for all grid squares. (b) Most common and most abundant (F-O) on hedgebanks, on acidic rock outcrops, and in deciduous woods; slightly less common and abundant (O-R) in conifer plantations, amongst rocks by water, in heather moors and grass moors; with scattered odd records for drystone walls, scrub and scree. (c) Equally common from sea-level to limit of survey at 810m.

27.10 **D. expansa**

Vida (1966) recorded this species from Kerry (V.C. H2) but Crabbe *et al* (1970) considered this record as extremely doubtful, and no other records are known. However, *D. remota* has been recorded which is an apogamous species probably originating from the hybrid between *D. expansa* and *D. affinis* (*Atlas*). *D. expansa* may then have occurred in area and may yet be found.

28.1 **Blechnum spicant**

(a) Widespread and common throughout the area. Recorded for all grid squares. (b) Occurred most commonly and abundantly (F-O) on acidic rock outcrops, on hedgebanks, in heather moors, in grass moors and in deciduous woods; occurred as abundantly but less commonly in conifer plantations and scrub; with a few records each for drystone walls and scree. (c) Recorded from sea-level to limit of survey at 810m, showed a slight increase in frequency with altitude.

RS recorded species to 960m

29.1 **Pilularia globulifera**

(a-c) Recorded once as locally frequent on bare mud at side of lake alt. 24m.

All other records for area are around the Killarney Lakes.

SUMMARY OF THE FLORA

In this survey 38 species and hybrids of native British pteridophytes, plus one introduced species (*Selaginella kraussiana*), were found growing in the study area. Reliable references to a further 14 species and hybrids, either post-1950 or pre-1950, were encountered during the searches of data banks and herbaria. Thus overall some 52 species and hybrids have been found in the area which is about two thirds of the native species and hybrids that occur in Ireland (Jermy *et al*, 1978). The area is thus rich in ferns. This is further emphasised when the area is compared with the rest of Europe. Jalas and Suominen (1972) record the number of species and subspecies of ferns in 50km grid squares for the whole of Europe. They divide all their squares into a number of classes of species richness, with the richest class having 43 or more. The study area falls into one of their squares which belongs to this richest class. Further fern taxa may be found in the area, particularly hybrids such as *Dryopteris x tavelii* which are difficult to pick out in the field. However, it is considered that this total of 52 species and hybrids is an accurate representation of the true flora of the area. This is



FIGURE 4. *Asplenium onopteris*



FIGURE 5. *Dryopteris oreades*

thought to be so since there are no species which are common in adjacent or similar areas of Ireland that are not recorded for the study except for *Selaginella selaginoides*.

The reason for this species richness of the area is due to the presence of mountains near the western seaboard of Europe. This allows the coming together of species with montane, or arctic/alpine affinities with species of more southern or oceanic affinities (Table 3). It is notable that all the areas in the British Isles that have the highest species numbers in Jalas and Souminen (1972) are also mountainous areas. However, examination of Table 3 shows that species of southern or oceanic affinities (Floristic elements 1-4) make a greater contribution to the species richness of the area than species of montane or arctic/alpine affinities (Floristic elements 7-8). Overall therefore the flora shows greater affinities with more southern and oceanic flora than more montane or arctic/alpine ones. This is further borne out by the abundance of the species from the various floristic elements in the area. Five of the seven montane or arctic/alpine species have only one or two localities in the area whereas many of the southern or oceanic species have numerous localities. Although the montane, arctic/alpine influence on the flora is less important than the southern, oceanic influence, it is still significant. This is shown by comparing the Killarney fern flora with that of the Burren (Willmot, 1979). This is an area on the western seaboard of Ireland just to the north of the study area. It similarly shows a coming together of southern or oceanic species with montane or arctic/alpine species. However, it does not have mountains and has only two species from floristic elements 7 and 8, whereas Killarney has 7 species.

Table 3 The phytogeographical affinities of the fern flora of the Killarney region

Floristic elements from Birks (1976)	Distribution in Europe	Number of species in element in:		
		(a) Killarney post-1950	(b) British Islands (pre-1950)	(c) Europe
1. <i>Selaginella denticulata</i>	Mediterranean	1	4	10
2. <i>Adiantum capillus-veneris</i>	Mediterranean/ Atlantic	3	6	6
3. <i>Phyllitis scolopendrium</i> (= <i>Asplenium scolopendrium</i>)	North Mediterranean/ Atlantic	13	14	14
4. <i>Hymenophyllum wilsonii</i>	Western seaboard	4	4	4
5. <i>Cystopteris fragilis</i>	Widespread	9 (3)	14	14
6. <i>Pteridium aquilinum</i>	Widespread	7	8	8
7. <i>Polystichum lonchitis</i>	Widespread Montane/ Sub-montane	4 (2)	9	11
8. <i>Woodsia alpina</i>	Arctic/Alpine	0 (1)	6	6

Table includes all species reliably recorded for the study area which are included in Birks (1976).

Examination of the relationship between the European distribution of the taxa noted as only doubtfully recorded for the area (Table 1) and those actually recorded might be thought to shed some light on the status of the doubtful taxa. However, it does not. Two of the four taxa *Equisetum x moorei* and *Dryopteris expansa* were no doubt recorded by mistake for other taxa. The two other species have different distributions in Europe; *Selaginella selaginoides* is an arctic/alpine species while *Gymnocarpium dryopteris* is widespread (Birks, 1976). This suggests that the latter is more likely to actually occur in the area than the former. However, the former is widespread in north Ireland while the latter has been recorded for only a few isolated localities in Ireland.

The breakdown of the flora into its floristic elements (Table 3) allows a further analysis of it to be made. One can identify species that may turn up in the area by noting which species, of elements that occur in the area, are not present. If this is done for elements 1-6, there are 10 species that occur in the British Isles but not Killarney.

These are:

<i>Isoetes histrix</i> (*)	<i>Asplenium billotii</i>
<i>Ophioglossum lusitanicum</i> (*)	<i>A. septentrionale</i>
<i>O. azoricum</i> (*)	<i>Gymnocarpium dryopteris</i>
<i>Anogramma leptophylla</i> (*)	<i>G. robertianum</i>
<i>Adiantum capillus-veneris</i>	<i>Dryopteris villarii</i>

It is not possible to suggest which of these species are more likely to turn up than others. All of them, except *Adiantum capillus-veneris*, are very rare in or absent from Ireland. Four species, marked (*) above, are small plants, which are easily overlooked or mistaken for other species. Careful examination of the right habitats at the right times of the year might turn up species from this four.

The origins of the Killarney flora is a problem that has interested botanists for a long time (Aalen, 1978; Jessen, 1948 and Mitchell, 1976). Discussion has centred around which plants if any survived the last ice age in the Killarney area and the routes taken by plants as they re-invaded the area after the ice. The geological evidence is that almost the whole of the upland part of the study area was covered in ice during the last ice age. This leaves two areas where plants would have survived within the area, the unglaciated area of the uplands (nunataks) and the lowlands in the north of the area. The climate in these would have been too severe for any species other than the montane or arctic/alpine ones to survive. Moreover there is no evidence in terms of fossils from this period that any of these species did survive in the region. A third area where species could have survived in the vicinity of the Killarney region is just off the present coast line of Kerry. Here there would have been areas of dry land due to the draw down of sea-level during the ice age. At present steep slopes extend off shore, so the draw down would have exposed sheltered, south-facing slopes. Mitchell (1976) considers that these could have had warm enough microclimates for species other than montane or arctic/alpine ones to occur. However, Jessen (1949) considers that the pattern of the spread of species in Ireland, after the last ice age, in terms of timing and relative order or arrival of species offers no evidence of refugia for thermophilous species in Ireland. Overall, therefore, there is no conclusive evidence either way for the survival of species in the Killarney area or nearby during the last ice age.

The question of routes taken by plants as they re-invaded the area after the ice age is as problematical as that of survival through the ice age. Two basic routes have been considered: overland through England and Wales or along an Atlantic seaboard exposed by the draw down of the oceans. However, the depth of water between southern Ireland and South Wales means that any route along an Atlantic seaboard would have been cut by the sea early in the post-glacial. It is unknown whether or not the climate of this Atlantic seaboard route would have been mild enough, before it was cut, to allow the southern elements in the flora to reach the area. However, the high representation of species liking warm and/or humid conditions in the area argues for an Atlantic seaboard route, at least for these species.

The evidence of macrofossils and spores in peat bogs gives concrete evidence for the existence of certain species in the area later on in the post-glacial. Jessen (1949) records evidence for five species. Records of spores of *Polypodium vulgare* extend back into zone IV. Spores of *Osmunda regalis* and *Isoetes lacustris* are recorded back to zone VI, while there is evidence of *Dryopteris filix-mas* and of *Thelypteris palustris* at Togherbane in zone VII. This last record is most interesting as this species only occurs at one locality now.

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REFERENCES

- AALLEN, F.H.A., 1978. *Man and the landscape in Ireland*. London.
- BIRKS, H.J.B., 1976. The distribution of European pteridophytes: A numerical analysis. *New Phytol.* 77: 257-287.
- BOUSKELL, F., 1905. Stray notes from South Kerry in 1903. *Trans. Leics. Lit. and Phil. Soc.* 9: 39-47.
- CRABBE, J.A., JERMY, A.C. & WALKER, S., 1970. The distribution of *Dryopteris assimilis* S. Walker in Britain. *Watsonia* 8: 3-15.
- CURTIS, T. & MHC DAEID, C., 1981. Mullaghanattin, Glencar, Co. Kerry. 21st-23rd July. *Watsonia* 13: 261-262.
- FRASER-JENKINS, C.R., 1980. *Dryopteris affinis*: a new treatment for a complex species in the European pteridophyte flora. *Willdenowia* 10: 107-115.
- HIND, W.M., 1857. Three days in Killarney. *Phytologist (N.S.)* 2: 25-28.
- JALAS, J. & SUOMINEN, J., 1972. *Atlas Florae Europaeae Vol. 1 Pteridophyta*. Helsinki.
- JERMY, A.C., ARNOLD, H.R., FARRELL, L. & PERRING, F.H., 1978. *Atlas of ferns of the British Isles*. London.
- JESSEN, K., 1949. Studies in late-Quaternary deposits and flora history of Ireland. *Proc. Roy. Irish Acad. Ser. B.* 52: 85-290.
- KELLY, D.L., 1981. The native forest vegetation of Killarney, south-west Ireland: An ecological account. *J. Ecol.* 69: 437-472.
- MITCHELL, F., 1976. *The Irish landscape*. London.
- MORE, A.G., 1876. *Lycopodium inundatum* in Kerry. *Journal of Botany* 14: 373.
- NEWMAN, E., 1844. *A history of British ferns & allied plants*. London.
- O'MAHONY, A., 1980. Some recent plant finds in the Kenmare-Kilgarvan area of South Kerry (H1). *Bull. Ir. Biogeog. Soc.* 4: 41-45.
- PRAEGER, R.L., 1934. *The Botanist in Ireland*. Dublin.
- RASOR, J., 1882. Notes on the Ferns of Killarney. *Science Gossip* 18: 162-3.
- ROBERTS, R.H., 1979. Spore size in *Asplenium adiantum-nigrum* L. and *A. onopteris* L. *Watsonia* 12: 233-238.
- RYAN, P., 1963. The soils of Ireland. *Irish Forestry* 20: 46-60.
- SCULLY, R.W., 1916. *Flora of County Kerry*. Dublin.
- SIMON, T. & VIDA, G., 1966. Neue Angaben zur Verbreitung der *Dryopteris assimilis* S. Walker in Europa. *Annls. Univ. Scient. bpest. Rolando Eötvös, Sect. biol.*, 8: 275-284.
- TURNER, J.S. & WATT, A.S., 1939. The oakwoods (*Quercetum sessiliflorae*) of Killarney, Ireland. *J. Ecol.* 27: 202-233.
- WATTS, W.A., 1963. Late-glacial pollen-zones in western Ireland. *Ir. Geog.* 4: 367-376.
- WILLMOT, A., 1979. An ecological survey of the ferns of the Burren, Co. Clare, Eire. *Fern Gaz.* 12: 9-28.
- WILLMOT, A., 1981. An ecological survey of the ferns of Berwickshire, Scotland. *Fern Gaz.* 12: 133-154.
- WRIGHT, W.B., 1927. *The geology of Killarney and Kenmore*. Dublin.

REVIEW

A MONOGRAPH OF THE FERN GENUS PLATYCERIUM (POLYPODIACEAE) by E. Hennipman and M.C. Roos. Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, Afd. Natuurkunde, 2nd series, part 80. North-Holland Publishing Company, 1982. 126 pp., 4 colour and 8 monochrome plates, 31 figs, 170 x 243mm. ISBN 0-4448 5569-6. Price: Dfl. 75.- (c. £14.00).

This is a beautifully produced and fully illustrated treatment of Stag's-horn ferns. The first part covers the taxonomic history and systematic position of the genus, with details of the morphology, anatomy and habitats of the species. The phylogenetic relationships of the species are investigated and their geographical distributions are discussed in relation to the proposed phylogeny.

The second part gives a helpful key, followed by full descriptions of all the species, which are presented in alphabetical order. Valuable notes cover points such as habitat, similarity to other species, native names and the fascinating uses of parts of these spectacular ferns: how I wish the authors had commented on the taste of the tea that can be made from *Platyserium holttumii*! Certainly those horticulturalists who talk to their plants will now be able to address their 'Pepelegbuku' or 'Tama halota' in a more ethnic way. Two short sections also give useful advice on the collection of these ferns from the wild.

The phylogenetic and biogeographic sections make use of the method of classification termed cladistics, which may appear daunting to anyone not already acquainted with the method. However, the clarity and consistency brought by this use of cladistics to the recording of characters (in this case features of morphology, anatomy and frond habit) are readily apparent. For example, the reason for assigning the so-called plesiomorphic (generalised) vs. apomorphic (derived) states for any character is given. Observations so recorded, in the form of a data matrix and diagram, can therefore be used readily by others when investigating further aspects, or even alternative methods, of classification. Additional data, for example on chromosomes, may be added easily to those provided by Hennipman and Roos. Indeed, information from biochemical analyses and cytology could be used to test their proposed phylogeny.

In the developing discipline of cladistics, there is inevitably some difference of opinion as to how the most parsimonious cladogram should be constructed and interpreted. Hennipman and Roos have stated clearly their method and reasoning, and I would criticize only two points. Firstly, a rather important proof error seems to have escaped detection. The last figure on p. 36 should surely have a solid, rather than open, circle to symbolise 'a'. Secondly, since two alternative transformation series are proposed for the base frond composite character '12,13', it would seem preferable to have two cladograms (each including one of these alternatives) with any difference between them discussed.

This monograph will be of great interest both to herbarium taxonomists and horticulturalists.

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THREE NEW *DRYOPTERIS* HYBRIDS FROM SPAIN AND THE CANARY ISLANDS

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ABSTRACT

Three new *Dryopteris* hybrids: **D. x gomerica** = *aemula* x *guanchica* and **D. x cedroensis** = *guanchica* x *oligodonta* from Gomera, Canary Islands and **D. x fraser-jenkinsii** = *affinis* with uncertain parentage, from Oviedo, N. Spain, are described with data on their chemistry, cytology and morphology.

INTRODUCTION

During collecting trips to the Canary Islands (1974) and Spain (1976), Fraser-Jenkins discovered three new *Dryopteris* hybrids. These have been investigated morphologically, cytologically and chemically in an attempt to determine their parentage.

***Dryopteris* x *gomerica* Gibby & Widén, hybrid.nova.**

(*D. aemula* (Aiton) O.L. Kuntze x *D. guanchica* Gibby & Jermy)

Holotypus: Canary Islands, La Gomera, El Cedro, Mña Quemada, 1100m alt. With *D. aemula*, *D. guanchica*, *D. oligodonta* Pichi-Serm. 31 March 1974, C.R. Fraser-Jenkins 4212 (BM).

Planta inter parentes putatos in morphologia intermedia. *Lamina* triangularis, glandulosissima. *Squamae* stipitis basi longae, contractae, brunneae. *Sporae* abortivae.

The plant is intermediate in morphology between its putative parents. The lamina is triangular and very glandular. The scales at the stipe base are long, tapering and brown in colour. Spores are abortive.

The hybrid is triploid with $2n = 123$, and at first metaphase of meiosis shows approximately 41 bivalents and 41 univalents; *D. guanchica* is an allotetraploid species, and pairing in the hybrid is allosyndetic. Diploid *D. aemula* is one of the parents of *D. guanchica* (Gibby *et al.*, 1978). The phloroglucinol composition of the hybrid is similar to that of *D. guanchica*, and the characteristic compounds from *D. aemula* appear to be suppressed (Gibby *et al.*, 1978). During a cytogenetic investigation of *D. guanchica* in 1973, hybrids of the constitution *D. aemula* x *guanchica* were synthesized, prior to the discovery of this hybrid in the wild. The wild and synthesized hybrids are very similar in morphology, cytology and phloroglucinol composition.

The site where they hybrid was discovered in La Gomera is the only locality in the Canary Islands where the two parents are known to grow together. Both *D. aemula* and *D. guanchica* are recorded from north-west Spain, but as yet they have seldom been found growing together (Fraser-Jenkins, *pers. comm.*)

***Dryopteris* x *cedroensis* Gibby & Widén, hybrid.nova.**

(*D. guanchica* Gibby & Jermy x *D. oligodonta* Pichi-Serm.)

Holotypus: Canary Islands, La Gomera, El Cedro, Mña Quemada, 1100m alt. With *D. aemula*, *D. guanchica* and *D. oligodonta*. 31 March 1974, C.R. Fraser-Jenkins 4211 (BM).

Planta inter parentes putatos in morphologia intermedia. *Fronde*s grandes, plus quam 1m longae, earum ad modum *D. oligodontae* laxae. *Squamae* in stipite usque ad 2cm longissimae. *Pinnulae* eis *D. oligodontae* plus divisae, segmentis ultimis *D. guanchicae* similibus dentatis. Sporae abortivae.

The plant is intermediate in morphology between the putative parents. The fronds are large, over a metre in length, and lax like those of *D. oligodonta*, and the scales on the stipe are long, up to 2cm. The pinnules are more divided than those of *D. oligodonta*, and the ultimate segments are toothed like those of *D. guanchica*. Spores are abortive.

The cytology and phloroglucinol composition of this hybrid have been investigated (Gibby *et al*, 1978). The plant is pentaploid with $2n = 205$. This finding was unexpected; *D. guanchica* is tetraploid and *D. oligodonta* is diploid — a hybrid between these species would be expected to be triploid. The result obtained can be explained if the hybrid has resulted from the fusion of an unreduced gamete from *D. guanchica* (164 chromosomes) with a normal gamete (41 chromosomes) from *D. oligodonta*. The meiotic analyses obtained are compatible with such an hypothesis; these show up to 80 bivalents with 43 univalents. The phloroglucinol composition of the plant is similar to that of *D. guanchica*.

***Dryopteris x fraser-jenkinsii* Gibby & Widén, hybrid.nova.**

Holotypus: Spain, Oviedo; beside road from Aviles to Ribadeo, by bend in road, 1km S. of Canero, E. of Luarca. 50m alt. Mixed *Pinus*, *Quercus* and *Castanea* forest, with *D. affinis* (Lowe) Fraser-Jenkins, *D. dilatata* (Hoffm.) A. Gray and *D. guanchica*. C.R. Fraser-Jenkins 4899, ex. hort. Chelsea Physic Garden, no. CPG 2189.

Hybrida in morphologia *D. affini* similis. *Pinnulae* autem plus dissectae ad costam fissae, segmentis rotundatis dentatisque. *Sporae* pleraeque abortivae, vix 5% ut videtur bene evolutae et haec grandes, rugosae eis *D. affinis* similes sed nonnumquam subspineae vel spinulosae.

The hybrid is similar in morphology to *D. affinis*, but the pinnules are more dissected, being cut at least halfway to the midribs, and the pinnule segments are rounded and toothed. Spores mainly abortive, less than 5% appearing normal, being large, rugose and like those of *D. affinis*, but often bear small spines or projections (Figure 1).

The hybrid is tetraploid with $2n = 164$. This has been confirmed by examination of root tip mitosis. Investigation of meiosis in spore mother cells reveals that the hybrid is partially apomictic, like *D. affinis*, and produces sporangia with eight spore mother cells that show 164 bivalents at metaphase I. More frequent are 16-celled sporangia, where each spore mother cell shows 164 univalents at metaphase I (Figure 2); anaphase separation in these cells is unbalanced and leads to the formation of abortive spores. The low percentage of good spores reflects the low frequency of eight-celled sporangia. Sporangial contents have been sown and germination of prothalli obtained, presumably from the unreduced spores (with 164 chromosomes) that result from eight-celled sporangia. The prothalli give rise to sporophytes apogamously.

The phloroglucinol composition of *D. fraser-jenkinsii* is given in Table 1, together with those of *D. affinis*, *D. dilatata* and *D. guanchica*. The hybrid is very different from *D. affinis*, and shows closest similarity with *D. guanchica*.

The parentage of this hybrid cannot firmly be established. It is clear that *D. affinis* must be one parent, as the hybrid is very similar to this in morphology, and it shows apomictic behaviour. This is typical of hybrids involving the apomictic *D. affinis* eg. *D. x tavellii* Rothm. (Manton, 1950). The second parent is in doubt, but probably belongs to the *D. dilatata* complex. Both morphological and chemical comparisons support this hypothesis. *D. dilatata* and *D. guanchica*, with which the hybrid was growing, are possibilities. Both are allotetraploid species, and hybridization of either with a diploid form of *D. affinis* would result in a tetraploid hybrid. During normal meiosis no pairing of chromosomes would be expected in such a hybrid; *D. x fraser-jenkinsii* shows this

TABLE 1. Phloroglucinol derivatives in *Dryopteris* x *fraser-jenkinsii* and putative parental species. Semi-quantitative amounts calculated as percentages of the phloroglucinol mixture (crude aspidin): +++ present in large amounts 20%; ++ present in moderate amounts 10 — 20%; + present in small amounts 5 — 10%; (+) present in trace amounts; — not found.

Species	Chromosome number (2n)	Aspidinol	"Albaspidin 1"	"Albaspidin 2"	"Albaspidin 3"	Aspidin BB (PB)	Aspidin AB	Para-aspidin	Desaspidin	Flavaspidic acid BB (PB)	Flavaspidic acid AB	Trisflavaspidic acid	Phloropyron	Fillicic acid
<i>D. x fraser-jenkinsii</i> CPG 2189	164	—	+	++	+	+	+	—	—	++	+	(+)	—	—
<i>D. affinis</i> ¹ TR 293	82	—	—	—	—	—	—	—	—	++ ³	++ ³	+	—	+
<i>D. affinis</i> ¹ (WG)	123	—	—	—	—	—	—	—	—	+++ ³	++ ³	+	—	+
<i>D. affinis</i> ¹	123	(+)	—	—	—	—	—	++	—	+++ ³	++ ³	+	—	++
<i>D. dilatata</i> ² Europe	164	+	(+)	—	— ³	+++	++	+++	(+)	+	(+) ³	—	(+)	—
<i>D. guanchica</i> ² TR 1964/2181	164	—	(+)	++	(+)	+++	+++	—	(+)	+	(+) ³	—	(+)	—

1) Widen et al. 1976 (sub *D. pseudomas*).
 2) Widen et al. 1975.
 3) Amendments to earlier results.
 4) The phloroglucinol composition was studied from 20.3mg ether extract obtained from 1.69 stipe bases (1.27%).

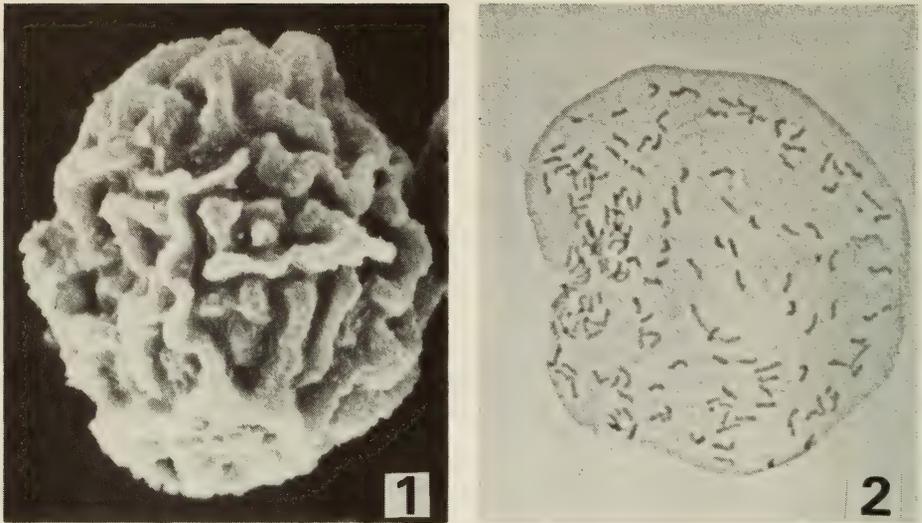


FIGURE 1. Spore of *Dryopteris x fraser-jenkinsii*, x 670.

FIGURE 2. Meiosis in a 16-celled sporangium of *Dryopteris x fraser-jenkinsii* (acetocarmine squash preparation showing metaphase 1), x 1000.

result. Hybridization between a triploid form of *D. affinis* with a diploid species like *D. aemula* would also result in a tetraploid hybrid. However, on morphological grounds it is unlikely that *D. aemula* is a parent of the hybrid, nor was this species growing in the vicinity.

ACKNOWLEDGEMENTS

We are grateful to Kathryn Kavanagh for the Latin diagnoses.

REFERENCES

- GIBBY, M., WIDÉN, C.-J. & WIDÉN, H.K., 1978. Cytogenetic and phytochemical investigations in hybrids of Macaronesian *Dryopteris*, (Pteridophyta: Aspidiaceae). *Pl. Syst. Evol.* 130: 235-252.
- WIDÉN, C.-J., LOUNASMA, M., JERMY, A.C., EUW, J.v. & REICHSTEIN, T., 1976. Die Phloroglucide von zwei Farnhybriden aus England und Schottland, von authentischem "*Aspidium remotum*". A. Braun und von *Dryopteris aemula* (Aiton) O. Kuntze aus Irland. *Helv. Chim. Acta.* 59: 1725-1744.
- WIDÉN, C.-J., LOUNASMAA, M., VIDA, G. & REICHSTEIN, T., 1975. Die Phloroglucide von drei *Dryopteris*-Arten sowie zwei Arten von Madeira und den Kanarischen Inseln zum Vergleich. *Helv. Chim. Acta.* 58: 880-904.

ASPLENIUM BOURGAEI A NEW ADDITION TO THE FLORA OF EUROPE

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ABSTRACT

Asplenium bourgaei, hitherto known only from a few localities on the East Aegean islands, along the southern coast of Anatolia, and in a single site in Lebanon, has been discovered on the island of Karpathos. It is here illustrated, and notes on its ecology are given, notably on its remarkable poikilohydric habit.

INTRODUCTION

Asplenium bourgaei Milde (1866) is a seldom collected fern whose known distribution is confined to the area bordering the eastern Mediterranean basin, and to a few off-shore islands. Meyer (1962) has reviewed the literature dealing with this species, and has provided a distribution map of the few localities then known. Since, *A. bourgaei* has been found in various other localities in S. Anatolia (Davis, 1965; Huber-Morath, 1966; Demiriz *et al*, 1969; Sorger, 1971), and on two islets of the Kastellorizo group belonging to Greece (Greuter, 1979). A further locality on the island of Rhodes has, in all probability, been reported by Finkl (1962) under the certainly erroneous designation "*Asplenium fontanum* (L.) Bernh." On the other hand, Mouterde (1966) has rectified an earlier erroneous record from Lebanon (Mt. Sannin), so that the long known locality in the Litani gorge remains the only one for that country. Rather suprisingly, no report from Cyprus has yet been published. The total known distribution of *A. bourgaei*, including our new finding (see below), is mapped in Figure 1.

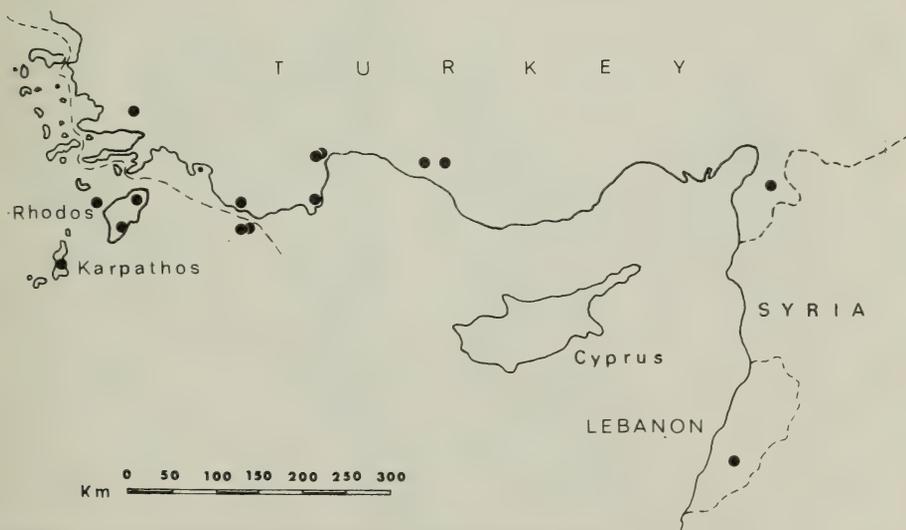


FIGURE 1. The total known distribution of *Asplenium bourgaei*.

Milde (1867) speaks of *Asplenium bourgaei* as a "species pulcherrima", meaning an excellent species. It is indeed a taxonomically isolated, presumably old relic taxon, and has a diploid chromosome complement according to Reichstein (1981) who cites an unpublished chromosome count by Lovis based on material collected by Reichstein in 1964 near Cakirlar (misspelt "Tcharyklar" on Bourgeau's label of 1860

and "Tscharydar" in Davis, 1965). Meyer believes that it is related to another very local old diploid, *Asplenium jahandiezii* (Litard.) Rouy from the Verdun gorge in southern France. It differs considerably, however, from the latter, not only in its more dissected foliar lobes with a less coarse dentation of a different shape, but also in the coloration of the rachis and stipe (see below).

OBSERVATIONS

Asplenium bourgaei has been found by us in a single locality on the South Aegean island of Karpathos (Dodekanisos, Greece). This appears to be the first finding in Europe as defined, for floristic purposes, in "Flora Europaea" (Tutin *et al.*, 1964; see also Greuter *et al.*, 1981). The exact data are as follows:

N. slopes of Mt. Asprovouno, between Mt. Kalilimni and the Apella Bay, 250m above sea level, 18 v 1982, W. & J.J. Greuter, Pleger & Raus 19162; *ibidem*, 9 viii 1982, W. & J.J. Greuter & Zimmer 19482.

Several individuals were growing in shaded clefts underneath big boulders of calcareous rock, in permanent shade but without any special water or moisture supply. The best developed specimens were considerably larger than any that had so far been found in this species (Figures 2 and 3). The frond length attained 28cm, whereas the normal measurements as given by Davis (1965) are 4-7cm. Such luxuriant specimens show particularly well the distinctive features of the species, especially the characteristic dissection of the frond. It is notable that the stipe and lower half of the



FIGURE 2. Luxuriant specimen of *Asplenium bourgaei* from Karpathos (Greuter *et al.*, 19162).



FIGURE 3. Single frond of the specimen in Figure 2.

rachis is dark-coloured on at least one side, but may be green distally on the opposite side (sometimes on the ventral sometimes on the dorsal side). This feature, which seems to be constant within the species, offers an easy means to distinguish even its most dwarfed specimens from the somewhat similar *Asplenium jahandiezii* where the whole rachis and stipe are green except at the very base.

Asplenium bourgaei is, throughout its range, a typical representative of the coastal Mediterranean belt. With a single exception, to be discussed below, all its known localities lie between sea level and an altitude of 900m. Surprisingly Davis (1965) gives the altitudinal range as "1000-2000m", although no single record from such altitudes yet exists. There is one completely aberrant indication of an occurrence at 2500m on Geyik Dag, which in our opinion is in need of confirmation (it might be due either to mis-identification, or to a confusion of feet with metres).

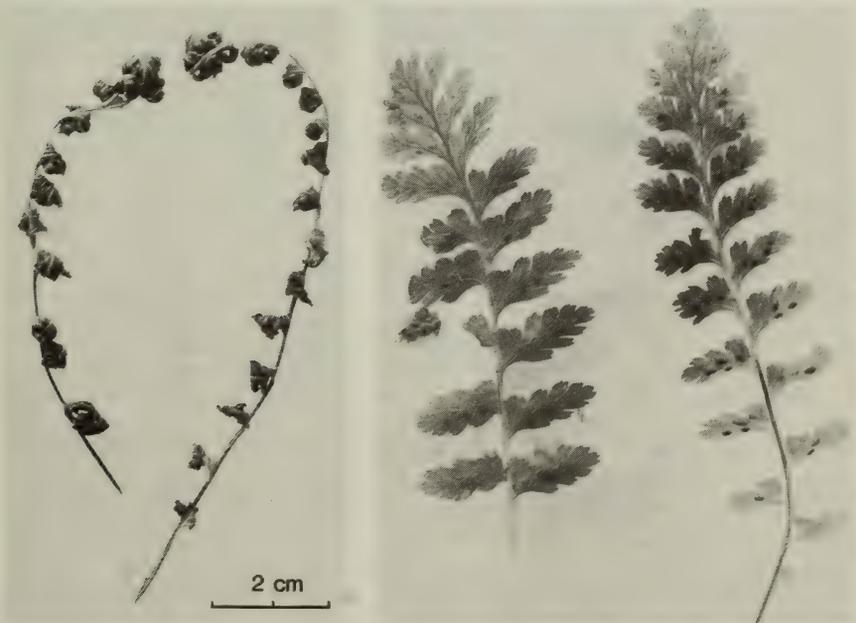


FIGURE 4. a, dry, but living fronds of *Asplenium bourgaei* collected in Karpathos in August 1982; b, the same fronds having recovered their normal shape after being kept for 2 days in moisture in a plastic bag.

The second gathering made in August enabled us to observe a quite remarkable feature. The fronds were at that season completely dry and brittle, with their segments spirally inrolled so as to conceal the sori and with the veins protruding as prominent, thread-like ridges (Figure 4a). They were nevertheless green, and completely recovered their normal form and function when kept under high moisture, in a plastic bag, for 2-3 days (Figure 4b). A similar observation was made by Reichstein (ms. note in the Berlin Herbarium) in November 1964 in the Cakirlar locality: after heavy rain two days earlier some plants, growing in rain shelter under rocks, were completely dry, while others growing nearby, where the soil had been soaked, had unrolled and turgescant fronds.

Such a poikilohydric habit is known for several ferns colonizing dry open habitats such as *Cheilanthes* and *Ceterach* species. It is usually associated with a dense scaly indumentum. Christ (1910: 83) mentioned this faculty of fern fronds to completely dry out without losing viability, while discussing epiphytic ferns, but referred to it only incidentally when commenting on xerophytes proper. In our opinion, the scaly cover is a protecting device against irradiation, not desiccation, whereas the poikilohydric habit is a genuine xerophytic feature — to be found, less pronouncedly, in other *Asplenium* species such as *A. trichomanes*. It may be mentioned that fronds collected in August and soaked before pressing shed their spores in the herbarium, which apparently demonstrates that the maturation of the spores is completed, at least in part, in the desiccated stage.

REFERENCES

- CHRIST, H., 1910. *Die Geographie der Farne*. Jena.
- DAVIS, P.H., 1965. *Flora of Turkey and the East Aegean Islands*. Vol. 1. Edinburgh.
- DEMIRIZ, H., TUTEL, B. & AYDIN, A., 1969. Türkiye flora ve vejetasyonu üzerinde araştırmalar: IV. Türkiye Pteridophyt'lerine ait yeni materyaller: Filicales. (Studia ad floram et vegetationem Turciae pertinentia: IV. New materials to the Pteridophytes of Turkey: Filicales.) *Istanbul Univ. Fen Fak. Mecm. Seri B*, 34: 137-181.
- FINKL, A., 1962. Beiträge zur Kenntnis der Flora der Insel Rhodos. *Acta Albertina Ratisb.* 24: 101-120.
- GREUTER, W., 1979. The flora and phytogeography of Kastellorizo (Dhodeskanisos, Greece). 1. An annotated catalogue of the vascular plant taxa. *Willdenowia* 8: 531-611.
- GREUTER, W., BURDET, H.M. & LONG, G., 1981. *Med-Checklist. I. Pteridophyta*. Genève & Berlin.
- HUBER-MORATH, A., 1966. Beiträge zur Kenntnis der anatolischen Flora III. *Bauhinia* 3: 7-45
- MEYER, D.E., 1962. Über neue und seltene Asplenien Europas. *Ber. Deutsch. Bot. Ges.* 75: 24-34.
- MILDE, J., 1866. Filices criticae. Dritter Artikel. *Bot. Zeitung* 24: 384-385.
- MILDE, J., 1867. *Filices Europae et Atlantidis, Asiae Minoris et Sibiriae*. Lipsiae.
- MOUSTERDE, P., 1966. *Nouvelle flore du Liban et de la Syrie*. Vol. 1. Beyrouth.
- REICHSTEIN, T., 1981. Hybrids in European Aspleniaceae (Pteridophyta). Significance, recognition, genome analysis, and fertility; checklist of species and hybrids. Description of some new hybrids and cytology of several already known hybrids. *Bot. Helv.* 91: 89-139.
- SORGER, F., 1971. Beiträge zur Flora der Türkei I. *Mitt. Bot. Arbeitsgem. Oberösterreich. Landesmus. Linz* 3 (2): 1-98.
- TUTIN, T.G., HEYWOOD, V.H., BURGESS, N.A., VALENTINE, D.H., WALTERS, S., & WEBB, D.A. 1964. *Flora Europaea*. Vol. 1. Cambridge.

NOTE ADDED IN PRESS

Since the above account was written, H. Runemark, Lund, has kindly communicated three additional localities for *Asplenium bourgaei* from unpublished records. These are: SW Turkey, province of Muğla: Fethiye area, N. of Göçük, 100-300m, 1974, *Runemark & Bentzer 29503*; Fethiye area, 2km SE of Yelceğiz, 50-100m, 1974, *Runemark & Bentzer 29452*; Marmaris, NW of the town, 20-50m, 1974, *Runemark & Bentzer 29414*. All lie within the general species area already indicated on the map (Figure 1).

CONTRIBUTIONS TO THE MORPHOLOGY OF THE TECTARIOID FERN STENOSEMIA

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ABSTRACT

The monotypic genus *Stenosemia* Presl exhibits all the characters of Tectarioideae and has several characters in common with those of *Tectaria* Cav. (especially the free-veined species) and tectarioid derivatives. Based on morpho-anatomical comparisons, it is suggested that *Stenosemia* is probably evolved in similar lines of reduction and simplification of characters as those of *Camptodium* Fée, *Hemigramma* Christ, and *Psomiocarpa* Presl. It has also been observed that *Stenosemia* is more nearly allied to *Tectaria* than to *Heterogonium* Presl and possibly derived from a group of free-veined species of *Tectaria* and not from *Ctenitis* C.Chr. as suggested by Copeland (1947). Thus, it seems apparent that *Stenosemia* is a tectarioid fern.

INTRODUCTION

Stenosemia Presl is a genus of tectarioid fern ranging from Solomon Islands across Malaya and the Philippines (Copeland, 1960). It consists of three species (Ching, 1940; Copeland, 1947, 1960). Holttum (1949) transferred *S. pinnata* Copel. to *Heterogonium*: *H. pinnatum* (Copel.) Holtt. According to Holttum (1975) and Hennipman (1977) *S. dimorpha* Copel. (Copeland, 1955) is a *Bolbitis*: *B. quoyana* (Gaud.) Ching. It appears thus that *Stenosemia* is probably a monotypic genus (Price, 1972), the type and sole species being *S. aurita* (Sw.) Presl. It is a rare and small limestone fern growing in shady places at an elevation of 250 metres.

Various authors have given different taxonomic treatment to the genus. Christensen (1938) regards, *Stenosemia* a tectarioid derivative and placed it in his tribe Dryopterideae of the subfamily Dryopteridoideae. Ching (1940) lists this genus under the tribe Aspidieae of the family Aspidiaceae. Copeland (1947) amalgamated Ching's tribes and placed *Stenosemia* along with many other genera in a single large family Aspidiaceae. Holttum (1968), Nayar (1974), Crabbe *et al* (1975) and Lovis (1977) placed the genus in a subfamily Tectarioideae.

Copeland (1947), pointed out its relationship to *Heterogonium* and suggested its derivation directly from *Ctenitis*. However, Holttum (1968) considers *Stenosemia* to have been derived from a true *Tectaria*. Hitherto, the morphology of the genus has not been known, except for a few taxonomic details (Copeland, 1905, 1929, 1947, 1960). Attributes of the sporophyte are here studied and assessed relative to the taxonomic status of the genus.

MATERIAL AND METHODS

The present study of sporophyte morphology is based on material collected by the author in April, 1978 from the Philippines (Luzon: Antimonan, Quezon National Forest Park; S. Chandra 126, PUH), 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 of the rhizome has been studied mainly from serial transections and reconstruction based on camera lucida tracings of the outline of the vascular cylinder. Spore morphology is based on acetolysed samples mounted in glycerine jelly.

OBSERVATIONS

Rhizome

The rhizome is erect, short (c. 5mm thick), infrequently branched, and covered

with closely placed dark brown paleae. The roots are thick, wiry, rust-coloured and profuse between leaf bases. The paleae are basally attached (Figure 1b), clathrate and with thin-walled hyaline marginal cells. The thickening of the walls gradually progresses from the apex downwards (Figure 1d). They are narrowly lanceolate with broad base and each one gradually tapers to a uniseriate club-shaped glandular apex. Rarely the paleae are non-glandular (Figure 1c). The paleal margins (Figure 1e, f) are smooth or nearly so and bear long, unicellular as well as multicellular (2-4 cells) hairs

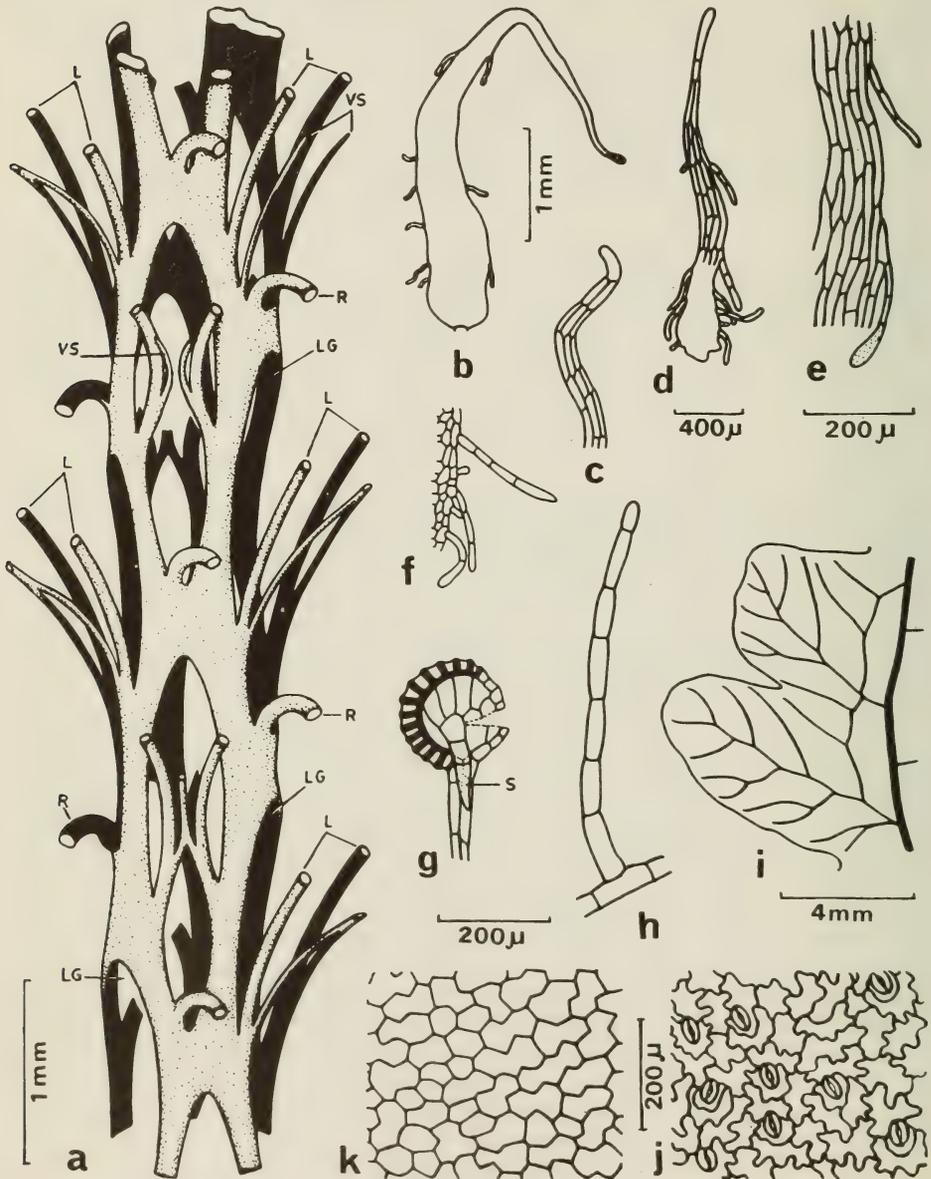


FIGURE 1. Morphology of *Stenosemia aurita* (Sw.) Presl: a, portion of stelar cylinder of the rhizome; b, mature palea; c, apex of mature palea; d, young palea; e, margin of mature palea; f, margin of young palea; g, mature sporangium; h, foliar hairs; i, venation pattern, j, k, upper and lower foliar epidermis ("L" = leaf trace; "LG" = leaf gap; "R" = root trace; "S" = third row of stalk cells; "VS" = vestigial strands).

which are sparsely distributed. The terminal cells of the multicellular hairs are usually club-shaped and non-glandular (Figure 1f); rarely the terminal cell is glandular (Figure 1e). In young paleae (Figure 1d), such hairs are more profuse towards the posterior half and points towards the base of the palea. Surface hairs like those on the paleae of *Ctenitis* are absent. The development of the paleae is as in other tectarioid ferns (Kaur, 1973, 1978; Chandra, 1976).

Structurally, the rhizome is soft and parenchymatous and contains starch deposits. The epidermal as well as ground tissue cells are thin-walled. Sclerenchyma strands as found in *Ctenitis* (Kaur, 1973) and in most species of *Tectaria* (Chandra, and Kaur, 1976), are absent in *Stenosemia* as in free-veined *Tectaria* (Chandra and Kaur, 1976), *Camptodium* (Chandra, 1976), *Hemigramma* (Chandra and Salgado, 1978), and *Psomiocarpa* (Zamora and Chandra, 1977).

Vascular cylinder of the rhizome is a radiosymmetric dictyostele (Figure 1a) similar in basic plan to that of *Ctenitis* (Kaur, 1973), *Tectaria* (Chandra and Kaur, 1976), *Camptodium* (Chandra, 1976), *Psomiocarpa* (Zamora and Chandra, 1977), and *Hemigramma* (Chandra and Salgado, 1978). The leaf gaps (Figure 1a "LG") are closely placed and prominently overlapping so that the stele has 4-5 nearly cylindrical to narrowly ribbon-shaped meristeleles in transectional view; they are ellipsoidal, nearly spindle-shaped openings in the vascular cylinder and taper upward to a broadly anterior end, while the posterior region slightly tapers downwards and becomes truncate because of the large median basal root trace.

The leaf traces (Figure 1a "L") are highly dissected by prominent longitudinal slits usually into 3 or 4 narrow, cylindrical leaf trace strands. The main leaf trace strands are given off one to either margin of the leaf gap near its middle plane, these further divide into four leaf trace strands; of which the abaxial ones unite to form a reticulate leaf trace consisting of 3 leaf trace strands (Figure 1a "L"). Thus the number of vascular strands in each leaf is much reduced in *Stenosemia* as in *Psomiocarpa* (Zamora and Chandra, 1977). Characteristic association of the root trace (Figure 1a "R") on the posterior base of the leaf gap is similar to that reported for other tectarioid ferns (Kaur, 1973; Chandra and Kaur, 1976; Zamora and Chandra, 1977). In contrast to *Ctenitis*, *Tectaria* and *Camptodium*, none of the root traces are associated with the leaf trace bundles as in *Psomiocarpa*. Roots other than those associated with leaves are absent as in most tectarioid ferns.

A peculiar feature of the vascular cylinder of *Stenosemia* is the possession of occasional blind ending stump-like, short vascular strands (Figure 1a "VS") between the leaf trace strands; these strands resemble leaf trace strands at origin, follow a similar course a short distance parallel to them and end blindly. These abruptly ending vascular strands are apparently the remnants of reduced leaf trace strands as also observed in *Tectaria devexa* (Chandra and Kaur, 1976) and *Camptodium* (Chandra, 1976).

The xylem tissue of the vascular cylinder is massive, 6- to 8-celled thick of rather large tracheids interspersed with few thin-walled parenchyma cells. A thin sheath (1 - 2 layers) of small parenchyma cells envelops the xylem tissue except at free ends. Protoxylem elements are usually present at the extreme ends. The phloem is not continuous and consists of usually one or two layers of narrow, thin-walled small cells. Pericycle is very prominent, consisting of usually one layer of large cells and is continuous around the vascular tissue. The endodermis is uniseriate and consists of radially compressed, thin-walled elongated cells. In contrast to *Camptodium*, no sclerenchyma sheath surrounds the meristele as in *Psomiocarpa* (Zamora and Chandra, 1977).

Leaf

Leaves are arranged spirally around the rhizome, stipitate, non-articulated to the rhizome and dimorphic (Figure 2). The stipes of the sterile fronds are dark-polished and shorter than the stipes of the fertile ones. In contrast to *Ctenitis*, the stipes of the sterile fronds bear sparse, mostly deciduous dark, linear paleae at the base only as in *Tectaria*, *Camptodium*, and *Psomiocarpa*. The stipes are cylindrical and beset with characteristic ctenitoid hairs as found on the lamina surface.

Structurally, the stipe (at the base) is similar to the rhizome except for the presence of a distinct, sheath (4-6 layers) of thick-walled narrow cells beneath the epidermis. The cortical sclerenchymatous sheath is interrupted laterally (at the region of the aerating tissue) by parenchymatous tissue in the basal portion of the stipe. The vascular supply to the stipe consists of usually three cylindrical strands (Figure 3). The adaxial strands are much larger than the abaxial one.

The lamina is thin, membranaceous drying dark or somewhat opaque, deltoid ovate, broadly trifoliolate in plan (Figure 2); its central part deeply pinnatifid with entire, or obtusely serrate, lanceolate lobes; lateral pinnae very unequal sided, with lowest basicopic segment pinnatifid, strongly developed as in *Ctenitis*, *Tectaria* (Holtum, 1968), *Camptodium* (Chandra, 1976) and *Psomiocarpa* (Zamora and Chandra, 1977). The lowest segments rarely becoming free pinnae; veins usually forming very narrow costal areolae only (Figure 1i), the remaining veins free, without included veinlets.

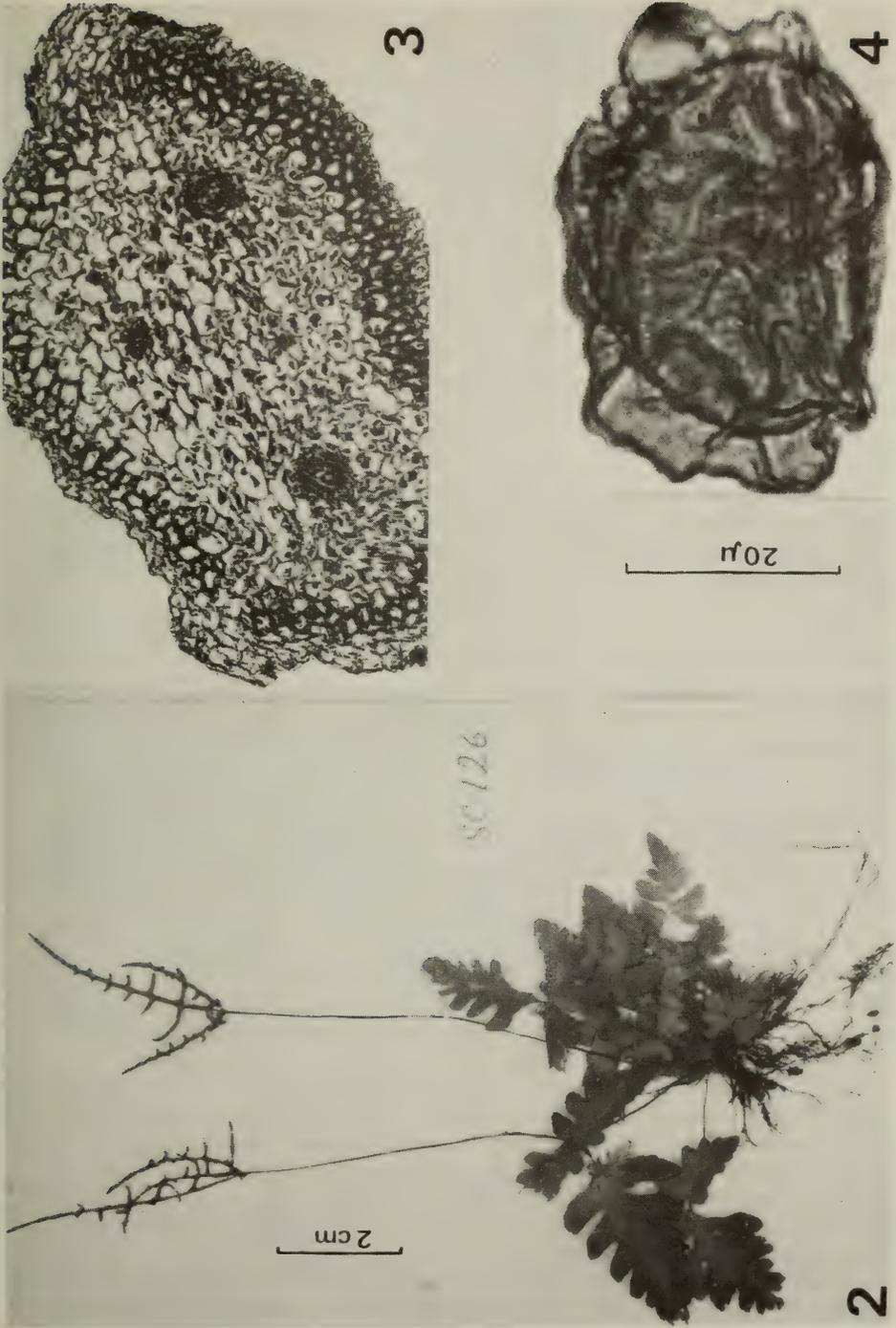
Similar ctenitoid hairs as found on the stipe occur profusely on both the surfaces of the lamina (especially on the veins) and the rachis (Figure 1h).

In the leaf segments, both the epidermises are chlorophyllous and with thick outer walls. In surface view, the upper epidermis is composed of broad, regular hexagonal cells (Figure 1k). In most cases the walls between the two hexagonal cells are dissolved and they look like large, elongated cells with regular straight walls, i.e., the epidermal cell walls are not sinuous. In contrast, the lower epidermis is composed of large, narrow, elongated cells with irregular sinuous walls (Figure 1j). Stomata (measuring on an average 41 x 30 microns) are restricted to the lower epidermis and oriented along the long axes of the leaf lamina (average frequency 51/sq.mm). The guard cells are elongated, oblong and chlorophyllous. The subsidiary cells of the stomata differ in shape from the other epidermal cells. They are broader with similar wavy outlines and usually surround nearly $\frac{3}{4}$, sometime, more of the circumference of the guard cells at the posterior end, whilst the anterior end is dovetail into the corners of usually 1-2 cells. A stoma encircled by a second subsidiary cell is not uncommon; the inner cell is narrow, small, and with smooth outline, the outer one is similar to those described above (Figure 1j). The foregoing stomatal type is classified as polocytic (Van Cotthem, 1970).

Fertile fronds are distinct from sterile ones, long stalked and on the same plan (trifoliolate) as the sterile. They are contrasted almost to wingless axes (Figure 2). The lamina area is reduced to linear segments bearing sori on both the surfaces. Similar hairs as found on the sterile frond lamina are present on the stipe but are smaller in size and are very sparse.

Sporangia

The sporangia (Figure 1g) are of the common leptosporangiate type with a large, pear-shaped capsule borne on short stalk usually 2-3 cells long, 2-celled thick. There is a short third row of stalk cells (Figure 1g "S") at the base of the capsule which is formed secondarily during sporangial development as a downward protrusion of the basal cell wall and the thin-walled stomial cell. However, the stalk is only one-celled thick at its extreme base. The sporangial capsule (measuring on an average 245 x 235 microns) is



FIGURES 2-4. *Stenosemia aurita* (Sw.) Presl: 2: habit of fronds; 3: transection of the stipe at the base, 4: lateral view of spore.

thin-walled and composed of one layer of 8-10 large, flattened cells with nearly smooth contours. The annular ring is well formed with a region of usually 12-14 highly indurated thick-walled cells protruding prominent from the surface of the capsule, and is not continuous with the stomium. As in all other tectarioid ferns, the stomium is well-developed and possesses a pair of unthickened lip cells with thin-walled accessory cells above and below it. Sporangial stalk hairs as found in other tectarioid ferns (Kaur, 1973; Chandra, 1976; Zamora and Chandra, 1977; Kaur, 1978) are absent. Paraphyses are absent as in *Camptodium* (Chandra, 1976). Abortive sporangia are occasionally found.

Spores

The spores of *Stenosemia*, like those of all ferns of aspidioid affinity are of the typical monolete bilateral type, planoconvex in lateral view (Figure 4), oblong in polar view, light brown, and measuring on an average 25 x 35 microns (polar diameter X longest equatorial diameter exclusive of perine) with a distinct perine. Perine protruding c. 7 microns from the exine surface nearly hyaline, sparsely spinulose, and characteristically wrinkled into thin, elongated, sinuous, lobate folds which appear papillate in optical section. The exine is 3 microns thick, densely and minutely spinulose, light brown and usually clearly discernible into sexine and nexine, often nearly of equal thickness. The laesura is 15 microns long, tenuimarginate. On acetolysis there is no alteration in the size and shape of the spores. The general morphology of the spore is that of the *Tectaria* group.

DISCUSSION

The morphology of the plant described in this paper shows all the characters of the Tectarioideae. As brought out in this study, *Stenosemia* closely resembles free-veined species of *Tectaria* (Chandra and Kaur, 1976) and some of the tectarioid derivatives like *Camptodium* (Chandra, 1976), *Psomiocarpa* (Zamora and Chandra, 1977), and *Hemigramma* (Chandra and Salgado, 1978). These genera share several characters in common including the following: rhizome with spirally arranged fronds and dictyostelic vascular cylinder, lack of sclerenchyma strands in the rhizome, greatly reduced leaf trace strands (2-3 in *Psomiocarpa*, 3-4 in *Stenosemia*, 4-5 in *Camptodium*, 4-6 in *Hemigramma*, 5-6 in free-veined *Tectaria*, 8-12 in most *Tectaria* species), root trace at the base of the leaf gap, basally attached clathrate paleae, glandular ctenitoid hairs on the paleal margin, lack of surface hairs on the paleae, articulated foliar hairs, small stature (like *Psomiocarpa* and *Camptodium*).

Though similar to *Tectaria* in some respects (especially in form of frond), *Stenosemia* differs constantly from most species of *Tectaria* in having much smaller stature; fronds trifoliate in plan (both sterile and fertile); fertile fronds contracted to linear segments with acrostichoid sori; greatly reduced leaf trace strands; lack of sclerenchyma strands; root traces not associated with leaf trace strands; unicellular papillate hairs on paleal margin; lack of sporangial hairs and paraphyses; free venation with costal areolae only; foliar buds in the axil of basal pinnae.

Copeland (1947) considers *Stenosemia* to have been derived from *Ctenitis* but the present studies have shown that *Stenosemia* differs markedly from *Ctenitis* in having few number (3-4) of leaf trace strands; lack of root associated leaf trace strands; lack of sclerenchyma strands in the rhizome and stipes; occasional vestigial leaf trace

lack of sclerenchyma strands in the rhizome and stipes; occasional vestigial leaf trace strands; lack of surface hairs on paleae; veins free with costal areolae only; stipes paleate at base only, fronds trifoliate in plan; fertile lamina contracted to linear segments with acrostichoid sori; lack of sporangial hairs; presence of abortive sporangia; much smaller stature.

It has also been observed that *Stenosemia* though similar to the acrostichoid *Heterogonium* (*H. pinnatum*) in general appearance (Copeland, 1929, 1947; Holttum, 1968) differs from *H. pinnatum* in having much smaller stature; fronds always trifoliate in plan; the lateral pinnae having the basal basiscopic segments much the longest; upper surface usually more or less hairy all over; fronds much more translucent, drying browning colour; the fertile frond contracted to linear segments; buds in the axil of basal pinnae. The sum of the differences between *Heterogonium* and *Stenosemia* and the close similarity of *Stenosemia* with free-veined species of *Tectaria* and tectarioid derivatives, seem to warrant the separation of the two genera as also suggested by Holttum (1968, 1975). In view of the foregoing, it appears that the similarity between *Stenosemia* and *Heterogonium* is probably due to parallel line of evolution; the former is possibly derived from free-veined species of *Tectaria* and the latter from *Ctenitis*.

There exists a tendency towards reduction and simplification of the venation pattern in Tectarioideae as shown by *T. devexa* and *T. fuscipes* (Kaur, 1974, 1978). This group of species is considered by Chandra and Kaur (1976) as evolutionary advanced; phylogenetically linked with the derivatives of *Tectaria*. It should be noticed that there is also a tendency towards reduction and simplification in several characters of *Stenosemia*, viz., much smaller stature, few leaf trace strands, fertile lamina reduced to linear segments; lack of sclerenchyma strands in the rhizome; lack of sporangial hairs, simplification of venation; suppressed leaf trace strands. On the other hand, *Stenosemia* shows similarities with a group of free-veined species of *Tectaria* and tectarioid derivatives like *Camptodium*, *Psomiocarpa*, and *Hemigramma* as mentioned earlier. From the above conclusions it seems more probable that *Stenosemia* is also evolved along similar lines of reduction and simplification of characters as those of *Camptodium*, *Hemigramma* and *Psomiocarpa*, from free-veined species of *Tectaria*. These results thus, support the earlier view of Christensen (1938) who considers *Stenosemia* a tectarioid derivative.

The sum of these characters, together with close relationship of *Stenosemia* with the derivatives of *Tectaria* point to a comparatively advanced position of the genus, and suggest, on balance, that *Stenosemia* is probably allied to the free-veined species of *Tectaria* and possibly derived from it and not from *Ctenitis* as suggested by Copeland (1947).

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REFERENCES

- CHANDRA, S., 1976. Morphology of the adult sporophyte of *Camptodium* Fee (Aspidiaceae). *Brenesia* 9: 15-23.
- CHANDRA, S. & KAUR, S., 1976. Contributions to the morphology of *Tectaria*: Vascular organisation of the rhizome. *Phytomorphology* 26: 143-150.
- CHANDRA, S. & SALGADO, A., 1979. Sporophyte morphology in two species of *Hemigramma*. *Kalikasan: Philipp. J. Biol.* 8: 69-78.
- CHING, R.C., 1940. On natural classification of the family 'Polypodiaceae'. *Sunyatsenia* 5: 201-269.
- CHRISTENSEN, C., 1938. Filicineae, in Verdoorn, F. *Manual of Pteridology*, Martinus Nijhoff. The Hague.
- COPELAND, E.B., 1905. *The Polypodiaceae of the Philippine Islands*. I. Bureau Public Print., Manila No. 28: 1-139.
- COPELAND, E.B., 1947. *Genera Filicum*. Chronica Botanica, Waltham Mass., U.S.A.
- COPELAND, E.B., 1955. New Philippine Ferns XI: *Philipp. J. Sci.* 84: 161-165.
- COPELAND, E.B., 1960. *Fern Flora of the Philippines*. Vol. II. Natl. Inst. Sci. Tech., Manila.
- CRABBE, J.A. *et al.*, 1975. A new generic sequence for the Pteridophyta. *Fern Gaz.* 11: 141-162.
- HENNIPMAN, E., 1977. A monograph of the fern genus *Bolbitis* (Lomariopsidaceae). *Leiden Bot. Ser.* 2: 1-331.
- HOLTUM, R.E., 1949. The fern-genus *Heterogonium* Presl. *Sarawak Mus. J.* 5: 156-166.
- HOLTUM, R.E., 1968. *A revised flora of Malaya*. Vol. II *Ferns*. Govt. Print. Off., Singapore.
- HOLTUM, R.E., 1975. The genus *Heterogonium* Presl. *Kalikasan: Philipp. J. Biol.* 4: 205-231.
- KAUR, S., 1973. Morphology of two Indian species of *Ctenitis*. *Bangladesh J. Bot.* 2: 37-42.
- KAUR, S., 1974. The family Lomariopsidaceae (Filicopsida) and its probable ancestors. *Bot. Jour. Linn. Soc.* 68: 153-162.
- KAUR, S., 1978. Contributions to the morphology of *Tectaria*. Venation pattern of sterile and fertile leaves. *Phytomorphology* 28: 14-19.
- KAUR, S., in press. Contributions to the morphology of *Tectaria*: Morphology of the sporophyte. *Phytomorphology*.

REVIEW

UNA GUIA TAXONOMICA PARA HELECHOS DE EL SALVADOR by Ralph Seiler, 58 pp., 238 x 180mm, San Salvador, Ministerio de Educacion, 1980. Price not known but obtainable from the Director of Publications, of the above Ministry.

This is a checklist of the ferns of El Salvador (279 species) with keys to families and genera. It is written by a keen pteridologist, who is professionally a geologist, who found himself seconded to this Central American country. It is an admirable effort and should encourage more local work in a tropical country where, like all tropical countries, every minute counts towards assessing what plants are to be found there before forests are destroyed.

A.C. JERMY

THE CHANGING ROLE OF CHEMISTRY IN FERN CLASSIFICATION

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ABSTRACT

This article reviews the use of plant chemicals, especially secondary compounds, in systematic and evolutionary studies in the Pteridophyta.

INTRODUCTION

The use of chemical characters in systematics has had a very long history (Gibbs, 1963). In ancient times, many medicinal plants were classified according to their "virtues" indicating a close chemical relationship. Camerarius in 1699 noted that "--et que celles de la même class ont aussi quelques rapports dans leur vertus--" (DeCandolle, 1816). But it was not until 20 years ago with the almost simultaneous publication of Alston and Turner's text on "Biochemical Systematics" (1963), the symposium on "Chemical Plant Taxonomy" in the same year (Swain, 1963) and the first volume of "Chemotaxonomie der Pflanzen" (Hegnauer, 1962), that the discipline became recognized in its own right. Since then, the field has developed rapidly due to the exploitation of the newer methods of separating and identifying compounds on an ever increasingly smaller scale.

The rationale of biochemical systematics is the same as in other taxonomic procedures. Plants, or other organisms, are regarded as being more closely related if they contain the same or biosynthetically closely related compounds. The substances examined include most macromolecules, especially proteins and nucleic acids, and a host of low molecular weight compounds (M W 1000 daltons), the so-called secondary products such as alkaloids and flavonoids (Smith, 1976; Ayala, 1977; Gutfreund, 1981). (Table 1).

TABLE 1: Chemical characters used in the classification of plants

SECONDARY METABOLITES	Flavonoids, alkaloids, terpenoids
ISOZYME VARIATION	Gel electrophoresis of plant enzymes
PROTEINS	Amino-acid sequencing of plant proteins
SEROLOGICAL REACTIVITY	Immunological cross reactions
DNA	Interspecific hybridization studies

Because of their diversity, chemical stability and ease of separation and identification, secondary compounds have been the most useful in systematic and evolutionary studies, especially since their mode of biosynthesis is known with reasonable certainty and their important ecological roles are becoming increasingly apparent. Their use in evolutionary studies has recently been discussed (Swain and Cooper-Driver, 1981) and it is obvious that many new biosynthetic pathways have evolved with time leading to a whole range of new compounds such as the betalains, hydrolysable tannins and aromatic alkaloids, all of which are confined to the flowering plants. Usually, the more ancient plants show much less chemical diversity than those which have evolved more recently (Table 2), but, as discussed below, there are exceptions.

TABLE 2: Classes of secondary metabolites present in vascular plants

Pteridophytes	Angiosperms and Gymnosperms
Cell wall components	Monoterpenes
Lignin	Acetylenes
Cutin	Aromatic alkaloids
Suberin	Glucosinolates
Diterpenoids	Betalains
Triterpenoids	Hydrolysable tannins
Lysine alkaloids	
Flavonoids	
Condensed tannins	

Of all the classes of secondary compounds which have been used in systematic studies, the flavonoids and related phenolic compounds have proved to be the most useful. This is because, in general, most plant leaves contain 10-20 of these compounds which can be readily separated by simple two-dimensional PC or TLC and their structures determined on a μg scale by UV spectrophotometry. Furthermore, they often show simple Mendelian genetical traits, and they were the first group of compounds to be used in biochemical genetics.

The flavonoids show an increase in complexity with evolutionary time (Figure 1), the simpler flavones (often as *C*-glycosides or other *C*-linked compounds) occurring in more primitive plants while the more advanced ferns and gymnosperms have flavonols and the ubiquitous procyanidin tannins of immense ecological importance. In the more advanced ferns and seed bearing plants, flavones again prevail (Figure 2). There is also a greater number of species containing xanthenes, (formed via a pathway involving 2 rather than 3 acetate additions to the original C_9 precursor), chalkones and isoflavones.

It was shown nearly 25 years ago that many enzymes occur in multiple forms in the tissues of most organisms (Ayala, 1977), and these could be readily differentiated using gel electrophoresis. The technique was rapidly adopted by population biologists to measure genetic variation and even though there is still a great deal of controversy about the significance of this polymorphism, it is an extremely useful and relatively simple technique for detecting similarities and differences between taxa and for proposing origins of allopolyploid taxa. Electrophoresis is perhaps most useful, however, in detecting and analyzing variability within and between populations. Through such analysis it is possible to determine the level of interaction between individuals in a population and, by correlating electrophoretic data with laboratory study of breeding systems, to propose mechanisms by which this interaction takes place. The individual forms of the enzymes (or storage proteins) are separable on the grounds of shape, molecular weight and net charge: this is determined by movement in an inert gel at a given pH, and ionic strength under the influence of a standard electric field. The technique cannot distinguish all different isozymes since many vary because of changes in amino acid sequence/charge which have no effect on mobility.

Variations in both DNA and RNA have also been used to examine evolutionary and systematic relationships (Ayala, 1977; Gutfreund, 1981). In prokaryotes, recent attention has been paid to gross sequence differences, but the homology between different nucleic acids (especially DNA) has also been determined by annealing procedures (Ayala, 1977) in which relatedness of two taxa is measured by the degree to which their single stranded DNA, separated by heating in buffer to ca. 90°C , reassociates on cooling.

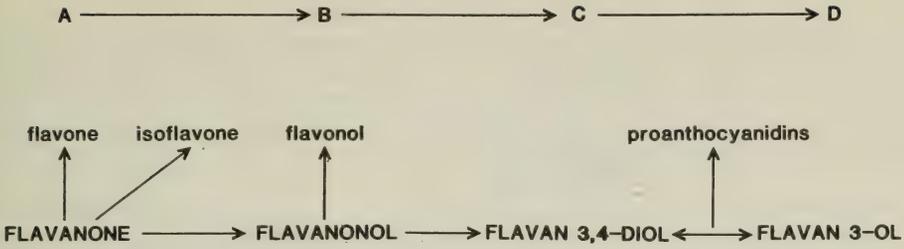


FIGURE 1. Biosynthetic pathways of the flavonoids.

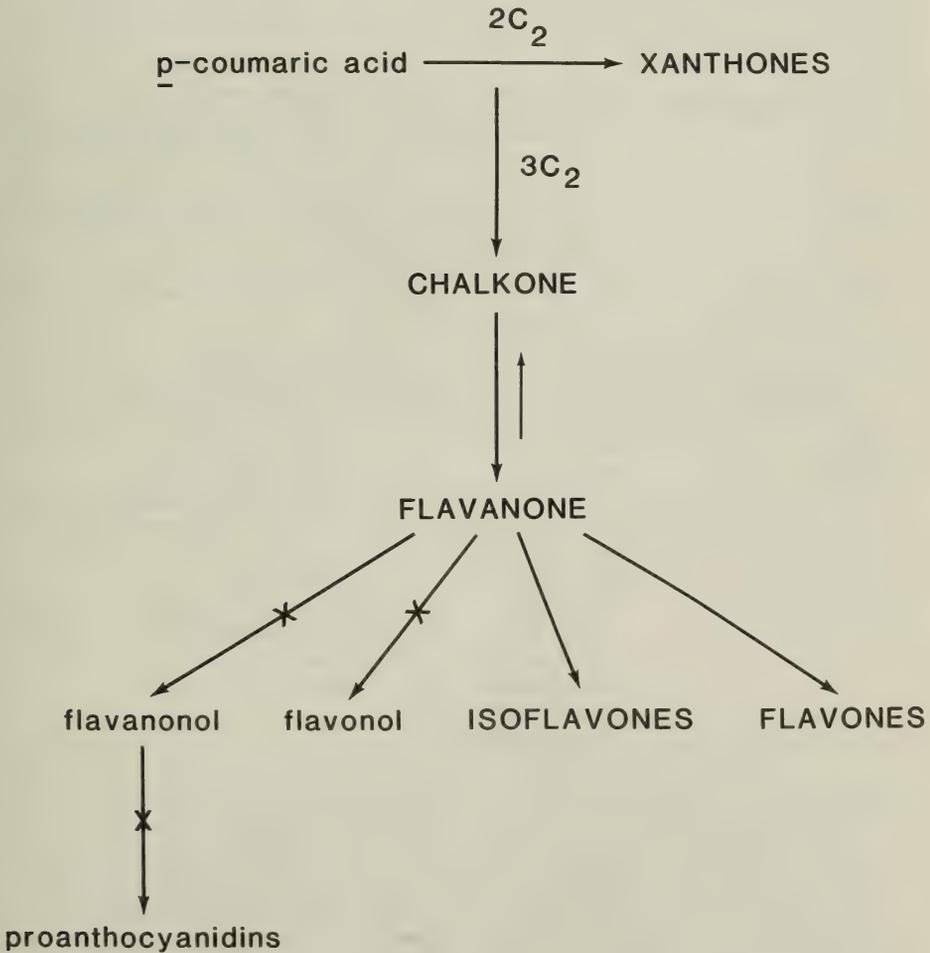


FIGURE 2. Reduction in the reaction sequence in flavonoids.

CHEMISTRY OF FERN AND FERN ALLIES

Most of the methods outlined in the introduction have been applied to ferns and fern allies (see Swain and Cooper-Driver, 1973; Giannasi, 1974) and in the last three or four years many new and exciting questions on fern taxonomy have been posed (Tryon and Tryon, 1982). The new chemical information has given us novel insights into this interesting group of ancestral plants.

Flavonoids

The flavonoids and related phenolic compounds have received most attention in fern systematics (Cooper-Driver, 1980). A three step scheme of biochemical evolution (Table 3) is as true for the pteridophytes (Cooper-Driver, 1980) as it is for the angiosperms (Gornall and Bohm, 1978). The more primitive taxa (Psilophyta, Lycopodophyta), contain only flavones, while flavonols and related 3-hydroxy compounds are found in *Equisetum*, eusporangiate and leptosporangiate ferns. In the more advanced fern taxa, the production of these components is suppressed and flavanones, chalcones, flavones and xanthenes are more common (Cooper-Driver, 1980; Wallace *et al* 1982). (Table 4).

TABLE 3: Biochemical evolution of the flavonoids

Primitive	Development of biosynthetic processes leading to the accumulation of flavones (including C-glycoflavones)
Advanced	Substitutional and skeletal diversification of compounds with 3-hydroxyl groups and other structural features (complex glycosylation)
Highly advanced	Greater utilization of primitive pathways and suppression of existing pathways

TABLE 4: The distributions of flavonoid groups in the Pteridophyta

Primitive Flavones	Advanced Flavonols	Highly Advanced, Flavonones, Chalkones, Xanthenes
Psilotaceae	Equisetaceae	Hymenophyllaceae
Lycopodiaceae	Ophioglossaceae	Pteridaceae
Selaginellaceae	Marattiaceae	Dennstaedtiaceae
Isoetaceae	Osmundaceae	Dryopteridaceae
	Schizaeaceae	Aspleniaceae
	Loxomataceae	Marsileaceae
	Stromatopteridaceae	
	Gleicheniaceae	
	Cyatheaceae	

The xanthenes, because of the ease of identification and apparent taxonomic importance have received considerable attention. The main compounds mangiferin and isomangiferin have been found in four disparate genera (*Athyrium-Asplenium*, *Elaphoglossum*, *Hymenophyllum-Trichomanes* and *Marsilea*). Their distribution here is valuable at the generic level (as in the angiosperms, Hostettman & Wagner, 1977), but has not thrown much light on overall fern evolution or systematics.

Other classes of flavonoids have continued to be particularly useful often correlating with known morphological features at the generic level as shown by recent work on *Bommeria* (Haufier, 1979; Haufier and Giannasi, 1982). (Table 5). This work

TABLE 5: Interspecific differences between species groups in *Bommeria*

<i>B. hispida</i> / <i>B. subpaleacea</i>	<i>B. ehrenbergiana</i> / <i>B. pedata</i>
Luteolin glycosides present	Luteolin glycosides absent
Large scales present	Large scales absent
Cristate spores	Reticulate spores

was extended to look at intergeneric affinities between *Bommeria* and *Hemionitis* (Giannasi, 1980). Species having spores with cristate surfaces were shown to contain common flavonols whereas those having rugose surfaced spores lacked these compounds. It is expected that more extensive chemical examination of related cheilanthoid fern genera may help to untangle other relationships.

The distribution of flavonoids and related compounds has proved to be particularly valuable in examining the complex relationships of many hybrids which are formed via allopolyploidy in ferns. This was earlier shown by the classical work of Smith and his coworkers (Smith and Levin, 1963; Smith and Harborne, 1971) on the Appalachian *Asplenium* hybrids. Here it was shown that it was relatively easy to demonstrate systematic relationships between the parental diploids and derived tetraploids on the basis of their flavonoids.

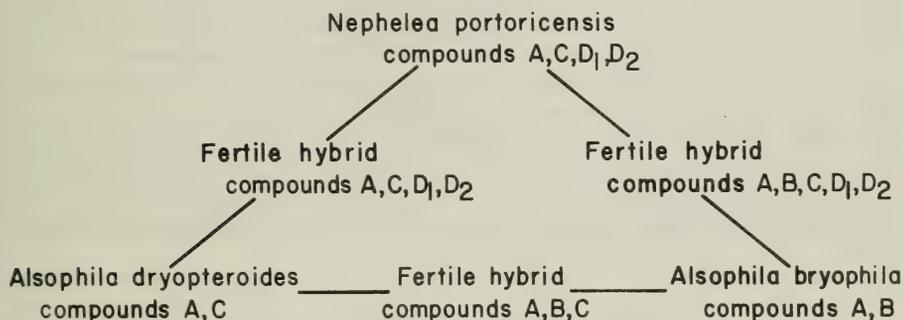


FIGURE 3. Flavonoid analysis of Puerto Rican tree ferns.

In many tropical cloud forests, tree ferns are prominent members of the ecosystem and there is great difficulty in deciding relationships between the putative species. For example, in the Greater Antilles *Alsophila* and *Nephrolepis* form a baffling array of interrelated species groups. Detailed analysis of populations in Puerto Rico, on morphological criteria, showed that there was probable hybridization between *A. bryophila*, *A. dryopteroides* and *N. portoricensis*, but the presumed hybrids could not be differentiated readily, as species and hybrids were all fertile and at the same ploidy level (Conant and Cooper-Driver, 1980). However, the parentage and presumed genetic linkages could be detected by examination of flavonoid patterns on 2-D paper chromatography (Figure 3). Other suspected cases of hybridization between species of the two genera in other islands, has also been detected using flavonoid data (Conant, 1982 *pers. comm.*).

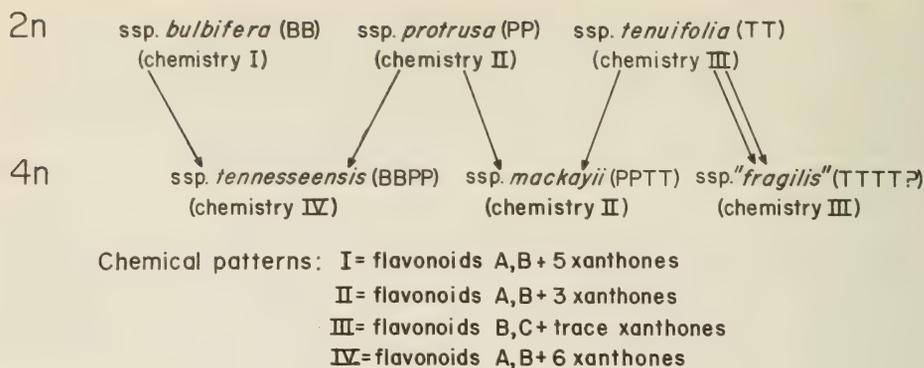


FIGURE 4. Relationships in the North American *Cystopteris fragilis* complex (after Timothy Reeves, 1981), supported by chromosomal, morphological and chemical data.

One of the most formidable systematic challenges in the ferns is the genus *Cystopteris* whose species are distributed worldwide and show remarkable variability in cytotypes ($2n - 8n$) and morphological intergradations. The diploid taxa are found only in the Americas, arguing for origination there. Recent preliminary data on the distribution of xanthones and related compounds (Figure 4) suggest that chemistry may be valuable in resolving species relationships in this complex genus.

In the lycopods, both flavonoids and the complex lysine-derived alkaloids have proved to be useful. Most authorities maintain that *Lycopodium* is a single genus, with three subgenera, *Lycopodium sensu stricto*, *Cernuistachys (Lepidotis)* and *Selago (Urostachya)* (Tryon and Tryon, 1982). While there is general agreement that *Lycopodium s.s.* is the most advanced sub-genus, there is often disagreement as to the evolutionary status of the other two subgenera (Pichi-Sermolli, 1977; Hickey, *pers. comm.*).

TABLE 6: Some chemical characteristics of the genus *Lycopodium*

Sub-genera	Selago	Cernuistachys	Lycopodium
Alkaloids	lucidine	cernuine inundatine	lycopodine
Syringyl Lignin	absent	absent	present
Flavonoids	O-methylated flavones	C-glycosyl flavones	5-O glycosyl flavones

Braeckman *et al* (1980) surveyed 33 temperate species of *Lycopodium* for alkaloids and found that the three subgenera showed distinct differences in the principal alkaloids accumulated. *Cernuistachys* accumulated mainly the alkaloid lucidine. *Selago* mainly cernuine and inundatine and *Lycopodium s.s.* mainly

lycopdine (Table 6). He concluded, on biosynthetic grounds, that the subgenus *Lycopodium*, which accumulated mainly the alkaloid lycopdine, was the most advanced. This is supported by studies in the lignins (Towers and Maas, 1965) which show that only *Lycopodium* contains the more advanced and angiospermlike syringyl groups. Flavonoid data also confirms the advanced status of this subgenus and also suggests that *Cerenuistachys* may be the most primitive. Flavones comprise the only group of flavonoids in the genus *Lycopodium* but within the basic flavone skeleton there is an astonishing diversity of substitution patterns based on *C* and *O*-glycosylation and *O*-methylation. *C*-glycosylation is generally regarded as the most primitive substitution pattern (Swain and Cooper-Driver, 1981) and the more primitive *C*-glycosyl derivatives are found in the subgenus *Cerenuistachys*. Complex 5-*O*-glycosides have been isolated from *Lycopodium s.s.* (Markham and Moore, 1980) again confirming their advanced status.

Protein Chemistry

A technique that is providing one of the most significant modifications of the role that chemistry can play in studying fern evolution is analysis of protein variability through electrophoresis. Some of the evidence generated through this technique is similar to other chemosystematic data since it provides cryptic markers that can be coordinated with existing data in distinguishing species and identifying plants of hybrid origin (Werth *et al* 1980; Moran, 1981; Haufler and Soltis, 1980; 1983).

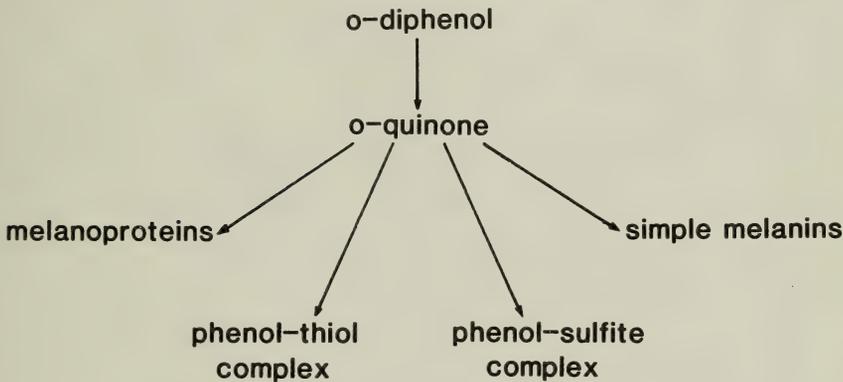


FIGURE 5. A summary of the chemical reactions by which phenolic compounds inhibit enzyme activity.

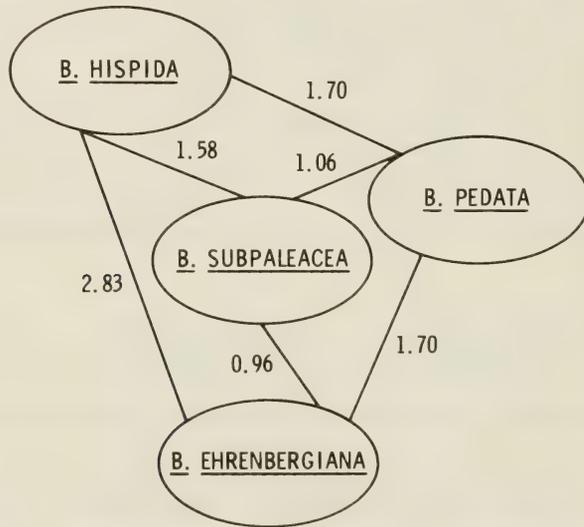
Electrophoretic data are of greatest utility, however, in analyzing variability among individuals and populations (Darrow and Gastony, 1981; Haufler and Soltis, 1983).

Assaying protein variability in the ferns is not as straightforward as with many other plants. When standard grinding procedures are followed, the high concentrations of tannins and other phenolics found in nearly all ferns denature the proteins (Figure 5). It is only recently that these problems have been overcome by using a complex extractant buffer and a procedure that inhibits tannin-protein interactions (Soltis *et al* 1980; 1983). Application of electrophoresis in work with ferns has proved particularly useful since ferns have some characteristics that can be studied best through enzyme analysis. For example, ferns are usually polyploid and it is possible to detect allopolyploid or duplicated sets of chromosomes through electrophoresis (Gottlieb, 1982). Many fern genera also have complex reticulate patterns of species relationships. Often it is possible to use chemical markers to determine the putative allopolyploid taxa have enzyme banding patterns which combine those of their presumed

parents (Werth *et al* 1980). Ferns are unique among vascular land plants in having separate, independent gametophyte and sporophyte generations. Through detection of cryptic protein polymorphisms, it may be possible to demonstrate that these two generations contain differing amounts of variability. If it can be shown that some variability is being filtered out by the gametophyte generation, it may be possible to assign an evolutionary role to this ephemeral life cycle stage. Finally, since it has been shown that there is a diversity of factors influencing gametophyte sex expression, and therefore breeding systems in the ferns (Klekowski, 1969; Lloyd, 1974), electrophoresis is proving valuable in assaying the consequences of this breeding system variability at the population level (Haufler and Soltis, 1983; Haufler, in prep.).

The value of enzyme analysis in fern systematics has been demonstrated by Werth *et al* (1980, 1981) in work with the Appalachian *Asplenium* complex mentioned earlier. An examination of eleven different enzyme loci showed that variability within species of the complex is low, except between well separated populations. However, the parental diploid species showed well defined enzyme band patterns which were found to be additive in the putative allopolyploid derivative species. Further, by detecting regional differences in enzyme patterns, it was possible to demonstrate multiple origins for the hybrid-derived, allopolyploid taxa.

In the genus *Bommeria*, electrophoretic analysis has provided valuable information on species relationships and evolutionary mechanisms (Haufler and Soltis, 1980; 1983). Of particular significance is that calculation of Nei's genetic identity (Green, 1979) within *Bommeria* (Figure 6) showed that the species were

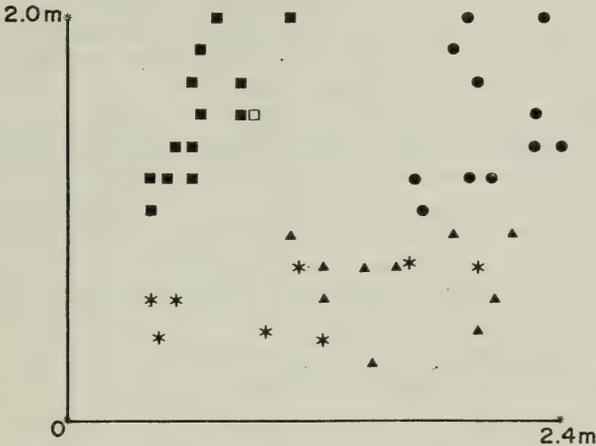


	<u>B. HISPIDA</u>	<u>B. SUBPALEACEA</u>	<u>B. EHREBERGIANA</u>	<u>B. PEDATA</u>
<u>B. HISPIDA</u>	-----	0.207	0.059	0.183
<u>B. SUBPALEACEA</u>	1.575	-----	0.382	0.348
<u>B. EHREBERGIANA</u>	2.834	0.961	-----	0.183
<u>B. PEDATA</u>	1.697	1.055	1.698	-----

FIGURE 6. Pictorial representation of Nei's genetic distance among *Bommeria* species (from Haufler and Soltis, 1983).

remarkably different from each other. The average genetic identity of *Bommeria* species, based on determination of allelic frequencies at 13 polymorphic loci, is 0.195. This figure contrasts markedly with similar infrageneric comparisons among angiosperm species where the average genetic identity was shown to be 0.673 and the values ranged from 0.28 to 0.99 (Gottlieb, 1981). These data suggest that *Bommeria* species may not have a common ancestor and that their morphological similarity may have resulted through convergent evolution to a similar dry-adapted morphotype. Another finding of evolutionary significance is that comparison of gametophyte and sporophyte enzyme banding patterns (Gastony and Gottlieb, 1982) shows that all populations of *B. hispida* are heterozygous at the cytosolic locus of phosphoglucosomerase (PGI-1). This indicates that each population has been initiated by at least two genotypically different spores whose resultant gametophytes have outcrossed to produce the heterozygous sporophytes. While the fact that *B. hispida* populations occur as isolated, disjunct units argues against the likelihood that such an obligate outcrossing scenario could be occurring, these enzyme data, based on field-collected samples, correlate with laboratory analysis of the breeding system (Haufler and Gastony, 1978) to indicate that this is the mechanism by which fertilization is taking place in nature.

Recent investigations of the genus *Cystopteris* have demonstrated a similar (outcrossing) breeding system in *C. protrusa* (Haufler, inprep.). Analysis of the enzyme variability and population structure (Figure 7) of this species have indicated that it is



ENZYME SYSTEMS

	PGI	EST	CAT	MDH	LAP	IDH
■	3	2,3	3,4	1,2,3,4	2,3	3
●	1,2,3	1	1	3,4	2	1,2,3
□	3	2,3	5	1,2,3,4	1,2,3	3
*	1,2,3	2,3	3,4	3,4	2,3	1
▲	1,2,3	-	2	2,3,4	2,3	3

BAND PATTERNS — Numbers indicate relative rates of migration

FIGURE 7. Map of population of *Cystopteris protrusa* based on similarities in band patterns of six enzyme systems. PGI = phosphoglucosomerase, EST = esterase, CAT = catalase, MDH = malate dehydrogenase, LAP = leucine aminopeptidase, and IDH = isocitrate dehydrogenase. This technique provides a method for determining the pattern of variability in populations and for assessing the distribution and extent of asexually reproduced clones. The actual genetic composition of these electrophoretic phenotypes has not yet been determined.

quite polymorphic (preliminary study of range-wide samples show a polymorphic index value of 2.50 alleles per locus based on eight resolved enzyme systems) and that a majority (93%) of the range-wide polymorphism is represented in a single population (Haufler, in prep.). Studies of other plant groups (reviewed in Hamrick *et al* 1979) have demonstrated that these results would be expected from a species that is outcrossing. Therefore, as was shown with *Bommeria*, these enzyme data on *Cystopteris* support the outcrossing breeding system proposed through study of laboratory-grown gametophytes.

With the advent of methods facilitating electrophoretic analysis of enzyme variability in ferns, chemistry takes a step beyond systematics and phylogeny toward describing the partitioning of variability in populations and toward understanding the mechanisms by which this variability is maintained in nature. Through coordination of breeding system and enzyme data it is possible to propose basic differences between fern taxa that may relate directly to the relative complexity of their patterns of evolution. It is clear, therefore, that enzyme analysis will play an increasingly important role in understanding interactions within and among fern species and, ultimately, in defining the various modes of evolution in the ferns.

DNA Analysis

The comparison of DNA's (and RNA's) from different organisms by annealing techniques and by electrophoretic methods following their splitting by restriction enzymes or other methods has proved to be of great importance in determining systematic and phylogenetic relationships for many organisms.

These techniques have been only recently applied to ferns, mainly because of the difficulties in obtaining pure nucleic acid fractions free from contamination by tannins (Stein and Thompson, 1978). With regard to nuclear DNA, there is also the problem of polyploidy, which often makes it difficult to detect homologies. Nevertheless, much progress has been made in this field and the phylogenetic relationships of three New England *Osmunda* species determined. Comparisons of their nuclear DNA showed that the three species most likely arose more or less simultaneously from a common ancestor (Stein *et al* 1979). More recently an examination of fern chloroplast DNA has been undertaken (Stein, *pers. comm.*). Here, the DNA is less complex and can be studied not only by annealing, but also by electrophoretic examination after splitting by specific restriction enzymes. Comparisons of labelled material with similar fractions from angiosperm chloroplasts has shown remarkable similarities and gives promise for more extensive future phylogenetic studies.

CONCLUSION

It is obvious that chemical and biochemical studies on ferns have a very positive role to play in defining phylogenetic and taxonomic relationships. It is now quite apparent that such studies can throw new light on variation within and between populations of a single species and on genetic interrelationships which are not discernable by morphological or other studies. Obviously the variations found demand that more careful sampling is carried out and one should not rely on results obtained from a single herbarium specimen. Fortunately, new developments of HPLC, gel electrophoresis, GC-MS and so on will enable such data to be obtained more easily. Improved methods of computerized numerical analyses have also been developed which will allow such data to be more competently utilized (Bisby *et al* 1980). Newer approaches to chemosystematics are constantly being explored and will widen the use made of chemical compounds for systematic research (Harborne, 1980). Fortunately, investigations on ferns are in the forefront of these exciting developments and it is to be expected that it will not be long before we are able to decipher new relationships in some of the more problematical taxa in this long evolved group of plants.

REFERENCES

- ALSTON, R.E. & TURNER, B.L., 1963. *Biochemical Systematics*. Prentice Hall, New Jersey.
- AYALA, F.J. Ed., 1977. *Molecular Evolution*. Sinauer, Sunderland, Mass.
- BISBY, F.A., VAUGHAN, J.G. & WRIGHT, C.A., Eds., 1980. *Chemosystematics: Principles and Practice*. System. Assoc. 16. Academic Press, London.
- BRAEKMAN, J.C., NYEMBO, L. & SYMOENS, J.J., 1980. Chimiotaxonomie des Lycopodiales: distribution des alcaloïdes. *Phytochem.* 19: 803-807.
- CONANT, D.S. & COOPER-DRIVER, G., 1980. Autogamous allohomoploidy in *Alsophila* and *Nephelea* (Cyatheaceae): a new hypothesis for speciation in homosporous ferns. *Amer. J. Bot.* 67: 1269-1288.
- COOPER-DRIVER, G., 1980. The role of flavonoids and related compounds in fern systematics. *Bull. Torrey Bot. Club* 197: 116-127.
- DARROW, D.C. & GASTONY, G.J., 1981. Electrophoretic genetic variation within populations of *Athyrium filix-femina*. *Bot. Soc. Amer. Misc. Publ.* 160: 57.
- DeCANDOLLE, A.P., 1804, 1816. *Essai sur les propriétés médicales des plantes, comparées avec leurs formes extérieures et leur classification naturelle*. Eds. 1 & 2. Paris.
- GASTONY, G.J. & GOTTLIEB, L.D., 1982. Evidence for genetic heterozygosity in a homosporous fern. *Amer. J. Bot.* 69: 634-637.
- GIBBS, R.D., 1963. History of plant taxonomy. In (SWAIN, T., Ed.) *Chemical Plant Taxonomy*: 41-88. Academic Press, London.
- GIANNASI, D.E., 1974. Phytochemical aspects of fern systematics. *Ann. Missouri Bot. Gard.* 61: 368-378.
- GIANNASI, D.E., 1980. Flavonoid evidence for generic lines in selected gymnostrum ferns. *Bull. Torrey Bot. Club* 107: 128-133.
- GORNALL, R.J. & BOHM, B.A., 1978. Angiosperm flavonoid evolution: a reappraisal. *Syst. Bot.* 3: 353-368.
- GOTTLIEB, L.D., 1981. Electrophoretic evidence and plant populations. *Prog. Phytochem.* 7: 1-46.
- GOTTLIEB, L.D., 1982. Conservation and duplication of isozymes in plants. *Science* 216: 373-380.
- GREEN, D.M., 1979. A BASIC computer program for calculating indices of genetic distance and similarity. *Jour. Hered.* 70: 429-430.
- GUTFREUND, H., 1981. *Biochemical Evolution*. Cambridge Univ. Press, London.
- HAMRICK, J.L., LINHART, Y.B. & MITTON, J.B., 1979. Relationships between life history characteristics and electrophoretically detectable genetic variation in plants. *Ann. Rev. Ecol. Syst.* 10: 173-200.
- HARBORNE, J.B., 1980. New experimental approaches to plant chemosystematics. In (BISBY, F.A., VAUGHAN, J.S. & WRIGHT, C.A. Eds.) *System. Assoc. 16: 39-70. Chemosystematics Principles and Practice*. Academic Press, London.
- HAUFLER, C.H., 1979. A biosystematic revision of *Bommeria*. *J. Arn. Arb.* 60: 445-476.
- HAUFLER, C.H. & GASTONY, G.J., 1978. Antheridiogen and the breeding system in the fern genus *Bommeria*. *Can. J. Bot.* 56: 1594-1601.
- HAUFLER, C.H. & GIANNASI, D.E., 1982. A chemosystematic survey of the fern genus *Bommeria*. *Biochem. Syst. Ecol.* 10: 107-110.
- HAUFLER, C.H. & SOLTIS, D.E., 1980. Detection and analysis of enzyme variation in the fern genus *Bommeria*. *Bot. Soc. Amer. Misc. Pub.* 158: 49.
- HAUFLER, C.H. & SOLTIS, D.E., 1983. Analysis of enzyme variability in the fern genus *Bommeria*. *Syst. Bot.* (in prep.).
- HEGNAUER, R., 1962. *Chemotaxonomie der Pflanzen* I. Birkhauser, Verlag.
- HOSTETTMAN, K. & WAGNER, H., 1977. Xanthone glycosides. *Phytochem.* 16: 821-829.
- KLEKOWSKI, E.J., 1969. Reproductive biology of the Pteridophyta. II. Theoretical considerations. *Bot. J. Linn. Soc.* 62: 347-359.
- LLOYD, R.M., 1974. Reproductive biology and evolution in the Pteridophyta. *Ann. Missouri Bot. Gard.* 61: 318-331.
- MARKHAM, K.R. & MOORE, N.A., 1980. Comparative flavonoid glycoside biochemistry as a chemotaxonomic tool in the subdivision of the classical "genus" *Lycopodium*. *Biochem. Syst. Ecol.* 8: 17-20.
- MORAN, R.C., 1981: *X Asplenosorus shawneensis*, a new natural fern hybrid between *Asplenium trichomanes* and *Camptosorus rhizophyllus*. *Amer. Fern J.* 71: 85-89.
- PICHI-SERMOLI, R.E., 1977. Tentamen Pteridophytorum genera in taxonomicum ordinem redigendi. *Webbia* 31: 313-512.
- SOLTIS, D.E., HAUFLER, C.H. & GASTONY, G.J., 1980. Detecting enzyme variation in *Bommeria*: An analysis of methodology. *Syst. Bot.* 5: 30-38.
- SOLTIS, D.E., HAUFLER, C.H., DARROW, D.C. & GASTONY, G.J., 1983. Starch gel electrophoresis of ferns: a compilation of grinding buffers, gel and electrode buffers, and staining schedules. *Amer. Fern J.* 73: 9-27.
- SMITH, D.M. & LEVIN, D.A., 1963. A chromatographic study of reticulate evolution in the Appalachian *Asplenium* complex. *Am. J. Bot.* 50: 952-958.
- SMITH, D.M. & HARBORNE, J.B., 1971. Xanthones in the Appalachian *Asplenium* complex. *Phytochem.* 10: 2117-2119.
- SMITH, P.A., 1976. *The Chemotaxonomy of Plants*. Elsevier, New York.
- STEIN, D.B. & THOMPSON, W.F., 1978. Isolation of DNA from tannin containing plants. *Plant Sci. Letters* 11: 323-328.

- STEIN, D.B., THOMPSON, W.F. & BELFORD, H.S., 1979. Studies on DNA sequences in the Osmundaceae. *J. Mol. Evol.* 13: 215-232.
- SWAIN, T., Ed. *Chemical Plant Taxonomy*. Academic Press, London.
- SWAIN, T., & COOPER-DRIVER, G., 1973. Biochemical systematics in the Filicopsida Suppl. 1. *Bot. J. Linn. Soc.* 67: 111-134.
- SWAIN, T. & COOPER-DRIVER, G., 1981. Biochemical evolution in early land plants. In NIKLAS, K. (Ed.) *Paleobotany, Paleoecology and Evolution*. Vol. 1, Praeger, New York. 103-134.
- TOWERS, G.H.N. & MAAS, W.S., 1965. Phenolic acids and lignins in the Lycopodiales. *Phytochem.* 4: 57-66.
- TRYON, R. & TRYON, A.F., 1982. *Ferns and Allied Plants with Special Reference to Tropical America*. Springer-Verlag, New York.
- WALLACE, J.W., MARKHAM, K.R., GIANNASI, D.E., MICKEL, J.T., YOPP, D.L., GOMEZ, L.D., PATTILO, J.D. & SOEDER, R., 1982. A survey for 1,3,6,7-tetrahydroxy-C-glycosyxanthones emphasizing the "primitive" leptosporangiate ferns and their allies. *Amer. J. Bot.* 69: 356-362.
- WERTH, C.R., GUTTMAN, S.I. & ESHBAUGH, W.H., 1980. Allozyme variation in the *Asplenium* complex of eastern North America: A progress report. *Intern. Cong. Syst. Evol. Biol. Abstr.* 390.
- WERTH, C.R., GUTTMAN, S.I. & ESHBAUGH, W.H., 1981. Multiple origins of allopolyploid species of *Asplenium*. *Bot. Soc. Amer. Misc. Publ.* 160: 60.

REVIEW

NEW FLORA OF JAPAN: PTERIDOPHYTA by T. Nakaike, 808 pp. 1982. Published by Shibundo Co. Ltd., Tokyo. 260 x 195mm. Price not given.

This is another beautifully printed and bound Japanese fern book, again in Japanese except for the Latin names. It contains however 849 photographs of herbarium specimens of almost all taxa described (including hybrids); in many cases the specimens shown are types. The photographs could have been of higher quality and in some cases larger to show more detail but it does give a very good idea of the general appearance, size and habit. Usually the outline of the frond is clear except in a few cases of larger ferns where the herbarium specimen photographed appears as a mass of overlapping leafy herbage. It is interesting to see the number of hybrids especially in *Dryopteris* and *Athyrium*. The filmy ferns are nicely treated according to Copeland's concepts of genera, with close-ups of fertile parts. Nakaike's concept of *Blechnum* excludes that group which contains our species, *B. spicant*, for which he uses the generic name *Struthiopteris*.

For those that collect world fern floras this is a must; for the grower of hardy ferns it is also immensely useful. All we need with it is a list of those that may be hardy — and hopefully this is not far off.

A.C. JERMY

THE FLAVONOIDS OF THE OSMUNDACEAE

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ABSTRACT

Flavonoids from fronds of all three genera of the Osmundaceae were studied. Twelve flavonoid compounds were found. *Osmunda cinnamomea* contains glycosides of the flavonols kampferol and quercetin. *Leptopteris superba* contains flavone glycosides which are absent from *O. cinnamomea* and both types of compounds are found in *Todea barbara*. These results are in accord with current concepts of delimitation of the genera. *Todea* forms a connecting link between the other two genera.

INTRODUCTION

All members of the fern family Osmundaceae share thick, erect stems with unique stelar structure, uniseriate hairs, fronds free of stomata on adaxial surface and large, vertically dehiscent sporangia with rudimentary, lateral annulus (Hewitson, 1962). Three extant genera are recognized in the family. *Osmunda*, with ca. 10 spp., has a cosmopolitan, discontinuous distribution. *Leptopteris*, a genus of 6 spp., occurs in New Guinea, New Zealand, Australia and Polynesia. The monotypic *Todea* is a southern hemisphere disjunct found in South Africa, Australia and New Zealand.

An extensive fossil record exists for Osmundaceae (Miller, 1971) and suggests that the family was once more widespread and diverse than at present. Form genera, *Thamnopteris* (leaves) and *Osmundacaulis* (stems), are assignable to the family and date back to the Permian. *Osmundites*, an *Osmunda*-like plant, is abundant in Mesozoic rocks. The genus *Osmunda* itself has a fossil record extending back 70 million years. Fossils are insufficient, however, to elucidate evolutionary relationships of extant genera.

Todea and *Leptopteris* seem closely related, and Hewitson (1962), studying morphology and anatomy, concluded that they should be considered sections of a single genus. The two are distinguished primarily by filmy fronds only two cell-layers thick in *Leptopteris* vs. thick coriaceous fronds in *Todea*. Miller (1971) has maintained these genera as distinct, in spite of Hewitson's interpretation. The relationship of *Todea* and *Leptopteris* to *Osmunda* is less clear.

Wagner, *et al* (1978) chromatographed a flavonoid extract of *Osmunda cinnamomea* in conjunction with a chemical study of hybridization between *O. claytoniana* and *O. regalis*. The chromatographic profile found by them differs substantially from the one presented here. They did not attempt to identify the compounds found, so the extent of differences in flavonoid structures between their collection and ours cannot at this time be assessed.

This present paper reports results of a preliminary comparative survey of flavonoids from fronds of all three genera of the Osmundaceae and discusses their bearing on the taxonomy of the family. Particular questions addressed are generic delimitation of *Todea* and *Leptopteris* and the appropriateness of their inclusion in the same family with *Osmunda*. Species investigated were *Osmunda cinnamomea* L., *Todea barbara* Moore and *Leptopteris superba* (Col.) Presl.

TABLE 1. UV spectral data of *Osmundaceae* flavonoids

Compound	Absorption maxima (nm)					
	MeOH	NaOMe	A1C1 ₃	A1C1 ₃ /HCl	NaOAc	NaOAc/H ₃ BO ₃
1. Kaempferol 3-0 glucoside	348	400	399	396	386	350
	302sh	324	350	348	307	303sh
	266	275	303	302	275	266
			275	275		
2. Kaempferol 3-0- rhamnoglucoside	350	400	397	395	387	353
	301sh	328	351	349	304	296sh
	267	275	303	302	273	267
			273	273		
3. Quercetin 3-0- glucoside	360	410	434	404	390	378
	301sh	328	334sh	369sh	325	259
	267sh	271	304sh	301	272	
	256		273	270		
4. Quercetin 3-0- rhamnoglucoside	355	402	429	397	394	370
	304sh	326	339sh	358	318	299
	266sh	272	302sh	301sh	272	261
	255		274	269		
5. Unidentified flavone glycoside	340	400	340	340	355	350
	280sh	320	300	300	268	265
	265	275	275	275		
6. Unidentified flavone glycoside	328	380	340	340	330	350
	385sh	320	300	330	275	285
	270	275	275	275		265

TABLE 2. Chromatographic properties of *Osmundaceae* flavonoids

Compound Number	Rf Value		Colour	
	TBA	HOAc	UV	UV + NH ₃
1	0.64	0.54	Purple	Green
2	0.55	0.65	Purple	Green
3	0.46	0.41	Purple	Yellow Green
4	0.42	0.58	Purple	Yellow Green
5	0.49	0.48	Dull Purple	Light Green
6	0.59	0.53	Purple	Green
7	0.20	0.80	Dull Purple	Light Yellow
8	0.63	0.56	Dull Purple	Dull Purple
9	0.36	0.27	Dull Purple	Light Yellow
10	0.20	0.66	Dull Purple	Dull Purple
11	0.87	0.66	Dull Purple	Dull Purple
12	0.69	0.79	Dull Purple	Green

TABLE 3. Taxonomic distribution of Osmundaceae flavonoids

	Flavonols				Flavones				Unidentified			
	1	2	3	4	5	6	7	8	9	10	11	12
<i>Osmunda cinnamomea</i>	+++	+++	+++	+++								
<i>Todea barbara</i>	+++		++	++		+++				+	+	+
<i>Leptopteris superba</i>					++		+	+	+			

+++ = highest concentration ++ = medium concentration + = low concentration

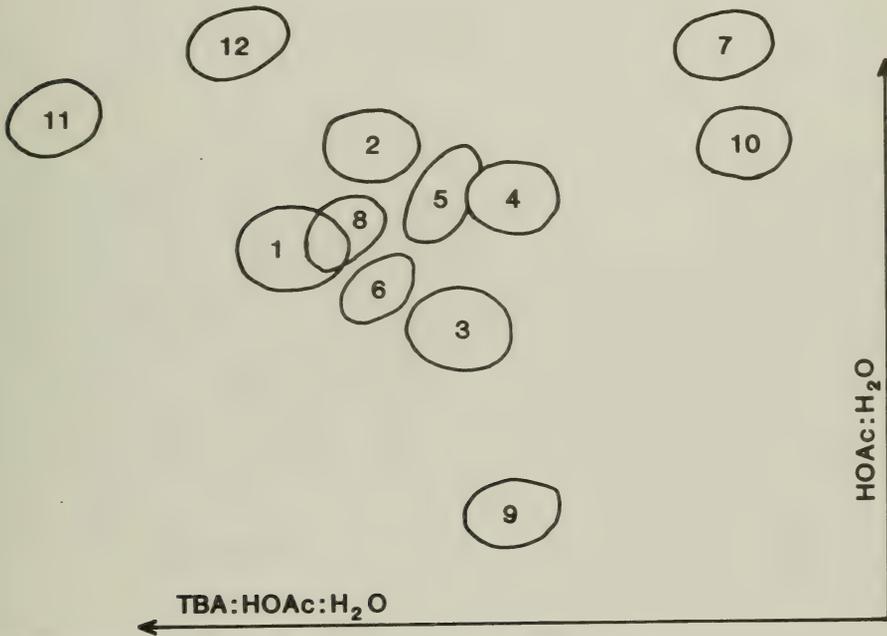


FIGURE 1. Distribution of Osmundaceae flavonoids on chromatogram

MATERIALS AND METHODS

Extraction and purification

5g of dried leaf material was extracted overnight in 50ml of 85% aq MeOH. The extract was filtered and evaporated to a small volume so most MeOH was removed causing chlorophyll to precipitate from solution. The concentrated flavonoid-containing extract was applied to the lower right corner of a sheet of Whatman 3MM chromatography paper, which was developed descending with 3:1:1 TBA:HOAc:H₂O as the solvent in the first (long) dimension and 15% HOAc in the second (short) dimension. The dried chromatogram was examined for fluorescent spots in UV light before and after fuming with NH₃. To isolate flavonoids for structural identification, 60-150 replicate chromatograms were run for each collection. Resulting spots were cut out and extracted briefly from the paper with spectral MeOH. For some collections, a second PC run was required for final purification of compounds.

Spectral analyses

Structural identifications of purified flavonoids relied heavily on UV spectrophotometry of their methanol solutions, employing the diagnostic reagents of Mabry, *et al* (1970). The only departure from their procedures was the use of fused rather than unfused NaOAc for reading the NaOAc and NaOAc/HBO₃ spectra.

Sugar analysis of O-glycosides

Acid hydrolyses were carried out in 2N HCl for 2 hr. Flavonoid aglycones were removed from the resulting sugar-flavonoid mixtures by extraction with EtOAc. The sugar containing aq fractions were chromatographed by ascent with standard sugars on cellose thin-layers with 12:5:4 EtOAc:Py:H₂O as solvent. Sugar spots were detected with aniline pthalate spray.

Plant materials

Voucher specimens for plant materials used in this study are on deposit at the Bailey Hortorium (BH), Cornell University: *Osmunda cinnamomea* L., G.L. Sobel 1715; *Todea barbara* Moore, J.J. Strudwick 2170 (BH 370609); *Leptopteris superba* (Col.) Presl. M. Howard, (BH 370610).

RESULTS

Twelve flavonoid compounds were found in fronds of members of the Osmundaceae studied. Their spectral and chromatographic properties are given in Tables 1 and 2 and in Figure 1. The taxonomic distributions of these substances are summarized in Table 3. *Osmunda cinnamomea* and *Leptopteris superba* have different foliar flavonoid profiles. Glycosides of the flavonols kampferol and quercetin prevail in the former but are absent from the latter. *L. superba* contains flavone glycosides which are absent from *O. cinnamomea*. Both types of compounds are found in *Todea barbara*.

These results are in accord with current concepts of delimitation of the genera in the Osmundaceae. Although chemical profiles of *Osmunda* and *Leptopteris* are very different, *Todea* forms a connecting link between them. The flavonoid structural types found in Osmundaceae are those typical of the leptosporangiate ferns in general (Voirin, 1970) and support the inclusion of the family in that group. The absence of flavonols from *Leptopteris* supports the separation of that genus from *Todea*. Further species of *Leptopteris* need to be examined to be certain that this substantial chemical distinction is consistent.

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REFERENCES

- HEWITSON, W., 1962. Comparative morphology of the Osmundaceae. *Ann. Missouri Bot. Gard.* 49: 57-93.
- MABRY, T.J., MARKHAM, K.R. & THOMAS, M.B., 1970. *The Systematic identification of flavonoids*. Springer-Verlag, New York.
- MILLER, C.N. Jr., 1971. Evolution of the fern family Osmundaceae based on anatomical studies. *Contr. Mus. Paleont. Univ. Mich.* 23: 105-169.
- VOIRIN, B., 1970. *Recherches chimiques, taxinomiques et physiologiques sur les flavonoids des Pteridophytes*. These, Docteur-Science. L'Universite de Lyon.
- WAGNER, W.H. Jr., WAGNER, F.S., MILLER, C.N. Jr. & WAGNER, D.H. 1978. New observations on the royal fern hybrid *Osmunda x ruggii*. *Rhodora* 80: 92-106.

SHORT NOTES

CULCITA MACROCARPA — A NEW LOCALITY IN SPAIN

Culcita macrocarpa Presl. belongs to a small genus, recently placed variously within the family Cyatheaceae in the wide sense, as a tribe, Thyrsopterideae (Holttum, 1963) or as a subfamily, Thyrsopteridoideae (Lovis, 1977), or within the order Dicksoniales as a family in its own right, Culcitaceae (Ching, 1940; Pichi Sermolli, 1977). It is therefore related to the tree-ferns (and to *Thyrsopteris* in particular) and is the only naturally occurring member of that group in the European flora. According to Copeland (1947) it is somewhat primitive within the Cyatheaceae. The genus *Culcita* is divided into two subgenera, of which the subgenus *Culcita* contains two species, *C. macrocarpa*, from Macaronesia, Spain and Portugal, and the closely related *C. conifolia* (Hook.) Maxon from Mexico, the West Indies and S. America.

Culcita macrocarpa is confined to Macaronesia (Canary Isles: N.E. Tenerife; Madeira; Azores: Sao Miguel, Terceira, Sao Jorge, Pico, Faial, Flores and Corvo) where it has long been known, and to a few localities in Atlantic Spain and Portugal, and is thus an interesting example of a Macaronesian element within the European mainland flora where it was virtually overlooked, until Allorge (1934) published on it. It was first collected from south-west Spain by Col. White in 1869 (Diels, 1899) (specimens in K! and B) not far from Gibraltar and presumably in Cadiz province near Algeciras (see Allorge, 1934). Subsequently it was collected but not published in 1929 by Ceballos (see Molesworth-Allen, 1971), and then collected in 1933 by Alorge (1934), and later by Nieschalk & Nieschalk (1965), Molesworth-Allen (1971 and 1977). In the Atlantic southern tip of Spain it is known, due mainly to Molesworth-Allen's searches, to grow in Cadiz province in the Sierra de la Luna, Miel valley, Sierra del Algarrobo, Sierra La Paloma and Sierra de Ojen (all shortly south-west of Algeciras), in the Sierra del Nino, and almost certainly in the Sierra Blanquilla, further east. It is not common, the largest populations being up to c 100 plants in 1969 and 1977, and it is therefore important that plants should not be collected, especially as this species has already been decimated in the past for medicinal extracts, and to a certain extent more recently by unscrupulous botanists selling sets of herbarium specimens, a practice which, if happening to any large extent with threatened species, should be most strictly and severely discouraged by the Universities concerned. It should be borne in mind that particularly with the disastrous droughts affecting south Spain recently, aggravated, or in the long term perhaps even caused, to a considerable degree by the widespread felling and almost uncontrolled burning of what remains of the tree cover, the fate of these few populations hangs in the balance.

Culcita macrocarpa is also known from the north of Portugal, where it was discovered by Rezende-Pinto (1940 and 1943) at Valongo, just to the N E of Porto, Douro Litoral. However this was a naturalised population of cultivated origin, as pointed out by Franco (1971 and 1974). (See also Greuter, Burdet & Long, 1981). More recently, *Culcita* was discovered in a second natural mainland locality by Lainz (1968 and 1973), at Caaveiro, Capela, La Coruña, in the north-west corner of Spain. This part of Spain, though much cooler than Cadiz province, receives considerably more rainfall, and the whole north coast of Spain is in general the main centre for the occurrence of Atlantic species in the Iberian peninsula, depending on their tolerance of the cold temperatures prevalent in winter. The natural occurrence of *Culcita* here is therefore a further indication of the richness of Macaronesian and Atlantic species in the area.

On a recent visit to the central part of the coast of North Spain, occupying only four days of June 1976, in order to search for *Dryopteris guanchica* Gibby & Jermy, one of us (CRFJ) found *C. macrocarpa* by chance in Oviedo province and made a herbarium

specimen (CRFJ 4884, 4th June 1976; *BM*). But it was not until a longer visit in 1981, that in discussions with the second author the significance of this third, natural population, a considerable distance from the others, was recognised and revisited. The plants there were very small, immature, though fertile, and the same size in both 1976 and 1981, the fronds reaching a maximum of *c* 10cm in length. The locality is below and north east of the Col de la Cruz de Llames, between Arriondas and Colunga, E of Gijón, Oviedo province. Approximately 20 plants were found altogether, growing at the edge of a path, now slightly widened along part of its length since 1976, but with no detrimental effect on the population of *Culcita*. The path is in an open area of *Erica* heath on a steep north-facing slope at 500-550m alt.; the substrate is white sandstone, and the *Culcita* plants were growing among mosses and grasses at the edge of where the dark peaty soil was exposed on the upper bank of the path, which is often a suitable area for ferns. Along with *Culcita* there were plants of *Dryopteris aemula* (Ait.) O. Ktze., *D. affinis* (Lowe) Fr. subsp. *affinis*, *D. dilatata* (Hoffm.) A. Gray, *Oreopteris limbosperma* (All.) Holub, *Blechnum spicant* (L.) Roth, *Pteridium aquilinum* (L.) Kuhn and *Athyrium filix-femina* (L.) Roth. Not far above and to the west at *c.* 600m alt., among rocks at the Mirador de El Fito, where the road passes through the Col de la Cruz de Llames, are *Dryopteris guanchica* discovered there by CRFJ in 1976 and the new species *D. corleyi* Fr. subsp. *corleyi*, discovered there by ML in 1981 (see Fraser-Jenkins, 1982). A brief search on the hillside and in the dense forest *c* 100-200m lower down failed to reveal any further plants and no mature plants were found, very probably because of the grazing and occasional burning of the locality, of which there were noticeable signs. It is emphasised and implored that in view of the small number of plants present, no further collections are made from this population. It is also unlikely that plants would survive if transplanted into cultivation. If any further record is needed it should be a photographic one.

The present discovery opens up the possibility that *Culcita* could occur in scattered localities on sandstone further west between Oviedo and La Coruña; further search is indicated.

REFERENCES

- ALLORGE, P., 1934. La *Culcita macrocarpa* Presl. [= *Balantium Culcita* (L'Herit.) Kaulf.] dans les montagnes d'Algésiras, *Bull. Soc. Bot. France* 81: 592-593.
- CHING, R.C., 1940. On natural classification of the family "Polypodiaceae", *Sunyatsenia* 5: 201-268.
- COPELAND, E.B., 1947. *Genera Filicum, the genera of ferns*. Waltham, Mass.
- DIELS, L., 1899. Pteridophyta, in Engler, A. (Ed.), *die Natürlichen Pflanzenfamilien*. Leipzig.
- FRANCO, J. do A., 1971. *Nova Flora de Portugal (Continente e Açores) 1: Lycopodiaceae - Umbelliferae*. Lisbon.
- FRANCO, J. do A., 1974. Phytogeographical survey of Portugal. *Bol. Soc. Broteriana, ser. 2a*, 47 (Suppl.): 89-90.
- FRASER-JENKINS, C.R., 1982. *Dryopteris* in Spain, Portugal and Macaronesia, *Bol. Soc. Broteriana, ser. 2a*, 55: 175-336.
- GREUTER, W., BURDET, H.M. & LONG, G. (Eds.) 1981. *Med-Checklist 1, Pteridophyta*: 12-13. Genève & Berlin.
- HOLTUM, R.E.H., 1963. Cyatheaceae, in *Flora Malesiana, ser. 2, Pteridophyta* 1 (2): 65-176.
- LAÍNIZ, M., 1968. Aportaciones al conocimiento de la flora gallega VI, *An. del Inst. Forestal Invest Exp.*: 36-37.
- LAÍNIZ, M., 1973. Aportaciones al conocimiento de la flora Cantabra-astur X. *Bol. Inst. Estud. Asturianos* 16: 163.
- LOVIS, J.D., 1977. Evolutionary patterns and processes in ferns. *Advances in Bot. Research* 4: 229-415.
- MOLESWORTH-ALLEN, E.A., 1971. Observations on Spanish ferns, *Brit. Fern Gaz.* 10: 200-202.
- MOLESWORTH-ALLEN, E.A., 1977. Observations on some rare Spanish ferns in Cadiz Province, Spain, *Fern Gaz.* 11: 271-275.
- NIESCHALK, A. & NIESCHALK, C., 1965. Ein Stammfarn (*Culcita macrocarpa*) auf europaischem Boden, *Natur u. Museum* 95: 495-498.

- PICHI SERMOLLI, R.E.G., 1977. Tentamen pteridophytorum genera in taxonomicum ordinem redigendi, *Webbia* 31: 313-512.
- REZENDE-PINTO, M.C., 1940. Contribuicao para a flora criptogamica do Norte de Portugal, 4. *Broteria, ser. cienc. nat.*, 9: 129.
- REZENDE-PINTO, M.C., 1943. *Culcita macrocarpa* Pr., contribuic o para o seu estudo monografico. *Bol. Soc. Broteriana, ser. 2a, 17*: 93-146.

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AZOLLA FILICULOIDES IN EDINBURGH

The Bawsinch Nature Reserve which borders Duddingston Loch and Bird Sanctuary was acquired by the Scottish Wildlife Trust in 1971, chiefly to act as a buffer zone for the Sanctuary. Since then extensive tree planting has taken place and in 1975 four ponds were excavated close to the Duddingston drainage ditch. In the ensuing 3-4 years the ponds were extensively planted as well as being colonised naturally, and it seems probable that *Azolla* spores were introduced along with plants brought in from England.

The presence of *Azolla filiculoides* was first noted in May 1980 in the smallest of the ponds, and by November 1980 it had so proliferated that by then half the pond surface was covered. This was roughly the state in the spring of 1981 when the author started a plant survey of Bawsinch, the *Azolla* having survived the relatively mild winter of 1980/81. Other surface plants in the pond included considerable quantities of *Lemna trisulca* (natural), some *Lemna minor* (natural) and *Ranunculus aquatilis* (planted).

The *Azolla* fruited well in May-July, and by August a number of patches of new growth were apparent. Further excavation was undertaken in August to double the size of the pond but drought prevented the final stages until September. Meanwhile the *Azolla* had expanded to cover the entire surface, and when the pond was finally allowed to double in size the *Azolla* followed suit. It has not so far spread to any of the other ponds, but fronds appeared in a small hole (an abortive digging) close to Mark Pond following the autumn gales — probably wind-blown. Subsequent observations showed the *Azolla* to eventually have succumbed in the severe winter of 1981/82, and it has not been seen here again since.

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THE REDISCOVERY OF ASPLENIUM X CONFLUENS

During a week's holiday in Eire, in August 1982, I had the good fortune to find *Asplenium x confluens* (T. Moore ex Lowe) Lawalr e growing in a roadside wall in County Kerry (v.c. H1). Both parent species, *A. scolopendrium* L. and *A. trichomanes* L. subsp. *quadrivalens* D.E. Meyer emend. Lovis, were present, growing in the wall and otherwise in the vicinity, though neither in great numbers. The hybrid was robust and, I would guess, long established, the stock having branched to form side crowns. Collected fronds were subsequently sent to A.C. Jermy (British Museum (Natural History)) who agreed with the determination which was further confirmed by

Professor T. Reichstein of Basel. A frond has been sent also to the Irish National Herbarium at Glasnevin. That, as a decidedly fallible amateur, I recognised the hybrid for what it was when I found it is indicative less of acuity on my part than of its distinctiveness: it exactly answered the description in Jermy *et al.* (1978). It can be presumed to be exceedingly rare since plants are unlikely to be overlooked, if seen, by those interested in ferns, and since both parent species are abundant in many parts of Britain, often together, commonly in easily accessible places, and are, besides, very popular with amateurs who scrutinise them for variants.



FIGURE 1. Frond of *Asplenium x confluens* from Kerry.

Apart from one record from Yugoslavia mentioned in Lovis (1975), and disregarding the accidental resynthesising of the hybrid in cultivation circa 1916 in the U.S.A. (Lovis and Vida, 1969), there appear to be only three accepted records, all from the British Isles. These were at Levens Park (now in Cumbria; v.c. 69) by Stabler in 1865; at Whitby (N. Yorkshire; v.c. 62) by W. Willson; and at Killarney (County Kerry; v.c. H2) by P.N. Fraser circa 1875 (Jermy *et al.*, Druery 1901). It is curious that these three finds were made seemingly within a period of ten years, yet more than one hundred years elapsed before it was found again. No less curious is that I found it approximately fifteen miles from Killarney, where the last accepted previous find was made. Moreover I found *A. scolopendrium* only fairly infrequently, and nowhere in abundance, in South Kerry, while *A. trichomanes*, though somewhat more numerous, seemed to occur in relative quantity only sporadically. Incidentally, I failed to find *A. ruta-muraria* and *A. ceterach* in South Kerry, though both have been recorded there.

Druery (1901) refers to two further finds of what he listed as 'Confluens Stabler' under *A. trichomanes*, both in Ireland, by W. Forster and J.J. Smithies (no further details): these are omitted from Jermy *et al.*, presumably because these records cannot be validated. Druery (1910), which has an illustration of the hybrid and suggests *A. scolopendrium x trichomanes* as more credible parentage than *A. marinum x trichomanes* as some had suggested, still refers to five finds. If, notwithstanding the absence of evidence, Forster and Smithies did find *A. x confluens*, it would mean that of six finds in the British Isles, four were made in Ireland.

ACKNOWLEDGEMENTS

I thank the staff of the Fern Section, BM (NH), and Profesor T. Reichstein for confirming my determination.

REFERENCES

- DRUERY, C.T., 1901. *The book of British Ferns*. London.
 DRUERY, C.T., 1910. *British ferns and their varieties*. London.
 JERMY, A.C., ARNOLD, H.R., FARRELL, L. & PERRING, F.H., 1978. *Atlas of ferns of the British Isles*. London.
 LOVIS, J.D., 1975. *Asplenium* in STACE, C.A. (Ed.) *Hybridisation and the Flora of the British Isles*. London.
 LOVIS, J.D. & VIDA, G., 1969. The resynthesis and cytogenetic investigation of *x Asplenophyllitis microdon* and *x A. jacksonii*. *Br. Fern Gaz.* 10: 53-67.

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AN ABERRANT FORM OF *EQUISETUM TELMATEIA* FROM THE ISLE OF WIGHT

Whilst carrying out a botanical survey of Luccombe Chine Ledge (40-583794) on the south coast of the Isle of Wight on 5th July 1981, I was surprised to find several striking specimens of *Equisetum telmateia* Ehrh. growing amongst an abundance of typical vegetative shoots of the species. The specimens in question were some 500 mm high, had moribund tips to the shoots and were producing a proliferation of side shoots, each terminating in a small cone (Fig. 1). Four or five such specimens were detected in relatively open ground over an area of some five square metres.



FIGURE 1. Aberrant shoot of *Equisetum telmateia*, Luccombe Chine Ledge, Isle of Wight, with numerous small cones.

The site is a coastal ledge produced by gault clay slipping over lower greensand deposits. The habitat is kept open by virtue of the shifting nature of the substrate. *E. telmateia* is abundant and is the only *Equisetum* present in the immediate area. Because of the presence of gault clay and greensand, the associated species include both calcicoles and calcifuge species. The main associates are *Phragmites communis*, *Tussilago farfara*, *Eupatorium cannabinum*, *Prunella vulgaris*, *Blackstonia perfoliata*, *Betula pubescens*, *Pulicaria dysenterica*, *Carex flacca* and *Lotus pedunculatus*.

ACKNOWLEDGEMENT

I am grateful to Dr. C.N. Page for identifying the specimen and for drawing my attention to the interest of the find.

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C-GLYCOSYLXANTHONES IN TECTARIA

C-glycosylxanthones are phenolic compounds which occur sporadically in ferns. They have previously been reported from *Asplenium*, *Athyrium*, *Cardiomanes*, *Ctenitis*, *Elaphoglossum*, *Hymenophyllum*, *Marsilea* and *Trichomanes* (see Richardson, 1982). A survey at New York Botanical Garden has discovered the compounds in the following genera: *Davallia*, *Humata*; *Nephrolepis* (Richardson, 1982); *Acystopteris*, *Gymnocarpium* and *Woodsia* (Richardson & Thaddeus, 1983). C-glycosylxanthones have now been found in a species of *Tectaria*. The compounds were not detected in 21 other species of *Tectaria* and in 13 related genera.

Tectaria decurrens (Presl.) Copel. (NYBG number 329/76) was collected in the Enid A. Haupt Conservatory at NYBG. A voucher specimen was deposited in the NYBG herbarium. The extraction and detection process has been previously described in detail (Richardson, 1982). The two-dimensional chromatograms of the extract and its hydrolysis products indicated the presence of three C-glycosylxanthones. Two of these were identified as mangiferin and isomangiferin by co-chromatography with authentic compounds from *Asplenium montanum* Willd.

A survey of herbarium material of *Polystichum* and related genera failed to reveal the presence of C-glycosylxanthones in further taxa. The following genera and numbers of species were examined: *Tectaria* (21); *Hemigramma* (2); *Quercifilix* (1); *Cionidium* (1); *Tectaridium* (11); *Fadyenia* (1); *Pleuroderris* (1); *Hypoderris* (1); *Dictyoxiphium* (1); *Camptodium* (1); *Stenosemia* (1); *Heterogonium* (2); *Cyclopeltis* (2) and *Didymochlaena* (1).

The rare occurrence of C-glycosylxanthones in *Tectaria* and related genera is typical of ferns. The only exception occurs in the Davalliaceae where almost half the examined species were found to contain the compounds (Richardson, 1982). On the basis of this evidence, it seems unlikely that C-glycosylxanthones will prove of much taxonomic value in the ferns.

REFERENCES

- RICHARDSON, P.M., 1982. C-glycosylxanthones in the fern genera *Davallia*, *Humata* and *Nephrolepis*. *Phytochemistry*.
 RICHARDSON, P.M. & THADDEUS, E. C-glycosylxanthones in the fern genera *Acystopteris*, *Gymnocarpium* and *Woodsia*. *Phytochemistry* (Submitted).
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BRITISH PTERIDOPHYTE RECORDS

Compiled by A.R. Busby

Since the appearance of the 'Atlas of Ferns', I have compiled an annual list of additions and corrections that have been notified to me by the Biological Records Centre, BSBI vice-county recorders and members of the BPS and the BSBI. Past lists have been published in the BPS 'Bulletin' but from now will appear in the *Fern Gazette*.

The records are presented thus: 100km square (letters are used for Irish grid squares to avoid confusion)/10km square followed by the recorders name. Nomenclature follows the *Atlas*. The following additions and corrections have been received up to the 1st November 1982.

PRE 1950

- 8.1 *Botrychium lunaria* 63/04 Unknown, 63/11 W. G. Clarke.
- 9.1 *Ophioglossum vulgatum* 12/90 S. B. Evans, 36/77 I. Martin.
- 21.8 *Asplenium viride* 17/53 not post-1950 as indicated.

POST 1950

- 1.1. *Lycopodium annotinum* 18/62 C.W. Murray.
- 1.2 *L. clavatum* 18/32 G. Halliday, 18/33, 53, 72 C.W. Murray, 18/60 E. Vickers, 34/30 D.S. Lambert, 35/07, 16 M. Martin, 43/36 M. Robson,
- 2.1 *Lycopodiella inundata* 18/61 M. & E. Vickers, 29/50 M.J. Marshall.
- 3.1 *Huperzia selago* 18/14 M. Coulson, 18/33, 34, 36, 44, 50, 54, 63 C.W. Murray, 18/60 E. Vickers, 21/94 K. Hearn, HOO/77, 88, 97 A. Willmot, H23/78 J. McNeil.
- 4.1 *Diphasiastrum alpinum* 18/24 M. Coulson.
- 5.1 *Selaginella selaginoides* 17/04 J. Clark, 18/56 C.W. Murray.
- 5.2 *S. kraussiana* 22/50 I.K. Morgan, 31/03 J.G. Keylock, 51/25 J. Byatt.
- 6.1 *Isoetes lacustris* 18/13, 33 G. Halliday, 18/55, 63, 71 C.W. Murray, 18/62 A. McG. Stirling, HOO/77, 97 A. Willmot.
- 6.2 *Isoetes echinospora* 07/94 A. Slack, 17/74 A.C. Jermy, 22/86 B. Seddon, 25/97 O.M. Stewart.
- 7.1 *Equisetum hyemale* 18/35, 45 C.W. Murray; H34/30 D.S. Lambert.
- 7.1x2 *E. x trachyodon* 18/45 C.W. Murray, 35/78 G.A. Swan.
- 7.2 *E. variegatum* H33/43 P. Hackney.
- 7.3 *E. fluviatile* 07/94 and 17/04 J. Clark, 18/41 H.J. Birks, 18/32, 37, 43, 54, 60 C.W. Murray, 52/35 Unknown, 63/02 P.W. Lambley, 63/11 E.T. Daniels; HOO/97 A. Willmot.
- 7.4 *E. arvense* 07/93, 94 and 17/04 J. Clark, 18/50, 54 C.W. Murray, 18/72 M. McCallum Webster; HOO/78 A. Willmot.
- 7.4x3 *E. x litorale* 22/51 A.M. Pell, 25/64 O.M. Stewart, 51/27 J. Byatt.
- 7.5 *E. pratense* 18/35 C.N. Page.
- 7.6 *E. sylvaticum* 18/50 C.W. Murray, 18/72 M. McCallum Webster, 22/13 S.B. Evans, 34/84 B. Oddie.
- 7.7 *E. palustre* 07/93, 94 and 17/04 J. Clark, 18/54, 60 C.W. Murray, 25/98, 35/39 M. Martin, 63/00 E.A. Ellis; HOO/98 A. Willmot.
- 7.8 *E. telmateia* 18/25, 26, 36 C.W. Murray.
- 8.1 *Botrychium lunaria* 41/86 W.E. Warner, 43/08 A. Willmot, 62/28 Miss C. Forrest; H24/73 D. Riley, H24/81, 84 D.S. Lambert.
- 9.1 *Ophioglossum vulgatum* 22/72 J. Humphrey, 25/46 P. Hopkins, 25/67 O.M. Stewart, 34/74 B. Oddie; H24/81 D.S. Lambert.
- 10.1 *Osmunda regalis* 18/24, 35, 41, 43, 63 C.W. Murray, 18/47 B. Philp, 24/45, 55 D. Glyn Jones, 41/96 T.R. Price, 51/44 J.E. Smith, 52/99 E.T. Daniels, 63/11 M. Wiggington.
- 11.1 *Cryptogramma crispa* 17/42 A. Kelham, 18/41 C.W. Murray, 18/71 H.J.B. Birks.
- 14.2 *Hymenophyllum wilsonii* 18/41 H.J.B. Birks; H10/07 A. Willmot.
- 16 *P. vulgare* agg. 42/56 R. Lamb.
- 16.1 *Polypodium vulgare* 18/33, 42, 43, 53 G. Ramsey, 25/89 J. Martin, 32/46, 57 M.H. Rickard, 32/47 A.R. Busby, 42/44 J.G. Sampson, 45/06, 15, 16 J. Durkin; HOO/78, 77, 97, H10/07 A. Willmot.
- 16.2 *P. interjectum* 07/93, 94 and 17/04, 05 J. Clark, 18/44, 54 G. Ramsey, 51/06 J.E. Smith, 54/41 F.E. Crackles, 63/10 P. Kirby.

16.
 2x1 **P. x mantoniae** 18/33 G. Ramsey, 25/97 M. Martin.
 16.3 **P. australe** 32/25, 29 P.M. Benoit, 32/39 A.R. Busby, 32/46 M.H. Rickard.
 16.
 3x2 **P. x shivasie** 25/97 M. Martin.
 17.1 **Pteridium aquilinum** 07/93, 94 and 17/04, 05 J. Clark, 18/37, 41 C.W. Murray, 45/36 J. Durkin, 53/34 N.J. Hards.
 19.1 **Phegopteris connectilis** 18/26, 53 H.J.B. Birks, 18/54, 62, 63 & 72 C.W. Murray, 21/83 P. Bullard, 22/73 I. Vaughan, 32/46 M.H. Rickard, 38/73 D. Welch; HOO/77 A. Willmot.
 20.1 **Oreopteris limbosperma** 18/36, 41, 56 C.W. Murray, 41/95, 96 Surrey FC, 43/34 A. Willmot, 45/15, 16, 25 J. Durkin; HOO/77, 88, 97, 10/07 A. Willmot.
 21.1 **Asplenium scolopendrium** 17/04 J. Clark, 18/32 C.W. Murray, 18/60 M. McCallum Webster, 36/92 J. Durkin, 43/08 A. Willmot, 45/24, 26 J. Durkin, 53/34 N.J. Hard, 62/19, 63/01, 02, 10, 23, 32, 40, 42, 50 E.T. Daniels.
 21.2 **A. adiantum-nigrum** 07/93, 94 and 17/04 J. Clark, 18/41 C.W. Murray, 18/72 H.J.B. Birks, 35/18 M. Martin, 53/51 R. Stevenson, 53/70, 71 P.W. Lambley, 53/93, 63/00.01, 04, 11, 12, 14, 41 E.T. Daniels, 62/01, 23 Nature in N E Essex; H34/13 H.D. Megaw.
 21.3 **A. onopteris** HOO/88, 98 A. Willmot.
 21.6 **A. marinum** 07/94 J. Clark, 18/32 C.W. Murray, 18/52 M. Coulson.
 21.7 **A. trichomanes** agg. 18/71 M. McCallum Webster, 34/79 J.G. Sampson, 41/93 J.E. Smith, 52/98, 53/93, 63/00, 03, 10, 11, 13, 20, 22, 33, 50 E.T. Daniels.
 21.7a **A. trichomanes**, subsp. *trichomanes* 18/33, 45 G. Ramsey, 22/98 P.M. Benoit.
 21.7b **A. trichomanes**, subsp. *quadrivalens* 17/04, 64 J.W. Clark, 18/33, 43, 44, 54, 62, 72 G. Ramsey, 35/95, 96, 97, 45/05, 06, 15, 19, 25, 26, 46/21 J. Durkin.
 21.8 **A. viride** 18/26 H.J.B. Birks; HOO/88 A. Willmot.
 21.9 **A. ruta-muraria** 22/25 A.O. Chater, 35/89 J.G. Sampson, 45/15 J. Durkin, 53/34 N.J. Hards, 53/93 P.W. Lambley, 62/19, 63/00, 11 E.T. Daniels.
 21.11 **A. ceterach** 17/48 C.W. Murray, 18/62 M. Gregory, 22/56, 67 A.O. Chater, 42/55 R. Lamb, 43/37 L. Storer, 45/16 J. Durkin, 53/42 R. Stevenson, 62/39 J. Silverwood; H24/72 D.S. Lambert, H34/02, 03, 04, H.D. Megaw
 22.1 **Athyrium filix-femina** 07/93, 94 and 17/04 J. Clark, 18/37 C.W. Murray, 22/25 A.O. Chater, 51/05, 34 R. Clarke, 52/65 C.D. Preston, 63/02 A.L. Bull, 63/33 E.T. Daniels.
 23.1 **Gymnocarpium dryopteris** 18/34, 71 H.J.B. Birks, 18/54, A. McG. Stirling, 22/53 R. Woods, 33/25 Unknown.
 23.2 **G. robertianum** 31/03 Miss C.J. Biddens, 34/61 P. Jepson.
 24.1 **Cystopteris fragilis** 18/71 C.W. Murray, 32/57 M. Henshall, 35/96, 45/16 J. Durkin; HOO/88 A. Willmot, H33/18 D.S. Lambert, H34/24 H.D. Megaw.
 26.2 **Polystichum aculeatum** 32/17 A.C. Powell, 32/46 A.R. Busby, 34/74 B. Oddie, 36/01 N.F. Stewart, 43/08 A. Willmot, 42/25 J. Durkin, 63/10, 20, 21 E.T. Daniels.
 2x3 **P. x bicknellii** 18/52 M. Barron.
 26.3 **P. setiferum** 22/56 A.O. Chater, 41/84 J.E. Smith, 41/85 J. Knight, 41/93, 51/06 K. Page, 43/23, 32 A. Willmot, 45/04 J. Durkin, 51/27 A.C. Leslie, 53/92, 62/19, 63/01, 33 E.T. Daniels, 62/18 P.W. Lambley.
 27.1 **Dryopteris oreades** 18/42 C.W. Murray, 18/51 M. Coulson, 18/62, 71 H.J.B. Birks, 25/86 O.M. Stewart; HOO/97 A. Willmot.
 27.2 **D. filix-mas** 07/93, 94 and 17/04 J. Clark, 18/33, 43, 46, 61 C.W. Murray, 18/71 M. McCallum Webster, 35/36 M. Martin.
 27.3 **D. affinis** 17/04 J. Clark, 22/35 A.O. Chater, 32/57 M.H. Rickard, 41/24 F. Rose, 41/94 Surrey FC, 45/14, 24, 26 J. Durkin, 43/17 N.J. Hards.
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 27.9 **D. austriaca** 07/94 and 17/04 J. Clark, 18/43 C.W. Murray, 22/25, 35 A.O. Chater, 32/46 M.H. Rickard, 53/34 N.J. Hards, 53/94 E.T. Daniels.
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 9x8 **D. x deweveri** 63/31 E.T. Daniels.
 27.10 **D. expansa** 22/87 A.O. Chater,
 28.1 **Blechnum spicant** 07/94 and 17/04 J. Clark, 18/37, 41, 54 C.W. Murray, 18/71 M. McCallum Webster, 43/33 A. Willmot, 63/11, 31 E.T. Daniels.

Pilularia globulifera 17/04 A. McG. Stirling — a new for V.-C. 103, 63/11 E.A. Ellis.
Azolla filiculoides 33/49 I.D. Wallace, 51/16, 17 J. Montgomery, 51/26 J. Byatt, 63/20
 E.T. Daniels, 63/10, 11, 32 P.W. Lambley.

Corrections to previous records

- 1.2 **Lycopodium clavatum** delete 63/01, 22, 23, 42, 51 fide P.W. Lambley.
 7.1 **Equisetum hyemale** delete 17/32 fide A.C. Jermy.
 29.1 **Pilularia globulifera** delete 63/01 fide P.W. Lambley.

REVIEWS

THE FERNS OF BRITAIN AND IRELAND by C.N. Page, pp xxi, 447; 102 figures, 1982. 228 x 152mm. Cambridge University Press. Price: paperback £15 (SBN 0 521 29872 5), hardback £40 (SBN 0 521 23213 9).

This is the first book to illustrate and describe every known species of British fern, fern ally and hybrid. As such it is an important addition to British botanical literature and will no doubt compete with *Welsh Ferns* as the principal work on British pteridophytes. It is written to a high scientific standard and yet is very readable at the amateur level.

In the introductory sections there are several unusual features. The standard dichotomous key has been replaced by two innovative keys — a chart key using easily sketched characters, and a multi-access key based on other distinctive features. Both are designed to help the beginner run a specimen down to a small group of genera. A diagram giving altitude ranges of species will be very useful, and a series of maps of environmental factors are fascinating, although that describing 'Oceanicity and Continentality' is difficult to understand.

The main text runs to about one and a half pages for each taxon and consists of a full guide to identification, notes on the natural range of variation, sources of possible confusion, technical confirmation and lengthy field notes. Taxa are arranged in five groups — 'primitive' ferns; modern frond forming ferns; clubmosses; quillworts; and finally horsetails. Within each group arrangement is alphabetical with hybrids again arranged alphabetically at the end of a genus. While this is an unusual arrangement I very quickly found it easy to use. A full systematic list is included at the beginning of the book. The main feature of this section, and indeed of the book, is the illustrations. A silhouette of a typical frond, or more usually a range of fronds, is given for every taxon. I was particularly pleased to see the illustrations of immature fronds — a traditional cause of confusion. Unfortunately two of the subspecies of *Dryopteris affinis* (Lowe) Fras.-Jenk. are represented only by part fronds and one is not illustrated at all. Another minor criticism is the choice of deceptively small fronds of *D. oreades* Fomin. These illustrations are reproduced from actual pressed material, they are therefore technically accurate — in effect modern versions of the nineteenth century nature prints. They are however, unlike their predecessors, not attractive, the black silhouette is often washed out to the point that in places it merges with the white background. In most cases the main illustration give no idea of growth form. To rectify this, habit sketches are included for many species. These are very useful for species like the crispy *D. aemula* (Ait.) Kuntze, while others leave something to be desired, for example the one of *D. dilatata* (Hoffm.) A. Gray looks little like that species.

Most latin names used here have become familiar in recent years; where names are in dispute I am pleased to see that Dr Page has erred on the conservative side, e.g. *Thelypteris palustris* Schott is maintained and *Polypodium australe* Fée is retained for the Southern Polypody, despite pressure for a change to *P. cambricum* L. It is however,

perhaps more surprising that *Phyllitis* and *Ceterach* have not been amalgamated in *Asplenium*. Problems of taxonomy within the *Cystopteris fragilis* (L.) Bernh. aggregate have not been resolved: *C. dickieana* Sim is treated in the narrow sense in the main entry, i.e. to include only those plants from sea caves in Kincardine, but under the section on variation, plants possessing non-spiny spores but more closely resembling *C. fragilis* in frond form are also considered *C. dickieana*.

Every taxon has been given a common name — in many cases for the first time, while some of the old familiar names have been changed. These changes will unfortunately cause some confusion but in most cases they are probably justified, particularly where names are inappropriate, however some losses, e.g. Intermediate Polypody for Western Polypody, achieve little in my view.

The text entry for each species begins with short sections on preliminary identification, guides to habit and occurrence, and a map, which, though only small in size, shows distribution together with an indication of frequency. Unfortunately there is no indication of distribution outside the British Isles, except for one comment I noticed alongside *Athyrium flexile* (Newm.) Druce — 'endemic'.

The next section is a full identification guide where key characters are given in italics. The paragraph on variation only covers the range of form normally found in the wild — it is not a guide to garden varieties. Another section gives technical details e.g. chromosome number and other microscopical ways of separating some of the more difficult taxa. 'Field Notes' terminate the account of each species and are a highlight of the book allowing the author to share some of his observations collected during many year's field work. Particularly useful in this section are lists of commonly associated species.

Perhaps inevitably coming from the pen of Dr. Page, the genus *Equisetum* gets very full coverage with the text enhanced by numerous diagnostic sketches. These will be very welcome to those who find this a difficult genus.

At the end of the book there are sections on growing ferns from spores, conservation, further studies needed and a bibliography very full on modern references, although most major Victorian works are omitted.

Overall this is an excellent book, innovative in many ways. It is a book which achieves its principal objective, that of being a field guide. It is not a book aimed at the grower although there will be much in it to interest him. There are a few typographical errors, most are unimportant, but *Cryptogramma* is consistently misspelt as *Cryptogamma*, and the illustrations must have a 'black mark' for their lack of appeal.

At £15 for the paperback edition (£40 hardback) the book is expensive, but the factual quality of the contents more than make up for the shortcomings of the illustrations and the presentation inevitable in a soft cover.

M.H. RICKARD

ATLAS DE DISTRIBUTION DES PTERIDOPHYTES ET DES PHANEROGAMES DE LA SUISSE by M. Welten & H.C.R. Sutter, Vols 1 and 2, pp. 716 and 698 with 2572 maps + 1:500,000 Landeskarte der Schweiz and 17 transparency overlays in end pocket of vol. 2. 296 x 210 x 50mm. Birkhäuser, Basel, 1982. ISBN 3-7643-1307-2 and 1308-0. Price SFr. 158 each volume.

These two massive tomes show the detailed distribution of the vascular species found in Switzerland. Base maps are shaded and show the topography very effectively; two maps are given to a page. Four symbols are used to indicate frequency and altitudinal range: circles for lowland, triangles for highland, solid symbols for abundant to frequent, open symbols occasional to rare. Where additional data have been obtained from herbarium specimens or literature records these are indicated on the maps by H or L respectively.

Seventeen overlays are given, some to habitats such as broad-leaved or coniferous forest, bogs and natural grassland, others to geological features and rock types, altitude and, most usefully, a key to the Swiss national maps at the 1:100,000, 1:50,000 and 1:25,000 scales. A map of the country at 1:500,000 scale is folded in the end pocket.

Volume 1 contains some 30 pages of introduction, each repeated in three languages, German, French and Italian. The fern distributions are shown on 82 maps (79 species and two hybrids, *Equisetum x trachydon* and *Asplenium x alternifolium* (as *breyinii*)). Names follow those used in the British Atlas except *Diphasium* is used instead of *Diphasiastrum* and *Thelypteris* includes *T. limbosperma* and *T. phegopteris*.

It is interesting to note the rarity of *Woodsia ilvensis* in this country of many potential habitats, emphasising its low level and southerly requirement. There are only five extant sites for *W. pulchella* Bertol, a species not seen in Britain. The importance of Ticino Canton in the southern foothills of the Alps as an area where more Atlantic species can overwinter is reflected in the distribution of *Polystichum setiferum*, *Matteuccia struthiopteris*, *Asplenium onopteris*, *Adiantum capillus-veneris* and *Osmunda regalis*. Verified records for *Cystopteris dickieana* are scarce and only three extant sites are known.

A very large percentage of the British flora is found in Switzerland and much ecological data can be extrapolated from the distribution maps given. Although an expensive book it is one that all institutes with an interest in European botany should try to obtain.

K.P. KAVANAGH

FERNS AND ALLIED PLANTS WITH SPECIAL REFERENCE TO TROPICAL AMERICA by Rolla M. and Alice F. Tryon, pp. xii, 857, 2028 figures, Springer-Verlag, New York, 1982. Price:

This splendidly produced tome provides a storehouse of information about the genera of pteridophytes occurring in the New World. It could perhaps best be described as a generic 'flora' of American ferns since the content and organization of the text follows the pattern of a regional flora. For each genus there is provided a description (which seems rather meagre for a work on this scale) with synonymy followed by sections on 'systematics', ecology, geography, spores, cytology (if known) and a bibliography. The descriptions are supplemented by abundant and excellent figures and close-up

photographs showing details of sori, indumentum and venation. Dot maps for each genus show its distribution in the New World and the range worldwide is also enumerated. The ecological notes on the American species are particularly valuable in view of the widely scattered floristic literature. The excellent habitat photographs mostly taken by W.H. Hodge help to provide a living picture of the wide variation in habit and form existing among modern ferns. The section entitled 'systematics' gives an overview of each genus, usually with a synopsis and/or a key to the species, which should again be of considerable practical value. Generic limits tend to be widely drawn but most larger genera are subdivided and the synopses are essential for comprehension of the variation within them.

The final sections on spores and cytology are also covered in portions of the introduction (as is biogeography) and the cytological information is conveniently summarized there with brief comments on each family. I would support the hypothesis put forward that many present day chromosome numbers are polyploids on a base number of 9 or 10.

For each family the description classifies the stele as proto-, soleno- or dictyostelic and includes the gametophyte but more details of both would have been valuable. A generic key is provided and also a synopsis when the family is subdivided.

It is in the description and illustration of the spores that the most substantial amount of new information has been introduced. For every genus there are beautiful SEM micrographs of the spores showing the external appearance and often also the complex structure of the spore wall. The study of fern spores at a magnification of x 1000 to x 10000 has literally opened up a new dimension to pteridologists and it is to be hoped that Dr. Alice Tryon will be able to publish more of her work in this field.

There is no discussion of the classification adopted and the arrangement is conservative in that among the homosporous leptosporangiate ferns all families comprising '*Polypodiaceae*' sensu lato have been kept together. The more primitive indusiate families are thus separated from the more advanced by the very distinct exindusiate gymnostrangiate ferns (*Pteridaceae* and *Vittariaceae*). Within the group 24 families are recognized and if the subfamilies and tribes are also taken into account I find myself in almost complete agreement with their circumscription, if not with their arrangement. This general accord among pteridologists on the identification of suprageneric taxa shows the progress that has been made since the first 'modern' scheme was published by Christensen as recently as 1937.

FRANCES M. JARRETT

FERNS AND FERN-ALLIES OF MEGHALAYA STATE, INDIA by A.K. Baishya and R.R. Rao x + 161 pp. 190 x 246 mm, 1962. Scientific Publishers, Jodhpur. Price US \$20.00, from United Book Traders, Ratanda, Jodhpur 342001 India.

Meghalaya State, formerly part of Assam abutts onto the north-eastern border of Bangladesh south of the expansive Brahmaputra river and Bhutan. It contains a low range of hills, the Khasi which are a spur from the high Naga Hills on the Burmese border. Interestingly 133 species belonging to 62 genera recorded there (i.e. some

53%) are found in the South Indian hills. Similarly some 140 species (56%) are common to the hills in and adjacent to the western Himalaya.

This local flora traditional in its approach is a very good example for others to follow. Accounts on the geology, physiography soil and climate are given with a general account of the vegetation and role of pteridophytes in the State. Useful synonyms are given, as are keys to family, genus and species. The book is better produced than many from India.

A.C. JERMY

REVIEW

ASPECTS OF PLANT SCIENCES (VOLUME 6), PTERIDOPHYTES: their morphology cytology, taxonomy and phylogeny, edited by S.S. Bir. 253pp., 240 x 415mm, 1983. Today and Tomorrow's Printers and Publishers, New Delhi, India 110005. Price Rs 95.00 : \$19.00.

This book is part of a serial on plant sciences and is in continuation of work discussed in Volume III (1980). We are told in an introductory note that "it reflects some aspects of the work done in Pteridology in India during the recent years". The contributions deal with the ecology, distribution, morphology, taxonomy and cytology of Indian members. Its authors and in particular its hard working editor have in fact reviewed papers on a world basis over the last 20 years at least, and often even older, e.g. "The work on the (sic) Pteridologic geography has been discussed by Christ (1910), Winkler (1938) and Tryon (1969, 1970a)". The works selected are however relevant to India.

The review by D.S. Loyal on 'Some recent advances in phylogeny and life-cycle of pteridophytes, particularly ferns', is detailed. Similarly, 'Chromosome numbers and evolutionary status of pteridophytes of Pachmarhi Hills (Central India)' by S.M. Vasudeva & S.S. Bir, gives chromosome diagrams for 33 species; only 15 are supported by photographs and of these the plate reproduction is very poor standard. It is interesting to note an octoploid being recorded for *Selaginella*.

Whilst some of the papers are superficial, the book as a whole will be useful for undergraduate (or specialist graduate) courses. A lot of references are given to papers and books available to in most university libraries.

A.C. JERMY

THE FERN GAZETTE

Original papers, articles, or notes of any length on any aspect of pteridology will be considered for publication. Contributions will be particularly welcomed on floristic, biogeographical and ecological aspects of ferns and their allies, worldwide. Members are especially encouraged to make use of short notes for reporting pteridophyte field observations and records. All may be illustrated with black and white photographs of good technical quality and line drawings. Short papers can usually be incorporated more quickly than longer ones.

Contributions should be sent to:

C.N. Page, Royal Botanic Garden, Edinburgh, U.K.

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Latin names: quote the authority at (usually) the first mention only, in the main text but, unless unavoidable for clarity, not in the title. All latin names should be underlined throughout the typed copy.

Illustrations: Any number and combination of line and half-tone illustrations (original drawings or diagrams in ink, or photographs **which must be black and white**, and of good technical quality) can be included with a manuscript where these help to augment or amplify the text. Photographs should be of the required magnification or larger and need not be made up to full page plates. Each drawing or photograph should be marked on the back with details of author and figure number, and the top edge clearly marked "top". Illustrations will not be returned to the author unless specifically requested.

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Books for review in the *Fern Gazette* or *B.P.S. Bulletin* should be sent to A.C. Jermy, Botany Department, British Museum (Natural History), Cromwell Road, London, SW7 5BD.

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THE FERN GAZETTE



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1984

THE JOURNAL OF THE
BRITISH PTERIDOLOGICAL SOCIETY

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Back numbers of the *Gazette*, *Pteridologist* and *Bulletin* are available for purchase from the Treasurer (address above), from whom further details can be obtained.

STUDIES IN THE FERN-GENERA ALLIED TO *TECTARIA*, I. A COMMENTARY ON RECENT SCHEMES OF CLASSIFICATION

R. E. HOLTUM

Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, England.

During the past three years I have made a world-wide survey of the genus *Tectaria* and other genera which I believe to be allied to it, including a detailed study of all the species of SE Asia, Malesia and the Pacific. In the course of this work it has become evident to me that some of the genera of this group in the Old World have never been clearly distinguished from each other. I have tried to define them more clearly, and in the course of this process have discovered that a few new genera need to be distinguished. I therefore intend to prepare a series of papers on these genera in the region above specified. My work began with a detailed study of the species in the Mascarene Islands (Holtum, 1983); most of these species belong to *Ctenitis* as first defined (as a subgenus) by Christensen in his Monograph of *Dryopteris* (1913 and 1920), and within *Ctenitis* to two species-groups which are mainly distributed in the Neotropics. The species of *Ctenitis* in SE Asia and Malesia all belong to a different group which has not yet been defined. Those of SE Asia were first brought together by R.C. Ching (1938). The only considerable attempt to write a systematic account of *Ctenitis* in any part of Malesia is Copeland's on the Philippine species (1960). As M.G. Price (1972: 36) has pointed out, Copeland there included species of several other genera. He also wrongly transferred to *Ctenitis* other species native in New Guinea. Some of the Philippine species included in *Ctenitis* belong, in my judgement, to *Tectaria*, and they show the difficulty of making definitions which will distinguish the two genera clearly. I have a list of 48 species wrongly transferred to *Ctenitis*; they properly belong to *Dryopteris*, *Tectaria*, *Dryoathyrium*, *Stenolepia*, *Acystopteris*, *Heterogonium*, *Lastreopsis*, *Oreopteris*, and to *Ctenitis* subgenus *Dryopsis* Ching which in my opinion should rank as a separate genus, more nearly allied to *Dryopteris*.

In 1940 Ching divided the old comprehensive family Polypodiaceae into smaller families, one being Aspidiaceae. Within this family he placed *Tectaria* and its allies in a tribe Aspidieae, *Dryopteris* and genera related to it comprising a second tribe Dryopterideae. When I was preparing my book on the ferns of the Malay Peninsula (1955). I was impressed by the differences between Ching's two tribes, and in a preliminary paper (1947) ranked them as subfamilies Tectarioideae and Dryopteridoideae in a larger family Dennstaedtiaceae (I chose this name as a taxonomic indicator, rather than Polypodiaceae, because it them seemed to me improbable that *Polypodium* could have a place in such a family; I would now accord family status to both subfamilies). I used the distinction "costae and smaller rachises grooved, grooves with raised edges" for the *Dryopteris* subfamily, as against "costae raised, not grooved, usually hairy" for *Tectaria* subfamily. I published drawings (1955: fig. 282 on p.479, fig.311 on p.529 and fig.314 on p.533) to indicate the differences; I also showed the similarity of the two latter to the condition of *Davallia* in fig.203 on p.350. I was led to observe these differences by Ching's observations when in 1938 he first distinguished the species of *Ctenitis* in Asia. I added further observations in a paper published in 1960. In 1965 Ching expressed agreement with me by recognizing a family Dryopteridaceae, distinct from Aspidiaceae (*Tectaria* and its allies), but he placed *Peranema* and a few other genera in a separate family.

Since 1964 four different systems of classification of the families and genera of ferns have been published, namely those of Nayar (1974), Crabbe, Jermy & Mickel (1975), Pichi Sermolli (1977b) and Tryon & Tryon (1982). Nayar placed the *Tectaria* group of genera in subfamily Tectarioideae in a family named Dryopteridaceae,

Dryopteris and its allies being in a separate subfamily; but he also included the Onocleoid and Athyrioid ferns in other subfamilies. He did not comment on distinctions between genera. Crabbe, Jermy and Mickel placed *Tectaria* and its allies as a subfamily in a family named Aspleniaceae; other subfamilies are Asplenioidae, Athyrioidae and Lomariopsidoideae. In 1947 I expressed in some detail my reasons for regarding Asplenioid and Athyrioid ferns as developments on different evolutionary lines; Crabbe, Jermy and Mickel offered no reasons for rejecting this view, with which the other schemes here considered are in accord. Within their subfamily Tectarioideae I accept their list of genera except for *Dryopolystichum* and *Didymochlaena*, which I think belong with *Dryopteris*. Pichi Sermolli includes the genera allied to *Tectaria* and also those allied to *Dryopteris* in one family Aspidiaceae, and discusses the relationships between the genera; I do not agree with some of his ideas on this subject, and will discuss them in some detail below. The Tryons, like Nayar, recognize a family Dryopteridaceae which includes both the *Tectaria* and *Dryopteris* groups of genera and also other groups in several tribes. I cannot accept their allocation of genera to their tribes Dryopterideae and Peranemeae, and will add a note of this after the following discussion which is based mainly on the concepts of Pichi Sermolli.

Pichi Sermolli states that if his family Aspidiaceae is to be subdivided (he makes no formal subdivision) the division must be into more than two parts. Part of his evidence for this is that there are four types of rachis structure in the family (they are distinguished in an earlier paper, 1977a: 238). But my distinction between the *Dryopteris* and *Tectaria* groups is based on the costae (or costules) of pinnules, and their relationship to the rachis which bears them, not solely on the rachis itself; the shape of the rachis is irrelevant (see Tryon & Tryon 1982: 458). In my judgement, Pichi Sermolli's statement about four rachis types is neither comprehensive nor fully accurate. He thus defines the ctenitoid rachis: "when the upper surface of the main rachis is grooved with the groove not open to admit the shallower groove of the secondary rachises or pinna-midribs, the raised edges of the groove of the main rachis being in any case fully fused with the secondary rachises or pinna-midribs also in their median part, where sometimes a junction is swollen". I judge from this that Pichi Sermolli is describing the condition of *Ctenitis apiciflora* (Wall. ex Mett.) Ching, which belongs to *Ctenitis* subgenus *Dryopsis* Ching and is quite unlike the type of *Ctenitis*. I regard *C. apiciflora* as a member of a different genus, still to be described (see below). The distinctive feature of true *Ctenitis* is that the costae or costules of the ultimate leaflets are more or less prominent and always covered with ctenitoid hairs; and the distal part of pinna-rachises to which the leaflets are attached are usually not grooved. The base of the lamina of the leaflets is sometimes narrowly decurrent, and then the only real difference from *Lastreopsis* is that the decurrent base is not thickened and does not extend downwards to the next leaflet.

My judgement still is that the genera of Pichi Sermolli's family can be divided into two groups, to both of which (with Ching) I would accord family status. The groups are thus distinguished:

Dryopteris group: midribs of ultimate leaflets grooved, the groove of the rachis bearing the leaflets being open to admit the leaflet-groove, the margin of the lamina of the leaflet being decurrent (but not prominent) down the side of the rachis; hairs of ctenitoid type lacking.

Tectaria group: midribs of ultimate leaflets more or less prominent (in *Tectaria* sometimes slightly grooved) and bearing ctenitoid hairs, usually many.

As Pichi Sermolli points out, there are two base chromosome numbers in his family, 41 and 40. The genera which are obviously allied to *Tectaria* all have 40. But it is also evident that some which have 41 are also much more nearly related to *Tectaria*

than to *Dryopteris*. A striking example is a species from southern China first named *Tectaria sinii* by Ching. In frond-form it is indistinguishable from *Tectaria*, and its venation is exactly that of the other species which I regard as free-veined *Tectaria*; but its scales, which are abundant on all axes of the frond, are closely similar to those of *Ctenitis rhodolepis* (Clarke) Ching and to those of the type species of *Ctenitis*. Ching later transferred *T. sinii* to his genus *Ctenitopsis* (which he established to accommodate what I would call free-veined species of *Tectaria*). Ohwi later transferred it to *Ctenitis*. It should perhaps be regarded as constituting a new monotypic genus; in any case it presents strong evidence of the close relationship between *Ctenitis* and *Tectaria*, which Christensen already recognized in 1913.

The upper surface of the midribs of pinnae may appear to lack ctenitoid hairs in *Pteridrys* and in some species of *Tectaria*, but there are nearly always some such hairs at the bases of pinnae or of the main rachis. In some species of *Tectaria* the upper surface of the pinna-midrib is shallowly grooved, never deeply so. Non-ctenitoid hairs occur on the upper surface of midribs of pinnules in species of Christensen's group of *Ctenitis subincisa* (in America and Africa: Monograph part 2: 59) and in some species of *Lastreopsis*. These hairs are longer than normal ctenitoid hairs, acicular (apical cell acute) and do not collapse on drying, as do typical ctenitoid hairs. They are normally accompanied by some true ctenitoid hairs in *C. subincisa* and its allies, but I cannot distinguish true ctenitoid hairs in some species of *Lastreopsis*, within which genus there is much variety of dermal appendages. So far as I have observed, the hairs on the upper surface of midribs in pinnae or pinnules of the *Dryopteris* group are never ctenitoid. In some genera (eg: *Polystichopsis*) slender hairs occur in the grooves. In *Stenolepia*, *Nothoperanema*, *Acrophorus*, *Peranema* and *Didymochlaena* there are complex outgrowths along the margins of grooves of the upper surface of leaflets; these structures have widened thick bases but distally are hair-like, though not like ctenitoid hairs.

Pichi Sermolli does not define his genera; he only cites the original publication and the type species, and he provides no keys. Thus his generic concepts are not always clear. An example of this is his concept of the genus *Heterogonium*.

The species of *Tectaria* which have anastomosing veins can be divided into those which have ample anastomosis with many branched veinlets in their areoles (typical *Tectaria*) and those which have narrow costal areoles and a variable number of other rather small ones which rarely have free veinlets within them, the few such being short and excurrent (*Sagenia* of Presl 1836: 86, t.II, fig.23-25). But there is every gradation from the latter condition to species which have all veins free. This situation is further complicated by the fact that some species with the venation of *Sagenia*, or with free veins, have basal pinnae with reduced basal basisopic lobes, thus differing from the form typical in *Tectaria* in which such lobes are much elongate; these species also have more or less dimorphic fronds and sori of various form. One species of this group has anastomosing veins and elongate exindusiate sori; it was made the type of a new genus *Heterogonium* by Presl (1851: 142). Copeland added another species in 1929 (p.61) and in so doing noted its resemblance to the species originally named *Aspidium sagenioides* by Mettenius, which has indusiate sori, free veins, and the basal pinnae like those of *Heterogonium* (in which genus I have placed it), not *Tectaria*. Ching (1938: 304) established a new genus *Ctenitopsis* for species allied to *Tectaria* sect. *Sagenia*, with free veins. In describing *Ctenitopsis* he carefully noted its difference in venation from *Ctenitis*, but he did not refer to the shape of the basal pinnae and included *Aspidium sagenioides* which he cited as type-species. The latter species, and also another placed in *Ctenitopsis* by Ching, are reported to have 40 chromosomes, as in *Tectaria*. But Copeland (1947: 123) included Ching's *Ctenitopsis* in *Ctenitis* (41 chromosomes), not noting the difference in venation specified by Ching;

at the same time (p. 127) he recognized a genus *Heterogonium* comprising two species as in 1929. In 1949 I pointed out that these two species are not clearly distinct generically from some others which have elongate sori, and that the shape of the basal pinnae is an important common character. I was subsequently able to study a wider range of species and wrote a fuller account of *Heterogonium* in 1975. This genus, as thus arranged, still seems to me valid. The species have *Sagenia* venation (even when pinnae are quite broad), or free veins, and their fronds are almost always somewhat dimorphous (in some species much so) and show a range of soral form from round and indusiate to a fully acrostichoid condition, the form of basal pinnae being constant in all of them. This contrasts with the *Sagenia* section of *Tectaria* in which sori are uniform and the basal pinnae always of *Tectaria* form. Pichi Sermolli (1977b: 341) rejects my interpretation of *Heterogonium* and includes *Aspidium sagenioides* in *Ctenitopsis*, but does not explain how he would define *Heterogonium*, a genus which he retains in his list. Copeland later (1960: 285-299) added more Philippine species to *Ctenitis*. Some of them belong, in my opinion, to *Tectaria*, but their venation pattern does not so clearly conform to that specified by Ching for *Ctenitopsis*, and one of them (*C. dubia* Copel.) is so different from both *Ctenitis* and *Tectaria* that I think it should be regarded as representing a genus distinct from both of them.

In Africa and the West Indies also there is a group of species (Christensen's group of *Dryopteris protensa*) some of which in Africa have anastomosing and some free veins (I think that Christensen did not know of the former). Alston (1969: 70) included these species in *Ctenitis*, but Kramer (1978: 104) thought them to be closer to *Tectaria*. Three species of this group in West Africa are reported to have the base chromosome number 41 (Manton's Appendix in Alston 1959: 80), an indication that Christensen was right in regarding them as allied to *Ctenitis*. Alston's key to the genera (p. 69) does not distinguish clearly between species which he ascribes to the two genera.

Thus in both the Old World and the New there are species which are not clearly assignable to well-defined genera. It is evident that more kinds of characters need to be taken into account in specifying distinctions between genera. Such characters in *Ctenitis* are the scales and glands. Christensen in 1913 described the scales of tropical American species of *Ctenitis*, but no-one has made a comparable study of the scales of species in the Old World. Cylindric glands are a constant character of *Ctenitis* in Malesia and SE Asia and are absent from *Tectaria* and its immediate allies. The species of Christensen's group of *C. subincisa* lack the characteristic glands of typical *Ctenitis* and have very different spores (Tryon & Tryon 1982: fig. 67.23 on p. 466). They have also very large fronds and distinctive scales, and might constitute another new genus. The species of Christensen's group of *Dryopteris protensa* are characterized by a peculiar frond-form and by a venation distinct from that of *Tectaria* but these have not been clearly specified.

The genera which I believe Pichi Sermolli has misplaced in his scheme for the family Aspidiaceae are *Didymochlaena*, *Dryopolystichum* and *Rumohra*.

Didymochlaena is placed close to *Ctenitis* with a statement that it has a rachis of ctenitoid type. Its rachis is however extremely unlike that of any *Ctenitis*, being very deeply grooved and lacking ctenitoid hairs. The pinnules are very asymmetric at their bases with a thickened basiscopic margin which is not distinguishable from the costule. The relationship of pinnules to pinna-rachis is obscured by a partial articulation of the pinnules. Near the apex of a pinna, where the pinnules are not articulated, it appears that the pinna-rachis groove is interrupted at the junction with a pinnule. The thick appendages on the margins of the groove near the bases of pinnules (not mentioned by Pichi Sermolli) are comparable with those in a similar position in *Peranema* and allied genera (see Ching 1966: 25). I believe that *Didymochlaena* is allied to these genera; it is however pantropic in distribution whereas *Peranema* and

its allies are only in SE Asia. The difference in distribution is perhaps to be correlated with the fact that *Didymochlaena* occurs only at medium altitudes in tropical forest, whereas *Peranema* and its allies are ferns of temperate or subtropical distribution, occurring in Malasia only on high mountains. No-one has ever made a careful morphological study of the pinnae and pinnules of *Didymochlaena*.

Dryopolystichum has grooved pinnae-midribs which near their bases bear some thick hairs on the margins of the grooves. These hairs are not well shown by herbarium specimens and need careful examination from fresh material; I think they may be comparable to the small scales on the margins of grooves in the genera allied to *Peranema*. I believe that *Dryopolystichum* belongs to the *Dryopteris* group of genera; its chromosomes have never been examined.

Rumohra is the one genus which I believe does not belong either to the *Dryopteris* or the *Tectaria* alliance. As I pointed out in 1947, it differs from *Davallia* and allied genera in little except its indusia. Kato (1974) also noted that its stipes are not jointed at their bases. In the very precise dorsiventral anatomy of its rhizome (as admitted by Kato) it is exactly like *Davallia*. Also the two larger vascular strands on the adaxial side of the stipe and rachis unite distally in the rachis to produce a strand X-shaped in section as in *Davallia* (this was not observed by Kato, who does not note that the union of the strands occurs in the rachis in some species of *Davallia*). Kato publishes a photograph of a young leaflet showing sori almost reniform. In the genus *Davallodes*, closely allied to *Davallia*, the indusia are very varied in form in the various species, some being almost reniform (*D. borneensis* (Hook.) Copel.). Pichi Sermolli compares the rhizome anatomy of *Rumohra* to that of *Maxonia*, a near ally of *Dryopteris*, quite unrelated to *Tectaria* and its allies; but even *Maxonia* is not comparable in its anatomy to the very specialized dorsiventral structure of *Davallia*. The genera *Pteridrys* and *Pleocnemia*, near which Pichi Sermolli places *Rumohra*, are very different from it in anatomy, scales and frond-form. I adhere to my opinion that *Rumohra* is related to *Davallia* and has no place in a family named Aspidiaceae.

I have not attempted a detailed study of the genera which I would place in a family Dryopteridaceae. So far as I have observed, I would place *Peranema*, *Diacalpe*, *Stenolepia*, *Nothoperanema*, *Acrophorus* and *Didymochlaena* as a natural group allied to *Dryopteris* but distinct in the peculiar scales described by Ching (1966) for *Nothoperanema*; I believe that *Ctenitis* subgenus *Dryopsis* Ching, excluding *C. eatonii* (Bak.) Ching and allied species, should form an additional genus belonging less nearly to this alliance. As above noted, I also suggest that *Dryopolystichum* belongs to this group rather than to the *Tectaria* group. I believe that *Lithostegia* is allied rather to *Polystichum* than to the *Peranema* group where Pichi Sermolli places it. Pichi Sermolli considers that the peculiar indusium of *Peranema* and *Diacalpe* is the primitive form in his Aspidiaceae. But I suggest that the indusia of almost all terrestrial ferns, except those included in Schizaeidae by Pichi Sermolli, are all homologous (ultimately derivable from the inner indusium of such ancient ferns as *Dicksonia*), and accordingly I regard the indusia of *Peranema* as a late and specialized development.

The type species of *Stenolepia* (*S. tristis* (Bl.) v.A.v.R.) seems to me to differ only from the later-named *Nothoperanema* in the prominent receptacle to which its sporangia are attached, the base of the indusium being attached to the receptacle. The indusium of *S. tristis* is cuneate, not cordate, at its base but is otherwise not distinctive. There are additional species in New Guinea which appear to belong to *Stenolepia*. Two of them have been placed in *Ctenitis*: *C. speciosissima* Copel. and *C. hypolepioides* (Rosenst.) Copel. I judge that *Lastrea rubiginosa* Brack. of Hawaii also belongs to *Stenolepia*; it has been transferred to *Ctenitis* by Copeland. A monograph of all species of *Stenolepia* and *Nothoperanema*, taking into account recent collections from New Guinea, is necessary for an understanding of these genera.

R.M. and A.F. Tryon (1982), dealing mainly with Neotropic genera, have recognized a family Dryopteridaceae very different from Ching's; it includes the genera placed in Aspidiaceae by Pichi Sermolli and also many others. The Tryons divide their family into six tribes, one of which (p.455) is Peranemeae (including *Peranema*, *Acrophorus*, *Nothoperanema* and *Stenolepia* but not *Didymochlaena*) and another is Dryopterideae which includes *Dryopteris*, *Ctenitis* and *Tectaria*. Their tribes Peranemeae and Dryopterideae thus together correspond to the Aspidiaceae of Pichi Sermolli. Other tribes are Physematieae (including *Athyrium* and *Diplazium*), Onocleaeae, Oleandreae and Bolbitideae; Pichi Sermolli has placed the genera of these groups in other families, and in general I agree with him. As above indicated, I believe that the genera placed by the Tryons in their tribe Peranemeae are closely allied to *Dryopteris*, and to place *Dryopteris* together with *Ctenitis* and *Tectaria* in another tribe appears to me quite unnatural. The Tryons however give a better description than Pichi Sermolli of the upper surface of costules of leaflets in relation to the axes which bear them, and provide excellent photographs of these features. Like Pichi Sermolli, they place *Rumohra* near *Lastreopsis* but do not mention the rhizome anatomy of the former.

Thus a taxon corresponding approximately to my concept of the *Tectaria* group of genera is recognized by Ching and Nayar, also by Crabbe, Jermy and Mickel, though only Ching accords family status to it, and I have strong objections to its being placed in a family Aspleniaceae by Crabbe, Jermy and Mickel. Pichi Sermolli's Aspidiaceae (excluding *Rumohra*) corresponds exactly to my concepts of the *Dryopteris* and *Tectaria* groups of genera, but he does not think that a natural separation of the family into two parts is possible. The Tryons' arrangement differs from all the others and is to me unacceptable.

It also appears evident to me that the genera within the *Tectaria* group in Asia, Malesia and the Pacific are not all well defined, and that to distinguish them more clearly monographic studies involving all species of all genera are necessary. The whole range of leptosporangiate forms is so great and so varied in detail that no-one can have a critical knowledge of all of them. Thus the family concepts in the schemes above mentioned are all based on partial knowledge, and they are all different. The result is that the name Aspidiaceae has no definite meaning unless one refers to a particular author and date of publication. In practice the only way in which the different families named Aspidiaceae can be described is to list the genera in each; the name Aspidiaceae merely means a family typified by the genus *Aspidium* Sw., this genus being typified by the species *A. trifoliatum* (L.) Sw. (*Tectaria* Cav. is typified by the same Linnaean species, so the names Aspidiaceae and Tectariaceae are equivalent). Until there is general agreement as to the determination of families of ferns, it seems to me irrational to argue about their legitimacy; to suppose that a family name is defined by the publication of a description in words is a delusion.

REFERENCES

- ALSTON, A.H.G. 1959. *The ferns and fern-allies of West Tropical Africa*. London, Crown Agents.
 CHING, R.C. 1938. A revision of the Chinese and Sikkim-Himalayan Dryopteris with reference to some species from neighbouring regions. *Bull. Fan Mem. Inst. Biol. Bot.* 8: 275-334.
 CHING, R.C. 1940. A natural classification of the family "Polypodiaceae". *Sunyatsenia* 5: 201-268.
 CHING, R.C. 1965. Dryopteridaceae, a new fern family. *Acta Phytotax. Sinica* 10: 1-5.
 CHING, R.C. 1966. Three new fern genera. *Acta Phytotax. Sinica* 11: 17-30.
 CHRISTENSEN, C. 1913. A monograph of the genus *Dryopteris*, part 1. *K. Dansk. Vid. Selsk. Skr. VII, 10*: 55-282.
 CHRISTENSEN, C. 1920. *Ibid.*, part 2. *K. Dansk Vid. Selsk. Skr. VIII, 6*: 1-132.
 COPELAND, E.B. 1929. The oriental genera of Polypodiaceae. *Univ. Cal. Publ. Bot.* 16: 45-128.
 COPELAND, E.B. 1947. *Genera Filicum*. Waltham, Mass., Chronica Botanica.
 COPELAND, E.B. 1960. *Fern Flora of the Philippines, part 2*. Manila, Bureau of Printing.

- CRABBE, J.A., JERMY, A.C. & MICKEL, J.T. 1975. A new arrangement for the pteridophyte herbarium. *Fern Gazette* 11: 141-163.
- HOLTUM, R.E. 1947. A revised classification of Leptosporangiate Ferns. *Journ. Linn. Soc. Bot.* 53: 123-186.
- HOLTUM, R.E. 1949. The fern-genus *Heterogonium*. *Sarawak Mus. Journ.* 5: 156-166.
- HOLTUM, R.E. 1955. A Revised Flora of Malaya, II, Ferns of Malaya. Singapore, Government Printing Office.
- HOLTUM, R.E. 1960. Vegetative characters distinguishing the various groups of ferns included in *Dryopteris* in Christensen's Index Filicum and other ferns of similar habit. *Gard. Bull. Singapore* 17: 361-367.
- HOLTUM, R.E. 1975. The genus *Heterogonium* Presl. *Kalikasan* 4: 205-231.
- HOLTUM, R.E. 1983. The fern-genera *Tectaria*, *Heterogonium* and *Ctenitis* in the Mascarene Islands. *Kew Bull.* 38: 107-130.
- KATO, M. 1974. A note on the systematic position of *Rumohra adiantiformis*. *Acta Phytotax. Geobot.* 26: 52-57.
- KRAMER, K.U. 1978. *The Pteridophytes of Surinam*. Utrecht, Naturwet. Studiekring voor Surinam en de Ned. Antillen.
- NAYAR, B.K. 1974. A classification of Leptosporangiate Ferns, pp. 111-201 in Nayar & Kaur, *Companion to Beddome's Handbook to the Ferns of British India*. New Delhi, Chronica Botanica.
- PICHI SERMOLLI, R.E.G. 1977a. Fragmenta Pteridologiae, VI. *Webbia* 31: 237-259.
- PICHI SERMOLLI, R.E.G. 1977b. Tentamen pteridophytorum genera in taxonomicum ordinem redigendi. *Webbia* 31: 313-512.
- PRESL, K.B. 1836. *Tentamen Pteridographiae*. Pragae, Haase.
- PRESL, K.B. 1851. *Epimeliae Botanicae*. Pragae, Haase.
- PRICE, M.G. 1972. A summary of our present knowledge of the ferns of the Philippines. *Kalikasan* 1: 17-58.
- TRYON, R.M. and TRYON, A.F. 1982. *Ferns and allied plants with special reference to tropical America*. New York and Berlin, Springer Verlag.

A NEW SPECIES OF *CTENITIS* FROM BORNEO AND A NEW COMBINATION IN THE GENUS

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ABSTRACT

Ctenitis muluensis, a new species from the Gunung Mulu National Park, Sarawak, is described, and the new combination *Ctenitis subobscura* (Christ) Holttum made.

INTRODUCTION

I have in preparation a monograph of the fern genus *Ctenitis* C. Chr. in SE Asia, Malesia and the Western Pacific. Material from this monograph relevant to two species from the Gunung Mulu National Park is here published in advance, so that their names may be included in the list of pteridophytes in the Park. One is a new species, *Ctenitis muluensis*, found on limestone; it has very small leaflets densely covered with glands and hairs. The other is widely distributed in Western Malesia and has been given two names in other genera; it is here transferred to *Ctenitis* and a statement of its synonymy is presented.

***Ctenitis muluensis* Holttum, sp. nov.**

Inter species malesianas generis *Ctenitidis* propter foliola minuta supra pilis glandulisque densissime vestita peculiaris; stipes usque 12cm longus, basi paleis angustis c. 10mm longis vestitus; lamina usque 23cm longa; pinnae usque 10-jugatae; pinnae infimae usque 7cm longae, pluripinnatae, pinnulis infimis basiscopis et acrosopicis fere aequalibus; foliola tertiaria 3mm longa; sori mediani, indusiis parvis pilis glandularibus minutis vestitis praediti; sporae c. 55µm, saccato-verrucatae, sporodermis granulis bacilliformibus.

Type: Borneo, Sarawak: Fourth Division, Gunung Mulu National Park, Gunung Api, between Camp 4 and summit, 1600-1700m, on roots, stems or mossy limestone rocks in montane forest with stunted *Leptospermum*, 15 April 1978, A.C. Jermy 14156 (holotype, BM; isotype K, SAR).

Caudex erect, covered with shiny castaneous scales less than 1mm wide at base, gradually tapering to a filiform apex and up to 13mm long, margins ± entire with a few short glands. **Fronde** up to 32cm long; stipes c. 12cm long, dark brown, densely covered with glands, short hairs and scattered scales, those near the base similar to the scales on the caudex, those above up to 5mm long, more ovate-triangular with a long attenuate apex, clathrate, red brown in centre and with paler margins, toothed towards base and with short glands above; **rachis** with similar indumentum; **lamina** triangular-lanceolate, bipinnate-pinnatifid, pinnae c. 10 pairs grading into apex of frond, lowermost 5-7cm long; acrosopic and basiscopic pinnules of similar length, pinnatisect at base, pinnatifid above with rounded lobes; lamina surface and veins covered with dense glandular stiff hairs above, underneath sparsely covered with appressed hairs; lower surface of costae and costules densely covered with glandular hairs and scales similar to those on the upper part of the stipe, upper surface with stiff short hairs and scattered scales at least on the costae. **Sori** median, indusium reniform covered with glandular hairs; **spores** saccate-verrucate, sporoderm with small rod-shaped granules c. 55µm.

The following new combination is validated here, as this species has also been recorded in Gunung Mulu National Park.

***Ctenitis subobscura* (Christ) Holttum comb. nov.**

Phegopteris subobscura Christ, *Bull. Herb. Boiss.* 5: (1898) 836.

Type: G. Schneider 35, Sumatra (P).

Synonyms: *Dryopteris squamulifera* v.A.v.R., *Bull. Jard. Bot. Btzg II*, 16: (1914) 9.

Type: C.G. Matthew 669, Sumatra, Padang Panjang (BO).

Ctenitis mannii sensu Holttum, *Revised Fl. Malaya* 2: (1955) 497. quoad pl. males.

CHROMOSOME NUMBERS AND ECOLOGICAL OBSERVATIONS OF FERNS FROM EL TIROL, PARAGUAY

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ABSTRACT

Chromosome numbers are given for 32 species of ferns from Paraguay, mostly from El Tirol. Included is the first report for the genus *Antigramma*, $n = 144$. Collections of *Polypodium singeri*, *P. truncorum*, *Thelypteris dentata*, and *T. torresiana* are the first reported of these species from Paraguay. About half of the 47 fern species from El Tirol are widespread in tropical America; the remaining species are more narrowly distributed in southern Brazil, Uruguay, Paraguay, and northeastern Argentina. Most of the ferns at El Tirol occur terrestrially in the forest, especially along creeks. Ten species are epiphytes, including three that are restricted to trunks of the tree fern, *Nephelea setosa*. Vegetative and reproductive growth appear to be concentrated in the months of heaviest rainfall, October to December.

INTRODUCTION

To date, there are chromosomal counts for very few South American pteridophytes. Reports are available only for plants from the Galapagos (Jarrett et al. 1968) and Amazonian Brazil (Tryon et al. 1975), or for a few species in particular families (eg: Polypodiaceae; Evans, 1963). Herein we report counts for 32 species (in 18 genera) from Paraguay. Our data represent the first counts for 13 of the species (including first counts for the genus *Antigramma*). For another 12 species, our counts agree with previous reports for the species in other parts of their ranges. Counts for seven species differ from previous reports for the same species in other localities. This last finding emphasizes the need for repeated sampling over the range of a fern species before a complete understanding of its chromosomal complexity can be achieved.

Equally poorly known are most aspects of fern ecology in tropical America. We are unable to locate a single report that provides information on habitat, phenology (including dormancy and time of year when meiosis and spore release occur), host specificity, abundance, and revivability for a community of ferns in this region.

MATERIALS AND METHODS

For all counts, material was fixed in the field in Carnoy's solution (6:3:1, ethyl alcohol: chloroform:acetic acid) by Foster and was stained with acetocarmine. Chromosome counts (by Smith) are observations of the configuration at metaphase I of meiosis. Photographs of chromosomes were made with a Zeiss photomicroscope.

Collections were made by Foster primarily from an ornithological study site at El Tirol (ca. 55°47'W, 27°11'S; elevation, 170-260m), 19.5km by road \pm NNE of Encarnación, Dpto Itapúa, Paraguay. A few additional counts were made from material collected at Parque Nacional Ybycuí (ca. 56°59'W, 26°1'S), ca. 30km NE of Ybycuí, Dpto Paraguari (abbreviated Y), 26-27 Mar 1980, and at Parque Nacional Cerro Corá (ca. 56°3'W, 22°39'S), Dpto Amambay (abbreviated C), 1-19 Sept 1980 and 30 Oct-4 Nov 1983. El Tirol was visited eight times: 29 Sept-17 Nov 1976; 4 Dec 1977-14 Jan 1978; 31 Aug-13 Oct 1978; 1-17 Oct 1979; 17-28 Aug and 23 Sept-3 Nov 1980; 21 Sept-19 Oct 1981; 19 Sept-3 Oct 1982; and 7-23 May 1983. These repeated visits allowed observations in different seasons and years.

Voucher specimens are deposited in the Herbarium of the University of California (UC), with duplicates and a few unicates of many collections in MO, LIL, and AAU. A

representative set will also be deposited in the herbarium of the Servicio Forestal Nacional in Asunción.

Rain data for El Tirol were obtained from records maintained at the site by Armando Reynaers. Temperature data, from the Meteorological Service of the Ministry of Defense, are for Capitán Miranda, a town ca. 4km by road SW of El Tirol.

STUDY SITES

The three collecting localities lie in a zone of temperate moist forest, though Ybycuí and Cerro Corá average 15-20% drier and a few degrees warmer than El Tirol (Farina Sanchez 1973). Days with rain per month are fairly constant throughout the year at El Tirol (Fig. 1), though rainfall may fluctuate greatly within months between years. July is the driest month; October, November, and December usually are the wettest. Temperatures vary seasonally; the warmest period occurs from November through February and the coolest from June through August, when temperatures occasionally may drop below freezing (Fig. 2).

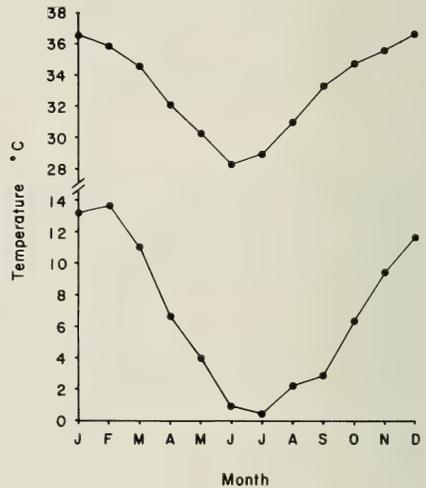
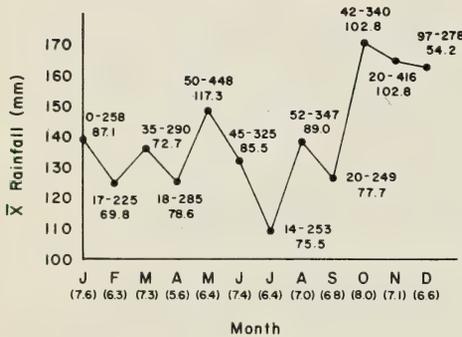


FIGURE 1. Mean monthly rainfall at El Tirol, Paraguay, January, 1971 — September, 1982. Range and one standard deviation adjacent to dots. Mean number of days with rain for each month in parentheses.

FIGURE 2. Mean monthly maximum and minimum temperatures at Capitán Miranda (4km by road SW El Tirol), Paraguay, January, 1964 — August, 1982.

The habitats at El Tirol are extremely varied. The main Tirol site includes about 50ha of forest adjacent to Hotel El Tirol de Paraguay. This forest, which is situated on moderately steep hillsides as well as flat areas, is cut by a series of northeast- and eastward-flowing creeks. Several are permanent; others flow intermittently following heavy rains. The forest is relatively low, with a canopy height in level areas of ca. 15-18 metres; the understory is open. This forest has not been extensively logged, though selected trees have been cut. In the last several years, however, the area has been increasingly disturbed and reduced in size by the cutting of trails for visitors, clearing of land for gardens, electric lines, and a road, and the diversion of a creek for irrigation.

Similar areas of forest, some on hillsides, others on flat or only gently sloping areas, are connected by corridors along creeks, though these zones are also rapidly disappearing. Adjacent to the Tirol forest are large areas of tall second growth originally planted in coffee or other crops. Also common (the zone is primarily

agricultural) are tung orchards, cattle pastures, and fields cultivated with corn, manioc, or other vegetables.

The entire area is characterized by a number of natural springs. These feed into permanent creeks or, in some flat sites, cause the formation of permanently boggy areas that flood with heavy rains. Natural seeps are found irregularly through the forest; these occasionally give rise to small pools or marshy areas.

Collections and observations at Ybycuí National Park were made either in forest areas that have experienced minimal human disturbance (Zona Primitiva of Comisión de Parques Nacionales de Paraguay, 1973) or in areas of extreme disturbance along roads and in park recreation zones. Collections at Cerro Corá National Park were made in areas of moderately disturbed forest, secondary growth, and scrubby pastures.

FERNS FROM EL TIROL

Below is a complete list of ferns known from El Tirol, plus a few additional Paraguayan species for which we have chromosomal counts. Collections cited (Foster numbers) are from El Tirol unless otherwise indicated. In the list, superscript "a" denotes the first chromosomal count for the species; superscript "b" denotes a count that differs from that previously reported; superscript "c" denotes a count agreeing with previous reports; (C) denotes Cerro Corá National Park and (Y) denotes Ybycuí National Park.

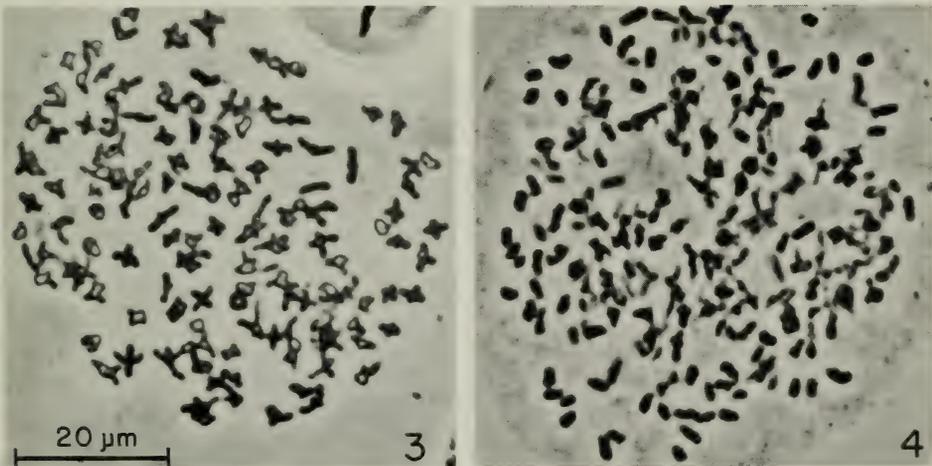


FIGURE 3. Meiosis in *Antigramma brasiliensis* showing 144 bivalents (Foster 81-23).

FIGURE 4. Chromosomes of *Antigramma plantaginea*, showing irregular meiosis, with pairs and univalents (Foster 80-2-67).

Adiantopsis radiata (L.) Fée^c 30 bivalents (79-16). Additional collections: 76-8; 78-2-26; 80-14 (Y); 80-2-26 (C).

Adiantum pseudotinctum Hieron.^a c. 58 bivalents (81-5). Additional collections: 76-20; 78-2-24; 79-12; 80-2-5; 81-4; 80-2-29 (C).

Adiantum tetraphyllum Humb. & Bonpl. ex Willd.^b 30 bivalents (80-2-17, C); 29 bivalents (80-12, Y). Walker (1966) reported $n = 58-60$ for a plant from Jamaica.

Anemia phyllitidis (L.) Sw.^c 76 bivalents (79-3). Additional collections: 76-12; 76-21; 78-2-10; 80-15 (Y); 80-2-37 (C).

Antigramma brasiliensis (Sw.) Moore^a 144 bivalents (81-23), Fig. 3; c. 144 bivalents (79-19; 81-35). Additional collections: 76-4; 78-2-18; 81-39; 80-27 (Y). Spores are well-formed, reniform, and 64 per sporangium. This represents the first count for the genus, placed by nearly all recent pteridologists in the asplenioid alliance (Aspleniaceae). The chromosome number indicates that the species is octoploid, based on $x = 36$.

Antigramma plantaginea (Schrad.) Presl^a Meiosis irregular, with many outlying univalents, bivalents, and perhaps a few trivalents (Fig. 4); the best cell showed c. $73II + 113I$ at meiotic

- metaphase (80-2-67), so the total is perhaps $2n = 288$ (octoploid). Spores are 16 per sporangium and are globose, indicating that this fern has unreduced spores and possibly an apogamous life cycle. Additional collections: 76-42; 78-2-59; 81-41; 81-42.
- Asplenium clausenii* Hieron.^a 36 bivalents (78-2-66; 79-14); c. 36 bivalents (79-13, MO; 81-44). Additional collections: 78-2-19; 78-2-41; 80-6 (Y).
- Asplenium hostmannii* Hieron. (76-11). Growing with *A. clausenii*, but differing from that species in the much lower number of lateral pinnae, pinnae broader and longer, with the lowermost the largest or only slightly shorter than the next pair. Also similar to *A. laetum* Sw., which differs in having a creeping rhizome and more atropurpureous stipes.
- Asplenium mucronatum* Presl (76-43; 78-2-31; 79-25; 81-15).
- Asplenium serratum* L.^b c. 144 bivalents (79-18). Additional collections: 78-2-66; 80-2-6; 80-2-7; 80-2-45 (C). The only previous count for this species was $n = 72$ (Wagner, 1963), based on material from Florida. One additional population (81-37) of this species from Paraguay was also examined cytologically, but an exact count could not be obtained. It showed a large number of chromosomal pairs, certainly more than 72. Spores are well-formed, 64 per sporangium.
- Blechnum australe* L. subsp. *auriculatum* (Cav.) Sota (80-2-53; 80-2-55).
- Blechnum brasiliense* Desv. (79-64; 81-19; 81-22; 80-16, Y; 80-2-44, C).
- Blechnum ensiforme* (Liebm.) C. Chr.^a 29 bivalents (80-2-47; 81-18); c. 29 bivalents (79-42). Additional collections: 78-2-51; 78-2-73. In South America, this species has often gone under the name *B. meridense* (Klotzsch) Mett., but that name is a later homonym of *B. meridense* Klotzsch [*B. fraxineum* Willd.]. We are unable to find reliable characters by which Paraguayan material differs from Mexican material; the type of *B. ensiforme* was collected in Mexico.
- Blechnum occidentale* L.^b c. 31 bivalents + 31 univalents [30-31 II + 29-33 I, 3 cells examined] (80-2-32, C). Another collection (80-18, Y) also showed irregular meiosis with many univalents and strongly malformed spores; exact counts could not be obtained. This species was previously recorded as $n = 62$ (eg, Walker, 1973). Hybrids of *B. occidentale* with several other species are known, but the Paraguayan specimen counted as triploid seems typical for the species. As Walker (1973) discussed, *B. occidentale* reproduces readily by stolons, so the triploids may be able to maintain themselves indefinitely without producing viable spores. Additional collections: 79-29 (spores malformed); 80-2-50.
- Campyloneurum lapathifolium* (Poir.) Ching^a 37 bivalents (80-2-71). Additional collection: 81-31.
- Campyloneurum phyllitidis* (L.) Presl^b 37 bivalents (80-2-1). Additional collections: 78-2-16; 78-2-17; 79-57. Previously counted as $n = 72$, for example by Wagner (1963) from Florida, Walker (1966) from Jamaica, and Jarrett et al. (1968) from the Galapagos. Paraguayan material generally has a narrower rhizome, with fronds arising at longer intervals, than material from North America and northern South America. Blades of Paraguayan specimens are also narrower. Monographic revision is needed.
- Cheilanthes chlorophylla* Sw.^a 30 bivalents (79-39; 79-54; 79-55, MO; 81-12; 81-33; 80-2-10). One collection (79-55) showed some cells with 27-29 II + 2-6 I. Additional collections: 76-14; 78-2-77; 80-2-64.
- Cheilanthes concolor* (Langsd. & Fisch.) R. & A. Tryon^b 30 bivalents (79-1; 79-10). Additional collections: 76-7; 80-24 (Y); 83-2-26 (C). This species previously counted as $n = 60$, from Taiwan (Mitui, 1968). It has often been placed in *Doryopteris* [= *Doryopteris concolor* (Langsd. & Fisch.) Kuhn]; the base chromosome number may lend additional support for placement in *Cheilanthes* ($x = 30$, a few 29) over *Doryopteris* (mostly $x = 29$).
- Ctenitis connexa* (Kaulf.) Copel.^a 41 bivalents (81-27). Additional collections: 78-2-34; 79-46. Closely related to *C. subincisa* (Willd.) Ching, widespread in tropical America; the differences seem rather slight.
- Ctenitis submarginalis* (Langsd. & Fisch.) Ching^c c. 41 bivalents (81-13). Additional collections: 78-2-11; 80-2-31 (C).
- Dennstaedtia globulifera* (Poir.) Hieron.^c 47 bivalents (81-21; 80-2-70). Additional collections: 79-66; 80-2-69; 83-2-33 (C).
- Dennstaedtia obtusifolia* (Willd.) Moore (78-2-83; 79-47).
- Didymochlaena truncatula* (Sw.) J. Smith^c c. 41 bivalents (79-24). Additional collections: 78-2-33; 80-2-65.
- Diplazium ambiguum* Raddi. No count, but undoubtedly a high polyploid, possibly octoploid ($n = 164$) (81-14). Additional collections: 78-2-74; 79-49. Most of the tropical American species of *Diplazium* that are bipinnate-pinnatifid or more divided seem to be octoploid (see Walker, 1966, for counts on *D. expansum*, *D. fuertesii*, *D. striatum*, all Jamaican species of this alliance.)

- Diplazium cristatum* (Desr.) Alston^c c. 82 bivalents (80-2-66). Additional collections: 78-2-37; 78-2-42; 79-27.
- Doryopteris nobilis* (Moore) C. Chr.^a c. 60 bivalents (80-2-48). Additional collections: 76-40; 78-2-9; 80-23 (Y); 80-2-27 (C).
- Doryopteris nobilis* × *pedata* var. *multipartita*^a c. 90 univalents (79-31); meiosis irregular, spores malformed.
- Doryopteris pedata* (L.) Fée var. *multipartita* (Fée) Tryon^b 29 bivalents (79-5; 79-32; 79-33, MO). Additional collections: 76-9; 78-2-7; 80-5 (Y); 80-2-28 (C). The species previously counted as $n = 60$ from the Galapagos (Jarrett et al. 1968), $n = 30$ from Jamaica (Walker, 1966), and $n = 58$ (Kurita, 1971).
- Gymnopteris tomentosa* (Lam.) Underw. (83-5; 80-2-43, C).
- Lastreopsis effusa* (Sw.) Tindale^c 41 bivalents (79-23; 79-34; 81-28). Additional collections: 78-2-36; 80-3 (Y).
- Microgramma lindbergii* (Mett.) Sota^a 21 bivalents + 30 univalents; 21 II + 29 I; 33 II + 6 I; 34 II + 4 I (80-13, Y), many malformed spores and meiotic abnormalities, but some spores appear well-formed. Additional collection: 80-2-15 (C).
- Microgramma squamulosa* (Kaulf.) Sota (76-6; 78-2-56; 80-11, Y).
- Microgramma vacciniifolia* (Langsd. & Fisch.) Copel.^c 36 bivalents (80-2-16, C); ca. 20 II + 34 I; 34 II + 6 I (80-25, Y). Evans (1963) also reported $n = 36$ for a plant from Brazil. Additional counts of species of *Microgramma* are desirable. Most other species have been reported as being based on $x = 37$; however, *M. vacciniifolia* and *M. lindbergii* seem to be $x = 36$, with some populations showing strong meiotic abnormalities.
- Nephelea setosa* (Kaulf.) Tryon (78-2-35; 79-61; 81-29).
- Pityrogramma trifoliata* (L.) Tryon (78-2-46; 79-4; 80-2-13; 81-40; 83-2-23, C).
- Polypodium filicula* Kaulf. a 37 bivalents (79-37; 79-38; 79-60). Additional collection: 80-2-34 (C).
- Polypodium hirsutissimum* Raddi (78-2-75).
- Polypodium pleopeltifolium* Raddi^a 35 bivalents (80-2-8); 37 bivalents (81-6). Additional collections: 78-2-15; 79-59; 80-2-35 (C). Foster 80-2-8 showed incomplete pairing in all five meiotic figures examined, from 30-34 II + 2-9 I (sum, $2n = 70$); nevertheless, spores appeared well-formed, 64 per sporangium. Evidence is accumulating that this group of *Polypodium*, probably closely allied to *Pleopeltis*, has a base chromosome number(s) other than $x = 37$. Smith and Mickel (1977) reported $n = 34$ for *Pleopeltis angusta*, $n = 35$ or 36 for *Polypodium pleolepis* and $n = 35$ for *P. friedricsthalianum*. Several Old World species of *Pleopeltis* (*Lepisorus*) are known to be based on $x = 35$.
- Polypodium polypodioides* (L.) Watt var. *minus* (Fée) Weatherby (78-2-14; 79-68; 80-2-19, C). Sometimes treated as a distinct species, *Polypodium squalidum* Velloso.
- Polypodium recurvatum* Kaulf.^c 37 bivalents (80-17, Y).
- Polypodium siccum* Lindm. (78-2-32; 79-36).
- Polypodium singeri* Sota (76-10; 80-2-49). First reports of the species from Paraguay; listed only from southern Brazil and northeast Argentina (Misiones) by Evans (1969).
- Polypodium truncorum* Lindm.^a 37 bivalents (81-43). Additional collections: 78-39; 81-16. First reports of the species from Paraguay; listed only from southern Brazil and northeastern Argentina by Evans (1969).
- Polystichum platyphyllum* (Willd.) Presl^b c. 82 bivalents (81-20). Additional collections: 79-22; 81-24. Previously reported as $n = 41$ from Mexico (Smith and Mickel, 1977).
- Pteridium aquilinum* (L.) Kuhn var. *arachnoideum* (Kaulf.) Brade 79-62, MO; 79-63; 80-22 (Y).
- Pteris deflexa* Link (78-2-71; 81-26).
- Pteris denticulata* Sw.^a 116 bivalents (81-30, octoploid); 174 bivalents (79-8, MO, dodecaploid); ca. 174 bivalents (79-9). Additional collections: 78-2-20; 80-2-24, C; 80-2-51; 80-20 (Y). 12x is the highest reported chromosome number in *Pteris*.
- Tectaria incisa* Cav. 78-2-76; 80-2-42 (C).
- Thelypteris dentata* (Forssk.) E. St. John^c 72 bivalents (79-51). Additional collections: 78-2-12; 83-2-31 (C). First reports of the species from Paraguay (see Smith, 1971); it is introduced from the Old World and now widely naturalized in tropical America.
- Thelypteris hispidula* (Decne) Reed^c 36 bivalents (79-7). Additional collection: 81-25.
- Thelypteris interrupta* (Willd.) Iwatsuki 79-65.
- Thelypteris torresiana* (Gaud.) Alston^c c. 62 bivalents (79-6; 79-43; 81-32). Additional collection: 80-2-39 (C). First reports of the species from Paraguay; introduced into the New World and rapidly expanding its range.

DISTRIBUTION AND BIOGEOGRAPHY

Four species occurring at El Tirol represent the first published records for Paraguay. *Polypodium singeri* and *P. truncorum* are recorded from the adjacent Argentine province of Misiones as well as from southern Brazil (Evans, 1969). Two species of *Thelypteris*, both introduced and widely naturalized in the Neotropics, are also new to Paraguay: *Thelypteris dentata* (see Smith, 1971) and *T. torresiana*, also known previously from Misiones, Argentina, and southern Brazil.

Nearly half of the species known from El Tirol are widespread in tropical and subtropical America, with distributions ranging from Paraguay and north-eastern Argentina to southern Mexico and the Antilles. Two species, *Thelypteris hispidula* and *T. interrupta*, are even pantropical. Seventeen species have a more restricted range, occurring in Paraguay, northeastern Argentina and southern Brazil, with some extensions into Uruguay and Bolivia. Included in this category are *Adiantum pseudotinctum*, *Antigramma* spp., *Asplenium mucronatum*, *Blechnum australe* subsp. *auriculatum*, *Ctenitis connexa*, *Microgramma squamulosa*, *Nephelea setosa*, *Polypodium hirsutissimum*, *P. pleopeltifolium*, *P. siccum*, *P. singeri*, *P. truncorum*, *Gymnopteris tomentosa* (also Peru), *Doryopteris nobilis* (disjunct in Colombia), and *Pteris denticulata* (disjunct in Hispaniola and Cuba).

Many of the species known from El Tirol are likely to be encountered in other areas of primary vegetation in Paraguay. Although Ybycuí and Cerro Corá National Parks were visited only briefly, 22 (of the 47 total species at El Tirol) were collected at one or the other (or both) of these two sites.

ECOLOGICAL OBSERVATIONS

Habitats and Abundance

Of the 47 species and one hybrid recorded from El Tirol, 36 were terrestrial, 10 were epiphytic, one hemi-epiphytic, and one was both terrestrial and epiphytic. The terrestrial species occurred in a variety of different habitats that can be categorised relative to light and moisture conditions.

Blechnum brasiliense, *Ctenitis connexa*, *Dennstaedtia obtusifolia*, *Didymochlaena*, *Diplazium* spp., *Nephelea*, *Polystichum*, *Pteris deflexa*, and *Tectaria* were found only along banks of permanent creeks in the forest. *Diplazium cristatum* occasionally grew on rocks in the creek as well. In most instances, plants of these species were in full shade. Some of the larger tree ferns (*Nephelea*) leaning into the creek beds received filtered sunlight, and the *Blechnum* also was often in somewhat sunnier areas. *Nephelea* lined the permanent creeks in a zone extending 1 to 3m from the stream edge at high water. In a few areas it also occurred on high banks 3 to 5m above the stream bed and, in one area of forest, pure stands of 0.5 to 1 hectare were growing. Although stands were bordered by permanent water along one side, most of the ferns were on a moderately steep slope. Whether this colonial habit is indicative of vegetative reproduction, as discussed by Gastony (1973) for *Nephelea sternbergii* var. *acanthomelas* in southern Brazil, is not known.

Of streambank species, perhaps the most common was *Didymochlaena*; in some areas it formed pure stands 5 to 10m wide to the exclusion of nearly all other vascular plants. Several other terrestrial species also showed a preference for moister areas. *Thelypteris hispidula* and *T. torresiana* were found along both creek banks and growing in the forest. The latter thrived in more open areas at the forest edge. *Antigramma plantaginea* was a locally common species often found in rocky areas around natural seeps and also in dense stands, often tens of metres across, in areas where the soil seemed particularly moist, but where no seeps were apparent.

A large number of terrestrial species grew only in the forest. *Asplenium serratum* was found only occasionally, usually in clumps of several plants. *Antigramma brasiliensis* was one of the most common ferns in undisturbed forest; in second

growth areas it was much less abundant. Isolated plants of *Campyloneurum lapathifolium* and *Doryopteris nobilis* were found in deep forest under low light intensities. Although both were relatively rare, the latter was locally abundant in patches several metres across. *Doryopteris pedata* was moderately common within the forest but also grew in shady areas at the forest edge. *Polypodium singeri* and *Asplenium hostmanii* grew only within the forest.

Lastreopsis effusa, *Pteris denticulata*, and *Ctenitis submarginalis* were somewhat less specialized in their habitat preferences. *Lastreopsis* was found along permanent creeks but also carpeted large expanses of the forest floor in areas of filtered sunlight and thick leaf litter. In some areas it grew with the *Ctenitis* which, along with the *Pteris*, also covered large areas of forest. All three species were especially common along well used paths. In addition, the *Ctenitis* occurred along forest and second growth edges; this may reflect its greater tolerance of sunny, dry conditions.

Several other species occupied a variety of habitats. *Adiantum pseudotinctum* was scattered in areas of deep shade but grew more commonly in areas of filtered sun at edges of second growth, where it formed carpets. *Cheilanthes concolor* and *Blechnum occidentale* similarly occupied both sites. *Adiantopsis* was extremely common everywhere in the forest and at the forest edge. *Anemia* was scattered in the forest, but became much more common in more open areas, such as along paths and at forest edge. *Dennstaedtia globulifera* grew in large clumps along forest creeks, at forest edge, and in open areas. Though occasionally found in heavy second growth, *Cheilanthes chlorophylla* was more characteristic of the forest edge, especially where areas had been cleared for pasture. Pinnules of this species were extremely soft and nearly always appeared wilted; however, fronds revived early in the morning, late in the evening, and during rains.

Blechnum australe and *Pteridium aquilinum* were characteristic of the second growth forest/pasture interface. Their blades were extremely leathery and transient wilting was not observed. *Thelypteris dentata* was especially common along the forest edge; it also was found in more open areas.

Thelypteris interrupta and *Pityrogramma trifoliata* were the only species found primarily in full sun. Though occasionally growing at the forest edge, they occurred most often in old fields and pastures where they sometimes formed dense carpets. The *Thelypteris* was most characteristic of marshy areas.

The epiphytic ferns all grew in shady sites. The most common microhabitat was in the axils of old stipe bases of *Nephelea*. *Asplenium mucronatum*, *Polypodium siccum*, and *P. truncorum* were found only in this niche. *Polypodium truncorum* generally formed a carpet of tiny plants along the length of the *Nephelea* trunk. The *Asplenium*, with pendant fronds to 75cm long, was rarely found below 2m and was distributed irregularly among the tree ferns, which bore zero to several individuals. Two species were epiphytic both on *Nephelea* and on other trees. *Campyloneurum phyllitidis* was found on *Nephelea*, on rocks along the creek, and on fallen trees in the forest. *Asplenium claussenii*, a common component of the forest floor, occasionally grew on *Nephelea*.

Microgramma squamulosa and four species of *Polypodium* (*P. filicula*, *P. hirsutissimum*, *P. pleopeltifolium*, and *P. polypodioides*) were epiphytic on trunks (not *Nephelea*) and large limbs (diameter greater than 6cm) of forest trees. The *Polypodium* spp. were generally several metres up on the tree trunk; the last two species were especially common 5 to 6m up; *P. hirsutissimum* was common even higher. In contrast, *P. filicula* grew low down, forming large carpeted areas on tree trunks, often within a metre of the ground. Rhizomes of *Microgramma squamulosa* formed dense mats most commonly on horizontal branches. All of these species seemed to continue

growing well when the host tree or limb fell to the ground. This is true also of *Campyloneurum phyllitidis*.

Blechnum ensiforme, the only hemi-epiphyte, was observed only along permanent creeks. The largest, reproductive plants grew up the trunks of *Nephelea*. Small, young sporophytes were moderately common in crevices of rocks bordering the creek.

Phenology

Because observations were not made throughout the year, it is difficult to describe adequately the phenology of the ferns at El Tirol. However, a review of the information available for the months of observation suggests several patterns of activity.

In many species reproduction appeared to be correlated with the periods of greatest rainfall, even though the number of days with rain are fairly constant from month to month (Fig. 1). In at least 29 of the 47 species, meiosis occurred from October to December. Some meiotic activity was evident as early as August in *Anemia*, *Antigramma brasiliensis*, *Campyloneurum phyllitidis*, *Cheilanthes* spp., *Diplazium cristatum*, *Polypodium truncorum*, *Pteris denticulata*, *Tectaria*, and *Thelypteris dentata*. In most of these, spores were in earliest stages of development; spore release may not occur until the later, wetter months. *Polystichum platyphyllum* sampled in October had fertile fronds bearing sporangia with mature spores as well as sporangia with spores undergoing meiosis; this suggests that reproduction was initiated at least in September. In contrast, *Adiantum pseudotinctum* and *Asplenium serratum* were entirely non-reproductive in August and September.

Indirect evidence suggests that some species reproduce earlier in the year, during the cold winter months of June to August. *Asplenium mucronatum* fronds bore old sori from October through January; sori produced in September were somewhat younger, though still post-meiotic.

During the one fall visit, in May, young fertile fronds were present on some *Adiantum pseudotinctum*, on nearly all *Anemia phyllitidis* and *Thelypteris torresiana*, and on most *Pityrogramma trifoliata* and *Polypodium pleopeltifolium*. Large numbers of plants of 26 additional Tirol species had no fertile fronds or only old, dried ones. Fertile fronds were found only on a few of nearly 100 plants of *Pityrogramma trifoliata* examined during the last half of August; these fronds were old and dried.

In general, the epiphytes, which are particularly sensitive to moisture conditions, underwent meiosis and produced spores in the wetter months. However, no fertile fronds of *Microgramma squamulosa* were located.

For a few species, flushes of new growth were obvious. In late August and September, vegetative growth in *Pityrogramma* was pronounced. In September, new growth was abundant in *Nephelea*, *Blechnum occidentale*, and *Adiantum pseudotinctum*. Generally, those species showing growth flushes were non-reproductive. Active new growth was evident in *Antigramma* spp., *Asplenium clausenii*, *Blechnum brasiliense*, *B. ensiforme*, *Cheilanthes concolor*, *Didymochlaena*, *Polypodium truncorum*, and *Pteris denticulata* in October. Finally, all species examined in May, 1983 showed active new growth. This was, however, one of the rainiest Mays on record.

Biological Interactions

Herbivore damage was noted consistently on only four species of ferns. *Diplazium ambiguum* suffered what appeared to be heavy insect damage on most plants. On many of these the costules were completely stripped of pinnules. This coincides with observations by Smith (unpubl.) on *Diplazium* spp. in Venezuela and southern Mexico. Fronds of *Nephelea* also were heavily eaten or otherwise damaged, at least in September and May when few pinnules are intact. Insect damage was noted occasionally on *Antigramma brasiliensis* and old fronds of *Thelypteris torresiana*.

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REFERENCES

- COMISION DE PARQUES NACIONALES DE PARAGUAY, 1973. Plan de manejo y desarrollo conceptual del parque nacional Ybycuí. *Doc. Tec. Trabajo No. 5* (Proyecto FAO-RLAT/TF/199).
- EVANS, A.M., 1963. New chromosome observations in the Polypodiaceae and Grammitidaceae. *Caryologia* 16: 671-677.
- EVANS, A.M., 1969. Interspecific relationships in the *Polypodium pectinatum-plumula* complex. *Ann. Missouri Bot. Gard.* 55: 193-293.
- FARINA SANCHEZ, T., 1973. The climate of Paraguay. Pp. 33-38 in J.R. Gorham (ed.), *Paraguay: Ecological Essays*. Acad. Arts Sci. Americas. Miami, Florida.
- GASTONY, G.J., 1973. A revision of the fern genus *Nephelea*. *Contr. Gray Herb.* 203: 81-148.
- JARRETT, F.M., MANTON, I., and ROY, S.K., 1968. Cytological and taxonomic notes on a small collection of living ferns from Galapagos. *Kew Bull.* 22: 475-480.
- KURITA, S., 1971. Chromosome study of four species of leptosporangiate ferns. *Ann. Rep. Foreign Students' Coll. Chiba Univ.* 3: 47-52.
- MITUI, K., 1968. Chromosomes and speciation in ferns. *Sci. Rep. Tokyo Kyoiku Daigaku, B.* 13: 285-333.
- SMITH, A.R., 1971. Systematics of the Neotropical species of *Thelypteris* section *Cyclosorus*. *Univ. Calif. Publ. Bot.* 59: 1-143.
- SMITH, A.R. and MICKEL, J.T., 1977. Chromosome counts for Mexican ferns. *Brittonia* 29: 391-398.
- TRYON, A.R., BAUTISTA, H.P., and DE SILVA ARAUJO, I., 1975. Chromosome studies of Brazilian ferns. *Acta Amazonica* 5: 35-43.
- WAGNER, W.H., JR., 1963. A biosystematic study of United States ferns. Preliminary abstract. *Am. Fern J.* 53: 1-16.
- WALKER, T., 1966. A cytotaxonomic survey of the pteridophytes of Jamaica. *Trans. Roy. Soc. Edinburgh* 66: 169-237.
- WALKER, T., 1973. Additional cytotaxonomic notes on the pteridophytes of Jamaica. *Trans. Roy. Soc. Edinburgh* 69: 109-135.

A NEW *OPHIOGLOSSUM* FROM INDIA

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ABSTRACT

A new species of *Ophioglossum*, from India, *O. eliminatum* Khandelwal & Goswami, is described.

INTRODUCTION

This paper presents observations on a new *Ophioglossum* species with features hitherto unknown in the genus. The plants described here were first collected in 1973 from Kanharjhir (near Gwalior) and at Chandpata (Shivpuri). Further collections during the rainy season (July — September) have been very extensive, and morphological, anatomical, biochemical and chromosomal studies have already been published (Khandelwal, 1978; Khandelwal and Goswami, 1977; Khandelwal, Goswami and Chaterjee, 1980; Goswami and Khandelwal, 1980; Das, Khandelwal and Dubey, 1981), incorporating other species occurring in the close vicinity (viz. *O. costatum* R. Br., *O. nudicaule* L., *O. lusitanicum* L., *O. gramineum* Willd. and *O. thermale* Kumarov).

DESCRIPTION

Ophioglossum eliminatum Khandelwal & Goswami sp. nov.

Holotypus: Kanharjhir, Gwalior, Sharda Khandelwal, 9 August 1973 (National Botanic Garden, Botanical Survey of India, Howrah). *Isotypes*: Forest Research Institute, Dehra Dun and Royal Botanic Gardens, Kew.

Plantae atro-virides, 1.8-15.0cm altae; rhizoma subglobosum; surculus communis 0.5-4.0cm longus; trophophyllum 0.5-3.5 x 0.3-2.5cm, ovatum, mucronatum, sine vitta mediana pallida, venatio non duplex et cum areolis longis in parte inferiore laminae sterilis. Surculus fertilis 1.0-8.0cm longus, spica 0.3-2.2cm longa; sporae triletiae, interdum biletiae, aletae et monoletae, liberae vel conjunctae, 18.0(34.5) 45.0µm in diam.

Plants dark green in colour, 1.8-15.0cm high; rhizome subglobose; common stalk 0.5-4.0cm long, trophophyll 0.5-3.5 x 0.3-2.5cm, ovate in shape, mucronate, without pale median band, venation not double and with long stretched areoles at the lower part of the sterile blade, tip of the trophophyll with a pointed end; fertile stalk 1.0-8.0cm long; spike 0.3-2.2cm long; spores trilete, biletate, monolete and alete in one and the same sporangium, occasionally jointed, 18.0-45.0µm in diameter (average 34.5); exine scubrate and with or without any outgrowth; spore output in a sporangium 4190-6651. Meiosis shows 90 bivalents, $2n = 180$.

The name of this species derives from the suggestion that it has originated through chromosome eliminations (Goswami and Khandelwal, 1980).

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REFERENCES

- DAS, R.R., KHANDELWAL, S. and DUBEY, S.N. 1981. Activity of certain oxido-reductases in different species of *Ophioglossum* L. *Bionature* 1, 1 & 2: 43-44.
- GOSWAMI, H.K. and KHANDELWAL, S. 1980. Chromosomal elimination in natural population of *Ophioglossum* L. *Cytologia*, 45: 77-86.
- KHANDELWAL, S. 1978. *Cytological and physiological studies of Ophioglossum* L. Ph D thesis. Jiwaji University, Gwalior, India.
- KHANDELWAL, S. and GOSWAMI, H.K. 1977. Stomata in *Ophioglossum palmatum* L. *Curr. Sci.* 46, 2: 51-54.
- KHANDELWAL, S., GOSWAMI, H.K., and CHATERJEE, A.K. 1980. Nitrogen and oil contents in *Ophioglossum* L. *J. Ind. Bot. Soc.* 59, 1: 78-80.

ASPLENIUM OBOVATUM IN BRITTANY, NW FRANCE

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ABSTRACT

The *Asplenium obovatum* group consists of two closely related species which may be difficult to distinguish on gross morphology. *A. obovatum* Viv. is a diploid Mediterranean species whereas *A. billotii* F.W. Schultz is a tetraploid with a much wider, more Atlantic, distribution.

The occurrence of *A. obovatum* in Brittany has recently been verified by chromosome counts, a discovery which throws new light on the distribution of this species. Further field investigations, however, will be necessary to determine whether these finds represent isolated relict localities or an hitherto overlooked Atlantic extension of *A. obovatum*.

INTRODUCTION

The *Asplenium obovatum* group consists of two closely related species, *A. obovatum* Viv. and *A. billotii* F.W. Schultz. The former is a diploid species confined to the Mediterranean region but occurring more commonly in the eastern part. *A. billotii*, on the other hand, is a tetraploid species having a more Atlantic distribution; in France it occurs in scattered localities in Lorraine, Alsace, the Bassin Parisien region, and the Massif Central, as well as along the Atlantic seaboard of the Iberian peninsula and the western Mediterranean coast (Sleep, 1966).

O. obovatum and *A. billotii* are of similar appearance and may at times be difficult to distinguish (Aymonin, 1974). The first diagnostic feature of the gross morphology which may be used to separate them is pinnule shape. In *A. obovatum* the pinnules are markedly rounded with very wide, obtuse, often inconspicuous teeth, whereas in *A. billotii* they are more acute, their teeth being more serrate and markedly distinct one from the other. The pinna apex is another good diagnostic character. It is rather wide and rounded in *A. obovatum*, being formed by the decidedly confluent apical pinnules. In *A. billotii* it is more acuminate, nearly all the pinnules remaining distinct (Badré et al., 1981).

The occurrence in France of a third similar species, namely *A. foreziense* Héribaud, does not make matters easier. This allotetraploid, derived by hybridisation between *A. fontanum* (L.) Bernh. and *A. obovatum*, bears a morphological resemblance to the two taxa of the *A. obovatum* group. As a result, identification is more difficult and the respective geographic distribution of the three species cannot be clearly defined (Jalas & Suominen, 1972).

Finally, it should also be borne in mind that the name *A. obovatum* was at one time frequently used to describe what is known today as *A. billotii*.

DETAILS OF THE BRITTANY PLANT

In July 1981, in crevices of coastal rocks at Pointe de Brezellec, NW of Cléden-Cap-Sizun, Finistère, Brittany, A. Labatut noticed a few plants of *Asplenium* which on morphological grounds he suspected to be *A. obovatum* (Fig. 1).

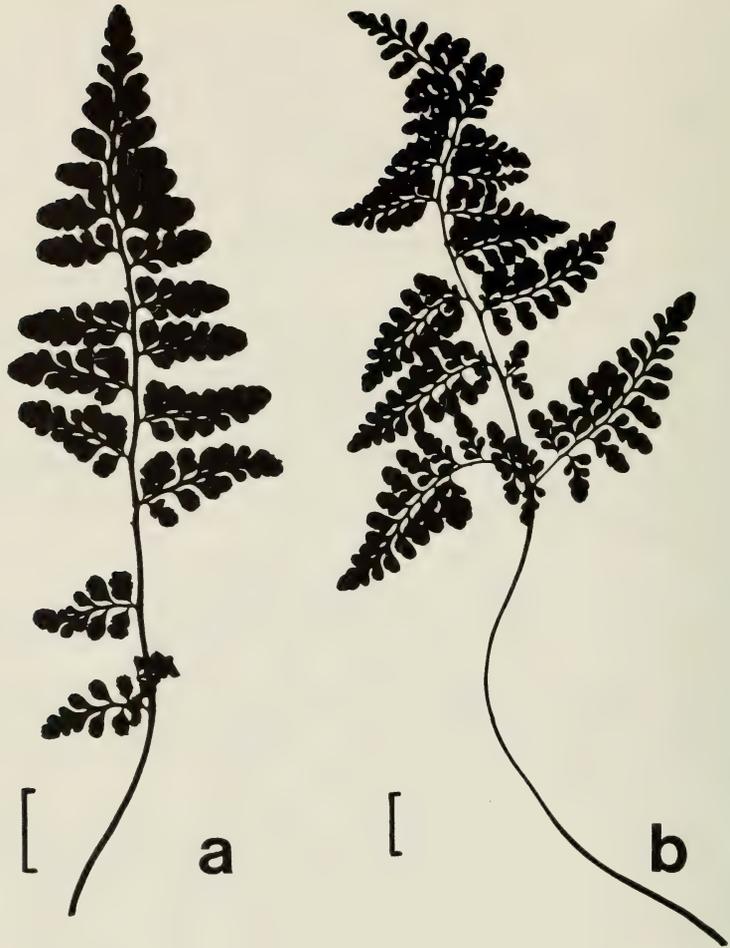


FIGURE 1. *Asplenium obovatum* Viv. from Pointe de Brezellec, 1 May 1982; the two cytologically confirmed plants. 1a, Prelli 1322; 1b, Prelli 1323. Scale = 1cm (silhouette by A. Zuppiger).

Spore measurements often provide a useful micro-morphological character for distinguishing between diploid and tetraploid species. Such measurements were accordingly made on this material by R. Prelli and they confirmed the original supposition; the spore length of our specimens proved to be 25-32 μ m, compared with 32-38 μ m for the tetraploid *A. billotii*.

In order to confirm our identification of *A. obovatum* a cytological study was undertaken by J. Schneller on material fixed in the field by R. Prelli on 1 May 1982. Chromosome counts (made according to the technique of Manton, 1950) from spore mother cells at meiosis in young sporangia from two different plants (Prelli 1322 and 1323) gave the same result; both plants were diploid with c. 36 bivalents. The occurrence of the diploid species, *Asplenium obovatum*, in Brittany has thus been clearly established.

The habitat of *A. obovatum* at Pointe de Brezellec is reminiscent of its ecology on the Mediterranean coast. About 10 plants have been observed in shady crevices of well-sheltered siliceous coastal rocks facing due east. These rocky outcrops bear an open vegetation composed of *Umbilicus rupestris*, *Armeria maritima*, *Silene maritima*, *Sedum anglicum*, *Daucus carota* spp. *gummifer*, *Cochlearia danica*, *Hedera helix*, together with the lichens *Ramalina* sp. and *Rocella* sp. The grassy ledges carry a heathland type of vegetation with *Euphorbia portlandica*, *Dactylis glomerata*, *Chrysanthemum leucanthemum*, *Jasione montana*, *Endymion non-scriptus*, *Scilla verna*, *Pteridium aquilinum*, *Viola riviniana*, *Ulex gallii*, *Erica cinerea*, *Calluna vulgaris*, *Teucrium scorodonia*, *Ruscus aculeatus*, *Lonicera periclymenum*, and *Rubus* sp.

This is not the only locality. Specimens collected on 18 August 1891 by E. Gadeceau at Pointe de Kerharo (1km E of Pointe de Brezellec) were identified as *A. obovatum* by G. Denizot (PI). Although the plants are small, measurement of spores taken from these specimens confirms the identification. G. Aymonin, in a handwritten note, indicates that he was unable to locate these plants in the field in spite of repeated searches over a number of years.

What is to be made of such Atlantic sites of a species up to now regarded as Mediterranean? They might be just a few relict localities, testifying to a previous, much wider, distribution stretching over the oceanic regions. On the other hand, these sites might be an hitherto overlooked extension of the distribution of this species which, in that case, would have to be regarded as Mediterranean-Atlantic. Only further discovery of other localities after a thorough investigation of the Armorican coast will help resolve this question.

REFERENCES

- AYMONIN, G., 1974. *L'Asplenium obovatum* Viv., plante de Corse. Observations sur la définition de l'espèce. *Bull. Soc. Bot. Fr.* 121, 95e sess. extr.: 61-65.
- BADRÉ, F., BOUDRIE, M., PRELLI, R., and SCHNELLER, J., 1981. *Asplenium* × *sleepiae* (*A. billotii* × *A. foresiense*) et *Asplenium* × *bouharmontii* (*A. obovatum* × *A. onopteris*), hybr. nov. *Bull. Mus. natn. Hist. nat. Paris*, 4e ser., 3, sect. B: 473-481.
- JALAS, J., and SUOMINEN, J., 1972. *Atlas florae europaeae. I Pteridophyta*. Helsinki.
- MANTON, I., 1950. *Problems of cytology and evolution in the Pteridophyta*. Cambridge University Press.
- SLEEP, A., 1966. *Some cytotaxonomic problems in the fern genera Asplenium and Polystichum*. PhD thesis, Leeds.

SHORT NOTES

SPIKE AND SPORANGIAL ABNORMALITIES IN *OPHIOGLOSSUM* OF RAJASTHAN, INDIA

Teratological conditions relating to spike, sporangium and leaf are well known in Ophioglossaceae. A survey has provided some undescribed abnormalities in *Ophioglossum* which are reported here.

A variety of branching patterns of spike were observed in natural populations of *O. costatum* R.Br. in SW Rajasthan, including a dichotomously branched spike, a twice branched spike with branches arising at different levels and oriented in different planes simulating the compound spike of *Botrychium*, and a branching of the spike with the lower part unbranched in a specimen from SE Rajasthan, a condition reported earlier in *O. pendulum* L. (Bower, 1926), *O. palmatum* L. and *O. pedunculatum* sensu Prantl (Mahabale, 1962) and recently in *O. nudicaule* L. (Goswami & Khandelwal, 1973). A similar type of branching of spike was observed in *O. petiolatum* Hook. from Central Rajasthan, where a small protuberance of the spike was perpendicular to the main spike. In *O. costatum* from SE Rajasthan, dichotomously branched spike stalks bearing normal unbranched spikes were frequently observed. In *O. reticulatum* L. from the same locality the branching of stalk was conspicuously unequal.

Sporangia as a rule are paired and lateral in *Ophioglossum*. However, terminal unpaired sporangia were found in *O. nudicaule* from SE Rajasthan and *O. petiolatum* from Central Rajasthan as recorded earlier in *O. costatum* and *O. gramineum* Willd. (Goswami & Khandelwal, 1973). In the same spike of *O. petiolatum* containing the unpaired sporangium, three successive sporangia were also found fused forming a linear compound sporangium or a synangium on one side of the spike only, similar to the fusion reported in *O. gramineum* but involving only two sporangia (Goswami, 1978).

A plant of *O. petiolatum* cultivated in the Botanical Garden, Government College, Ajmer (Central Rajasthan) has a leaf with an emarginate apex.

Unlike Goswami & Khandelwal (1973), we could not locate any specimen with sporangia on the tropophyll in *O. nudicaule* or any other species of the genus. It is significant, however, that in plants with sporangial or spike abnormalities we could not observe any well marked difference in the spore types (normal, irregular, enucleate or deformed spores) in normal and/or abnormal spikes, nor was there any relationship between the twisting of spike and occurrence of enucleate spores in the twisted portion. Spike twisting is a regular feature in *O. petiolatum* in Rajasthan and was not observed in the other species. Twisting of the spike seems to be related to an enhanced period of humidity affording a prolonged period of development to the spike and does not indicate that a genetic mechanism leading to sterility is operative as suggested by Goswami & Khandelwal (1973).

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REFERENCES

- BOWER, F.O. 1926. *The ferns Vol. II*. Camb. Univ. Press.
 GOSWAMI, H.K. 1978. A morphogenetic study of sporangia-partitioning complex. *Acta Soc. Bot. Poloniae*. 47: 307-315.
 GOSWAMI, H.K. & KHANDELWAL, S. 1973. Abnormalities in *Ophioglossum*. *Brit. Fern Gaz.* 10: 311-314.
 MAHABALE, T.S. 1962. Species of *Ophioglossum* in India. Their taxonomy and phylogeny. *Bull. Bot. Surv. India*. 4: 71-84.

A NEW SPECIES OF *MICROLEPIA* FROM SOUTH INDIA

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ABSTRACT

A new species of *Microlepia*, *M. manohara*, similar to *M. speluncae*, is described from Wynad, South India.

INTRODUCTION

The Wynad plateau (South India) is c. 700m above sea level and juts into the Malabar plains, ending rather precipitously on the western side. Lying on the windward side of the Western Ghats, Wynad receives an average annual rainfall of c. 380cm, mostly between May and August. It is criss-crossed by streams and supports a dense tropical forest which until recently was nearly impenetrable and hence floristically little known. Destruction of the forests for establishing tea, coffee and cardamom plantations has now opened up most regions for botanical exploration. While studying the fern flora of Wynad we came across a new species of *Microlepia* which is described here. *Microlepia* C. Presl. (Dennstaedtiaceae) contains 47 species, 10 of which occur in India (Beddome, 1892; Nayar & Kaur, 1963, 1964).

*Microlepia manohara** Nayar & Madhusoodanan sp. nov.

Species *Microlepia speluncae* similis; sed magnitudine grandior, folia magna ovato-deltata cum sporangiis et sporis minoribus. Rhizoma ramosum, c. 2cm crassum, pilis uniseriatis lanea marciduaque ornatum. Folium erectum, c 3m longum. Lamina foliorum late ovato-deltata, c. 170x150cm, quadripinnata. Omnes divisiones acroscopicae basales ampliores quam divisiones ceterae eiusdem ordinis. Pinae primariae oblongo-lanceolatae, 75x25cm cum apicibus longe acuminatis. Pinae secundariae late lanceolatae, 12x3cm cum apicibus longe acuminatis. Pinae tertiariae acroscopicae basales pinnatim divisae; ceterae pinnatifidae, 2.0 x 0.75cm, rhombicae, cum apicibus obtusis. Pinae quaternariae rhombicae, 6 x 3mm, cum marginibus serratis et apicibus obtusis. Rachis et omnes rami et primae venae laminae pilis uniseriatis glandulosis etiam pilis uniseriatis acicularibus praeditae. Lamina pilis parvis acicularibus praeter illas duas species pinnarum praedita. Sporangia cum paraphysibus mixta. Annulus sporangii 20-26 cellulis longus. Sporae triletae, leves, 20x30µm, in forma trianguli cum lateribus concavis.

Holotypus: B.K. Nayar & P.V. Madhusoodanan CU 7265, Chembra Peak, Wynad, India Meridionalis, 1000m. Feb. 1976, in Central National Herbarium, Calcutta. Isotype in the herbarium of Calicut University, Kerala. Paratypes: B.K. Nayar & P.V. Madhusoodanan CU 7280, Chembra Peak; P.V. Madhusoodanan CU 21306, Chembra Peak, both in Calicut University Herbarium.

Rhizome long-creeping, branched. Fronds to 3m tall; stipe c. 125cm x more than 10mm at base, erect, glabrous and shining when mature, purplish-brown basally, with a shallow broad adaxial median groove. Young stipes covered with hairs which are shed except in adaxial groove when mature. Lamina c. 175 x 150cm, broadly ovate-deltate in outline, broadest slightly above base, quadripinnate. All lamina divisions oblique at base, acroscopic side markedly longer than basicopic; acroscopic basal division of each series conspicuously larger than others, resembling divisions of previous order. Primary pinnae up to 75 x 25cm, oblong-lanceolate, with c. 22 pairs of 2° pinnae, acuminate at apex. Secondary pinnae c. 12 x 3cm, broadly lanceolate, distinctly stalked, long-caudate at apex. Basal acroscopic 3° pinnae distinctly pinnate, other 3° pinnae deeply pinnatifid, c. 20 x 7mm, rhombic, obtuse at apex, broadly rounded at acroscopic base. Ultimate lobes (Fig. 1) ovate-rhombic, crenate at margin and obtuse at apex. Quaternary pinnae c. 6 x 3mm, serrate at margin and with pinnate venation. Rachis, its branches and midribs of ultimate pinnae straight, adaxially grooved, groove not continuous on branches of different orders. Lamina with hairs throughout, most of which are shed from the main rachis during maturity. Sori submarginal at apex of veinlets (mostly on acroscopic basal veinlets of ultimate lobes). Indusium broader than long (0.5 x 0.8mm), with entire glabrous margin.

*The specific epithet 'manohara' is derived from Sanskrit and means 'elegant'.



FIGURE 1. *Microlepia manohara*, tertiary pinna showing sori and venation (scale = 3mm).

Sporangia mixed with uniseriate glandular paraphyses. Annulus of (20-)22(-26) indurated cells. Spores $20 \times 32\mu\text{m}$ (P x E), trilete-tetrahedral, with triangular amb, broadly rounded corners and concave sides, flat proximal face and tenui-marginate laesura, with a few large yellowish-brown oil globules and many plastids when fresh.

Microlepia manohara is a large and elegant fern forming clumps near margins of forests. Except for its markedly larger size, it resembles *M. speluncae*, which is widespread in South India (Sledge, 1956). The broadly deltate lamina of *M. manohara* is nearly three times as broad with the primary and secondary pinnae more than twice the size of those of *M. speluncae*, while the ultimate segments are much smaller. As in *M. haflangensis* (Nayar & Kaur, 1964) the margin of the indusium is naked. The annulus of the sporangium consists of 20-26 cells in contrast to 15-20 cells in *M. speluncae*. Despite the markedly larger size of the plant, the spores of *M. manohara* are the smallest in the genus (Nayar & Devi, 1968) being only $20 \times 32\mu\text{m}$ in contrast to those of *M. speluncae* ($28 \times 34\mu\text{m}$) and *M. hancei* ($25 \times 40\mu\text{m}$). The exine is smooth in *M. manohara* whereas it is granulose in the other species mentioned.

ACKNOWLEDGEMENTS

It is a pleasure for us to thank Mgrs Rev. Fr Thomas Moothedan for correcting the Latin diagnosis.

REFERENCES

- BEDDOME, R.H. 1892. *Handbook to the ferns of British India, Ceylon and Malay Peninsula* (with supplement). Thacker, Spink & Co., Calcutta.
- NAYAR, B.K., and DEVI, S. 1968. Spore morphology the the Pteridaceae — II: the Dicksonioid, Dennstaedtioid and Lindsaeoid ferns. *Grana Palyn.* 7: 185-203.
- NAYAR, B.K., and KAUR, S. 1963. Ferns of India — VIII: *Microlepia* Presl. *Bull. natl bot. Gdns* 79: 1-25.
- NAYAR, B.K., and KAUR, S. 1964. Ferns of India — XII: some new taxa of Indian ferns. *Bull. natl bot. Gdns* 94: 1-15.
- SLEDGE, W.A. 1956. *Microlepia speluncae* (L.) Moore, *M. trapeziformis* (Roxb.) Kuhn and *M. firma* Mett. in Kuhn. *Kew Bull.* 3: 523-531.

ANOTHER INTERGENERIC HYBRID IN GRAMMITIDACEAE: *CTENOPTERIS LONGICEPS* × *GRAMMITIS SUMATRANA*

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ABSTRACT

The naturally occurring hybrid between *Ctenopteris longiceps* (Rosenst.) Copel. and *Grammitis sumatrana* (Baker) Copel. is reported for the first time. It is found in Papua New Guinea.

INTRODUCTION

The family Grammitidaceae is represented in New Guinea by approximately 150 species. The largest genera are *Grammitis* and *Ctenopteris* with 64 and c. 50 species respectively. As with many other groups of tropical plants, a large number of species belonging to the same family may be found in one area, theoretically providing opportunities for hybridisation, but hybrids even within a genus appear to be extremely uncommon. It is of great interest, therefore, to find plants that are intermediate between two species from different genera and which are apparently of hybrid origin.

In 1980 I collected ferns on Mt Hagen (Western Highlands Province) and Mt Giluwe (Southern Highlands Province) in Papua New Guinea. *Ctenopteris longiceps* (Rosenst.) Copel. and *Grammitis sumatrana* (Baker) Copel. occur on both mountains, and plants intermediate between the two species were occasionally found in both places. I was unable to find any intermediates during extensive collecting in other years (Mt Hagen in 1971 and Mt Giluwe in 1977 and 1981) although both species were found during these expeditions.

DESCRIPTION

Species of *Grammitis* have simple ± entire fronds; those of *Ctenopteris* usually have fronds pinnately divided to pinnate, although some may be bipinnate. *Grammitis sumatrana* has slender fronds entire to crenately lobed to 5-12mm from the midvein in the centre of the frond, while *Ctenopteris longiceps* has broader fronds which are pinnate or very deeply pinnately divided to c. 0.5mm from the midvein in the centre of the frond. Plants intermediate between these two species have fronds of intermediate proportion, rather irregularly pinnately divided to 2-4mm from the midvein in the centre of the frond. Figure 1 shows the two species and the intermediate.

All three taxa have the following characters in common: short to long-creeping rhizome, with ± lanceolate ± acute pale to medium red-brown glabrous scales, rather dense ± patent red-brown simple eglandular stipe hairs c. 0.1-0.3mm, scattered to occasional ± patent medium to dark red-brown simple eglandular hairs c. 0.2-0.7mm on margin and midvein or rachis above and below, the lateral veins forked several times, and the sori ± circular in outline. The microscopic characters given in Table 1 show no significant differences in sporangial size, length and number of sporangial setae nor in spore size between the two species. The spores of both species are ± globose and chlorophyllous, while those of the intermediate plants are ± globose, usually pale and without chlorophyll, or occasionally blackish.

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TABLE 1. Microscopic characters of *Ctenopteris longiceps*, *Grammitis sumatrana* and intermediate plants, based upon material from Mt Hagen and Mt Giluwe (10 measurements of each character from each plant: range in brackets, other figures represent one standard deviation each side of the mean).

	<i>C. longiceps</i> (5 plants)	intermediates (3 plants)	<i>G. sumatrana</i> (7 plants)
sporangia	(170-)203 - 235(-250) μm	(170-)200 - 252(-260) μm	(180-)207 - 257(-310) μm
setae	1-5, medium to dark red-brown, 100-180 μm	1-4, medium to dark red-brown, 100-170 μm	1-6, medium to dark red-brown, 110-200 μm
spores	(29-)32 - 40(-45) μm	(23-)26 - 31(-33) μm	(28-)30 - 40(-44) μm

DISTRIBUTION AND ECOLOGY

C. longiceps is endemic to Papua New Guinea and has a rather limited distribution in the Western, Southern and Eastern Highlands and Morobe provinces between 2300 and 3000m alt. *G. sumatrana* occurs elsewhere in Malesia (Sumatra, Borneo, Java and the Philippines), and is one of the commonest and most wide-spread species of the family in New Guinea, occurring between 950 and 3350m alt.

On Mts Giluwe and Hagen both species are rather common between 2300 and 3000m alt. in midmontane forest which is often dominated by *Nothofagus*. *C. longiceps* is usually a low epiphyte from \pm ground level to c. 3m up on tree trunks of 3cm to more than 1m in diameter in primary montane forest, but occasionally grows on the downstream side of large mossy boulders in the beds of small mountain streams in forest. *G. sumatrana* is usually epiphytic from \pm ground level to at least 8m up on tree-ferns, lianes and tree trunks of 1cm to more than 1m in diameter in primary montane forest, young secondary forest and rather open recently logged forest, but occasionally grows on the down-stream side of large mossy boulders in streams in exactly the same habitat as *C. longiceps* and sometimes with it. The intermediate plants were found between 2300 and 2820m alt. as epiphytes from 0.7 to 2m up on lianes and tree trunks of 1cm to 20cm in diameter in primary montane forest. In each of the three localities where the intermediate was found it was as a solitary plant, with neither species present in the immediate vicinity, but with both species present in the same area. No intermediate plants were found in areas where only one species occurred.

DISCUSSION

It is obvious from the above descriptions that not only are the intermediate plants probably hybrids between *C. longiceps* and *G. sumatrana* (although artificial synthesis of this hybrid and study of its chromosome behaviour at meiosis would provide useful confirmation that hybridisation is possible), but also that these two species are closely related in spite of their superficially very different appearance.

The genus *Grammitis* contains many species groups each of which contains a number of closely related species, but the relationships between the species groups are sometimes unclear. *Ctenopteris* as presently understood also contains a diversity of species groups, some of which appear to be more closely allied to species groups currently treated in other genera than to other groups within *Ctenopteris*, eg: *C. longiceps* with the group of *G. sumatrana*, *C. heterophylla* (Labill.) Tindale with the group of *G. billardieri* Willd. (Parris, 1977) and *C. curtisii* (Baker) Copel. (syn. *Polypodium decrescens* Christ) with the group of *G. fasciata* Blume (Copeland, 1952) which should probably also include *Xiphopteris conjunctisora* (Baker) Copel. (Parris,

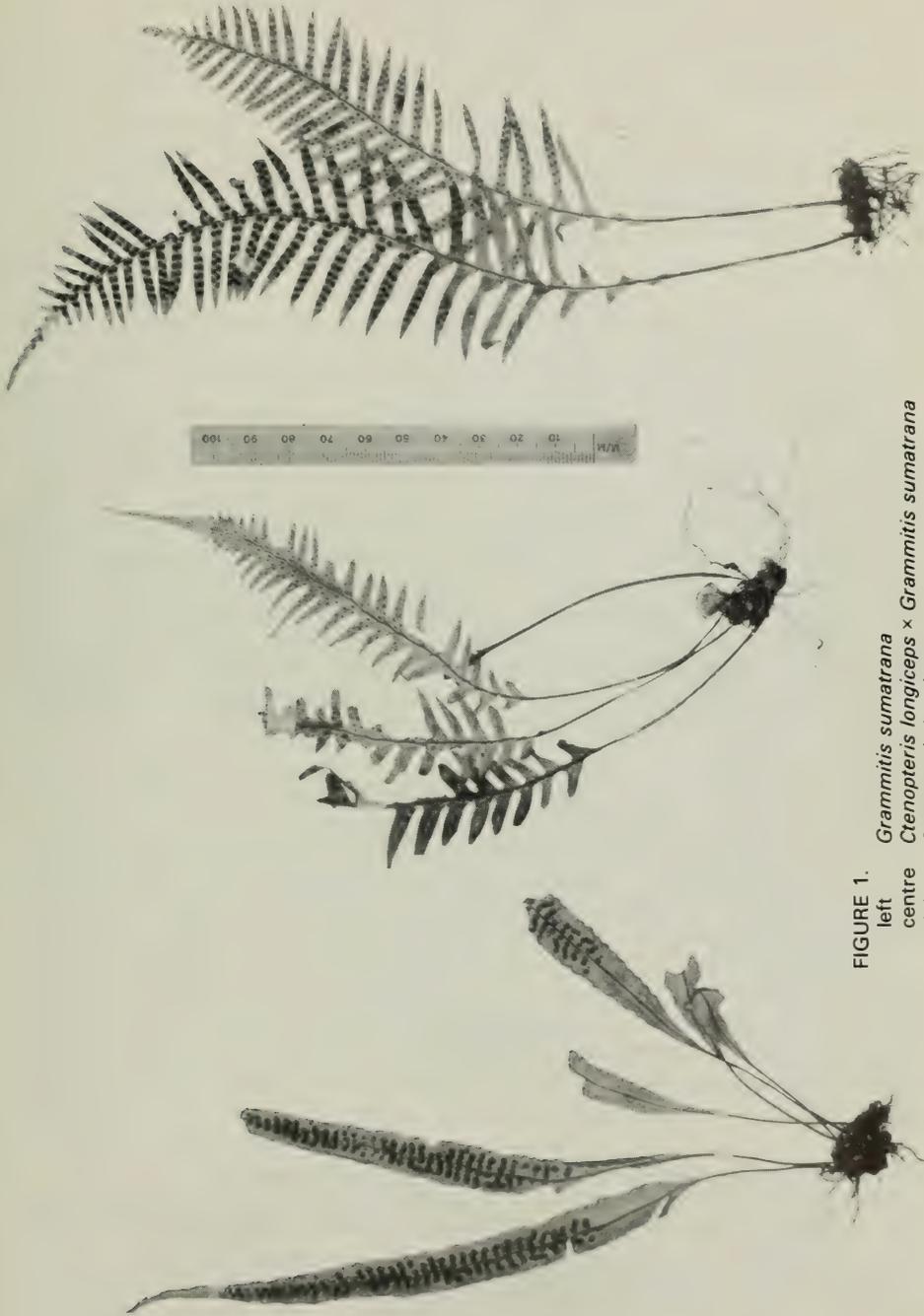


FIGURE 1.
left *Grammitis sumatrana*
centre *Ctenopteris longiceps* × *Grammitis sumatrana*
right *Ctenopteris longiceps*

1983). *C. heterophylla* and *G. billardieri* hybridise, as do *C. curtisii* and *G. fasciata*. *G. sumatrana*, together with the only other member of its species group, *G. torricelliana* (Brause) Parris of the Philippines and New Guinea, has a rather isolated taxonomic position with the genus *Grammitis* because of the lateral veins being several times forked and bearing several rows of sori on each side of the midvein in well-developed fronds. *C. longiceps* appears at first sight to be a typical member of *Ctenopteris* because of its frond dissection, but has no near relatives in that genus; apart from the size of the frond and the depth of the lobes it is nearly identical with *G. sumatrana*.

The smaller geographical and ecological range of *C. longiceps* compared to *G. sumatrana* may indicate that the former has originated from the species group of the latter in Papua New Guinea. Although both grow in primary montane forest there appears to be some ecological separation between them as they very rarely actually grow together (only on stream boulders). Reproductive isolation between the two species may be indicated by the absence of normal spores in the hybrid (although it would be of interest to attempt the germination and growth of both the pale and the dark spores of the hybrid to test whether they are viable in spite of their appearance).

Alternatively *G. sumatrana* may be regarded as a stabilised hybrid between an unknown *Grammitis* species or *G. torricelliana* and *C. longiceps*; the artificial synthesis of a hybrid between these two species would be interesting. There is no evidence at present to indicate which possibility is more likely.

Some of the problems in supra-specific classification within the Grammitidaceae are outlined above. Both the variation and the relationships of many species in the family are poorly known and it is premature to tamper with the existing generic classification until these problems are resolved. It must be borne in mind, however, that *Ctenopteris* as generally understood is an artificial assemblage of Grammitids which have a certain type of frond dissection and lack the distinctive characters of *Adenophorus* and *Prosaptia*; *Grammitis* may also be artificial in part, and *Xiphopteris* is certainly so. I am currently working on a more natural circumscription of the Grammitid genera.

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REFERENCES

- COPELAND, E.B. 1952. *Grammitis*. *Philippine Journal of Science* 80: 214.
 PARRIS, B.S. 1977. A naturally occurring intergeneric hybrid in Grammitidaceae (Filicales): *Ctenopteris heterophylla* × *Grammitis billardieri*. *New Zealand Journal of Botany* 15: 597-599.
 PARRIS, B.S. 1983. A taxonomic revision of the genus *Grammitis* Swartz (Grammitidaceae: Filicales) in New Guinea. *Blumea* 29: 13-222.

HYBRIDIZATION IN *ELAPHOGLOSSUM* IN THE MASCARENE ISLANDS

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ABSTRACT

Five new interspecific hybrids in the fern genus *Elaphoglossum* (Lomariopsidaceae) from the Mascarene Islands of Mauritius and Réunion are described: *E. × adulterinum* D. Lorence, *E. × cadetii* D. Lorence, *E. × heterophlebium* D. Lorence, *E. × revaughanii* D. Lorence and *E. × setaceum* D. Lorence. Habitat preferences and probable parentage of the hybrids is discussed together with the possible role of hybridization in the evolution of the genus.

INTRODUCTION

The importance of the role played by hybridization in the evolution of angiosperms has been well documented (Raven, 1980; Stebbins, 1969, 1977), and hybridization is thought to be particularly significant in the evolution of island floras (Carlquist, 1965, 1974; Gillett, 1972; Raven, 1972). Likewise, hybridization among ferns appears to be a common phenomenon (see Knobloch, 1973 and 1976 for compilations and an extensive bibliography) and the evolution of discrete taxa *via* hybridization, at times involving a reticulate pattern of phylogeny, has been well documented in temperate ferns (Manton, 1950; Wagner, 1954, 1969, 1973; S. Walker, 1961). However, in spite of some excellent work done in the tropics (eg: Manton and Sledge, 1954; Wagner and Wagner, 1975; Wagner, Wagner and Gomez, 1978; T. Walker, 1958, 1973), relatively less attention has been focused on interspecific hybridization in tropical ferns, particularly on islands, with only a single previous report involving hybridization in *Elaphoglossum* (Lomariopsidaceae) (Knobloch, 1976), a large and complex genus of c. 400 species distributed in tropical montane forests of both hemispheres.

METHODS AND CRITERIA EMPLOYED

While undertaking a systematic revision of the species of *Elaphoglossum* occurring in the Mascarene Islands (SW Indian Ocean) for "Flore des Mascareignes" (Lorence, in press), I collected a number of specimens in Mauritius differing morphologically from well known taxa. Similar irregularities were observed in a collection from neighbouring Réunion Island. As pointed out by Wagner (1962), morphological and structural irregularities are usually strong indicators of hybridism in pteridophytes. It is further stated (Wagner and Lim Chen, 1965) that a fern hybrid may be detected by: (1) possession of morphological characters intermediate between two species; (2) deficiencies in the reproductive apparatus, ie: a large percentage of underdeveloped or aborted spores or sporangia resulting from abnormal chromosomal pairing behaviour at meiosis (may also be observed microscopically in meiotic squash preparations); (3) apomixis, which often occurs in the case of sterile triploid hybrids; (4) artificial synthesis of the hybrids by crossing parental gametophytes (see Lovis, 1968 for the experimental procedures involved).

Of the five hybrid combinations described here, which most likely represent F₁ segregates, four display abnormal sporogenesis in addition to being morphologically intermediate. The fifth hybrid, *E. × setaceum*, was not fertile but the fact that it was growing intimately associated with its putative parents, in addition to being morphologically intermediate, leaves little doubt as to its probable parentage. *Elaphoglossum* gametophytes are slow-growing and long-lived (Stokey and Atkinson, 1957), as are the sporophytes which may take several years to achieve fertility and therefore no attempt was made to recreate the hybrids described here. A study of the gametophytes in culture to detect the presence of apomixis was not undertaken for the same reason.

Fern scales provide excellent diagnostic features in groups where most taxa exhibit strikingly constant and distinctive types of palea on their rhizome, stipe and lamina. The scales of *Elaphoglossum* species have long played an important role in their taxonomy and many keys rely to a large extent on scale morphology; scales also appear to be an extremely reliable indicator of hybridism, at least among Mascarene members of the genus.

Venation in the vast majority of *Elaphoglossum* species is dichotomous-pinnate, although inter-vein reticulations occur in a few members (eg: *E. reticulatum* (Kaulf.) Gaud. from the Hawaiian Islands). Among the dichotomous-pinnate members vein endings in most species are free and often thickened near the margin, sometimes into hydathodes. A number of species, however, possess veins which reunite into an intramarginal commissure or series of arcs around the periphery of the lamina. Species displaying this latter character were formerly placed in the genera *Aconiopteris* and *Offersia*. Some Mascarene Island species displaying this feature are *E. macropodium* (Fée) Moore, *E. richardii* (Bory) Christ, *E. sieberi* (Hook & Grev.) Moore and *E. tomentosum* (Bory ex Willd.) Christ. Apart from two species to be discussed later (*E. angulatum* (Bl.) Moore and *E. lanatum* (Bojer ex Baker) D. Lorence), I found venation type to be extremely constant for all species and also a feature useful in detecting hybrids.

Other useful morphological characters employed in this investigation were shape of the lamina and characters of the rhizome, including spacing of the fronds and number of rows in which they are produced. Finally, spore size and percentage of aborted spores were employed as criteria for detecting reproductive irregularities.

DESCRIPTION OF NEW HYBRIDS

Elaphoglossum × *revaughanii** D. Lorence, *hybr. nov.*

(*E. sieberi* (Hook. & Grev.) Moore × *E. lepervanchii* (Fée) Moore).

Hybrida *Elaphoglossum sieberi* similis sed differt: habitatio terrestris (haud numquam epiphytica) in clones densos vegetatos aggregata; frondes steriles c. duplo quam eis *E. sieberi* grandiores apice breviter acuminatae; venis laminis sterilis pro parte liberis, pro parte in arcus intramarginales conjunctis; paleae rhizomatis sparsiores et multo breviores angusto-ovatae ad subulatae, 3.0-6.0 x 0.5-0.8mm, nigrae nitentes opacae; sporae fuscae irregulares, c. 65% abortae. Fig. 1.

Type: Mauritius, Mare Longue Plateau, *Lorence 14.3 sub MAU 15818* (holotype, MAU; isotypes, K, MAU, MEXU, MO, P, REU).

Other specimens examined: Mauritius, Mare Longue Plateau, *Lorence 11.1* (MAU, MEXU, MO), *Lorence 8.6 sub MAU 15531* (K, MAU, MO, P, REU), *Lorence 1176* (MO); Pétrin Nature Reserve, *Lorence 1497* (MAU, MO).

Rhizome short-creeping, dorsiventral, occasionally branching, 5-6mm diam., densely paleaceous at apex, fronds in 2 ranks, 6-15mm distant; rhizome scales narrowly ovate to subulate, 3-6 x 0.5-0.8mm, black, shiny, rigid, apex long acute, base truncate to cordate or auriculate, paler, with short glandular cilia, margins entire or with a few long, glandular cilia, cells small, seriate, rectangular, black and opaque; phyllobase scaly, grayish to yellowish-brown, 15-20mm long x 3.0-3.5mm diam., slightly swollen, abscission distinct. Sterile frond (300-) 440-530mm long; stipe 140-160 (-190) x 2.0-2.6mm, canaliculate, stramineate, scaly when young, scales dark brown to black, ovate to subulate, 0.5-4.0 x 0.2-0.5mm, base cordate to auriculate, fringed by short, glandular cilia, apex sinuate, margins sinuate with scattered glandular cilia, cells dark brown; lamina narrowly elliptic to very narrowly elliptic, (190-)300-350 x (43-) 55-70mm, apex acute to acuminate, base acutely cuneate, decurrent along top 1/4-1/3 of stipe then continuing as dark lines, texture subcoriaceous, margin revolute, rounded, veins visible, slightly raised, forking 1-2 times, making a 75-80° angle with costa, in part free and thickened, in part reuniting into intramarginal arcs, costa canaliculate adaxially, bearing abaxially scattered brown scales 0.5mm diam., with glandular cilia. Fertile frond (300-) 350-420mm long; stipe (150-) 170-220mm long; lamina 150-230x15-26mm, very narrowly elliptic or lorate, apex acute to acuminate, tip rounded, base acutely cuneate, adaxial surface pallid with minute,

*Named in honour of Dr R.E. Vaughan, former curator of the Mauritius Herbarium, who called my attention to the hybrid and whose numerous contributions to the botany of Mauritius include initiation of the "Flore des Mascareignes" project.

scattered scales, veins not visible, texture thin, flexible. Spores: 4-5% very large (75-88 x 50-60µm, excluding perine); 65-67% aborted; 29-30% normal (40-50 x 30-35µm, excluding perine), perine bearing large, ruffled crests 10-15µm high.

Distribution: Mauritius, known only from Mare Longue Plateau (630m elevation, precipitation 3400mm per year) and Pétrin Nature Reserve (660m elevation, precipitation 4000m per year).

Elaphoglossum × *revaughanii* was first collected from a single large and subcircular clone c. 13 x 17m on Mare Longue Plateau growing in the light shade of low, scrubby vegetation over lava with skeletal lateritic soil. The hybrid apparently reproduces vegetatively by rhizome branching, as young plants and sporelings were not observed in the clone or in the vicinity. Wagner (1963) states, "sterile hybrids of most other species of ferns are likewise capable of such vegetative reproduction, usually by rhizome "twinning" and dying off of the older stem parts". The area covered by this clone consists of a fairly dense network of rhizomes and mass of fibrous roots which have formed a thick layer of humus. This massive humus deposit, the clone's large size, and the relatively slow growth rate of the hybrid suggest that it is quite old. Rhizomes of plants in cultivation were observed to elongate at the rate of c. 30mm per year. As the radius of the clone is c. 7.5m, it could conceivably be approximately 250 years old. A second much smaller clone was subsequently discovered growing in open *Philippia* heath vegetation at Pétrin Nature Reserve 2km distant.

E. × *revaughanii* superficially resembles *E. sieberi*, for which it was first mistaken. Closer examination revealed its morphology to be intermediate between *E. sieberi* and *E. lepervanchii*, although the hybrid is more robust than either parent. Both putative parents occur in this same biotope, usually as depauperate individuals growing at the bases of stunted trees and shrubs because it is a marginal, suboptimal habitat for these shade-loving, wet forest epiphytes. *E.* × *revaughanii*, however, behaves like a terrestrial heliophilous or hemisciophilous species and is obviously much more successful than either parent in this particular ecological setting of low scrub vegetation.

The hybrid's most distinctive morphological irregularities are apparent in the venation and scales. *E.* × *revaughanii* has veins which are partly free (as in *E. lepervanchii*) and partly reunited into an intramarginal commissure (as in *E. sieberi*). Scales on the lower portion of the stipe and phyllobase of the hybrid are intermediate between those of both parents.

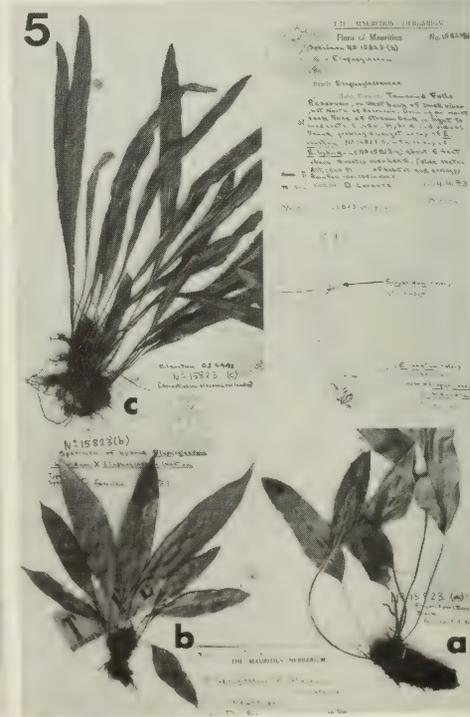
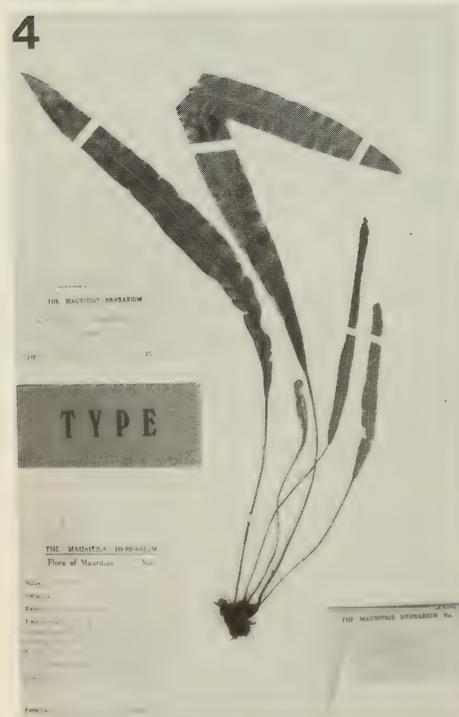
Most spores are completely aborted (65-67%), about a third are relatively normal (c. 30%), and a few are exceptionally large (4-5%). All spores are strikingly dark in colour with highly cristate perines. In addition, the internal sporangial walls are lined with a dark coloured deposit, findings that agree with those reported by Wagner and Lim Chen (1965) for *Dryopteris* hybrids. Furthermore, the number of spores per sporangium in *E.* × *revaughanii* is extremely variable (16, 17, 18, 32 or 48), probably as a result of pairing abnormalities at meiosis. These phenomena are suggestive of observations reported by Morzenti (1962) and Hickok and Klekowski (1973) regarding non-reduction meiosis in fern hybrids. Further research on spore viability and chromosomal behaviour in *E.* × *revaughanii* is obviously desirable.

***Elaphoglossum* × *heterophlebium** D. Lorence, hybr. nov.**

(*E. heterolepis* (Fée) Moore × *E. tomentosum* (Bory ex Willd.) Christ).

Hybrida *Elaphoglossum heterolepe* similis, sed differt: paleae rhizomatis castaneae margine sparse et breviter dentato ad ciliato; paleae stiptis magis pallido-brunneae marginibus

*The specific epithet refers to the hybrid's mixed venation, as the veins from the middle portion of the lamina unite into an intramarginal commissure (as in *E. tomentosum*) while those at the extremities of the lamina are free with thickened tips (as in *E. heterolepis*). All examples of *E.* × *heterophlebium* that I encountered were robust.



3



FIGURE 1. Holotype collection of *Elaphoglossum* × *revaughanii* from Mare Longue Plateau, Mauritius, *Lorence* 14.3 sub MAU 15818 (MAU).

FIGURE 2. Holotype collection of *Elaphoglossum* × *heterophlebium* from Pétrin Nature Reserve, Mauritius, *Lorence* 14.2 sub MAU 15821 (MAU).

FIGURE 3. Holotype collection of *Elaphoglossum* × *cadetii* from Plaine des Sables, Réunion, *Cadet* 2063 (REU).

FIGURE 4. Holotype collection of *Elaphoglossum* × *adulterinum* from Cascade 500 Pieds (Cascade Alexandra), Mauritius, *Lorence* 874 sub MAU 16309 (MAU).

FIGURE 5. Holotype collection of *Elaphoglossum* × *setaceum* and its putative parents, all from Tamarind Falls Reservoir, Mauritius: a) *E. hybridum* var. *hybridum*, *Lorence* sub MAU 15823a (MAU); b) *E. setaceum*, *Lorence* sub MAU 15823b (MAU); c) *E. lanatum*, *Lorence* sub MAU 15823c (MAU).

scarioso-fimbriatis et centris castaneis; lamina sterilis apice acuta ad vix acuminata, superficiebus ambabus indumento homoganeo squamarum uniformium bubalinarum peltatarum orbicularium ad ovatarum praeditis; venae laminae sterilis apicibus incrassatis pro parte liberis ornatae, pro parte in arcus intramarginales conjunctae; sporae 52-85% abortae. Fig. 2.

Type: Mauritius, Pétrin Nature Reserve, *Lorence* 14.2 sub MAU 15821 (holotype, MAU).

Other specimens examined: Mauritius, Brise Fer Road, *Lorence* 16.2 sub MAU 15819 (MAU); Plaine Champagne, *Lorence* sub MAU 15099 (MAU), *Lorence* 996 sub MAU 16518 (MAU), *Lorence* 1544 (MAU, MO).

Rhizome short-creeping, 5mm diam, occasionally branching, densely paleaceous, fronds caespitose, 2-ranked; rhizome scales thick, opaque, castaneous, narrowly ovate to subulate, 5-7 x 0.5-0.7mm, slightly falcate, apex acute, setaceous, base cordate, margins thin, bearing short sparse acicular teeth or rare glandular cilia; phyllobase dull brown, 10-20mm long, unthickened, abscission irregular. Sterile frond 330-450mm long; stipe 80-130 x 1.5-2.0mm, stramineate, flattened adaxially, densely scaly when young; stipe scales narrowly ovate, 2-5 x 0.8-1.5mm, falcate, centres dark, castaneous, opaque, margins pale brown, scarios, fimbriate to ciliate-dentate, with acicular or glandular-tipped teeth, base peltate and obtuse, or basifixed and cordate to auriculate; lamina very narrowly elliptic to lanceolate, 225-320 x 26-34mm, base acutely cuneate, apex acute to slightly acuminate, costa raised and slightly caniculate adaxially, margin rounded, slightly revolute, texture chartaceous, veins making a 70-75° angle with costa, in part free with thickened tips, in part reuniting into intramarginal arcs; both laminar surfaces bearing a homogeneous covering of thin, appressed and matted scales, soon caducous; laminar scales buff coloured, hyaline, peltate, orbicular to ovate, 0.5-1.0 x 0.5mm, base and margins prolonged into numerous arachnoid cilia 0.1-0.3mm long with acicular or inflated tips, cells thin walled. Fertile fronds 325-360mm long; stipe 165-195 x 1.2mm; lamina linear,

160-165 x 10-15mm, adaxial laminar surface and abaxial surface of costa covered by a thin layer of scales. Normal spores 35-38 x 25-27 μ m (excluding perine), perine cristate, crests 2-3 μ m high, minutely spinulose. In *Lorence* 14.2 52% of the spores were aborted, whereas 85% of the spores were aborted in *Lorence sub MAU 15099*.

Distribution: endemic to Mauritius.

All four gatherings of *Elaphoglossum* \times *heterophlebium* were made on the central plateau of Mauritius (elevation 600-700m, precipitation 2400-4200mm annually) in the following evergreen formations: *Philippia* heath formation at Pétrin; open, stunted scrub over laterite at Plaine Champagne; open lower montane wet forest of *Sideroxylon puberulum* A. DC. at Pétrin; mature lower montane wet forest at Brise Fer in a light gap. In all cases the hybrids were growing in fairly close proximity to or in association with the parental species.

Although both *E. heterolepis* and *E. tomentosum* are generally epiphytic or only casually terrestrial and prefer moderate to dense shade, *E. \times heterophlebium* almost always occurs terrestrially and prefers light shade or partial exposure to sunlight. As was the case for the previous hybrid, *E. \times heterophlebium* is able to occupy a niche that the parental species are unable to exploit.

Segregates of *E. \times heterophlebium* are remarkably uniform morphologically and very nearly intermediate between both parents, although tending to resemble *E. heterolepis* somewhat more than *E. tomentosum*.

***Elaphoglossum* \times *cadetii** D. Lorence, hybr. nov.**

(*E. acrostichoides* (Hook. & Grev.) Schelpe \times *E. coursii* Tard).

Hybrida *Elaphoglossum coursii* similis sed differt: paleae rhizomatis duplo longiores sed tenuiores, 2-4 x 0.5-1.0mm, marginibus subintegris vel sparsim ciliatis; frondes steriles breviores, 60-140mm longae, apice obtuse-acuminatae; sporae c. 90% abortae. Fig. 3. Type: Réunion, Plaine des Sables, *Cadet* 2063 (holotype, REU; isotype, P).

Rhizome short-creeping, 2-3mm diam., densely paleaceous; rhizome scales shiny black, discolorous, ovate, 2-4 x 0.5-1.0mm, apex black, opaque, acute to acuminate, base pale brown, cordate to auriculate, margins bearing rare, glandular cilia, fronds in two dorsal ranks, 2-4mm distant; phyllobase 5.0-7.5mm long, swollen, dark brown to black, colour change and abscission distinct, bearing at base scales similar to those on rhizome. Sterile frond (60-)80-140mm long; stipe (22-)36-65 x 0.5-1.0mm, stramineate, adaxially canaliculate, bearing scattered dark brown, discolorous, sparsely ciliate, ovate scales 2-3 x 0.5-1.0mm; lamina narrowly elliptic, 40-100 x 7-15mm, apex acute with rounded tip, base acutely cuneate, decurrent as low ridges along top half of stipe, margin thin, cartilaginous, revolute, costa slightly canaliculate adaxially, veins immersed, indistinct, forking once, making a 50-60° angle with costa, tips free and thickened, texture coriaceous, lamina glabrous adaxially, abaxially bearing scattered, minute, brown, substellate scales 0.5mm diam., with a few larger scales along abaxial surface of costa. Fertile frond 140-185mm long; stipe 75-140mm long, about three times longer than sterile stipe; lamina narrowly elliptic, 60-85 x 9-10mm, glabrous adaxially, apex obtuse, base acutely cuneate, sides slightly decurrent, costa stramineate, veins indistinct, texture thin, flexible.

Distribution: known from Réunion Island (La Réunion). A collection from Mt Ankarotra, Madagascar (*Humbert & Cours* 17521, P) may possibly represent this hybrid, as both parents also occur in Madagascar.

The type of *Elaphoglossum* \times *cadetii* is from Plaine des Sables on the Piton de la Fournaise massif, Réunion's active volcano, where it was found growing in lava fissures. The hybrid is morphologically intermediate between *E. acrostichoides* and *E. coursii* which both occur in the wet and cloud forest zones of Réunion. Although *Cadet* makes no mention of associated species of *Elaphoglossum* on the type specimen, *E. acrostichoides* occurs in the Piton de la Fournaise region (D. Lorence, pers. obs.). The Plaine des Sables (elevation 2300m, precipitation c. 3500mm per year) supports

*Named in honour of its collector, Dr T. Cadet who has contributed eminently to the study of the flora of Réunion and that of the Mascarene Islands in general.

scattered patches of high altitude heath vegetation and herbaceous plants over porous rocky and sandy substrates. No forest occurs in the area and the few epiphytes able to grow here are restricted to sheltered rock crevices. This appears to be yet another case where the hybrid is able to occupy a habitat unfavourable to either parent.

Scale morphology of *E. × cadetii* is intermediate between that of *E. acrostichooides* and *E. coursii*. Venation is free in all three taxa. The hybrid's somewhat irregular frond morphology and the extremely high percentage of aborted spores (about 90%) leave little doubt as to its probable hybrid origin.

Hybridization in *Elaphoglossum lanatum*

Elaphoglossum lanatum is unique in being the only Mascarene representative of the genus to grow exclusively on vertical faces of cliffs and stream banks composed of decaying lava, a fact noted by Bojer on the type collection at Kew ("ad rivulorum ripas"). Certain morphological features of this species are extremely variable, notably frond size and shape, the degree to which the veins are free or reunite into an intramarginal commissure, and percentage of aborted spores (Lorence, 1976). For example, some individuals possess linear laminae 250-300mm long with acute to acuminate apices, while others have narrowly obovate, obtuse laminae only 65mm long in fertile plants. Certain other species of *Elaphoglossum* are quite polymorphic and the range of variation encountered in laminar size and shape for *E. lanatum* certainly lies within the range of normal phenotypic variability.

As previously mentioned, venation type is almost invariably constant in most taxa, being either free or united at the margin. However, in *E. lanatum* intermediates and extremes of both conditions may occur, even on the same individual. A similar situation was found in plants of *E. angulatum* from Réunion. In addition, both species produce a significant percentage of aborted spores, (4-40% in *E. angulatum* and 15-32% in *E. lanatum*), much higher than the 5-10% observed for most other species. These morphological and reproductive irregularities suggest that *E. angulatum* and *E. lanatum* may be of hybrid origin.

Although of possible hybrid origin, *E. lanatum* is certainly a viable species that exploits a niche which the other members of the genus in Mauritius are unable to. In addition, it is able to reproduce sexually and appears to hybridize with two other species of the genus forming two hybrid combinations described below.

Elaphoglossum × adulterinum D. Lorence, *hybr. nov.*

(*E. lanatum* (Bojer ex Baker) D. Lorence × *E. tomentosum* (Bory ex Willd.) Christ).

Hybrida *Elaphoglossum tomentosum* similis sed differt: rhizoma resiniferum; paleae rhizomatis in margine glanduloso-dentatae; stipites c. duplo longioribus; paleae laminae sterils peltatae vel basifixae, margo ciliis longis arachnoideis implicatis ferens; venae laminarum sterilium pro parte liberae ad apicem incrassatae sed pro parte majore in arcus intramarginales conjunctae; sporae c. 82% abortae. Fig. 4.

Type: Mauritius, Valley of Cascade 500 Pieds (Cascade, Alexandra), Lorence 874 sub MAU 16309 (holotype, MAU).

Other specimens examined: Mauritius, Valley of Cascade 500 Pieds (Cascade Alexandra), Lorence sub MAU 16307 (MAU, MO), Lorence 1609 (MO), Lorence 1610 (MO).

Rhizome prostrate, short-creeping, rarely branching, resiniferous, 2-3mm diam., densely paleaceous apically, fronds in two ranks, 3-5mm distant; rhizome scales opaque, castaneous, rigid, narrowly ovate to subulate, 4-6 x 0.4-0.6mm, apex filiform, sinuate, base cordate to auriculate, entire or bearing clear, globose marginal glands, margin sparsely glandular dentate-ciliate; phyllobase dark brown, 6-8mm long, thickened, colour change abrupt, abscission distinct, bearing basally scales like those of rhizome. Sterile frond (270-)350-485mm long; stipe (80-)100-150 x 1.0-1.5mm, stramineate, canaliculate adaxially, bearing scattered, appressed, brown, caducous, ovate scales 1-2 x 0.5mm, margins scarios, glandular-ciliate, these intermixed with smaller, matted scales; sterile lamina (190-)250-320 x (14-)18-25mm, very narrowly elliptic to linear, base acutely cuneate to decurrent, apex acute to acuminate, both surfaces of lamina covered with a homogenous layer of thin, matted ± appressed, pale brown to buff coloured scales; laminar

scales orbicular to ovate, 1.0-1.5 x 1.0mm, peltate or basifixed, base rounded to cordate or sagittate, base and margins bearing long, spreading arachnoid cilia, pedicel and centre darker brown, subtended by cluster of globose glands, cells hyaline, thin-walled, scales caducous adaxially, costa stramineate, rounded abaxially, canaliculate adaxially, veins visible, slightly raised, making a 60-65° angle with costa, simple or forking once, in part free with thickened tips, in part reuniting intramarginally, texture subcoriaceous. Fertile frond 200-250mm long; stipe 100-115x1.0mm; lamina linear, 110-140x7-10mm, base acutely cuneate, apex acute, adaxial surface with a dense layer of matted scales as in sterile frond, margin revolute, texture thin, flexible. Spores 82% aborted; normal spores 35-38 x 25-27µm (excluding perine), perine cristate, crests low, 1.5-3.0µm high, sinuate to finely erose-dentate.

Distribution: endemic to Mauritius.

Elaphoglossum × *adulterinum* is known only from the type locality at Cascade Alexandra in the Valley of Cascade 500 Pieds located at the southern extremity of the central plateau, altitude ca. 600m, precipitation 4800mm per year. Habitats of both *E. lanatum*, which grows on cliff faces, and *E. tomentosum*, epiphytic or epipetric, are adjacent along the margins of this particular valley, thus providing a unique opportunity for hybridization between the species.

Lorence 874 was found growing on a mossy boulder with *E. tomentosum* at the base of a cliff supporting large populations of *E. lanatum*; the other collections of *E.* × *adulterinum* were also growing in the vicinity. The hybrid resembles *E. tomentosum* in habitat preference (epiphytic or epipetric), in its erect fronds (pendulous in *E. lanatum*) and in the shape of the lamina. Laminal scales of *E.* × *adulterinum* are intermediate between the parental types. Rhizome scales, however, are glandular and resiniferous as in *E. lanatum*. Venation is also intermediate between that of the parents, being in part free, and in part united at the margin as in *E. tomentosum*. Both conditions occur in *E. lanatum*, as previously noted. The high percentage of aborted spores (c. 82%) is also suggestive of hybridity.

***Elaphoglossum* + *setaceum* D. Lorence, hybr. nov.**

(*E. hybridum* (Bory) Brack. × *E. lanatum* (Bojer ex Baker) D. Lorence).

Hybrida *Elaphoglossum hybridum* var. *hybrido* similis, sed differt: rhizoma gracile 3mm diametro; paleae rhizomatis breviter dentatae dentibus glandulosis; laminae frondium sterilium paleis minoribus pallidioribus in superficiebus ambabus laminae dispersis; paleae laminae margine solum basi involuto, basi paribus aliquot ciliorum elongatorum glandulosorum praedita; marginibus ciliis aut dentibus acicularibus ascendentibus brevibus praeditis. Fig. 5.

Type: Mauritius, Tamarind Falls Reservoir, *Lorence sub MAU 15823b* (Holotype, MAU). Rhizome dorsiventral, short-creeping, 3mm diam., densely paleaceous, fronds caespitose, in 3 ranks, 2mm distant; rhizome scales light castaneous, subulate to narrowly ovate, 3-4 x 0.5mm, base cordate, the apex filiform, margins bearing short teeth each terminated by a globose gland, cells rectangular-fusiform; phyllobase 2-4mm long, dark brown, scaly abscission distinct. Sterile frond 80-140mm long; stipe 30-35 x 0.5-0.7mm, yellowish-brown, adaxially grooved, bearing numerous simple capitate hairs and scales; stipe scales brown, squarrose, bristle-like, subulate 1.5-2.5 x 0.2mm, apex filiform, base cochleariform with involute margins bearing several long cilia and short glandular teeth or cilia, cells fusiform; lamina narrowly elliptic to narrowly ovate, (50-)90-105 x (10-)15-20mm, apex acuminate, base acutely cuneate, decurrent as low ridges along stipe, costa pale yellow-brown, raised on both surfaces, veins slightly raised and visible, forking once, tips free and thickened, margin slightly revolute, rounded, ciliate with fringe of pale brown bristle-like scales; marginal scales 2-3 x 0.2-0.3mm, apex filiform, base cochleariform, margins involute basally and bearing several long, spreading glandular-tipped cilia and sparse acicular teeth; both surfaces of lamina villous with bristle-like scales intermixed with smaller flat, deltoid scales, each with a single pair of long, spreading basal cilia and scattered simple hairs.

Distribution: endemic to Mauritius.

A single sterile individual of *Elaphoglossum* × *setaceum* was found growing in a population of *E. lanatum* on a shady stream bank in secondary forest at Tamarind Falls Reservoir (altitude c. 500m, precipitation 2600mm) at the western edge of the central plateau of Mauritius. A vigorous fertile clone of *E. hybridum* var. *hybridum* was growing at the base of the tree directly overhead but no other members of the genus occurred in the vicinity.

E. × *setaceum* possesses morphological characters which are almost exactly intermediate between those of the putative parents (Fig. 5), notably shape of the lamina and scale architecture. Furthermore, its rhizome bears three ranks of fronds, whereas *E. lanatum* is a two-ranked species and *E. hybridum* var. *hybridum* has three to four ranks. Unfortunately, the only specimen is sterile, thus precluding an examination of the spores. The hybrid's association with its congeners and its intermediate appearance, however, leave little doubt as to its putative parentage.

DISCUSSION AND CONCLUSIONS

Elaphoglossum is a large and taxonomically complex pan-tropical genus of over 400 species with its greatest concentration in the mountains of Central and South America. Seventeen species are reported from the Mascarenes (nine in Mauritius, 14 in Réunion), of which seven are endemic to the islands (three in Mauritius, two in Réunion, two shared) (Lorence, in press). The genus is in an active state of evolution in the Mascarenes and hybridization appears to play a significant role in speciation of the members.

Although up to four or five *Elaphoglossum* species may occur sympatrically in the montane wet and cloud forests of Mauritius and Réunion, hybrids are virtually absent here. This may be due to the fact that hybridization in stable habitats is adaptively disadvantageous (Lewontin and Birch, 1966). Indeed, all five Mascarene *Elaphoglossum* hybrids occur in either of two situations: (1) at the abrupt interface of two distinct habitats, thus bringing together species with differing ecological requirements and greatly enhancing their chances for hybridization, (eg: *E.* × *adulterinum*, *E.* × *setaceum*); (2) in habitats generally unfavourable to either parent (eg: *E.* × *cadetii*, *E.* × *heterophlebium*, *E.* × *revaughanii*).

In the first instance hybrids must occupy a habitat not differing from that of one of the parental species. Intermediate hybrids would be adaptively disadvantageous here and the hybrid would be expected to persist only if its ecological requirements matched those of either parent. This appears to be the case for *E.* × *adulterinum* and *E.* × *setaceum*, each of which grows together with one parent.

The remaining three hybrids occupy habitats apparently not greatly utilized by either parent. *E.* × *revaughanii* has been able to thrive in a habitat where both parents are uncommon and only marginally successful. Similarly, *E.* × *heterophlebium* was collected four times in more highly exposed and isolated habitats than those in which the parental species occur. This likewise appears to be the case for *E.* × *cadetii*, although more information is required regarding distribution of its putative parents.

Finally, hybrid origin can be suspected for successful and widespread but often ecologically specialized species such as *E. lanatum* and *E. angulatum* which display certain morphological and reproductive irregularities.

In conclusion, the findings presented here suggest that hybridization in the large genus *Elaphoglossum* may provide an evolutionary stimulus capable of generating novel genetic combinations enabling certain hybrid segregates to survive better in habitats unfavourable to either parent. A successful hybrid could thus maintain itself either by vegetative propagation or by apogamy.

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REFERENCES

- CARLQUIST, S. 1965. *Island life*. Natural History Press, New York.
- CARLQUIST, S. 1974. *Island biology*. Columbia University Press, New York.
- GILLETT, G.W. 1972. The role of hybridization in the evolution of the Hawaiian flora. In, D.H. Valentine (ed.), *Taxonomy, Phytogeography, and Evolution*, 205-219. Academic Press Inc., London.
- HICKOK, L.G. and KLEKOWSKI, E.J., JR., 1973. Abnormal reductional and nonreductional meiosis in *Ceratopteris*: alternatives to homozygosity and hybrid sterility in homosporous ferns. *Amer. J. Bot.* 60: 1010-1022.
- KNOBLOCH, I.W. 1973. The present status of hybridity among the pteridophytes. *Taiwania* 18(1): 29-34.
- KNOBLOCH, I.W. 1976. Pteridophyte hybrids. *Publ. Mus. Michigan State Univ., Biol. Ser.* 5(4): 277-352.
- LEWONTIN, R.C. and BIRCH, L.C. 1966. Hybridization as source of variation for adaptations to new environments. *Evolution* 20: 315-336.
- LORENCE, D. 1976. Notes on some Mascarene species of *Elaphoglossum* (Lomariopsidoideae sensu Holttum). *Fern Gaz.* 11: 199-205.
- LORENCE, D. Lomariopsidacées. In, J. Bosser et al. (eds), *Flore des Mascareignes*. L. Carl Achille, Imprimeur du Gouvernement, Port Louis, Ile Maurice (in press).
- LOVIS, J.D. 1968. Fern hybridising at the University of Leeds. *Brit. Fern Gaz.* 10: 13-20.
- MANTON, I. 1950. *Problems of cytology and evolution in the Pteridophyta*. Cambridge University Press.
- MANTON, I. and SLEDGE, W.A. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. *Philos. Trans. Ser. B.* 238: 127-185.
- MORZENTI, V.M. 1962. A first report on pseudomeiotic sporogenesis, a type of spore reproduction by which "sterile" ferns produce gametophytes. *Amer. Fern J.* 52: 69-78.
- RAVEN, P.H. 1972. Evolution and endemism in the New Zealand species of *Epilobium*. In, D.H. Valentine (ed), *Taxonomy, Phytogeography, and Evolution*, 259-274. Academic Press Inc., London.
- RAVEN, P. 1980. Hybridization and the nature of species in higher plants. *Canadian Botanical Association Bulletin, Suppl. vol. 13, 1*: 3-10.
- STEBBINS, G.L. 1969. The significance of hybridization for plant taxonomy and evolution. *Taxon* 18: 26-35.
- STEBBINS, G.L. 1977. *Processes of Organic Evolution*. Prentice Hall, Englewood Cliffs, New Jersey.
- STOKEY, A.G. and ATKINSON, L.R. 1957. The gametophyte of some American species of *Elaphoglossum* and *Rhipidopteris*. *Phytomorphology* 7: 275-292.
- WAGNER, W.H., JR. 1954. Reticulate evolution in the Appalachian *Aspleniums*. *Evolution* 8: 103-118.
- WAGNER, W.H., JR. 1962. Irregular morphological development in hybrid ferns. *Phytomorphology* 12: 87-100.
- WAGNER, W.H., JR. 1963. Biosystematics and taxonomic categories in lower vascular plants. *Regnum Veg.* 27: 63-71.
- WAGNER, W.H., JR. 1969. The role and taxonomic treatment of hybrids. *BioScience* 19: 785-789.
- WAGNER, W.H., JR. 1973. Reticulation of Holly ferns (*Polystichum*) in the western United States and adjacent Canada. *Amer. Fern J.* 63: 99-115.
- WAGNER, W.H., JR., and LIM CHEN, K. 1965. Abortion of spores and sporangia as a tool in the detection of *Dryopteris* hybrids. *Amer. Fern J.* 55: 9-29.
- WAGNER, W.H., JR., and WAGNER, F.S. 1975. A hybrid polypody from the New World tropics. *Brit. Fern Gaz.* 11: 125-135.
- WAGNER, W.H., JR., WAGNER, F.S. and GÓMEZ, P., L.D. 1978. The singular origin of a Central American fern, *Pleuroderris michleriana*. *Biotropica* 10(4): 254-264.
- WALKER, S. 1961. Cytotaxonomic studies in the *Dryopteris spinulosa* complex. II. *Amer. J. Bot.* 48: 607-614.
- WALKER, T.G. 1958. Hybridization in some species of *Pteris* L. *Evolution* 12: 82-92.
- WALKER, T.G. 1973. Additional cytotaxonomic notes on the pteridophyta of Jamaica. *Trans. Roy. Soc. Edinburgh* 69: 109-135.

STOMATA IN *PSILOTUM* AND *TMESIPTERIS*

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ABSTRACT

Stomata in some species of *Psilotum* and *Tmesipteris* show a characteristic incrustation of an unknown nature. Unlike the situation in other plants the incrustation is confined to the guard cells, the other epidermal cells being naked. However, whilst the common possession of such features may be an additional argument for a close relationship between *Psilotum* and *Tmesipteris*, the total absence of incrustation in *Psilotum complanatum* is a warning that absence may be of only limited value as evidence of lack of affinity.

INTRODUCTION

During the course of a comparative investigation of triploid and tetraploid specimens of *Psilotum nudum* (L.) Beauv. measurements were made of stomatal length (Walker, in press). In some cases the limits of the guard cells were not very clearly defined and it was also evident that the stomata were not lying in exactly in same focal plane as the general surface of the epidermis. In order to clarify the position the epidermis was examined in the SEM. These initial scans lead to a broadening of the investigation to include other members of the Psilotales and the results are presented below.

MATERIALS AND METHODS

The wild origins of the plants used are set out in Tab. 1. The samples of material of *Psilotum nudum* were taken from living plants which had been in cultivation at Newcastle for almost two decades, whilst samples of *P. complanatum* Sw. and *Tmesipteris lanceolata* Dang. agg. were from herbarium specimens.

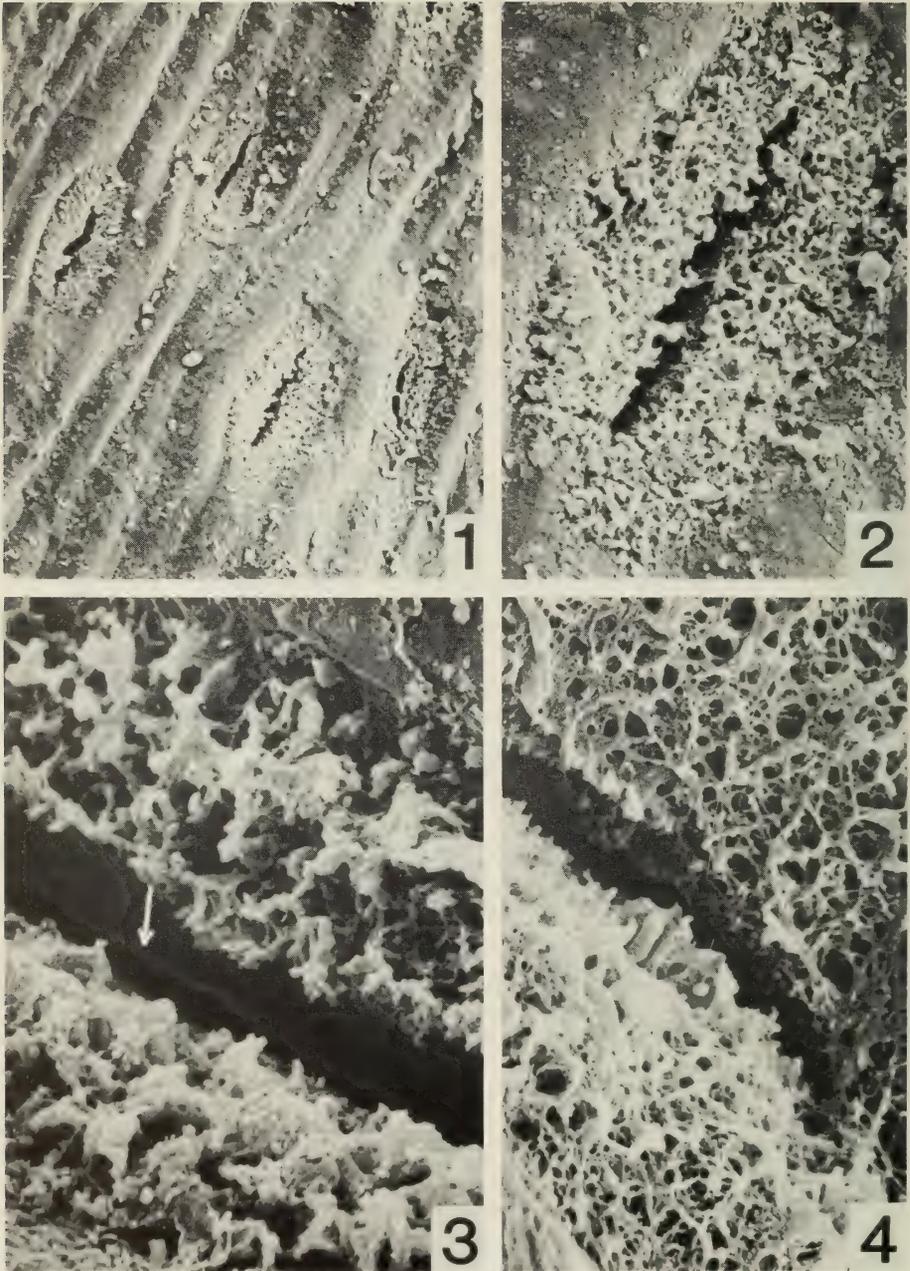
The herbarium material was rehydrated by immersion in hot water containing some detergent and then treated as for the living samples. This involved fixation for 3 hours in 0.1 cacodylate at pH 7 and room temperature, followed by dehydration in an ascending acetone series and critically point dried using a Tousimis Samdri 780 critical point drier with liquid carbon dioxide. The specimens were then sputter-coated with gold.

OBSERVATIONS

Both triploid and tetraploid forms of *Psilotum nudum* from Papua New Guinea and Mauritius respectively had deeply sunken stomata on their aerial shoots. These stomata were heavily incrustated by a network of material which totally obscured the guard cells, leaving only the opening free (Figs. 1-4). A noteworthy fact is that the incrustation is confined to the stomata and does not occur elsewhere on the epidermis (Fig. 1). Whilst cuticular secretion of waxes is a common phenomenon in plants (see, for example, Martin & Juniper, 1970; Juniper & Jeffree, 1983; Brandham & Cutler, 1978) resulting in deposits of various morphology, as far as the author is aware all such deposits occur over both epidermal and stomatal cells. The present observations are still at a preliminary stage and an analysis of the nature of the incrustation has not yet been attempted. However, immersion of the material for several hours in xylene and in chloroform has no effect and presumably it is not composed of the more soluble waxes.

It will be seen that the incrustation is relatively thick, the edge of the guard cell being arrowed in Fig. 3. Although accurate measurements have not been possible because of the angle of the specimen the indications are that the thickness is of the order of 8µm.

The investigation was extended to include the stomata of the other very different-looking member of the Psilotales, *Tmesipteris*.



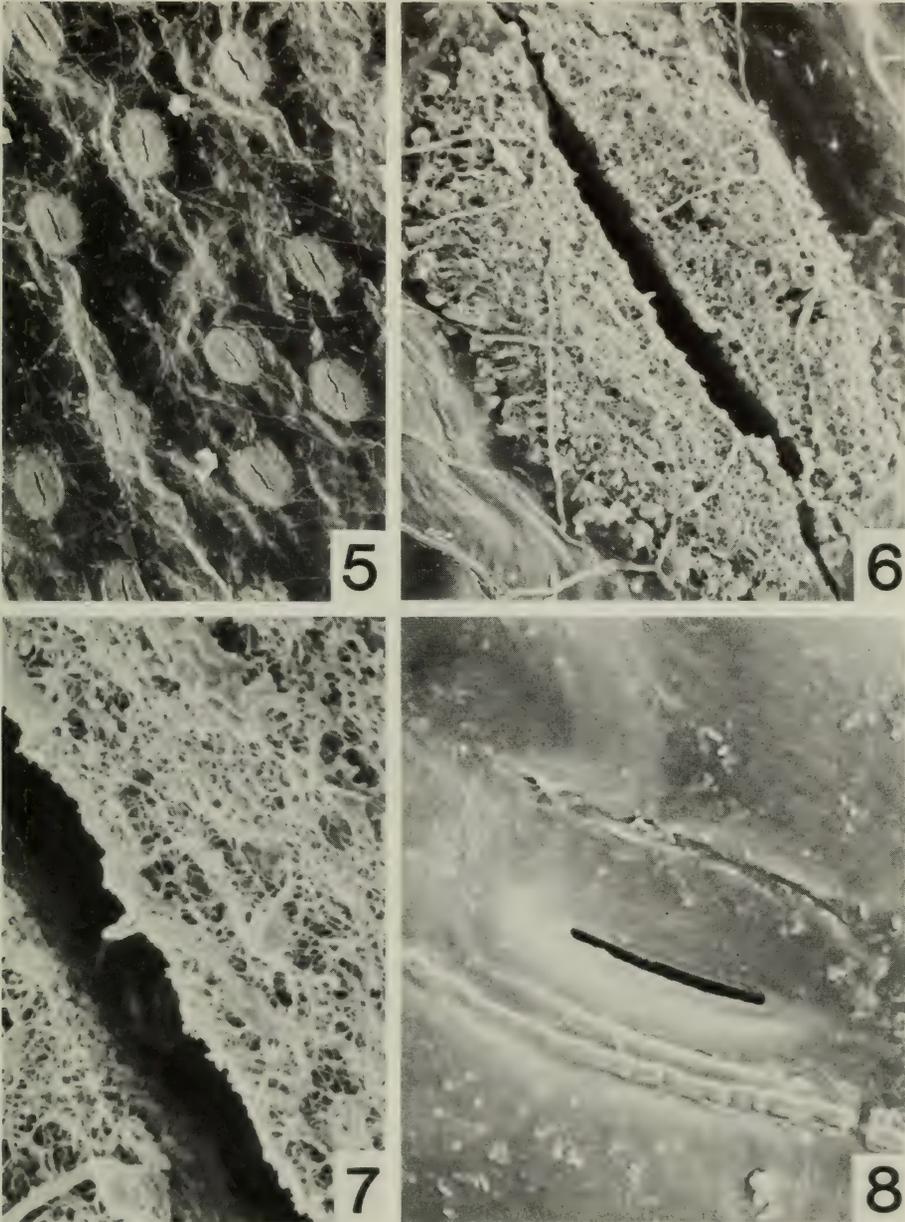
FIGURES 1-3. *Psilotum nudum* C2142 (4x) aerial shoot.

1. Epidermis & stomata, x 300;

2. Stoma, x 1000;

3. Part of stoma, edge of guard cell arrowed, x 2000.

FIGURE 4. *P. nudum*, T8897 (3x) aerial shoot; part of stomatal incrustations, x 4000.



FIGURES 5-7. *Tmesipteris lanceolata*, T12399, leaf surface.
5. Epidermis & stomata, x 300;
6. Stoma, x 1000;
7. Part of stoma, x 3000.
FIGURE 8. *Psilotum complanatum*, T9545, Stoma, x 1000.

TABLE 1. Sources of material of *Psilotum* and *Tmesipteris*.

	Collector's Number	Origin
<i>P. nudum</i> (L.) Beauv.		
a) triploid	Walker T8897	Papua New Guinea. Near Moro, Finisterre Mts, c. 1700m, terrestrial 1964.
b) tetraploid	Page 2142	Mauritius. Macabé Forest, c. 580m, epiphytic, 1968.
<i>P. complanatum</i> Sw.	Walker T9545	Papua New Guinea. Wagau, c. 1130m, epiphytic, 1964.
<i>imesipteris lanceolata</i> Dang. agg.	Walker T12399	Sulawesi, on ridge above N. bank of River Pasui, Latimodjong Mts, c. 1750m, on trunk of tree fern, 1969.

Rehydrated herbarium material of a leafy appendage of *T. lanceolata* agg. gave satisfactory results (Figs. 5-7), although it was contaminated by a sparse network of fungal hyphae. In this instance the stomata do not appear to be as deeply sunken as in *Psilotum nudum* but they also have the incrustation which is likewise absent from other epidermal cells. Some idea of the fineness of the constituent fibrils of the incrustation may be gained by comparing the diameter of the fibrils with that of the contaminating fungal hyphae (Fig. 6 and bottom left hand corner of Fig. 7). It will also be seen that the fine structure of the *Tmesipteris* incrustation is virtually identical with that found in triploid *Psilotum* (compare Figs. 4 & 7) and argues for it being of the same or very similar nature in both cases.

Psilotum consists of only a few species, many authors recognizing only two, *P. nudum* and *P. complanatum*. *P. complanatum* contrasts with the former species in being an epiphyte with long pendulous, flat, ribbon-like shoots instead of the erect rounded or angular ones of *P. nudum*. A piece of herbarium specimen of *P. complanatum* was rehydrated and on examination showed very deeply sunken stomata as in *P. nudum* but contrasted strongly from other members of the Order in completely lacking any incrustation (Fig. 8).

DISCUSSION

The presence of incrustations on the stomata of pteridophytes appears to be a rare phenomenon, particularly when associated with a lack of similar material on the epidermis. The only other notable example of stomatal ornamentation occurs in *Equisetum* (Page, 1972) but here the structure and constitution are quite different, being siliceous in nature and in the form of very precisely delimited protrusions or small papillae instead of a reticulum. The presence in common of such unusual incrustations in both *Psilotum* and *Tmesipteris* helps to strengthen the evidence for the association of the two genera in the same Order. However, the lack of such a phenomenon in *P. complanatum* indicates that presence of incrustations is more important than absence as positive evidence of relationships.

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REFERENCES

- BRANDHAM, P.E. and CUTLER, D.F., 1978. The influence of chromosome variation on the organisation of the leaf epidermis in a hybrid *Alöe* (Liliaceae). *Bot. J. Linn. Soc. Lond.* 77: 1-16.
- JUNIPER, B.E. and JEFFREE, C.E., 1983. *Plant surfaces*. Edward Arnold, London.
- MARTIN, J.T. and JUNIPER, B.E., 1970. *The cuticles of plants*. Edward Arnold, London.
- PAGE, C.N. 1972. An assessment of inter-specific relationships in *Equisetum* subgenus *Equisetum*. *New Phytol.* 71: 355-369.
- WALKER, T.G. Cytological observations on *Psilotum*. *Indian Fern J.* (in press).

CYTOMORPHOLOGICAL STUDIES OF PROGENY OF *ADIANTUM PERUVIANUM*

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ABSTRACT

Adiantum peruvianum Klotz. ($2n = 60$), a plant of horticultural importance in India, has a gigas habit, irregular meiosis and is propagated vegetatively. Germination of spores is low, and selfed prothalli give rise to sporophytes that do not resemble the parent in morphology. The progeny show variation in form and in chromosome number, from $2n = 56$ to $2n = 62$; some plants show regular meiosis whereas others have mostly bivalents but a few univalents at metaphase 1. The probability that *A. peruvianum* is of hybrid origin, and derived from *A. capillus-veneris* L. is discussed.

INTRODUCTION

Adiantum peruvianum Klotz. exhibits a conspicuous gigas habit of fronds as compared with other species of the genus *Adiantum*. It is one of the most popular ferns in Indian gardens, and is maintained by vegetative propagation of the rhizome. Meiotic investigations of the taxon have established its diploid nature ($2n = 60$), with irregular meiosis and a presumed hybrid origin (Roy and Sinha, 1956). Development of the gametophyte has been studied by Kachroo and Nayar, 1953. Cytological and morphological studies of selfed progeny of this taxon are reported here.

MATERIALS AND METHODS

Spores were obtained from live plants in cultivation in several botanic gardens of India, and referable to *Adiantum peruvianum*. The procedure followed for sowing and raising the gametophytes was that of Lovis (1968). In the experimental gardens where these investigations were carried out, no other variety or form of *Adiantum* was grown, to prevent cross-contamination. Fully developed prothalli with archegonia were selfed in a watch-glass in a drop of tap-water containing a good swim of antherozoids from prothalli bearing mature antheridia. The young sporophytes were raised to maturity in a temperature-controlled glasshouse, the process taking a year to eighteen months. Such mature plants were selected for morphological studies.

Cytological preparations were made following the schedule of Manton (1950). All micrographs have been taken from permanent slides. Live plants are growing in the department greenhouse and herbarium specimens have been deposited in the Department of Botany, Patna University.

RESULTS

A dense sowing of spores produced only a few prothalli that had different shapes and sizes at maturity; some remained vegetative, whilst others bore sex-organs. Details of the selfing attempts and the results are presented in Tab. 1.

Morphology: None of the selfed progeny resembles the parent stock plant, and the progeny show considerable morphological variation (Fig. 1). Using major points of difference, the progeny have been divided into five groups, and the characters of each of these groups are set out in Tab. 2.

Cytology: A few of the sporophytes showing wide morphological differences were cytologically investigated to determine the chromosome number and the pairing behaviour of chromosomes during meiosis. Formation of regular bivalents was observed in most cells, but the number of bivalents was variable, ranging from 28 to 31 in different sporophytes (see Tab. 3 and Fig. 2). In some plants a few univalents are observed; in such cases, the total chromosome number was higher than the diploid number of the parent.

TABLE 1. Details of gametophytes selfed, percentage of sporophytes raised and number of adult sporophytes surviving.

Year		Number of gametophytes selfed	Number of sporophytes obtained	Number of adult sporophytes survived	Percentage of sporophytes in relation to number of gametophytes selfed
1969	I	16	6	3	18.75
	II	32	6	5	15.62
	III	84	19	15	17.85
1970	I	8	2	2	25.00
	II	32	12	11	34.37
1971	I	8	3	2	25.00
	II	35	13	9	25.71
TOTAL		215	61	47	21.86 (Mean)

TABLE 2: Morphology of different groups of selfed plants

Group number	General appearance of the frond	Size of frond in cms	Size of stipe in cms	Number of pinnae	Size of pinnae (average) in cms	Shape of pinnules	Scales
I	Oblong	16	5.5	16	2.1	Rhomboid. Margins of lower pinnules with shallow incision but terminal ones with deep incision. Pinnules distantly placed.	Absent
II	Lanceolate	14	4.6	13	1.9	Rhomboid. Incisions deep. Pinnules rather close.	Sparse
III	Ovate	20.8	11.6	13	3	Pinnules dissected, incision irregular, pinnules very close giving denser appearance to the fronds.	Dense
IV	Spathulate	14	9.2	11	0.9	Somewhat orbicular, with irregular dentate margin, pinnules closer.	Sparse
V	Elliptic	4.8	1.6	9	0.8	Rhomboid with shallow incisions in margin, pinnules sparse.	Dense

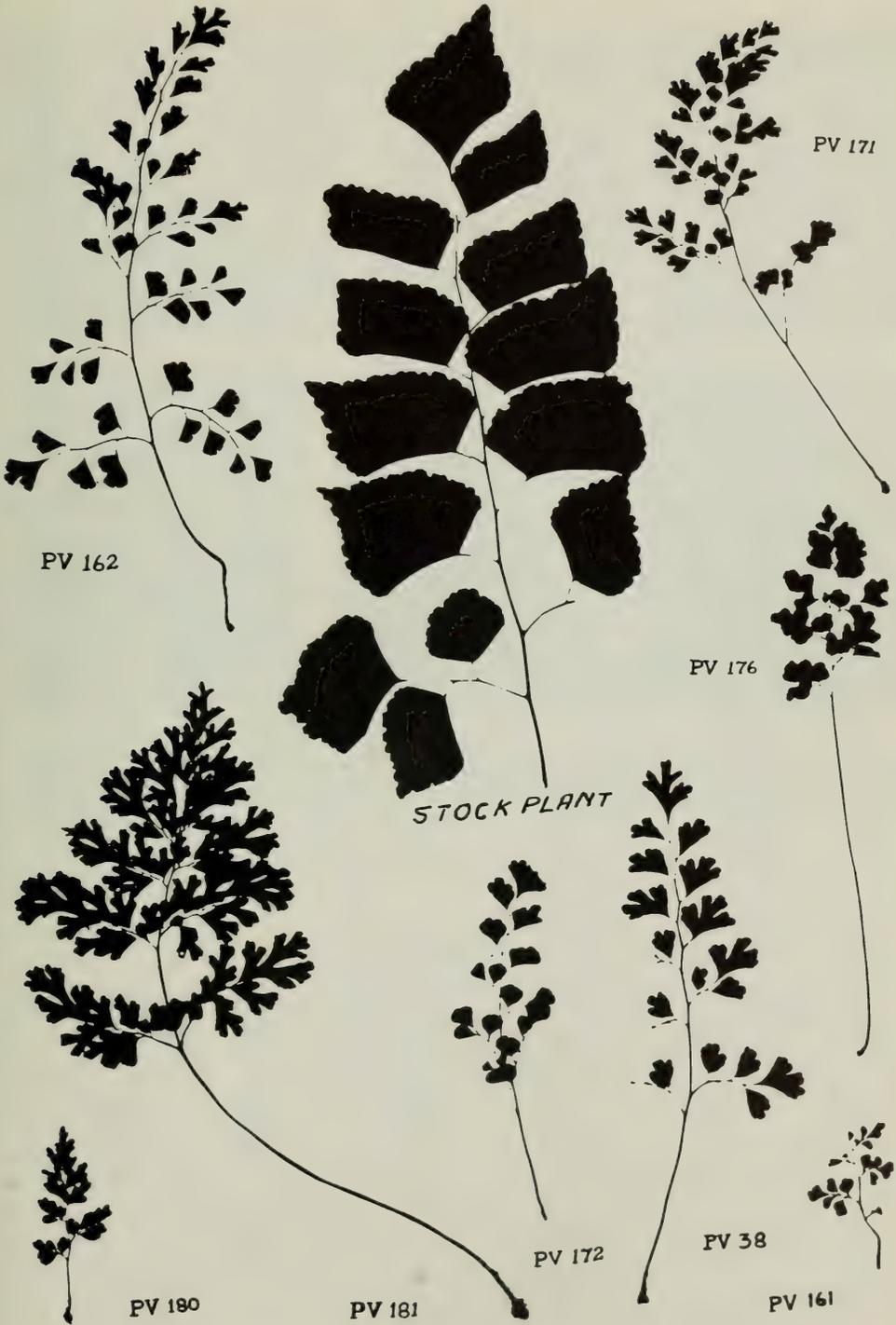


FIGURE 1. Silhouettes of fronds of the stock plant 1/5 nat. size and a few raised progeny. Each frond bears the number of the selfed plant from which the frond has been taken.

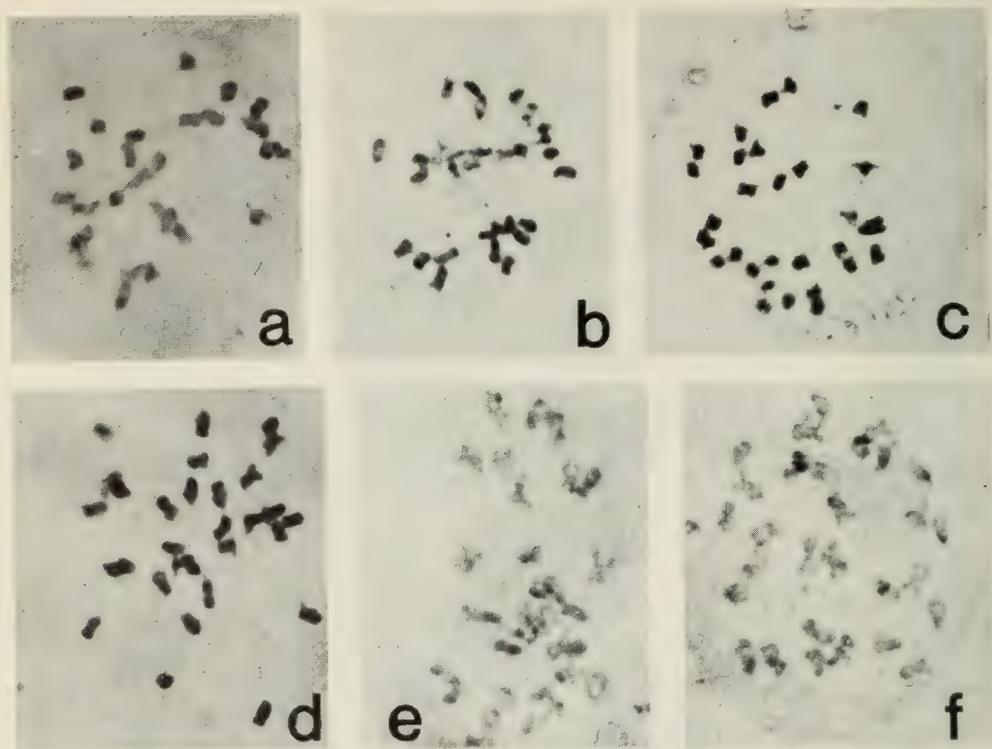


FIGURE 2. Dividing spore mother cells at diakinesis from a few selected sporophytes showing: 28 pairs (A), 29 pairs (B), 29 pairs and 2 singles (C), 30 pairs (D), 31 pairs and 1 single (E) and 31 pairs (F), all at x1000.

TABLE 3. Cytological observations in the selfed plants

Number of investigated plants	<i>Nature of chromosomal associations</i>				Total number of chromosomes
	<i>Univalents</i>		<i>Bivalents</i>		
	Range	Mean	Range	Mean	
2	0-2	2	27-28	27	56
25	0	0	30	30	60
10	0-2	2	29-30	29	60
8	0	0	29	29	58
1	1-3	1	30-31	31	63
1	19-23	21	22-25	24	69

DISCUSSION

The population of *Adiantum peruvianum* that has been investigated is a garden sample, and belongs to a single clone since it is always propagated vegetatively. Nayar (1962) has described the taxon in India, mentioning its gigas habit. Results of the experimental investigations here are noteworthy for the total absence of progeny resembling the parent in morphology. These progeny differ not only from the parent plant, but also amongst themselves. Of the five groups into which they have been divided (Tab. 2), one is very similar to *A. capillus-veneris* whilst others resemble garden varieties of this species. It is suggested that some form of *A. capillus-veneris* and one of its varieties may have hybridized, giving rise to a plant with fronds with a gigas habit. Selfing of such a hybrid would result in segregation of genes, with morphological variation in the offspring and possible loss of the gigas habit.

The selfing attempts were inter-gametophytic and this, coupled with the non-homology of a few chromosomes in *A. peruvianum* (Roy and Sinha, 1956) may be responsible for the presence of univalents in some of the progeny. The range in morphology and chromosome number in the progeny supports the view that *A. peruvianum* is of hybrid origin.

ACKNOWLEDGEMENTS

The authors are grateful to Prof. R.P. Roy, F.N.A., for encouragement and critical comments. We are further thankful to Dr D.B. Lellinger, Prof. G.L. Stebbins and Dr T.G. Walker for their comments. Financial assistance from the U.G.C., New Delhi has been received in the form of a research grant.

REFERENCES

- KACHROO, P. and NAYAR, B.K. 1953. Studies in Pteridaceae I. Observations on gametophytes of some species of *Adiantum* L. *Phytomorphology*, 3: 240-248.
- LOVIS, J.D. 1968. Fern hybridists and fern hybridising II. Fern hybridising at the University of Leeds. *Brit. Fern Gaz.* 10: 13-20.
- MANTON, I. 1950. *Problems of cytology and evolution in the Pteridophyta*. University Press, Cambridge.
- NAYAR, B.K. 1962. Studies of Indian Ferns (*Adiantum*). *Bull. N.B. Garden*, Lucknow.
- ROY, R.P. and SINHA, B.M.B. 1956. Meiotic studies in *Adiantum peruvianum* Klotz. *Curr. Sc.* 25: 268-269.

A CHROMOSOME COUNT FOR *OSMUNDA VACHELLII* FROM PENINSULAR MALAYSIA

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ABSTRACT

A chromosome count of $2n = 44$ (22 bivalents) is recorded for *Osmunda vachellii* from peninsular Malaysia, thus providing further confirmation of the cytological uniformity of the genus.

INTRODUCTION

Osmunda L. is a nearly cosmopolitan genus, with about fifteen species belonging to the temperate and tropical regions of both northern and southern hemispheres (Tryon & Tryon, 1981). Ten species are present in Asia, some of which have overlapping ranges. *O. vachellii* Hk. occurs in southern China, and has been found at several localities in Vietnam, Cambodia and Thailand (Schmid, 1974; Holttum, pers. comm.). The only representative of the genus so far recorded in the Malaysian region is *O. javanica* Blume, where it is mainly a species of higher elevations (Holttum, 1966).

CYTOLOGY

The genus *Osmunda* has been the subject of many studies, especially focussed on the temperate species *O. regalis* L. Autotetraploid and triploid plants were experimentally produced by Manton (1950). Cytological records for wild species from all over the world are, however, uniformly $2n = 44$ (Lovis, 1977).

The author found *O. vachellii* plants on a rocky bank of the River Tembeling (elevation c. 50m.), together with *Adiantum stenochlamys* in Taman Negara National Park in Pahang, Malaysia, in March 1983. Only two populations were found, at different places along the riverbank. The plants differed from *O. javanica*, where the



FIGURE 1. Meiosis in *Osmunda vachellii* Hook. from West Malaysia National Park in Pahang (AB 1741). 1000 x.

fertile pinnae are restricted to the middle part of the frond, as in both populations large and small specimens regularly produced fertile pinnae from both the base and middle part of the frond, whilst the upper half remained sterile.

Professor R.E. Holttum at the Royal Botanic Gardens, Kew, confirmed descriptions and photographs of the plants as *O. vachellii*, adding that he had seen a number of plants of this species growing in a similar habitat in Canton, China.

Live specimens brought back to the Universiti Kebangsaan Malaysia rapidly became fertile, and a meiotic squash clearly showed that these specimens are diploid, with 22 pairs of chromosomes at metaphase 1 (Fig. 1).

ACKNOWLEDGEMENT

This work is partially supported by the Universiti Kebangsaan Malaysia Research Grant No. 18/82, to which I am indebted.

REFERENCES

- HOLTTUM, R.E., 1966. Flora of Malaya, Vol. II. *Ferns of Malaya*. Singapore.
 LOVIS, J.D., 1977. Evolutionary patterns and processes in ferns. *Adv. Bot. Res.*, 4: 229-45.
 MANTON, I., 1950. *Problems of cytology and evolution in the Pteridophyta*. Cambridge Univ. Press, London.
 SCHMID, M., 1974. *Vegetation du Viet-Nam*. Office de La Recherche Scientifique, Paris.
 TRYON, R.M. & TRYON, A.F., 1981. *Ferns and allied plants*. Springer-Verlag, New York, Heidelberg, Berlin.

SHORT NOTES

PSILOTUM NUDUM: A NEW RECORD FOR ARABIA

Psilotum nudum (L.) Beauv. is widely distributed in the tropics but until now has not been found in North Africa, tropical North East Africa or South West Asia. In October 1983 a single gathering was made by Mr Ken Gordon in the extreme south of the Yemen Arab Republic, in the Hujariyah region near Turbah above Aduf. This new locality fills a large gap in its distribution in the Old World Tropics, its nearest station being some 1200 miles away in southern Kenya. The Hujariyah region is particularly interesting, and forms a distinct phytogeographical unit within SW Arabia, containing many endemics. It is relatively dry with uncertain spring rain, although unfortunately no rainfall figures are available.

Psilotum was found growing associated with a small plant of *Ficus salicifolia* (Moraceae) in a shaded crevice on sandstone cliffs at about 5600ft. Only one plant was seen but the area is botanically little explored, and other sites could well be found. I am grateful to John Wood for the following comments about the locality: "The valley is very interesting; there is an abundance of the endemic species *Crotalaria squamigera* (Leguminosae), *Vernonia bottae* (Compositae) and a new species of *Centaurea* (Compositae). There is also plentiful *Wenlandia arabica* (Rubiaceae), *Aloe rivierei* (Liliaceae) and many other interesting plants. The outstanding plant, however, is *Fuirena felicis* (Cyperaceae), known only from this valley. The locality consists of a steep 'V'-shaped valley cut through sandstone descending from the Dubhan plateau. A nearly permanent stream flows along the valley bottom with deeper pools, and there are springs emerging from the cliff side."

A voucher specimen has been deposited in the herbarium at the Royal Botanic Garden, Edinburgh.

A.G. MILLER
 Royal Botanic Garden, Edinburgh

ASPLENIUM × *CONFLUENS* ? IN SNOWDONIA

A single plant of what appears to be *Asplenium* × *confluens* (T. Moore ex Lowe) Lawalrée (*A. scolopendrium* L. × *A. trichomanes* L. subsp. *quadrivalens* D.E. Meyer emend. Lovis) has been found near Llyn Idwal in Snowdonia. It was growing under a rock on a heavily grazed slope of mostly *Festuca ovina* L. and *Nardus stricta* L. Many similar rocks in the vicinity had *Blechnum spicant* (L.) Roth growing under them. Neither of the parents of the hybrid were evident in the immediate area, although *A. trichomanes* subsp. *quadrivalens* was seen a few hundred metres away. *A. scolopendrium* and *A. trichomanes* subsp. *trichomanes* are recorded in the relevant 10Km square. The underlying rock in the vicinity appears to be acidic ordovician rhyolite, but there are other lime-rich rocks within a short distance. The occurrence of the hybrids on such apparently acidic soil is surprising when the preferences of the parents are considered.



FIGURE 1. The *Asplenium* hybrid from Cwm Idwal (life size).

The plant appears to be quite consistent with *A.* × *confluens* although there seems no reason why it might not be *A. scolopendrium* × *A. trichomanes* subsp. *trichomanes* as this would be very difficult to distinguish morphologically. A small piece of the plant has been propagated and it is intended for this to be examined cytologically. A frond of the plant has been deposited in the herbarium of the British Museum (Natural History) (Fig. 1).

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BRITISH AND IRISH PTERIDOPHYTE RECORDS

Compiled by A.R. BUSBY, BPS Recorder

The following records are additions to the *Atlas of Ferns* (1978) and are communicated to the vice-county recorder concerned. One error is reported. I would like to express my thanks to all BPS and BSBI members, to the many vice-county recorders, and especially to C.D. Preston and his staff at the Biological Records Centre, Monks Wood (ITE), for their help.

As in previous years, records are presented thus; 100km square/10km square followed by the recorder's name. Irish records are prefixed with an H.

POST 1950

- 1.2 *Lycopodium clavatum* 36/51 J. Durkin, 31/49 A. Lewis.
 5.1 *Selaginella selaginoides* 36/82 N.J. Hards.
 6.2 *Isoetes echinospora* 07/94 A.A. Slack.
 7.1×2 *Equisetum* × *trachydun* H10/57 T. O'Mahony.
 7.3 *Equisetum fluviatile* 45/22 J. Durkin.
 7.3×7 *Equisetum* × *dycei* 17/39, 18/30 H. McHaffie.
 7.4×7 *Equisetum* × *rothmaleri* 18/30 H. McHaffie.
 7.4×3 *Equisetum* × *litorale* 17/49, 27/04, 60, 36/15 H. McHaffie.
 7.7×8 *Equisetum* × *font-queri* 33/32 A.R. Busby.
 7.8 *Equisetum telmateia* 45/34 J. Durkin.
 14.2 *Hymenophyllum wilsonii* 22/91 M. Dohrn.
 16.1 *Polypodium vulgare* H00/56 R. Rush, 38/80 J. Durkin, 52/94, 62/13 E.M. Hyde.
 16.2 *Polypodium interjectum* H00/56, 67, 68 R. Rush, 35/15, 45/24 J. Durkin, 42/57 R.P.H. Lamb, 62/16 E.M. Hyde.
 16.2×1 *Polypodium* × *mantoniae* 36/16 H. McHaffie, 52/94, 62/03, 13, 16 E.M. Hyde.
 16.3 *Polypodium australe* H10/67 R. Rush, 35/42 F.J. Roberts.
 17.1 *Pteridium aquilinum* 45/46 J. Durkin, 53/24 N.J. Hards.
 19.1 *Phegopteris connectilis* H13/69 D. Kingston.
 21.1 *Asplenium scolopendrium* 36/51 J. Durkin, 53/04 N.J. Hards.
 21.1×7b *Asplenium* × *confluens* H00/86 R. Rush.
 21.2 *Asplenium adiantum-nigrum* 35/94, 45/05 J. Durkin, 44/95, 53/04, 54/07, 16 E. Chicken.
 21.7 *Asplenium trichomanes* agg. 44/84, 54/07 E. Chicken.
 21.7b *Asplenium trichomanes subsp. quadrivalens* 35/76, 88, 45/29, 46/02, 12, 22 J. Durkin.
 21.9 *Asplenium ruta-muraria* 36/51, 45/18, 28 J. Durkin, 44/84, 54/05, 16, 27 E. Chicken.
 21.11 *Asplenium ceterach* 51/50 R. Hibbs.
 22.1 *Athyrium filix-femina* 36/51 J. Durkin, 53/34 N.J. Hards.
 24.1 *Cystopteris fragilis* 36/51, 46/14 J. Durkin.
 26.2 *Polystichum aculeatum* 36/51 J. Durkin.
 26.3 *Polystichum setiferum* H00/55 R. Rush, 36/43 BSBI Party, 43/97, 53/34 N.J. Hards, 54/14 F.E. Crackles.
 27.2 *Dryopteris filix-mas* H00/56 R. Rush, 27/09 N.J. Hards, 36/51, 80, 45/46 J. Durkin.
 27.3 *Dryopteris pseudomas* 35/15, 36/80, 90, 45/44 J. Durkin.
 27.5 *Dryopteris aemula* H13/69 D. Kingston, 22/64 I.K. Morgan.
 27.8 *Dryopteris carthusiana* 45/05 J. Durkin.
 27.9 *Dryopteris austriaca* H00/46 R. Rush, 36/51, 45/46 J. Durkin.
 29.1 *Pilularia globulifera* 17/04 A. McG. Stirling.
 30.1 *Azolla filiculoides* 36/27 J. Muscott, 43/97 I. Weston, 45/27 J. Durkin, 52/76 G. Heathcote.

ERRORS

- 23.2 *Gymnocarpium robertianum* NOT 33/21 A.R. Busby.

REVIEWS

MEMOIR OF THE LIFE AND WORK OF EDWARD NEWMAN by his son *Thomas Richard Newman*, 82 pp. 1876. 141 x 213mm. Reprinted by *E.W. Classey*, 1980, (from *Park Road, Faringdon, Oxon SN7 7DR*). Price £2.50.

This small book is an interesting sketch of the life of the most energetic of naturalists. Born on 13 May 1801 Edward Newman developed his interest in ferns when at school in Gloucestershire. Although his first love was entomology, which remained with him throughout his life, he began his first fernery in 1826 at Leominster in Herefordshire. Newman observed how ferns grew in the wild and built replicas of their habitats in his garden, the principles of which are graphically described in the Introduction to his *History of British Ferns* (1844).

This little book that Mr. Classey has reprinted makes interesting reading. One wonders how Newman found time for botany! It emphasises, however, the need for someone to write a biography of Edward Newman — the pteridologist.

A.C. JERMY

THE FERNS AND FERN ALLIES OF SOUTHERN AFRICA by *W.B.G. Jacobsen*, 542pp. 1983. *Butterworths, Durban*. 225 x 290mm. Price £47.

This book is more than a fern Flora in the conventional sense. The first 113 pages contain six chapters. A general introductory one on classification and morphology includes a note on the conservation of ferns. The author's discussion on the loss of habitats is realistic and frightening and emphasises the role of invading exotics (Australian Wattle and other *Acacia* species in particular) in destroying dry land scrub, macchia, and kloof (ravine) forest. Deprivation of forests is mainly the result of man's clearing; indigenous forest now covers less than 0.2 per cent of the whole of South Africa and even less of Zimbabwe. A chapter on the distribution and one on phytogeography follow and two very substantial chapters on ecology, one in which the factors of topography, substrate and climate are discussed and a second where the fern flora of some 42 communities are described for this extensive area.

The second part (382 pp) is the Flora proper — detailed descriptions of families, genera and some 300 species. As might be expected of this author, extensive and original field notes are given, as are keys, distribution maps and photographs (of herbarium specimens usually — unfortunately). This is little mention of spore characters which is a pity, especially in the discussion on *Cystopteris fragilis*, where we would like to know the distribution of the *C. dickieana*-spore type.

The production is clear in two columns but the printers have not used a very fine screen for the photographs and the detail is lost. This is unfortunate as the habitat pictures in part 1 are unique. There are two appendices: A, a list of the species given and their relationships to rainfall, environment and distribution; and B, a similar list of species showing the relationship to altitude. There are few printing errors; one, which is consistent, is *Hymenophyllum tunbridgense* which it is interesting to see is the commonest filmy-fern in South Africa, and I noticed Widén in the bibliography misspelt as Vidén. But these are minor points. This is an excellent book and the author, by profession a geologist, has indeed contributed to our knowledge of ferns as they are seen in the field in southern Africa. This may not be the last word on the taxonomy of these ferns but it is certainly a mile-stone and an excellent example of field observation.

A.C. JERMY

***PTERIDOPHYTIC FLORA OF GARHWAL HIMALAYA* by S.S. Bir, C.K. Satija, S.M. Vasudeva and P. Goyal. 83 pp 1983. Jugal Kishore, Dehra Dun, 248 001 India. 195 x 258mm. Price Rs 95.**

This is an annotated catalogue of the ferns and fern allies of Mussoorie, Dehradun, Chakrata and the adjoining hills; in all, the flora consists of 157 species. The account abounds with bibliographical references but individual records are listed with useful ecological notes. There is a general chapter on the ecology of pteridophytes in the region which is interesting for the account of lithophytes and xerophytes. The reader is reminded of the food value of young *Diplazium esculentum*, *D. polypodioides* and, surprisingly, the hairy *Botrychium lanuginosum*. Medical uses are several: *Adiantum* for expectorants and diuretics, spleenworts to counteract enlarged spleens, and the siliceous stems of *Equisetum debile* for gonorrhoea.

There is still much taxonomic work to be done on the ferns of India. Professor Bir's little book highlights some of the problems and will hopefully stimulate comprehensive monographic studies.

A.C. JERMY

***THE AUSTRALIAN FERN JOURNAL*, published annually by the Fern Society of Victoria, Vol 1 No 1 1984.**

In 1979 the Fern Society of Victoria in Australia was launched under the Presidency of Chris Goudey, with an initial membership of over 200. Now it has more than 500 members and is still expanding. Right from its beginning the Society issued a monthly *Newsletter* which has increased much in size and in the interest of its contents since then. I enjoy receiving this publication.

Now the Society has taken another step forward and has begun to publish the *Australian Fern Journal* under the editorship of David Jones. A copy of Vol 1 No 1 for 1984 is before me as I write. It consists of 33 pages, containing much fern matter of interest, with 26 colour photographs (24 of them of ferns) of superb quality, most of them the work of Chris Goudey and David Jones, of the same high standard as those appearing in their book *Exotic ferns of Australia*. The coloured cover depicts a magnificent tree-fern in its natural habitat. Papers included are on the ferns of Victoria and New South Wales, the endemic ferns of Lord Howe and Norfolk Islands, and a trip to Borneo.

I intend to offer copies of this first issue for sale through *BPS Booksales* and estimate that I shall be able to sell them at around £1.60. Purchasers of this first issue may find it of interest to join the Fern Society of Victoria. The annual subscription for membership, which includes the monthly *Newsletter*, but not the *Australian Fern Journal*, is Australian Dollars 12.50 for members *outside* Australia. Information on the additional cost for the new journal can be obtained from the Secretary of the Fern Society of Victoria, 14 Afton Street, Essendon, Victoria 3040, Australia.

J.W. DYCE

PTERIDOPHYTES OF TAIWAN by C.M. Kuo, 1982. Published by the Taiwan Provincial Department of Education, Taiwan, Republic of China. Available from K.S. Hsu, Taiwan Forestry Research Institute, Botanical Garden, 53 Nan-Hai Road, Taipei, Taiwan.

This is Volume III in a set of ten books prepared for high-school students. It is written in Chinese, but an English edition will likely be published within a year or two.

A systematic list of the families and genera of Taiwan pteridophytes is given, which follows Pichi Sermolli's classification of 1977. A colour plate and a description of one species in each genus found on Taiwan is given. Family and scientific names are in Latin, common names are in Chinese. No synonyms are given. The world-wide distribution, ecological notes, and distribution in Taiwan are given for the species illustrated. The colour photos are excellent and are printed on high grade glossy paper. Nearly all photos were taken of plants in their natural habitat. Mr Kuo uses the 'small genus' concept so, instead of using one species to represent *Lycopodium*, he gives six photos and descriptions for six segregate genera recognized.

Some of the other volumes in this set also deal with pteridophytes, but there is no duplication of photos or descriptions. For example, in Volume I, *The Rare and Threatened Plants of Taiwan*, seven species are listed and the descriptions and illustrations are not the same as those used in Volume III. Dr Hsu Kuo-Shih tends to use more familiar names, for example: *Schizaea digitata* (L.) Sw. instead of *Actinostachys digitata* (L.) Wall. ex J. Sm.

CHARLES E. DEVOL

BOOK NOTES

FLORA OF ECUADOR No 18 (edited by G. Harling and B. Sparre) 14 (4) POLYPODIACEAE-THELYPTERIDOIDEAE by Alan R. Smith. 147 pp. 1983. 168 x 234mm. Swedish Research Council, Stockholm.

One hundred and one species, all treated as of *Thelypteris* Schmidel, are concisely and clearly described, with a key to their identification. Useful notes are given on their ecology reflecting the high standards of recent collections of the Aarhus school whose herbarium labels give more information than just altitude! The taxonomy is very sound and the whole work is what we have come to expect from the pen of Alan Smith. We look forward to other accounts in this series.

ICONOGRAPHIA SELECTA FLORAE AZORICAE, Vol. 1, fasc. 1 & 2, edited by A. Fernandes and Rosette Batarda Fernandes, pp 285, 51 plates. 1980-1983. Coimbra.

Volume One of this nicely prepared and printed work contains Pteridophyta and Gymnospermae; of the 51 plates only four however are gymnosperms. Each species account (47 in all) is individually signed and authors include the editors, Isabel Noqueira and Magarida Queiros, the latter with M. Lameiras being the principal artists. Edmund Launert and Georg Paiva describe a new *Marsilea* (*M. azorica*). All plants are described in full and although the text is in Portuguese, the full-page plates are excellent and the books are well worth obtaining for these alone.

A.C. JERMY

AZOLLA AS A GREEN MANURE: USE AND MANAGEMENT IN CROP PRODUCTION by Thomas A. Lumpkin and Donald L. Plucknett. Westview Tropical Agriculture series No 5 Boulder, Colorado. 230 pp. 1982. 148 x 224mm.

Azolla species contain, in cavities within their leaves, bluegreen algae (*Anabaena* spp.) which have the ability to 'fix' atmospheric nitrogen. On decay (rapid in the tropics), nitrogenous compounds are released and become available to other plants growing nearby. The species is there encouraged in the rice fields and *Azolla* culture is 'big business' in SE Asia and in China in particular.

This book is about management of the crop but it contains useful chapters on the identification, morphology and ecology of *Azolla* species. There is obviously need for a definitive monograph and further field studies on this interesting genus. The book is impressive for its extensive bibliography, especially Chinese (450 entries).

A.C. JERMY

THE FERN GAZETTE

Original papers, articles, or notes of any length on any aspect of pteridology will be considered for publication.

Contributions should be sent to:

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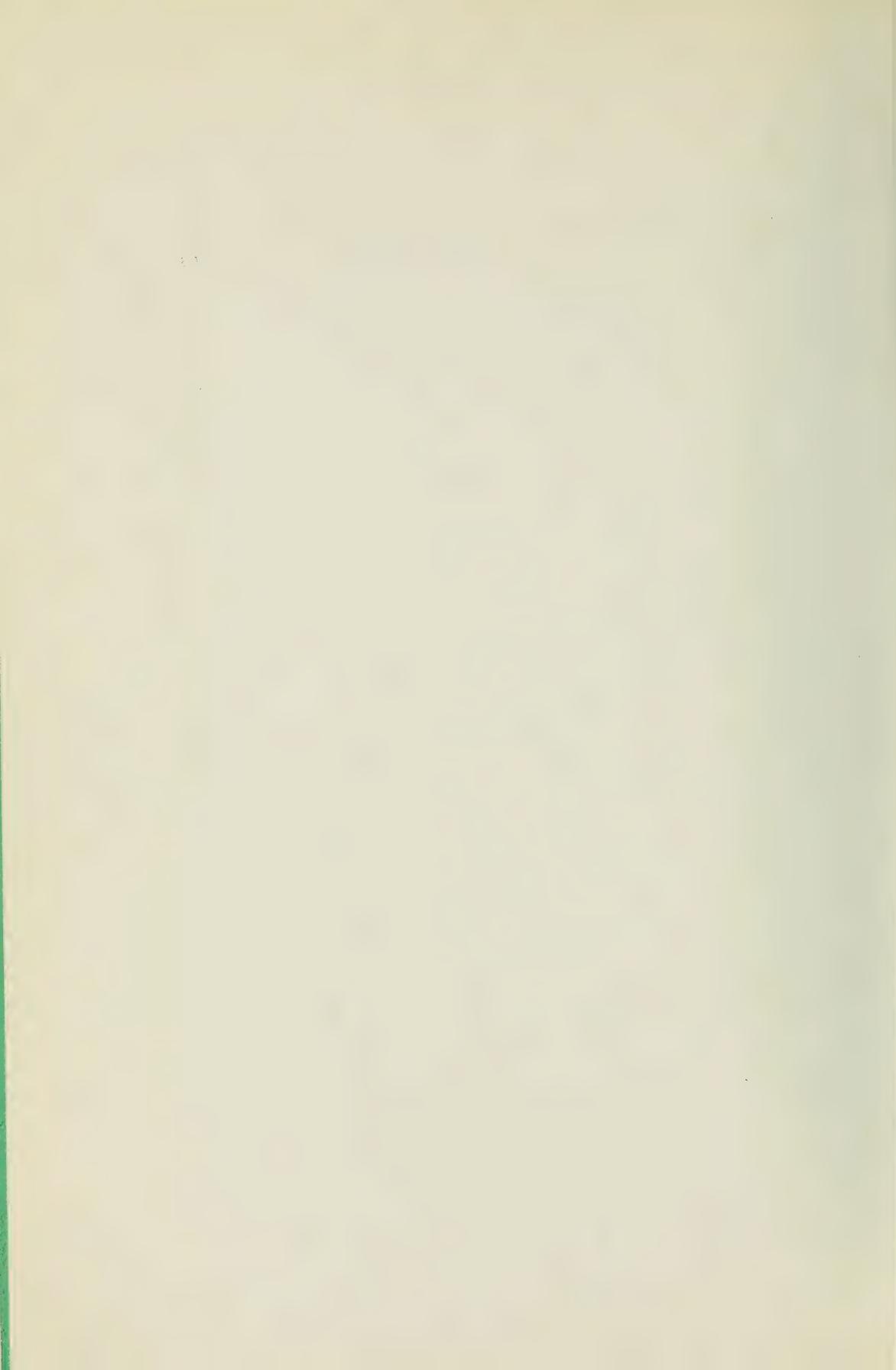
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