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(THE FERN GAZETTE Volume 12 Part 4 was published 11th November 1982)

Published by THE BRITISH PTERIDOLOGICAL SOCIETY, c/o Department of Botany, British Museum (Natural History), London SW7 5BD

ISSN 0308-0838

Metloc Printers Ltd., Old Station Road, Loughton, Essex.
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.
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 I, 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.


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 AS. Old and recent records refer to pre-1950 and post-1950 records respectively. Where unqualified, "grid squares" refer to 10 x 10 km squares and "monads" refer to 1 x 1 km 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, Muckross Lake area and in Atlas pre-1950 for V/98. 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/0184).

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
FERNS OF KILLARNEY DISTRICT

TAXA

Isoetes lacustris
Equisetum fluviatile
Equisetum xlltorale
Equisetum arvense
Athyrium filix-femina
Osmunda regalis
Dryopteris affinis
Blechnum spicant
Dryopteris dilatata
Pteridium aquilinum
Dryopteris aemula
Dryopteris flilx-mas
Polystichum setiferum
Polystichum aculeatum
Oreopteris limbosperma
Huperzia selago
Asplenium scolopendrium
Asplenium adiantum-nigrum
Asplenium trichomanes
Asplenium ruta-murana
Asplenium ceterach
Polypodium vulgare agg.
Hymenophyllum wilsonii
Hymenophyllum tunbrigense

MAJOR HABITAT TYPES

Open water
Rocks by water
Marsh
Dead wood
Conifer wood
Scrub
Hedge
Heather moor
Grass moor
Tall herb
Bush rock
Sedge
Wells
Epiphyte

NUMBER OF MONADS

| 33 | 42 | 11 | 49 | 15 | 18 | 62 | 44 | 45 | 12 | 94 | 10 | 81 | 37 |

Table 2
6.1 Isoetes lacustris
(a) Widespread but local throughout the south and west of the area. Recorded for Clon Lake V/70.78, Lough Caragh V/71.88, Hag's Glen V/81.84, Lough Nambrackdarrig V/94.78 and Muckross 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 Guinate (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 Muckross Lake in the vicinity of Muckross 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, Muckross 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, Muckross 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.


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/0.8. (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/0.8.

7.4x3 E. x litorale (E. arvense x fluviatile)
(a) Recorded for 8 monads around Muckross 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 Muckross 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/01-73) 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 Roughty 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 Muckross to Dininish 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 Muckross 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.

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, scree, 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 Muckross 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 Muckross 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 Muckross (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 Phlegopteris 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 Muckross (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 it occurred in more than 50% of monads below 60m but less than 10% above 240m.

21.1.7b  *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 810 m 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 33um and 32um respectively. The mean lengths for 4 specimens of *A. adiantum-nigrum* from same area measured at the same time were 42, 37, 37 and 38um.

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*  

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 *Cytopteris 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 Muckross, 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, Carrautnooohil (V/80.83) alt. 600m with *Asplenium viride*.  
Recorded elsewhere as very rare at high altitudes on rocks: Mullaghannattin c. V/73.77 (Curtis and Mhic Daed, 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, Muckross (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); Mullaghannattin (c. V/74.77) and cliffs south of Lough Erhagh (c. V/99.80). Recently Curtis and Mhic Daed (1981) have reconfirmed the species in the Mullaghannattin area. and Mhic Daed 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 Gortracsusane (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**  

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 hedgerbanks (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 heathbanks (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 heathbanks and on acid 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 heathbanks and on an earthed, drystone wall; altitudinal range 30-375m. Selected records: occasional earthed, drystone wall Cloughera 120m (V/72.78); occasional hedgebank Gortnagan 150m (V/72.88); frequent acid rock outcrops Boughil 240m (V/85.77); rare hedgebank Cummeenduvaisig 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. remotata*
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-0) 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. remotata* 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**

<table>
<thead>
<tr>
<th>Floristic elements from Birks (1976)</th>
<th>Distribution in Europe</th>
<th>Number of species in element in:</th>
<th>(a) Killarney post-1950</th>
<th>(b) British Islands</th>
<th>(c) Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Selaginella denticulata</em></td>
<td>Mediterranean</td>
<td>(b)</td>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>2. <em>Adiantum capillus-veneris</em></td>
<td>Mediterranean/Atlantic</td>
<td>(b)</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>3. <em>Phylitis scolopendrium</em> (= Asplenium scolopendrium)</td>
<td>North Mediterranean/Atlantic</td>
<td>(b)</td>
<td>13</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>4. <em>Hymenophyllum wilsonii</em></td>
<td>Western seaboard</td>
<td>(b)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5. <em>Cystopteris fragilis</em></td>
<td>Widespread</td>
<td>(b)</td>
<td>9 (3)</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>6. <em>Pteridium aquilinum</em></td>
<td>Widespread</td>
<td>(b)</td>
<td>7</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>7. <em>Polystichum lonchitis</em></td>
<td>Widespread Montane/Sub-montane</td>
<td>(b)</td>
<td>4 (2)</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>8. <em>Woodsia alpina</em></td>
<td>Arctic/Alpine</td>
<td>(b)</td>
<td>0 (1)</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

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:

- *Isoetes histrix* (*)
- *Ophioglossum lusitanicum* (*)
- *O. azoricum* (*)
- *Anogramma leptophylla* (*)
- *Adiantum capillus-veneris*

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 coastline 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 offshore, 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.
ACKNOWLEDGEMENTS

I should like to thank E.C. Mhic Daeid, Maura Scannell and D.A. Webb for advice on localities to visit, and Mary Gibby, C.R. Fraser-Jenkins, A.C. Jermy, C.N. Page and Anne Sleep for determining critical matter. I am grateful to the British Ecological Society who provided financial assistance for the 1981 field work. Finally I should like to thank for technical help in preparing the manuscript: A. Skinner, figures; P. Holdcroft, photographs and Mrs S.A. Bullock and Mrs P. Comber, typing.

REFERENCES


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REVIEW


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 *Platycerium holttumii*! Certainly those horticulturists 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. apomorph (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.

J. M. CAMUS
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)


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).

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 Cañero, E. of Luarca. 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. affinis 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 subsimile 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 sporophore 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>
<thead>
<tr>
<th>Species</th>
<th>Chromosome number (2n)</th>
<th>Aspidinol</th>
<th>&quot;Albaspidin 1&quot;</th>
<th>&quot;Albaspidin 2&quot;</th>
<th>&quot;Albaspidin 3&quot;</th>
<th>Aspidin BB (PB)</th>
<th>Aspidin AB</th>
<th>Para-aspidin</th>
<th>Desaspidin</th>
<th>Flavaspidic acid BB (PB)</th>
<th>Flavaspidic acid AB</th>
<th>Trisflavaspidic acid</th>
<th>Phloropyron</th>
<th>Filic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. × fraser-jenkinsii</td>
<td>164</td>
<td>+</td>
<td>(+)</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<tr>
<td>D. affinis (WG)</td>
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<td>(+)</td>
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3) Amendments to earlier results.  
4) The phloroglucinol composition was studied from 20.3 mg ether extract obtained from 1.69 stipe bases (1.27%).

TABLE 1. Phloroglucinol derivatives in Dryopteris × fraser-jenkinsii and putative parental species. Semi-quantitative amounts calculated as percentages of the phloroglucinol mixture (crude aspidinol): +++ present in large amounts 20%; ++ present in moderate amounts 10-20%; + present in small amounts 5-10%; (+) present in trace amounts; - not found.
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.

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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 offshore 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 surprisingly, 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.

![Map of the distribution of Asplenium bourgaei](image)

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 Cakırlar (misspelt "Tcharyklar" on Bourgeau's label of 1860
and "Tscharrydar" in Davis, 1965). Meyer believes that it is related to another very local old diploid, Asplenium jahandiezi (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:


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).**
The 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 jahandiezi*ii 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).
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 Cakırlar 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 turgent 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


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 Göcek, 100-300m, 1974, Runemark & Bentzer 29503; Fethiye area, 2km SE of Yelcegiz, 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 tectarioioid 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 tectarioioid fern.

INTRODUCTION
*Stenosemia* Presl is a genus of tectarioioid 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 tectarioioid 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 meristele 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 envelopes 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 trifoliate in plan (Figure 2); its central part deeply pinnatifid with entire, or obtusely serrate, lanceolate lobes; lateral pinnæ very unequal sided, with lowest basiscopic segment pinnatifid, strongly developed as in Ctenitis, Tectaria (Holttum, 1968), Camptodium (Chandra, 1976) and Psomiocarpa (Zamora and Chandra, 1977). The lowest segments rarely becoming free pinnæ; 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 epidermis 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 ¾, 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 polycytic (Van Cotthem, 1970).

Fertile fronds are distinct from sterile ones, long stalked and on the same plan (trifoliate) 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 acetyolysis 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), *Psomioarpa* (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 Psomioarpa, 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 Psomioarpa 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 trifoliolate 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).

ACKNOWLEDGEMENTS

I am thankful to Dr. T.N. Khosshoo, Director, National Botanical Research Institute, Lucknow, India, for providing facilities and giving encouragement during the course of this study. Thanks are also due to Mr. Lalita Tiwari for the preparation of microtome serial sections.
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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 meme 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 "Bioc hemical 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 (MW 1000 daltons), the so-called secondary products such as alkaloids and flavonoids (Smith, 1976; Ayala, 1977; Gutfreund, 1981). (Table 1).

Due to 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

<table>
<thead>
<tr>
<th>Pteridophytes</th>
<th>Angiosperms and Gymnosperms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell wall components</td>
<td>Monoterpenes</td>
</tr>
<tr>
<td>Lignin</td>
<td>Acetylenes</td>
</tr>
<tr>
<td>Cutin</td>
<td>Aromatic alkaloids</td>
</tr>
<tr>
<td>Suberin</td>
<td>Glucosinolates</td>
</tr>
<tr>
<td>Diterpenoids</td>
<td>Betalains</td>
</tr>
<tr>
<td>Triterpenoids</td>
<td>Hydrolysable tannins</td>
</tr>
<tr>
<td>Lysine alkaloids</td>
<td></td>
</tr>
<tr>
<td>Flavonoids</td>
<td></td>
</tr>
<tr>
<td>Condensed tannins</td>
<td></td>
</tr>
</tbody>
</table>

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 genetic 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 xanthones, (formed via a pathway involving 2 rather than 3 acetate additions to the original C₉ 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 (Psilotophyta, 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, chalkones, flavones and xanthones are more common (Cooper-Driver, 1980; Wallace et al 1982). (Table 4).

<table>
<thead>
<tr>
<th>TABLE 3: Biochemical evolution of the flavonoids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primitive</strong></td>
</tr>
<tr>
<td><strong>Advanced</strong></td>
</tr>
<tr>
<td><strong>Highly advanced</strong></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>TABLE 4: The distributions of flavonoid groups in the Pteridophyta</th>
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</thead>
<tbody>
<tr>
<td><strong>Primitive Flavones</strong></td>
</tr>
<tr>
<td>Psilotaceae</td>
</tr>
<tr>
<td>Lycopodiaceae</td>
</tr>
<tr>
<td>Selaginellaceae</td>
</tr>
<tr>
<td>Isoetaceae</td>
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<td></td>
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The xanthones, 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 (Haufler, 1979; Haufler and Giannasi, 1982). (Table 5). This work
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.

![Flavonoid analysis of Puerto Rican tree ferns](image)

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 *Nephelea* 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.*).
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***

<table>
<thead>
<tr>
<th>Sub-genera</th>
<th>Selago</th>
<th>Cernuistachys</th>
<th>Lycopodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloids</td>
<td>lucidine</td>
<td>cernuine</td>
<td>lycopodine</td>
</tr>
<tr>
<td></td>
<td>inundatine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syringyl Lignin</td>
<td>absent</td>
<td>absent</td>
<td>present</td>
</tr>
<tr>
<td>Flavonoids</td>
<td><em>O</em>-methylated flavones</td>
<td><em>C</em>-glycosyl flavones</td>
<td>5-<em>O</em> glycosyl flavones</td>
</tr>
</tbody>
</table>

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
lycopodine (Table 6). He concluded, on biosynthetic grounds, that the subgenus *Lycopodium*, which accumulated mainly the alkaloid lycopodine, 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 angiosperm-like syringyl groups. Flavonoid data also confirms the advanced status of this subgenus and also suggests that *Cernuistachys* 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 *Cernuistachys*. 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; Hauffer and Soltis, 1980; 1983).

![FIGURE 5. A summary of the chemical reactions by which phenolic compounds inhibit enzyme activity.](image)

Electrophoretic data are of greatest utility, however, in analyzing variability among individuals and populations (Darrow and Gastony, 1981; Hauffer 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 allopoloid 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 (Hauffler and Soltis, 1983; Hauffler, 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 (Hauffler 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

![Figure 6](image-url)

**FIGURE 6.** Pictorial representation of Nei's genetic distance among Bommeria species (from Hauffler 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 phosphoglucoisomerase (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, in prep.). Analysis of the enzyme variability and population structure (Figure 7) of this species have indicated that it is

![Figure 7: Map of population of *Cystopteris protrusa* based on similarities in band patterns of six enzyme systems. PGI = phosphoglucoisomerase, 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.](image-url)
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


**REVIEW**


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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and

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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 kaempferol 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. Former 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

<table>
<thead>
<tr>
<th>Compound</th>
<th>MeOH</th>
<th>NaOMe</th>
<th>A1C1$_3$</th>
<th>A1C1$_3$/HC1</th>
<th>NaOAc</th>
<th>NaOAc/H$_3$BO$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kaempferol 3-0-glucoside</td>
<td>348</td>
<td>400</td>
<td>399</td>
<td>396</td>
<td>386</td>
<td>350</td>
</tr>
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<td></td>
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<td>275</td>
<td>303</td>
<td>302</td>
<td>275</td>
<td>266</td>
</tr>
<tr>
<td>2. Kaempferol 3-0-rhamnoglucoside</td>
<td>350</td>
<td>400</td>
<td>397</td>
<td>395</td>
<td>387</td>
<td>353</td>
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<td>275</td>
<td>303</td>
<td>302</td>
<td>273</td>
<td>267</td>
</tr>
<tr>
<td>3. Quercetin 3-0-glucoside</td>
<td>360</td>
<td>410</td>
<td>434</td>
<td>404</td>
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<td>378</td>
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<td>273</td>
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<td>4. Quercetin 3-0-rhamnoglucoside</td>
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<td>5. Unidentified flavone</td>
<td>340</td>
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<td>6. Unidentified flavone</td>
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<td>380</td>
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<td>340</td>
<td>330</td>
<td>350</td>
</tr>
<tr>
<td>glycoside</td>
<td>385sh</td>
<td>320</td>
<td>300</td>
<td>330</td>
<td>275</td>
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<td></td>
<td>270</td>
<td>275</td>
<td>275</td>
<td>275</td>
<td>265</td>
<td>265</td>
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</tbody>
</table>

TABLE 2. Chromatographic properties of Osmundaceae flavonoids

<table>
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<tr>
<th>Compound Number</th>
<th>TBA</th>
<th>HOAc</th>
<th>UV</th>
<th>UV + NH$_3$</th>
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</thead>
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<tr>
<td>1</td>
<td>0.64</td>
<td>0.54</td>
<td>Purple</td>
<td>Green</td>
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<tr>
<td>2</td>
<td>0.55</td>
<td>0.65</td>
<td>Purple</td>
<td>Green</td>
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<tr>
<td>3</td>
<td>0.46</td>
<td>0.41</td>
<td>Purple</td>
<td>Yellow Green</td>
</tr>
<tr>
<td>4</td>
<td>0.42</td>
<td>0.58</td>
<td>Purple</td>
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</tr>
<tr>
<td>5</td>
<td>0.49</td>
<td>0.48</td>
<td>Dull Purple</td>
<td>Light Green</td>
</tr>
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<td>6</td>
<td>0.59</td>
<td>0.53</td>
<td>Purple</td>
<td>Green</td>
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<tr>
<td>7</td>
<td>0.20</td>
<td>0.80</td>
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<td>Light Yellow</td>
</tr>
<tr>
<td>8</td>
<td>0.63</td>
<td>0.56</td>
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<td>10</td>
<td>0.20</td>
<td>0.66</td>
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<td>Dull Purple</td>
</tr>
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<td>11</td>
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<tr>
<td>12</td>
<td>0.69</td>
<td>0.79</td>
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TABLE 3. Taxonomic distribution of Osmundaceae flavonoids

<table>
<thead>
<tr>
<th>Flavonols</th>
<th>Flavones</th>
<th>Unidentified</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Osmunda cinnamomea</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Todea barbara</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Leptopteris superba</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

+++ = 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 HC1 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.

ACKNOWLEDGEMENTS
The senior author was supported for the majority of this study by the School of Agriculture and Life Sciences, Cornell University Honors Degree Program. I wish to thank P. Mick Richardson for his comments on the manuscript.

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**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, Thyropterideae (Holtum, 1963) or as a subfamily, Thyropteridoideae (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 *Thyropteris* 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 richnes 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 (CRF J 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 Gijon, 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) Fras.-Jenk. 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 CRF J in 1976 and the new species D. corleyi Fras.-Jenk., 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


C.R. FRASER-JENKINS,  
c/o British Museum (Natural History), London.  
and  
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Apartado 425, Colegio de la Immaculada, Gijon, Spain.

**AZOLLA FILICULOIDES IN EDINBURG**

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-blowen. 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.

J. MUSCOTT,  
69 Warrender Park Road, Edinburgh.

**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 confluentes* (T. Moore ex Lowe) Lawalrée 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.

Apart from one record from Jugoslavla 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., Drury 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.

Drury (1901) refers to two further finds of what he listed as 'Conflns 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. Drury (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 Professor T. Reichstein for confirming my determination.

REFERENCES

B.J. Rush, 17 Toronto Road, Ilford, Essex.
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.

C.R. POPE, Haverstreet, Isle of Wight.

**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); *Pleuroderis* (1); *Hypoderris* (1); *Dictyoxyphium* (1); *Camptodium* (1); *Stenosemia* (1); *Heterogonium* (2); *Fuldopeltis* (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.

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P.M. RICHARDSON & E. LORENZ-LIBURNAU, New York Botanical Garden, Bronx, NY 10458, U.S.A.
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, 36/77 C. W. Murray.
4.1 Diplasiastrum alpinum 18/24 M. Coulson.
5.1 Selaginella selaginoides 17/04 J. Clark, 18/56 C. W. Murray.
5.2 S. krausliana 22/50 I. K. Morgan.
6.2 Isoetes echinospora 07/94 A. Slack.
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. Willmott.
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. Willmott.
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. Willmott.
7.8 E. telmateia 18/25, 26, 36 C. W. Murray.
8.1 Botrychium lunaria 41/86 W. E. Warner, 43/08 A. Willmott, 62/28 Miss C. Forrest; H24/73 D. Riley, H24/81, 84 D. S. Lambert.
14.2 Hymenophyllum wilsonian 18/41 H. J. B. Birks; H10/07 A. Willmott.
16 P. vulgare agg. 42/56 R. Lamb.
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.
P. x mantoniae 18/33 G. Ramsey, 25/97 M. Martin.


P. x shivasie 25/97 M. Martin.

P. x bicknellii 18/33 G. Ramsey, 25/97 M. Martin.

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. Hardis.

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.

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.

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.


A. trichomanes 18/33, 45 G. Ramsey, 22/98 P.M. Benoit.

A. trichomanes, subsp. trichomanes 18/33, 45 G. Ramsey, 22/98 P.M. Benoit.

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.

A. onopteris HOO/88, 98 A. Willmot.

A. marinum 07/94 J. Clark, 18/32 C.W. Murray, 18/52 M. Coulson.

A. viride 18/26 H.J.B. Birks; HOO/88 A. Willmot.


G. robertianum 31/03 Miss C.J. Biddens, 34/61 P. Jeppson.

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.

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, 45/25 J. Durkin, 63/10, 20, 21 E.T. Daniels.

Blechnum spicant 18/82 M. Barron.


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.

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. Hardis.

D. aemula 18/43, 46 C.W. Murray, 18/60 H.J.B. Birks 22/04, 32/46 M.H. Rickard.


**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**


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 ‘Oceanity 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 taxa. 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* Féé 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

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 *breyni*)). 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 gymnogrammoid 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


Meghalaya State, formerly part of Assam abuts 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 Nagi 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