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American Fern Journal

Vol. 54 JANUARY-MARCH, 1964 No. 1

The Genus Cyathea (sensu lato) in Malaysia

R. E. Holttum

I have lately completed a study of the family Cyatheaceae for *Flora Malesiana* (Holttum, 1963), and have been led to formulate a new arrangement of infra-generic groupings of species within a comprehensive genus *Cyathea.* The present paper presents comments on this classification, and incidentally poses some questions which may be relevant to a consideration of the classification of the species of tropical America.

In the area covered by *Flora Malesiana* there are almost 200 species of *Cyathea.* In the mainland of Asia and the adjacent non-Malaysian islands I can distinguish only 24 or 25; in the Pacific and Australasia are 50 to 60 species (no full comparative survey of these has yet been made). There is no species in mainland Asia or the Pacific region which has no close relative in Malaysia. Thus a discussion of the genus in Malaysia applies in essentials also to the species of these other regions.

The traditional basis for a classification of this group of ferns long has been the character of the indusium, upon which Robert Brown (1810, p. 158) established the genera *Hemitelia* and *Alsophila* as distinct from the earlier *Cyathea* Smith (1793, p. 416). Although there were some minor differences as between different subsequent authors in the definition of these genera, the generic characters may be thus broadly summarized: in *Cyathea* the indusium is cup-shaped, in *Hemitelia* it is attached only on one side of the receptacle, and in *Alsophila* there is no indusium. Careful inspection with the use of modern optical equipment shows this to be an over-simplification, and indeed Hooker (1844, pp. 28, 34) had some understanding of this, but the use of the three genera persisted for over a century. Copeland (1909, p. 353) was the first to point out clearly that, in the Malayan region at least, the grouping of species provided by the generic definitions is unnatural. His solution was to include all species in one genus, *Cyathea*; but other authors thought that though this might be right for Malaysia, it was not necessarily so for species of the American tropics, for which reason Christensen continued the use of the three genera in the third *Supplement* to his *Index Filicum* (1934, pp. 20, 58, 110), though in his taxonomic papers on ferns of Malaysia he followed Copeland (1934, p. 218).

Copeland (1947, pp. 98, 99) later attempted to segregate two genera in Malaysia, namely *Gymnosphaera* Bl. and *Schizocaena* J. Smith, but in my judgment he did not clearly define them and included in each case diverse elements not conforming to the characters of the type species; in particular, he overlooked the characters of the scales (Holttum 1957, pp. 41-45). I believe that it is possible to establish two natural groups of species around the type-species of *Gymnosphaera* and *Schizocaena* (including in each case some that Copeland retained in *Cyathea*); but both groups seem to me to be parts of larger groups, and I do not think the latter are sufficiently distinct to warrant generic separation. This judgment is supported by cytological evidence; the haploid chromosome number in all species investigated (including some from each of my major groups), is 69.

My two major groups within *Cyathea* are: subgenus *Cyathea*, having flabelloid stipe-scales, and subgenus *Sphaeropteris* (Bernh.) Holttum having setiferous scales. The distinction between these groups is not only in the characters of the edges of the scales but also in their development (Holttum & Sen 1961, p. 410). It appears to me that, judged by other characters also, this division is a natural one, though it is difficult to describe the differences in precise terms. The following is a conspectus of the subgenera and their sections.

SUBDIVISION OF THE GENUS CYATHEA IN MALAYSIA

Stipe-scales flabelloid; hairs on lower surfaces, if present, crisped and appressed; pinnules in most cases deeply lobed, basal basiscopic vein rarely from costa; indusia in many cases hemitelioid. Subgenus CYATHEA

Indusiate (indusia in some cases very small) or if exindusiate hairy on lower surface of pinna-rachis; axes not very dark; little dimorphism between sterile and fertile pinnules. Section *Cyathea*

Exindusiate; axes very dark, not hairy beneath; fertile and sterile pinnules usually very dimorphous. Section *Gymnosphaera*

Stipe-scales setiferous; hairs on lower surfaces, if present, rather thick and spreading; where pinnules are shallowly lobed, basal basiscopic vein always from costa; indusia complete, or lacking, or formed of separate scales (in a few cases imperfect, and then not hemitelioid). Subgenus SPHAEROPTERIS

Costules not widely spaced (rarely over 4 mm. apart in pinnules 10 cm. long); pinnules usually 10 cm. or more long, lobed almost or quite to costa throughout, or fully pinnate. Section *Sphaeropteris*

Free tertiary leaflets few; indusia present or absent; sori never covered with overlapping scales. Subsection *Sphaeropteris*

Free tertiary leaflets many; no indusia; sori covered with overlapping scales. Subsection *Fourniera*

Costules widely spaced (at least 4 mm. apart except where pinnules are under 4 cm. long); pinnules mostly less than 10 cm. long, not lobed to within 1 mm. of costa except near base; basal basiscopic vein always from costa; indusiate or not. Section *Schizocaena*

Scales of stipe 1 cell thick throughout. Subsection *Schizocaena*

Scales of stipe thick and fleshy at base, tapering and flat distally. Subsection *Sarcopholis*

Each subgenus is divisible into two sections. Subgenus *Cyathea* comprises the sections *Cyathea* and *Gymnosphaera* (Bl.); subgenus *Sphaeropteris* comprises the sections *Sphaeropteris* and *Schizocaena* (J. Sm.). The sections *Gymnosphaera* and *Schizocaena* have the same type-species as the genera of the same names recognized by Copeland, but a different assemblage of other species.

Species which lack indusia, and have therefore in the past been included in the genus *Alsophila*, are to be found in section *Gymnosphaera*, section *Sphaeropteris* and section *Schizocaena*. In sections *Sphaeropteris* and *Schizocaena* there are both indusiate and exindusiate species; the exindusiate species in each section seems to me more nearly related to the indusiate ones within the section than to exindusiate species in other sections. In section *Gymnosphaera* there are no indusiate species, but there are exindusiate species which appear to be on the border-line between sections *Gymnosphaera* and *Cyathea*. Thus, in my view, Copeland's statement that a genus *Alsophila* defined solely by absence of indusia is an unnatural one is amply justified.

But another definition of a genus *Alsophila* R. Br., and by modern standards a more important one, is that it is a genus which includes the original species of *Alsophila*, namely *A. australis* R. Br. This certainly does not belong to section *Gymnosphaera*, as it lacks the characteristic dark axes and constricted fertile lamina; it lacks also small scales with dark median band shown by Miss Tindale to be normally present in that group (1956, p. 331). I would place *A. australis* in subgenus *Cyathea* section *Cyathea*. In its scales it is near *C. pruinosa* Rosenst. and other indusiate species of New Guinea, but it has no indusium. It has, however, a variable number of small scales attached to the base of the receptacle, and in this resembles *Alsophila aspera* (L.) R. Br. of the West Indies (the scales in *A. aspera* are much larger than in *A. australis*). This might seem to justify the inclusion of *A. aspera* in the genus *Alsophila* as typified by *A. australis*. But some other tropical American species which are included in *Alsophila* (as defined by lack of indusium) lack such scales and are in other ways very different.

It is interesting to note that in the subgenus *Sphaeropteris* a much larger number of species have small scales attached to the base of the receptacle, and in the subsection *Fourniera* these scales are usually quite large, overlapping and covering the sorus almost to maturity; the subsection *Fourniera* is characterized also by almost fully tripinnate fronds. The Malaysian members of this subsection (*C. celebica* Bl., *C. tripinnata* Copel. and others) have been described as indusiate, but are not so; the scales which appear to form an indusium are quite separate, and have the cell-pattern of scales, not of indusia.

The section *Schizocaena* appears to me a very natural one. In it I include the species which Copeland placed in *Gymnosphaera* sect. 3, which have scales exactly like those of the type species of *Schizocaena.* I include also some indusiate species (*C. integra* J. Sm. and allies) which Copeland placed in *Cyathea.* I exclude the Ceylon species *Cyathea sinuata* Hook. and *C. hookeri* Thw., which have very different scales and appear to me most nearly related to some species in Madagascar, not to any others in Asia.

I have rather tentatively subdivided *Schizocaena* into two subsections, based on the fact that in New Guinea and the Pacific are species which have stipe-scales arising from ascending fleshy bases; these I place in the subsection *Sarcopholis.* I am however not sure whether there is a sharp distinction between these species and those with large thin scales, and I have not seen good fresh material of any species with fleshy scale-bases, so that I do not understand their structure and development.

Subgenus *Cyathea* section *Cyathea* is by far the largest section, and includes species with indusia of every kind. Sen and I have argued that the *Hemitelia* type of indusium is primitive in the genus, and homologous with the "inner indusium" of *Dicksonia.* I suggest that the cup-shaped *Cyathea* indusium has evolved, perhaps on several distinct lines, from the *Hemitelia* type. There are species in Malaysia which show transitions between a *Hemitelia*-type of indusium and a shallow cup-shaped one, sometimes on the same leaflet, notably *C. javanica* Bl., and *C. sumatrana* Bak. In Ceylon, the species *Cyathea walkerae* Hook., as usually interpreted, comprises forms with shallow cup-shaped indusia as well as the normal form with a conspicuous hemitelioid indusium, and I have also seen one with a very small indusium attached to one side of the receptacle and quite hidden by the sporangia. Very small indusia of this type are characteristic of several species in Malaysia (e.g., *C. latebrosa* (Wall.) Copel.); such species were placed in the genus *Alsophila* by Baker and other 19th century taxonomists because with their optical equipment they did not see the indusia. A very similar small indusium occurs in *Alsophila aquilina* Chr. of tropical America. Maxon thought this so different from the indusium of species of *Hemitelia* in tropical America that he saw no obligation to transfer *A. aquilina* to Hemitelia (1928, p. 317). But in Malaysia there is every gradation from very large hemitelioid indusia to very small ones, and nearly all are dark at the base, as that of *A. aquilina*. I wonder therefore whether *Hemitelia* in the American tropics can be clearly distinguished on indusial (or other) characters from Old World species which have been called *Hemitelia*. Among the latter is *H. capensis* (L. fil.) R. Br., which occurs also in South America, so that the distinction is not a geographical one. If a clear distinction can be established between New World *Hemitelia* (in Maxon's sense) and Old World ones, then the former should retain the name *Hemitelia;* but I suggest that it ought to be as a section of the subgenus *Cyathea*. However, a comprehensive monograph of all tropical American species of Cyatheaceae is necessary before the status of such a group can be fairly judged.

Just as I think the cup-shaped (typical *Cyathea*) type of indusium developed on more than one evolutionary line, so also the exindusiate condition developed on various lines by loss of the indusium. In Malaysia one can see every stage of reduction down to complete loss, in the species I have placed in section *Cyathea*. I have not seen such transitions among tropical American species, but I have not attempted a full survey of them. I would only call attention to the remarkably similar vegetative character and scales in the type-species of *Cyathea*, *C. arborea* (L.) Sm., and in the quite exindusiate *Alsophila leucolepis* Mart.; surely these two species must be rather closely related.

The Malaysian species formerly called *Cyathea* in the strict sense have sori completely covered by indusia almost to maturity. In some cases the indusium finally opens at the top and forms a perfect cup with a smooth rim; in other cases the swelling sporangia break the indusium, the final form of which is a cup with torn edges. There are other species the indusia of which superficially resemble this latter condition at maturity.

and have been described as cup-shaped, but which have in fact large indusia of *Hemitelia*-form; an example is *C. oinops* Hassk. of Java. The indusium here is attached only to the costular side of the receptacle but covers the top of the sorus like a hood. In *C. spinulosa* Wall., where the indusium is very thin and is partly lost on breaking, the sori look like a true *Cyathea* when they are young and like *Hemitelia* when they are old; specimens in the latter condition were called *Hemitelia decipiens*.

One fact that puzzles me considerably is that the hemitelioid condition does not occur in subgenus *Sphaeropteris*; one finds only complete indusia which break at maturity (never truly cup-shaped with smooth rim) or none, except in the few cases where there appear to be hybrids, in which various forms of rudimentary indusia occur, but not the hemitelioid condition. This consistent absence of hemitelioid indusia is another indication of the distinctness of subgenus *Sphaeropteris*. But if the *Hemitelia* form of indusium is the primitive form in *Cyathea*, it must have been present in *Sphaeropteris* ancestors, and presumably has died out.

The case of the probable hybrid group called *Cyathea alternans* (Wall.) Pr. is of considerable interest. *C. alternans* is very variable, not only in the extent to which the pinnae are lobed or partially pinnate, but also in the development of the indusium, and there is no clear correlation between indusial form and extent of lobing of the pinnae. Some specimens show quite complete indusia, others every gradation down to a small irregular disc round the base of the sorus (only detectable by very careful observation). The presumed parent species are *C. moluccana* R. Br. (which is simply pinnate and normally has a complete indusium) and *C. squamulata* (Bl.) Copel. (quite exindusiate and fully bipinnate).

Though *C. moluccana* normally has complete indusia, many specimens have been found, especially in Borneo, which are vegetatively like normal *C. moluccana* but have only small fragments of an indusium, much as in some specimens of *C. alternans;* Copeland gave the names *C. pseudobrunonis* and *C. kinabaluen-*

sis to such specimens. It seems to me possible that this may be a case where suppression (or almost complete suppression) of the indusium has passed from one species to another as the result of a long series of hybridization; but I see no indication of the reverse process of the development of an indusium in ferns like *C. squamulata.* The nearest indusiate bipinnate species is *C. assimilis* Hook., but this seems to be quite distinct.

There are tropical American species which (as judged by scale characters) appear to belong to the subgenus *Sphaeropteris;* those I have noted are *C. crassipes* Sod., *C. insignis* Eaton and *C. princeps* (Linden.) Meyer. These are all indusiate (indusia quite covering young sorus, breaking irregularly at maturity) whereas a majority of Malaysian species of subg. *Sphaeropteris* lack indusia. A careful comparison of these tropical American species with Malaysian ones having similar scales seems to me desirable.

After long study of all the many Malaysian *Cyathea* species, I believe I have found natural groupings among them; but I do not see how those groupings can apply to tropical American species. It appears to me that a full monograph of New World Cyatheaceae is much overdue, and I hope someone will find the time and patience to attempt it. Only by such a comprehensive study can inter-relationships within the family be apprehended. The study of a limited number of species may be helpful as a preliminary, but conclusions based on a small sample may not be valid when considering the whole.

LITERATURE CITED

BROWN, ROBERT. 1810. Prodromus Florae Novae Hollandiae. London.

CHRISTENSEN, C. 1934. The ferns of Mt. Kinabalu. Gard. Bull. Str. Settl. **7:** 191–324.

———. 1934. Index Filicum. Suppl. Tertium. Copenhagen.

COPELAND, E. B. 1909. New species of Cyathea. Philip. J. Sci. Bot. **3:** 353–365.

———. 1947. Genera Filicum. Waltham, Mass.

HOLTTUM, R. E. 1957. The scales of Cyatheaceae. Kew Bull. **1957:** 41–45.

———. 1963. Flora Malesiana, Ser. II Pteridophyta, part 2.

——— and U. SEN. 1961. Morphology and classification of the tree

ferns. Phytomorphology **11**: 406–420.
HOOKER, W. J. 1844. Cyatheae, in Species Filicum **1**: 14–55.
MAXON, W. R. 1928. A new tree fern from Haiti. Jour. Wash. Acad. Sci. **18**: 316–317.
SMITH, J. E. 1793. Tentamen botanicum de filicum generibus dorsiferarum. Mem. Ac. Turin **5**: 401–422.
TINDALE, M. D. 1956. The Cyatheaceae of Australia. Contr. N.S.W. Nat. Herb. **2**: 327–361.

KEW GARDENS, RICHMOND, SURREY, ENGLAND.

A New Species and Variety of Bolbitis from India

B. K. NAYAR AND PRAKASH CHANDRA

Recently a detailed morphological study of the genus *Bolbitis* was undertaken by the Pteridology Laboratory of the National Botanic Gardens (India), and in this connection several species of the genus from different parts of India were collected and studied (Nayar, 1960; Kaur, 1962). During November and December, 1962, two new types of *Bolbitis* were collected from the Castle Rock area in the Western Ghats of South India. They were transferred to the fernery of the National Botanic Gardens at Lucknow, along with specimens of *Bolbitis presliana, B. semicordata, B. subcrenata,* and *B. virens.* One of them matches *B. semicordata* (Moore) Ching, except that its rachis and stipe are narrowly winged and the margins of the pinnae are conspicuously lobed. It is described as a variety of *B. semicordata.*

The other is a large fern forming extensive colonies on gravelly soil on the western slopes of the hills in deep shade. This appears to be an unrecorded species and is described below. Herbarium specimens of both new ferns are deposited in the Herbarium of the National Botanic Gardens, Lucknow, India.

BOLBITIS **kanarensis** Nayar & Chandra, sp. nov.

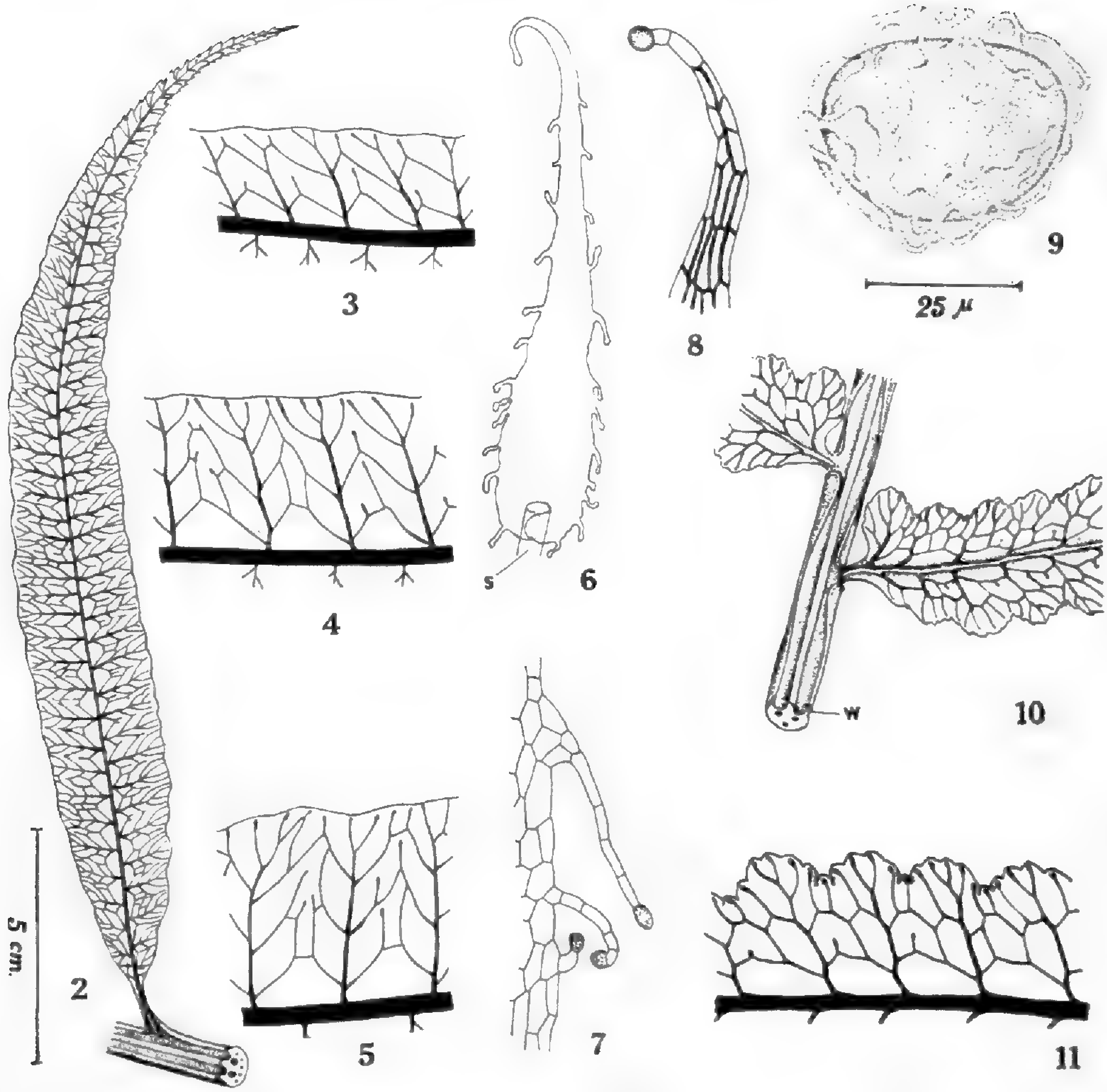
Rhizoma repens ca. 2.5 cm. diam., crassum dense paleaceum, filis sclerenchymatis in pulpa centrali dissitis praeditum; paleae atrofuscae lanceolatae, basi auriculatae, acuminatae, glanduloso-ciliatae; folia bifaria alterna in dorso rhizomatis; frondes steriles ca. 150 cm. longae, pinnatae, apice elongato linguliformi penduli apice bulbifero; stipes usque ad 60 cm. longus, tetragonus, latere adaxiali bicanaliculatus, canalibus in rhachi continuis, basi dense paleatus, aerophoris cariniformibus lateralibus praeditus; pinnae laterales numerosae, inferiores breviter petiolulatae, superiores sessiles, supremae coadunatae, lanceolatae, ca. 25 × 2.5 cm., non gemmiferae, apice acuminatae serratae, basi late cuneatae, margine irregulariter undulatae; lamina plus minusve coriacea, supra atroviridis lucens, subtus pilis atrofuscis parvis sparsis praedita; venae laterales 30–40-jugae (apice excluso) fere usque ad marginem distinctae, venulis secundariis 3 vel 4 utrinque latere, venulis 2 basalibus (raro 3) anastomosantibus, areolis goniopteroideis venulis excurrentibus 1–3 liberis vel unitis et ita areolis primariis in areolis secundariis 2 vel 3 divisis; frondes fertiles usque ad 100 cm. longae (stipite 40 cm. longo incluso), pinnis 10 × 0.2–0.3 cm., linearibus, apice obtusis, terminalibus coadunatis plus minusve prolongatis et saepe gemmiferis; sporae bilaterales 32 × 42 × 32 μ, perino rugoso psilato, exino psilato.

Type in the herbarium of the National Botanic Gardens, Lucknow, India, collected at Gudkewadi, Castle Rock, North Kanara, Mysore, India, alt. 400 meters, Dec. 9, 1962, *P. Chandra 95146.*

Bolbitis kanarensis (Fig. 1) is a large fern, restricted to deeply shaded, moist localities, growing on gravelly soil and forming large colonies on account of its "walking habit." The rhizome is short-creeping, tenaciously attached to the substratum by strong, wiry roots; it is soft, ca. 2.5 cm. thick, and densely paleaceous. The paleae are dark-brown, lanceolate (Fig. 6), acuminate, gland-tipped (Fig. 8) ca. 6 mm. long, basally attached by a broad flat stalk, with small but overlapping basal auricles, and bearing many elongated, multicellular, uniseriate, gland-tipped hairs (Fig. 7) along the margin. The rhizome is parenchymatous, but a few, slender, dark-brown, irregularly cylindrical sclerenchyma strands occur scattered in the pith; sclerenchyma strands generally are absent in the cortex. The stelar cylinder of the rhizome is composed of a broad, slightly curved, ribbon-like, ventral vascular strand and a small, cylindrical dorsal one separated from each other by large, broad, closely placed leaf gaps which alternate on either side. The leaves are in two closely placed alternating rows on the dorsal surface of the rhizome, and a

FIGURE 1. PHOTOGRAPH OF TYPE SPECIMEN OF BOLBITIS KANARENSIS NAYAR & CHANDRA, SP. NOV.

prominent lateral bud is associated with each leaf base on the side away from the median line of the rhizome. The sterile fronds are large, pinnate, upwardly spreading, and with a long, ribbon-like, terminal pinna which often reaches the substratum and roots at the tip. The stipe is up to 60 cm. long and 5 to 6 mm. thick, densely paleate at the base, glossy green and sparsely paleaceous upward, tetragonal (with smoothly rounded corners), and with two closely placed, parallel, adaxial grooves separated by a prominent, slender median ridge. The ridge becomes inconspicuous and the grooves merge into one broad, shallow depression toward the base of the stipe. A pair of prominent, discolored, thin, ridge-like aerating bands (more prominent at the base) occur on both lateral surfaces of the stipe. The lamina is lanceolate in outline. The rachis is up to 80 cm. long, green, sparsely paleaceous, and possesses two broad adaxial grooves separated by a prominent median ridge. The lateral pinnae are numerous, in alternate to subopposite pairs, more or less loosely placed and attached to the lateral margins of the adaxial grooves on either side. The basal pinnae are short-stalked (the stalk 5 mm. long and with a slightly dilated base); the upper are sessile and gradually reduced in size toward the apex of the leaf, the uppermost few pairs being coadunate with the terminal pinna. The larger lateral pinnae are 25 $\times$ 2.5 cm., lanceolate (Fig. 2) and with attenuated, long-acuminate, serrate apices, irregularly wavy margins, and broadly cuneate bases. They are deep green in color, coriaceous in texture, and glabrous above, but bearing brown, glandular hairs all over the lamina and small paleae along the main veins on the lower surface. The midrib is strongly raised on the lower surface; it bears (excluding the acuminate apex of the pinna) 30 to 40 pairs of lateral veins more or less horizontally (Fig. 2). The lateral veins are distinct to the margin of the lamina and bear three to four subopposite or alternate pairs of obliquely placed secondary veins (Figs. 3–5). The basal secondary veins unite in pairs forming two (rarely three) rows of goniopteroid areoles, with one, or usually more, excurrent veinlets in each. The secondary veins are free toward the mar-



FIGURES 2–9, BOLBITIS KANARENSIS; 10–11, B. SEMICORDATA VAR. INCISA. FIGURE 2. LATERAL PINNA. FIGS. 3–5. PARTS OF LAMINA, FIG. 3, FROM NEAR APEX; FIG. 4, NEAR MIDDLE; FIG. 5, NEAR BASE OF PINNA. FIG. 6. PALEA (S, STALK). FIG. 7. MARGIN OF YOUNG PALEA BEARING GLANDULAR HAIRS. FIG. 8. APEX OF MATURE PALEA. FIG. 9. SPORE, EQUATORIAL VIEW. FIG. 10. PART OF RACHIS SHOWING ATTACHMENT OF PINNAE AND WINGS (W) OF RACHIS. FIG. 11. VENATION PATTERN OF PART OF STERILE PINNA OF B. SEMICORDATA VAR. INCISA.

gin and their apices are clavate. The excurrent veinlets are irregular, sometimes uniting with the upper secondary veins and dividing the primary areoles into two or three secondary areoles. In some cases some of the excurrent veinlets from the outermost row of areoles extend to the margin and may unite with an upper secondary vein on that side (Fig. 4). The areoles are irregularly formed and there is often a slight variation in the venation pattern even in the same pinna, but the typically goniopteroid pattern found in *B. subcrenata* rarely occurs. The venation is free in the attenuated apical region of the pinnae. Vegetative buds are absent on the lateral pinnae. The terminal pinna is much elongated, ribbon-like, 20 to 35 cm. long, gradually narrowed toward the apex and bearing a vegetative bud laterally on the dorsal surface of the midrib a few centimeters below the apex. The venation of the terminal pinna is simpler than that of the lateral, with rather distantly placed main lateral veins. The margin is more or less undulate, except at the apex of the pinna, where it is serrate. The outer margins of the dorsal grooves of the rachis merge with the lamina of the terminal pinna.

The fertile fronds are usually smaller than the sterile ones, being up to a meter long, of which the stipe is about 40 cm. The laminae of the pinnae are highly reduced. The larger fertile pinnae are up to 10 cm. long and 2 to 3 mm. broad, linear, with a blunt apex and parallel sides. The lower are short-stalked. The terminal pinna is coadunate, up to 10 cm. long, and often bears a vegetative bud as on the sterile leaves. Sporangia occur over all of the lower surface except on the midrib and the main lateral veins. The annulus is 16 to 18 cells long. The spores (Fig. 9) are bilateral, measuring $32 \times 42 \times 32\ \mu$ ($P \times E_1 \times E_2$, exclusive of the perine), with a prominent, smooth perine which is folded into short, thin, sinuous ridges.

Bolbitis kanarensis resembles *B. virens*, but can be distinguished by its larger size, distinctive venation of the sterile leaf, and by the size and morphology of the spores (Nayar & Kaur, 1963).

BOLBITIS SEMICORDATA var. **incisa** Nayar & Chandra, var. nov.

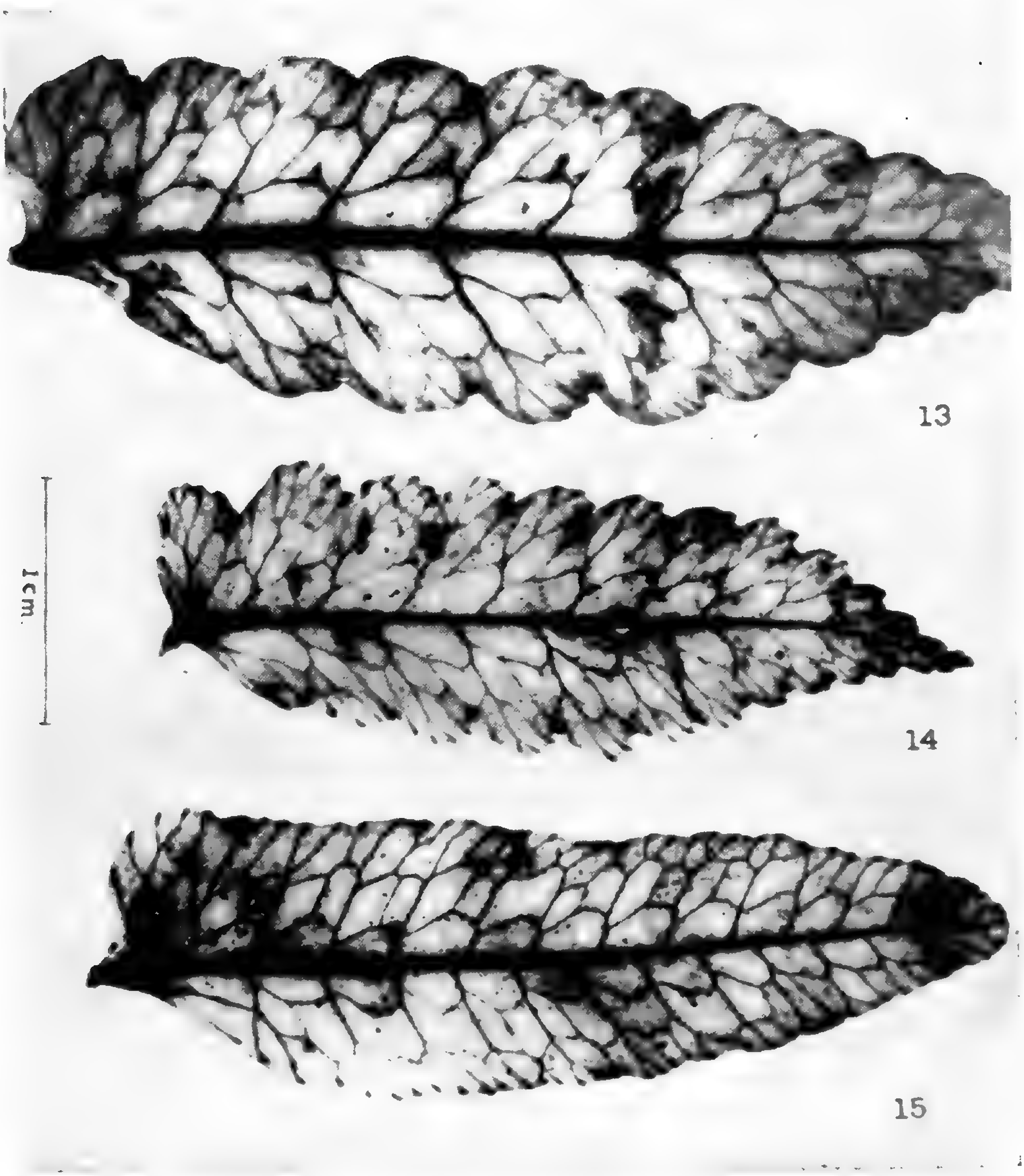
Rhizoma breviter repens dorsiventrale, ca. 1 cm. diam., filis sclerenchymatis in pulpa centrali paucis praeditum; stipes frondium sterilium 15–20 cm. longus tetragonus, basi dense paleatus, sursum parce paleatus, sursum latere adaxiali utrinque anguste alatus; lamina sterilis lanceolata, 25–30 × 12 cm., pinnis lateralibus alternis sessilibus, 6 × 1.5 cm., acutis, basi superiore truncata vel auriculata, margine in lobis crenatis semicircularibus incisis, supremis in pinnam paullo elongatam sub apice gemmiferam coadunatis; rhachis in latere abaxiali laeviter rotundata, in adaxiali utrinque anguste alata; venatio goniopteroidea, areolis saepe bifariis serie secundaria per venulam tertiariam venulis primariis parallelem in areolam superiorem majorem (saepe cum venula libera inclusa) et in areolam inferiorem majorem (sine venula inclusa) divisa, venis ultra seriem areolarum secundariarum liberis margine attingentibus; frondes fertiles usque ad 40 × 2 cm., apice obtusae, pinna terminali lateralibus simili; sporae bilaterales, perino granulato in lobis conicis rugosae.

Type in the herbarium of the National Botanic Gardens, Lucknow, India, collected at Gudkewadi, Castle Rock, North Kanara, Mysore, India, alt. 400 meters, Dec. 9, 1962, *P. Chandra 95145.*

Bolbitis semicordata var. *incisa* (Fig. 12) is a small fern easily distinguished from *B. semicordata* (Moore) Ching var. *semicordata* (see Copeland, 1928) by its lobed pinnae and winged rachis. It grows in small clumps on moist, rocky substrata. The rhizome is short-creeping, dorsiventral, and tenaciously attached to the substratum by strong wiry roots. It is ca. 1 cm. thick, more or less soft and brittle, and has a few, rather thick, dark-brown to blackish, sclerenchyma strands scattered in the ground tissue. The ventral vascular strand is broadly gutter-shaped. The paleae are small, lanceolate, basally attached, and pseudopeltate owing to the prominent overlapping basal auricles. The leaves are more or less crowded in two alternating rows on the dorsal surface of the rhizome, and associated with each leaf is a vegetative bud posteriorly lateral to the leaf-base on the side away from the median line of the rhizome. The stipe of the sterile frond is 15 to 20 cm. long, ca. 2 mm. thick, tetragonal, densely paleate at the base, and sparsely so upward. Aerating strands form prominent ridges on each side toward the base. The adaxial surface is nearly flat in the basal half, but gradually becomes strongly ridged upward, the ridge being continuous on the rachis. On either adaxial margin of the stipe is

FIGURE 12. PHOTOGRAPH OF TYPE OF BOLBITIS SEMICORDATA VAR. INCISA.

a prominent, narrow wing that tapers gradually downwards and becomes inconspicuous nearly halfway down the stipe. The wing is prominent and continuous on the rachis except for interruptions at the insertion of the lateral pinnae, and curved upward so as to form two dorsal grooves, one on either side of the median ridge of the rachis (Fig. 10). The lamina is lanceolate in outline, broadest slightly above the base, 25 to 30 cm. long, and ca. 12 cm. wide. The rachis is rounded on the lower surface; the upper has a prominent slender median ridge and two narrow grooves on each side of it. The lateral pinnae are alternate, sessile, or the lower ones short-stalked, oblong-lanceolate, ca. 6×1.5 cm., acute or rarely more or less acuminate at the apex, and devoid of vegetative buds. The bases of the pinnae are unequal. The upper base is more or less auricled and often overlapping the rachis on its lower surface; the lower base is obliquely cuneate (Figs. 13–15). The pinnae are generally reduced towards the apex of the leaf, the uppermost often being coadunate with the terminal pinna. The terminal pinna is more or less elongated, but not ribbon-like, and often bears a dorsal vegetative bud on the midrib a little below the apex. The margins of all the pinnae are prominently lobed, with the lobes nearly semicircular and the incisions between them extending nearly a quarter of the way to the midrib (Figs. 13, 14). Each marginal lobe corresponds to a main lateral vein of the lamina. The ultimate margin is crenate, each tooth receiving one of the free ending veinlets. Usually there is a prominent tooth at the bottom of the incision between the marginal lobes. This is usually red-tinged and curved towards the upper surface of the leaf, recalling the seta in some species of *Egenolfia* (Copeland 1947; Kaur, 1960; Holttum, 1954). The midrib is strongly raised on the lower surface and forms a blunt ridge on the upper surface. This ridge interrupts the lateral wing of the rachis at the base, but is not continuous with the median ridge of the rachis. The lateral veins are in subopposite or alternate pairs, ca. 5 mm. apart, distinct to the margin, and slightly raised on the upper surface. The areoles are generally in two rows on each side of the mid-



Figures 13–15. Lateral Pinnae of Bolbitis semicordata. Figs. 13, 14. B. semicordata var. incisa. Fig. 15. Bolbitis semicordata var. semicordata.

rib; the costal areoles are large and the second row often is divided longitudinally into two, with the anterior secondary areole sometimes having a small excurrent, included veinlet. Beyond the second row of areoles there are many excurrent veinlets that are nearly parallel, extend to the margin, and have clavate tips. Both surfaces of the lamina are glabrous. There are a few narrow paleae on the ventral surface, where the pinnae are attached to the rachis.

The fertile fronds are seasonal, and up to 40 cm. long, including the stipe which is ca. 15 to 20 cm. long. The fertile pinnae are up to 4 cm. long and 2 mm. broad, with bluntly rounded apices. The terminal pinna is small and resembles the lateral ones. The wing on the rachis of the fertile frond is not prominent. The spores are bilateral, $25 \times 37 \times 28\mu$ ($P \times E_1 \times E_2$, exclusive of the perine), and with a prominent, faintly granulate perine which is folded into a few obconical lobes.

Bolbitis semicordata var. *incisa* differs from var. *semicordata* in the deeply lobed margins of its pinnae (see Figs. 14, 15), and in having a prominently winged rachis. Both varieties grow together in localities where they are restricted to deeply shaded forest beds, growing generally on rocky substrata or on gravelly soil, and forming small clumps.

We gratefully acknowledge the keen interest evinced in the work by Professor K. N. Kaul, and C. V. Morton's help in preparing the Latin descriptions.

LITERATURE CITED

COPELAND, E. B. 1928. *Leptochilus* and genera confused with it. Phil. Jour. Sci. **33**: 33–416.

———. 1947. Genera Filicum. Waltham, Mass.

HOLTTUM, R. E. 1954. Flora of Malaya. II. Ferns. Singapore.

KAUR, S. 1962. *Bolbitis*, *Egenolfia*, and related ferns. Ph. D. Thesis. Agra University.

NAYAR, B. K. 1960. Morphology of two Indian species of *Bolbitis*. Jour. Indian Bot. Soc. **39**: 259–277.

———, AND KAUR, S. 1963. Spore morphology of some Indian members of the Lomariopsidaceae. Pollen et Spores. **5**: 87–94.

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The Effect of Sucrose on Apogamy in Cyrtomium falcatum Presl[1]

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The phenomenon of apogamy provides an excellent opportunity to study the direct origin of a vascular plant from a nonvascular fern gametophyte. Besides the investigation of the change from the gametophytic to the sporophytic developmental pattern, apogamy which is a deviation in the normal life cycle provides a site to study the factors controlling the alternation of generations.

Studies by Whittier and Steeves (1960, 1962) have demonstrated a new method for controlling induced apogamy, i.e. the formation of a sporophyte directly from the vegetative cells of a gametophyte which is able to form sporophytes by fertilization under other conditions. Several species of fern gametophytes grown in sterile culture on nutrient media containing suitable concentrations of sugar produce apogamous sporophytes. In the absence of sugar no apogamous plants are formed by the gametophytes. The availability of supplementary sugar to the gametophytes has a direct relationship to the formation of the apogamous plants.

Obligate apogamy, i.e. the formation of a sporophyte directly from the vegetative cells of a gametophyte which is unable to form sporophytes by fertilization, has been described in many ferns, but this type of apogamy has been the subject of few experimental investigations. In one such study with *Pteris cretica* L., Bell (1959) reported apogamy occurred sooner on prothalli supplied with sugar than others without sugar. In view of this report and the effect sugar has on induced apogamy, this study was undertaken to determine if sugar influences obligate apogamy other than accelerating its appearance.

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[1] This investigation was carried out with assistance from the Virginia Agricultural Experiment Station and the University of Virginia, Mountain Lake Biological Station.

Materials and Methods

Cyrtomium falcatum Presl. was chosen for this study because the spores of this ferns were readily available and the development of the apogamous plant had been described (DeBary, 1878; Allen, 1914).

The spores were wetted with a 0.1% solution of Tween 80 and exposed to a 15% Clorox solution for two minutes to sterilize them. The sterile spores were collected on filter paper, washed several times with sterile water and suspended in sterile water. The spores were innoculated into square one ounce bottles containing 15 cc of nutrient medium. The nutrient medium was composed of Knudson's solution of mineral salts, minor elements and 0.5% agar. This medium differed from the one reported by Whittier and Steeves (1960) in that the iron was supplied as ferric sodium ethylenedianime tetra-acetate (Fe-EDTA) instead of ferric citrate. In a preliminary experiment the fastest growth took place on a medium containing 2.5% sucrose, therefore this concentration along with 0, 0.5 and 6.0% were employed in this investigation. The cultures were maintained at a temperature of $24 \pm 1°$ C with 12 hours of illumination every 24 hours from Sylvania Gro-Lux lamps at an intensity of ca. 100 foot-candles. The remaining sterile culture techniques were those employed by Whittier and Steeves (1960).

The area of the gametophytes was found with a microprojector and a polar planimeter. Tracings of the projected prothallial images were measured with the polar planimeter. The mean area of twenty gametophytes was employed as a measure of prothallial growth. The size of the gametophytes undergoing initial apogamy was determined by calculating the mean area of twenty prothalli with early stages of apogamous development. The mean cell size of the gametophytes was found by dividing the cell number of twenty similar sized gametophytes into the area of these gametophytes. A T—test was employed to determine if the differences between the responses on the concentrations of sucrose were significant.

RESULTS

The spores on all concentrations of sucrose germinated the seventh day after innoculation. The least growth took place on the medium without sugar and the largest growth on the 2.5% sucrose medium (Table I). The differences between the growth on the various media were significant at the 5% level.

TABLE I. THE EFFECT OF SUCROSE ON APOGAMY AND THE GAMETOPHYTE OF CYRTOMIUM FALCATUM.

Sucrose %	Mean Prothallial Size in Sq. mm 37th Day	Mean Prothallial Size in Sq. mm Initial Apogamy	Day First Apogamy	Mean Cell Size Sq. mm.
0.0	0.43±0.02[1]	2.15±0.04[1]	41st	0.0021±0.0001[1]
0.5	1.45±0.09	1.85±0.04	35th	0.0021±0.0001
2.5	1.89±0.08	1.46±0.02	30th	0.0022±0.0001
6.0	0.80±0.05	1.05±0.03	36th	0.0023±0.0001

[1] Standard error of mean.

The prothallial development proceeded normally from the filamentous to the cordate stage. Some time after the cordate shape was attained a pale green area, which later turned brown, appeared a short distance behind the sinus. This pale green region formed behind the sinus after the cordate prothallus had become more than one cell thick in that area. Although this light region was not initially apogamous, it was considered the first stage leading to apogamous development because the apogamous sporophyte originated from the cells of this area. The initiation of the apogamous plant occurred once the pale green area had become a few cells thick.

On the 30th day the apogamous development was initiated on the 2.5% sucrose medium (Table I). This was five or six days earlier than on the other sucrose media and eleven days before apogamy started on the medium lacking sugar. At the time the apogamous plants were being initiated on the 2.5% medium, none of the prothalli without exogenous sugar were more than one cell thick or beyond the early cordate stage.

The decrease in the size of the prothalli undergoing initial apogamy with the increase in the sucrose concentration was significant at the 5% level (Table I). The mean cell size of the prothalli on the various sugar concentrations did not vary significantly from each other (Table I). Since the prothallial size is determined by the cell number and cell size, the decrease in prothallial size was due to a reduction in the number of cells per gametophyte because the mean cell sizes were not significantly different.

DISCUSSION AND CONCLUSIONS

The growth rate of the prothalli was increased significantly above the rate on no sugar by the addition of sucrose to the medium, although at 6.0% sucrose the growth decreased significantly from that on 2.5% sucrose. This decrease in growth on the high concentration of sugar probably was due to the high osmotic potential of the medium interfering with the growth. This has been found to be true in other studies on the growth of gametophytes in sterile culture (Mitra & Allsopp, 1959; Whittier, 1962).

Besides the change in growth rate the size of the prothalli undergoing initial apogamy decreased significantly as the concentration of sugar increased. This observation does not support Bell (1959) who reported no change in gametophyte size undergoing apogamy on different concentrations of sugar. This difference in size was due to a reduced number of cells in the gametophytes because the mean cell sizes on the various concentrations of sugar were the same. Consequently, less growth and fewer cell divisions were required for the prothalli to initiate apogamy on the media containing sugar.

In terms of the number of days for the occurrence of apogamy, it was initiated on the 2.5% sucrose medium about 15% sooner than on the other sucrose media and 25% sooner than on the medium without sugar which is in agreement with Bell's report on *P. cretica* (1959). This was due to the gametophytes on the 2.5% sucrose medium having the fastest growth and a small prothallial size which would produce apogamy. It can be concluded that the time necessary for obligate apogamy is determined by the growth rate and the prothallial size undergoing apogamy on any concentration of sucrose.

The sugar brought about the requisite conditions for obligate apogamy in the gametophyte sooner with fewer cell divisions and less prothallial growth. One of the required conditions is the thickening of the gametophyte which always precedes the development of the light green area behind the sinus and the apogamous plant. In other species the thickening of the prothallus before the initiation of the obligate apogamous plant has been reported (Duncan, 1943). Also, a thickened prothallial growth is necessary for induced apogamy (Whittier, 1962; Whittier & Steeves, 1960). Thus, the thickening of the gametophyte is a requisite condition for both types of apogamy. In sterile culture the thickening necessary for induced apogamy, which is many times the thickening required for obligate apogamy, is controlled by the sugar in the medium. Without sugar the necessary thickening of the gametophyte for induced apogamy is absent, and apogamy fails to occur. The supplementary sugar causes the thickening required for induced apogamy and accelerates the normal thickening preceding obligate apogamy probably by modifying the carbohydrate metabolism of the prothallus.

LITERATURE CITED

ALLEN, R. F. 1914. Studies in spermatogenesis and apogamy in ferns. Trans. Wis. Acad. **17**: 1–44.

BELL, P. R. 1959. The experimental investigation of the pteridophyte life cycle. Jour. Linn. Soc. Bot. **56**: 188–203.

DEBARY, A. 1878. Über apogame Farne und die Erscheinung der Apogamie im allgemeinen. Bot. Zeit. **76**: 449–487.

DUNCAN, R. E. 1943. Origin and development of embryos in certain apogamous forms of *Dryopteris*. Bot. Gaz. **105**: 202–211.

MITRA, G. C. & A. ALLSOPP. 1959. II. The effects of sugar concentration on the development of the protonema and bud formation in *Pohlia nutans* (Hedw.) Lindb. Phytomorphology **9**: 64–71.

WHITTIER, D. P. 1962. The origin and development of apogamous structures in the gametophyte of *Pteridium* in sterile culture. Phytomorphology **12**: 10–20.

WHITTIER, D. P. & T. A. STEEVES. 1960. The induction of apogamy in the bracken fern. Canad. Jour. Bot. **38**: 925–930.

————. 1962. Further studies on induced apogamy in ferns. Canad. Jour. Bot. **40**: 1125–1131.

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Ferns and Fern Allies of Pine Hills Field Station and Environs (Illinois)

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This is one in a series of studies which have emanated from the Southern Illinois University Field Station. A check-list of vascular plants has been prepared (Mohlenbrock & Voigt, in press). The study of the ferns and their allies of the area was completed during the summer of 1961 when the junior author participated in a National Science Foundation Research Participation Program.[1,2] The authors are grateful to the graduate council of Southern Illinois University for assistance in this study.

THE PINE HILLS AND ENVIRONS

Two representative areas were chosen for exhaustive study of the fern and fern ally groups native to the Pine Hills and its environs. These areas were the Pine Hills Recreation Area and the adjoining Union County Forest Preserve. Both areas are located in the Shawnee Hills of Southern Illinois.

Pine Hills Recreation Area is approximately 37 miles from Carbondale, Illinois, off of Illinois Route 3. The territory covered in the survey extended from the second set of railroad tracks on the Aldridge Levee Road to Hutchins Creek, and from the Pine Hills Recreation Area entrance to the edge of Otter Pond. All of the roads, trails, picnic areas, and the penetrable interior of the Recreation Area were covered.

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[1]N. S. F. Grant 16,180.

[2]Contribution from the Pine Hills Field Station and the Department of Botany, Southern Illinois University.

A less intensive search of the Union County Forest Preserve was conducted since there was considerable uniformity in ecological habitats in this area. Collections were made along roads, fire trails, picnic areas and a portion of the lower interior region near the entrance.

History of Fern Collecting in the Pine Hills Area

Prior to June, 1961, only nine species of ferns had been reported from the Pine Hills Recreation Area. These were: *Asplenium pinnatifidum* (Hatcher, Oct. 21, 1949); *A. resiliens* (Hatcher, Oct. 21, 1949); *Athyrium pycnocarpon* (Mohlenbrock, July 1, 1954); *Dryopteris marginalis* (Evers, Oct. 2, 1948); *Onoclea sensibilis* (Mohlenbrock, July 1, 1954); *Pellaea atropurpurea* (Hatcher, Oct. 21, 1949); *Polypodium polypodioides* (Hatcher, Oct. 8, 1949); *Polystichum acrostichoides* (Mohlenbrock, July 12, 1954); and *Woodsia obtusa* (Hatcher, May 28, 1954). Six additional species had been found near the Pine Hills area. Five of these were collected in the Union County Forest Preserve. They were: *Adiantum pedatum* (Sanders, June 26, 1952; *Asplenium platyneuron* (Kaeiser, Spring of 1952); *Dryopteris austriaca* var. *intermedia* (Sanders, April 7, 1952; *D. austriaca* var. *spinulosa* (Hatcher, May 21, 1949); and *Botrychium dissectum* var. *obliquum* (Swayne and Bailey, Sept., 1949). *Azolla mexicana* (Bailey, Sept. 22, 1947), was found floating on the waters of Wolf Lake.

During the present study, 12 species previously unreported from the Pine Hills-Union County Forest Preserve were found: *Asplenium trichomanes, Athyrium filix-femina, A. thelypterioides, Botrychium virginianum, Camptosorus rhizophyllus, Cheilanthes feei, C. lanosa, Cystopteris bulbifera, C. fragilis, Thelypteris hexagonoptera, Ophioglossum vulgatum,* and *Pteridium aquilinum.* Only one fern ally, *Equisetum hyemale*, was found.

Ecology of Southern Illinois Ferns and Fern Allies

The ferns and fern allies of Southern Illinois that occur in our areas are listed in Table 1, with check marks to show their usual environmental habitats. Table 2 lists ferns known from Southern Illinois, but not yet found in the Pine Hills-Union County Forest Preserve areas.

TABLE 1

FERNS AND FERN ALLIES OF SOUTHERN ILLINOIS KNOWN TO OCCUR IN THE PINE HILLS RECREATION AREA AND THE UNION COUNTY FOREST PRESERVE, IN RELATION TO HABITAT

	Dry woodlands Open fields	Limestone rock Calcareous soil	Sandstone rock	Wet rocks and ledges	On tree trunks	Moist woodlands	Ditches Stream beds	Ponds and stagnant water	Swamps and swamp margins
Adiantum pedatum						x			
Asplenium pinnatifidum			x						
Asplenium platyneuron		x				x	x		
Asplenium resiliens		x							
Asplenium trichomanes		x							
Athyrium filix-femina	x					x	x		
Athyrium pycnocarpon				x		x			
Athyrium thelypterioides						x			
Azolla mexicana								x	
Botrychium dissectum	x					x	x		
Botrychium virginianum	x					x			
Camptosorus rhizophyllus		x	x		x				
Cheilanthes feei		x							
Cheilanthes lanosa			x	x					
Cystopteris bulbifera		x				x			
Cystopteris fragilis				x		x			
Dryopteris austriaca						x	x		
Dryopteris marginalis				x		x			
Equisetum hyemale							x		
Onoclea sensibilis	x								x
Ophioglossum vulgatum	x								
Pellaea atropurpurea		x							
Polypodium polypodioides				x	x				
Polystichum acrostichoides	x					x			
Pteridium aquilinum	x								
Thelypteris hexagonoptera						x			
Woodsia obtusa				x					

The Pine Hills Field Station is a region of limestone bluffs, moist woodlands, and swamps. It provides a variety of ecological habitats for ferns and fern allies, limited primarily by the extreme temperature ranges (—22 to 106°F.) in southern Illinois. High temperatures during the summer cause a correspondingly high transpiration rate in the plants during the time when water supplies in the soil and creeks are diminishing. Plants that survive this seasonal drought must either be adapted to high temperatures or grow in cooler, moister habitats. The woodland and water ferns are examples of plants that occur in a more temperate environment. The woodland ferns grow in moist, shaded sites, protected from direct sunlight most of the day. They tend to be tall, dark green, and delicate in texture and cutting of leaves.

Aquatic ferns have an even greater water requirement than do woodland ferns. They grow in or on the surface of still, shallow ponds or at the swamp's edge. *Equisetum* frequently grows near creeks and rivers, not so much because it needs a great quantity of water, but because it requires large amounts of silica found in the sand and gravel of creek banks. For this reason, *Equisetum* is also common on sandstone rocks and beside well-graveled railroad tracks.

The rock ferns have become adapted to extremes in temperature. Ferns best able to live in xerophytic or desert-like conditions grow on limestone. They are protected from excessive transpiration by having thin, wiry stems and small leaves protected either by a covering of hairs or by a thick, leathery cuticle —or both. The smaller size of the plants enables them to expose less surface from which water escapes, while a thick cuticle helps to keep moisture inside the plant. Ferns that can survive with little water but not able to exist on the desert-like limestone outcrops may grow well on wet limestone, dry sandstone, or bluff-top woods. They tend to grow in mats, transpiring mainly from the undersides of their leaves and partially trapping water vapor between their bodies and the rock, thus reducing the desiccation of their leaves. They also have a cuticle and thin

TABLE 2

FERNS AND FERN ALLIES OF SOUTHERN ILLINOIS NOT FOUND IN THE PINE HILLS RECREATION AREA AND THE UNION COUNTY FOERST PRESERVE, IN RELATION TO HABITAT

	Dry woodlands Open fields	Limestone rock Calcareous soil	Sandstone rock	Wet rocks and ledges	On tree trunks	Moist woodlands	Ditches Stream beds	Ponds and stagnant water	Swamps and swamp margins
Asplenium bradleyi			x						
Dennstaedtia punctilobula				x					
Equisetum arvense							x		
Equisetum laevigatum							x		
Isoetes butleri			x						
Isoetes melanopoda							x		
Lycopodium complanatum			x						
Lycopodium lucidulum			x			x			
Marsilea quadrifolia								x	
Ophioglossum engelmannii		x							
Osmunda cinnamomea				x					
Osmunda claytoniana				x					
Osmunda regalis				x					
Pellaea glabella		x							
Polypodium vulgare				x			x		
Selaginella apoda						x			
Selaginella rupestris			x						
Thelypteris noveboracensis						x			
Thelypteris palustris									x
Trichomanes boschianum				x					

stipes, but these features are not as highly developed in the sandstone and acid soil ferns.

Rock ferns are scattered throughout bluff-top areas of the upper Pine Hills road. They are abundant nowhere, but the greatest variety of them occurs on land of the Southern Illinois University Field Station.

The woodland ferns grow tallest and are most prolific on damp, wooded hillsides and along ditches or creeks. The best area for these ferns is near the picnic grounds at the entrance to the Pine Hills. At the Union County Forest Preserve they are abundant in all the shaded areas. Aquatic ferns occur on the wet mud or on the surface of swamps and ponds of the Pine Hills. A colony of *Equisetum hyemale*, the only fern ally found in the Pine Hills, grows on the banks of Big Muddy River near the railroad tracks.

LOCAL DISTRIBUTION OF SOUTHERN ILLINOIS FERNS

OPHIOGLOSSUM—ADDER'S TONGUE FERN

These are short, green ferns, often overlooked because of their small size. They have an erect, scaleless rhizome with a smooth, fleshy stipe and an entire leaf blade. Arising at a point about half way up the stem is a fertile stalk bearing sporangia distally. The gametophytes are tuberous and exist underground for long periods. In the spring, the young sporophytes push straight up from the soil, unlike most ferns which arise in a coiled position.

OPHIOGLOSSUM VULGATUM L. Adder's Tongue Fern.—Local in moist woods throughout southern Illinois. A colony of var. *pycnostichum* Fern. occurs in a frequently inundated woods near Winter Pond in the Pine Hills. Variety *pseudopodum* (Blake) Farwell, not known to occur in the Pine Hills, is known from only a single station in southern Illinois.

OPHIOGLOSSIUM ENGELMANNII. Prantl. Limestone Adder's Tongue Fern.—Unknown from the Pine Hills Area, although to be expected on limestone ledges. Known from Randolph, Johnson, and Hardin counties.

BOTRYCHIUM—GRAPE FERN

Both species of *Botrychium* found in southern Illinois grow in the Union County Forest-Pine Hills area. In our region, they are usually about 8–12 inches tall, with cut or lobed sterile blades. In one species, the leaves turn bronze-colored in the fall. They have a soft, fleshy stipe and a short, erect rhizome as in *Ophioglossum*, but their leaf veins are open and forked, unlike the closed veins of *Ophioglossum*.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Rattlesnake Fern.—Abundant in moist woods or dry shaded areas throughout southern Illinois.

BOTRYCHIUM DISSECTUM Spreng. Grape Fern.—Two varieties occur in southern Illinois, the much-divided var. *dissectum,* and the less-divided and more common var. *obliquum* (Muhl.) Clute. Variety *dissectum* is restricted to moist woods, while var. *obliquum* occurs also in dry open fields and ditches.

OSMUNDA—ROYAL FERN

No representatives of this genus have been found in the Pine Hills area, although *O. regalis, O. cinnamomea,* and *O. claytoniana* are known from southern Illinois. Members of this group have scaleless rhizomes and fibrous roots.

OSMUNDA REGALIS L. Royal Fern.—Only var. *spectabilis* (Willd.) A. Gray is found in southern Illinois. It differs from var. *regalis* in the absence of black hairs from the stems. Native in swamps, bogs, and on very wet ledges, although in southern Illinois it inhabits moist sandstone ledges.

OSMUNDA CLAYTONIANA L. Interrupted Fern.—Reported from Union County in 1955, where it is very rare. It usually grows in moist woods and along swamp margins, although it occurs on sandstone ledges in southern Illinois. It has not been collected in the Pine Hills.

OSMUNDA CINNAMOMEA L. Cinnamon Fern.—Occasionally on damp ledges in southern Illinois. It is rare in this part of the state and unknown from the Pine Hills.

TRICHOMANES—FILMY FERN

In Illinois this genus has been collected only in Pope and Johnson counties. *Trichomanes boschianum* Sturm has a scaleless, branching rhizome with black root hairs. Its leaves are very fragile, being only one cell thick. They are cut into about six overlapping divisions. A distinctive feature is the character of its sori, with their tubular indusium with its included hairlike bristle. The fern grows only in damp acid soil in caves or in pockets on sandstone cliffs.

Azolla—Mosquito Fern

Azolla mexicana Schlecht. & Cham., the only species reported from southern Illinois, is a tiny, moss-like plant floating on the swamp waters in the Pine Hills area. A cluster of this little fern is about as large as a thumbnail. It has branched rhizomes, tiny, twice-lobed leaves, and sporocarps at the leaf bases. The fronds often become reddish in late summer.

Marsilea—Pepperwort

Marsilea quadrifolia L. is also an aquatic. It has been found twice in southern Illinois, both times in ponds in Carbondale. It has a branched rhizome rooting at the nodes, a frond that resembles a four-leaf clover, twice-branched veins, and sporocarps at the base of the leaf stalks, with each sporocarp containing several spore cases.

Adiantum—Maidenhair Fern

Adiantum pedatum L.—Common in the Pine Hills area, and usually grows in wooded areas along streams and occurs commonly throughout southern Illinois.

Asplenium—Spleenwort

Four of the five species of this genus that occur in southern Illinois grow in the Pine Hills area. Only *A. bradleyi* is absent.

Asplenium bradleyi Eaton. Bradley's Spleenwort—On sandstone in southern Illinois; known only from Piney Creek (Jackson and Randolph Counties) and Panther's Den (Union County).

Asplenium pinnatifidum Nutt. Pinnatifid Spleenwort.—This fern usually grows on non-calcareous rocks. It was reported from the Pine Hills in 1949, but was not found during our survey. It is rather infrequent even in sandstone areas. The degree of leaf-cutting is variable.

Asplenium platyneuron (L.) Oakes. Ebony Spleenwort.—The slightly serrated forma *platyneuron* is the more common form in our area. Forma *serratum* (E. S. Miller) Hoffm. is a minor variation with deeply jagged-serrate pinnae. Both forms grow in moist woods, ditches, and on wet rocks throughout southern Illinois.

ASPLENIUM RESILIENS Kunze. Black Spleenwort.—This species is distinguished from *A. platyneuron,* with which it is often confused, by its black rachis and opposite pinnae. It grows in calcareous soils and on limestone rock in the Pine Hills. It is unknown elsewhere in Illinois.

ASPLENIUM TRICHOMANES L. Maidenhair Spleenwort. This fern is distinguished from *A. resiliens* by its smaller size, purple stipe, and non-auriculate rounded pinnae. It is found on limestone rock and in calcareous soils of the Pine Hills and elsewhere in Southern Illinois. It occurs occasionally on sandstone.

ATHYRIUM—LADY FERN

All three species of this genus known from southern Illinois occur in the Pine Hills area.

ATHYRIUM FILIX-FEMINA (L.) Roth. Lady Fern.—Only var. *michauxii* Farwell has been found in southern Illinois. It has black basal scales on the stipe, stalked glands, sori that are long, narrow, and slightly hooked apically, and a frond with the fourth or fifth pair of pinnae the largest. It is found near the Pine Hills Research Station and in many other parts of southern Illinois. It has not been found in Union County Forest. It grows in moist woods, in fields, and along stream banks.

ATHYRIUM PYCNOCARPON (Spreng.) Tidestr. Narrow-leaved Spleenwort.—In moist woods of Pine Hills, Union County Forest, and elsewhere in southern Illinois.

ATHYRIUM THELYPTERIOIDES (Michx.) Desv. Silvery Spleenwort.—In moist woods of Pine Hills, Union County Forest, and other parts of southern Illinois.

CHEILANTHES—LIP FERN

Both species of *Cheilanthes* reported from southern Illinois occur in the Pine Hills. They are small, rock-inhabiting ferns.

CHEILANTHES FEEI Moore. Slender Lip-fern.—In calcareous soils and on limestone rocks of Pine Hills and various other parts of southern Illinois. Not abundant.

CHEILANTHES LANOSA (Michx.) D. C. Eaton. Hairy Lip-fern. —On dry rocks and shale outcroppings in Pine Hills and elsewhere in southern Illinois. It is distinguished from *C. feei* by its larger size and less dense, whitish, jointed hairs.

CAMPTOSORUS—WALKING-FERN

This genus produces plantlets where the attenuated tips of the leaves touch the ground. The genus is closely related to *Asplenium;* some pteridologists consider the two genera to be the same. The only North American species, *C. rhizophyllus* (L.) Link, occurs in both limestone and sandstone areas throughout southern Illinois.

CYSTOPTERIS—FRAGILE FERN

Two species of this genus grow in southern Illinois, and both occur in the Pine Hills Area.

CYSTOPTERIS BULBIFERA (L.) Bernh. Bulblet Bladder Fern.—On limestone rocks and in calcareous soils of southern Illinois, including the Pine Hill area. It can be distinguished from *C. fragilis* by the bulb-like structures on the rachis and by having veins that run to the sinuses rather than to the teeth of the leaflets.

CYSTOPTERIS FRAGILIS (L.) Bernh. Fragile Fern.—Three varieties grow in southern Illinois. *Cystopteris fragilis* var. *mackayi* Lawson has a short rhizome and subleaflets without a petiolule and with a cleft tip; var. *protrusa* Weatherby has a long-creeping rhizome and basal subleaflets petiolulate. *Cystopteris fragilis* var. *fragilis* has rhizomes similar to those of var. *mackayi,* but the sori in var. *fragilis* are nearly twice as large as those of var. *mackayi,* these structures being only about 0.5 mm. wide in var. *mackayi.* All three varieties are found in the Pine Hills Recreation Area and in Union County Forest Preserve.

DENNSTAEDTIA—HAY-SCENTED FERN

This genus is not present in the Pine Hills area. These ferns have scaleless branching rhizomes, smooth stipes, and much divided fronds that have an odor like hay. The sori are protected by a white, cup-like indusium. Only *D. punctilobula* (Michx.) Moore occurs in southern Illinois.

DRYOPTERIS—SHIELD FERN, WOOD FERN

Two species, one represented by two varieties, occur in the Pine Hills Area. All are ferns of moist woodland habitats.

DRYOPTERIS AUSTRIACA (Jacq.) Woynar. Spinulose Shield Fern.—The two varieties are briefly characterized by the following key:

Rhizome thick, suberect; stipe medium brown; subleaflets prominently lobed, the lowermost shorter than the next ones above; sori part way back from tips of veins.......... var. *intermedia*
Rhizome creeping; stipe stramineus to green; subleaflets slightly lobed, the lowermost longer than others; sori at tips of vein or nearly so. var. *spinulosa*

Both varieties occur in Union County Forest, although neither is plentiful. They grow best in moist woods or along stream banks and ditches.

DRYOPTERIS MARGINALIS (L.) A. Gray. Marginal Shield Fern. —Considerable variation occurs in leaf morphology. This species grows in moist woods in southern Illinois. It was reported from the Pine Hills in 1948, but was not found during our survey. It is unknown in the Union County Forest Preserve.

ONOCLEA—SENSITIVE FERN

ONOCLEA SENSIBILIS L. Sensitive Fern.—This is a weedy fern in woodlands and along swamp margins of the Pine Hills area. It is the only species of the genus known from southern Illinois.

PELLAEA—CLIFFBRAKE

One of the two species native in southern Illinois is represented in the Pine Hills area. Members of this genus have shiny, wiry, red or purple stipes, leathery, once- to thrice-cut fronds, and sporangia borne near the margins and covered by the incurved edges of the leaves. *Pellaea* grows only on calcareous rocks in our area.

PELLAEA ATROPURPUREA (L.) Link. Purple Cliffbrake.—In calcareous soils and on limestone rock at Pine Hills and elsewhere in southern Illinois.

PELLAEA GLABELLA Mett. Smooth Cliffbrake.—This species, with glabrous stipes and rachises, is known in southern Illinois only from Pope County.

POLYPODIUM—POLYPODY

Two species occur in southern Illinois.

POLYPODIUM POLYPODIOIDES (L.) Watt. Resurrection Fern.—This species frequently is epiphytic on trees, although it occurs on rocks also. It was reported in 1949 that a large bed of this fern grew on a limestone bluff at Pine Hills. It has not been collected there or at the Union County Forest Preserve since. Our plants belong to var. *michauxianum* Weatherby.

POLYPODIUM VULGARE L. Common Polypody.—Only var. *virginianum* (L.) Eaton is known in southern Illinois. It has smaller rhizome scales and its leaves are less scaly than those of var. *vulgare*. Common Polypody grows on rocks, cliffs, and moist bluffs. Sometimes it inhabits dead trees or logs. It is fairly common in southern Illinois, including the Pine Hills area.

POLYSTICHUM—CHRISTMAS FERN

POLYSTICHUM ACROSTICHOIDES (Michx.) Schott, the only species of the genus found in southern Illinois, is abundant in the Pine Hills area. Several forms or minor variations occur occasionally in southern Illinois. The forms in the Pine Hills area can be put into four groups: (1) long, deeply serrated, prominently barbed leaflets; (2) membraneous textured, rounded-barbed, very shallowly serrated leaflets; (3) short, rounded leaflets with almost entire margins and inconspicuous barbs; and (4) long, slightly serrated leaflets with a prominent barb.

PTERIDIUM—BRACKEN

Only one member of this genus grows naturally in southern Illinois.

Pteridium aquilinum var. latiusculum Underw.—This variety has been reported from southern Illinois, and can be distinguished from var. *aquilinum* in having an almost totally hairless stipe and leaf surface. Our variety grows in dry fields or burned-over areas in the Pine Hills area and a few other places in southern Illinois. It is not common in this area, probably because farmers have tried to eliminate it because it is poisonous when eaten by livestock.

Thelypteris—Beech Fern

Members of this genus have black, slender, scaly, creeping rhizomes, twice-lobed to once-cut, triangular, membranous, hairy fronds, and small kidney-shaped sori. Many taxonomists include this genus within *Dryopteris.*

Thelypteris hexagonoptera (Michx.) Weatherby. Broad Beech Fern.—Abundant in moist woods of Pine Hills, Union County Forest Preserve, and other localities in southern Illinois.

Thelypteris noveboracensis (L.) Nieuwl. New York Fern.—Found only once in southern Illinois (Seymour, 1880). It was then growing in a woods near Giant City State Park.

Thelypteris palustris Schott. Marsh Fern.—Grows naturally in mashy land only. It is known from a few scattered stations in southern Illinois, but has not yet been found in the Pine Hills area.

Woodsia—Wood's Fern, Cliff Fern

Woodsia obtusa (Spreng.) Torr. Blunt-lobed Woodsia.—This is the only species of the genus listed from southern Illinois. It is found at Pine Hills and its environs.

Fern Allies

Although nine species of fern allies (*Lycopodium,* two species, one of them with two varieties; *Selaginella,* two species; *Isoetes,* two species; *Equisetum,* three species) occur in southern Illinois, only one grows in the Pine Hills area.

Equisetum hyemale L. Common Scouring Rush.—Several varieties of this species occur in the United States. In our area var. *elatum* (Engelm.) Morton is dominant. It is distiguished from other varieties by its pointed teeth which remain attached to the sheath throughout the winter. The plant occurs in the Pine Hills area and elsewhere in southern Illinois. It is common in sandy areas, such as along river banks and railroad embankments.

SUMMARY

The twenty-nine ferns and fern allies from the Pine Hills Field Station Area and environs reported here constitute 62 per cent of the ferns and fern allies known to occur naturally in the southernmost 17 counties of Illinois.

SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE, ILLINOIS.

Shorter Notes

LITOBROCHIA IN FLORIDA.—I read with interest the article, "More Florida Rarities," by Thomas Darling, Jr. (THIS JOURNAL **52**: 137–148. 1962). Especially notable to me was the author's mention of finding *Litobrochia* (*Pteris*) *tripartita* in a hammock near the Plant Introduction Station, south of Miami. Mr. Darling's comment that this was one of the "ferns which formerly I had considered nearly extinct" is noteworthy, for this Giant Bracken is poorly known in South Florida.

I would like to point out, though, that *Litobrochia tripartita* is not as rare in our area as is often believed. For instance, the most impressive colony of it that I know is in the Fairchild Tropical Garden, near Miami, where several hundred handsome plants, exposed to full sun, form an almost solid mass along a coral wall at the Bailey Palm Glade. Since this is one of our showiest ferns, the colony should certainly be protected.

The Giant Bracken was formerly frequent along the roadsides, growing on the margins of cypress swamps in deep, rich, constantly moist soil and in semishade west from Fort Lauderdale. This area, now destroyed by the encroachments of housing subdivisions, supported dozens of plants that often towered well over my head—and I am just a shade under six feet tall!

Within the past few months, I have also found scattered plants of *Litobrochia* in marginal growth of several cypress sloughs along the Tamiami Trail, about fifty miles west of Miami, and also on the edges of wet thickets beside the Sunshine State Parkway, between Fort Lauderdale and Pompano Beach. In these localities, the plants are always, insofar as my experience extends, few and far between.

This stately fern has also made its way into a few of our southern Florida gardens. I have two friends in the Miami area who have brought specimens of *Litobrochia tripartita* to me for identification within the past year, the plants having "just come up" amidst shrubbery in their private gardens.

The Giant Bracken is among our finest Florida ferns, and it is encouraging to find that it is spreading within our region, in spite of the tremendous destruction of our forests and fields through the processes of "civilization."—ALEX D. HAWKES, *Coconut Grove 33, Florida.*

Notes and News

1963 FERN FORAY TO THE WOODSTOCK-DORSET AREA OF VERMONT.—A group of Fern Society members gathered at the Wallingford Inn, Wallingford, Vermont, on Thursday evening, August 22, where Dr. R. L. Hauke presided over the indoctrination meeting prior to the foray. Dr. Benjamin R. Allison, Mr. Henry Potter and Dr. Ralph C. Benedict discussed the places we were to visit and some of the ferns we could be expected to see. There was a slight disagreement as to the hour of departure in the morning, but a compromise of 9 A.M. was agreed upon.

Due to slow service in the dining room, we were delayed until 9:30 when a convoy of ten loaded cars started off. After a stop between Tyson and Reading, where a number of ferns were seen, the convoy drove to the remote but beautiful home of Mr. and Mrs. H. W. Newton, Reading, Vermont. Everyone enjoyed a tour of Mrs. Newton's extensive garden which contained the following ferns: maidenhair, maidenhair spleenwort, a cut-leaf form of ebony spleenwort, lady fern, slender rock-brake, bulbous and fragile bladder ferns, hay scented, marginal and spiny-toothed wood ferns, ostrich, interrupted, royal, purple cliff-brake, rock polypody, Braun's holly fern, northern holly fern, New York, marsh and rusty woodsia. Many people also enjoyed a tour of the very old house which Mr. and Mrs. Newton had beautifully restored and furnished with antiques.

Lunches were delivered by Mr. Gibson of the Wallingford Inn but, since he got lost and didn't find us until 2 P. M., everyone was ravenous. After lunch, most of the group walked up the mountain to the "stone chimney" which is the site of a long-gone colonial house. This trip was made mainly to see a beautiful colony of Braun's holly fern, though many other ferns were seen along the way.

That evening Mr. F. Gordon Foster showed some excellent slides of ferns in various stages of development, including many superb close-ups. He discussed photographic techniques and also stressed the satisfaction to be derived from close observation of ferns with a lens.

Saturday morning dawned cloudy, windy and chilly, but this did not deter us "from our scheduled rounds." During the day there were a few sprinkles, but none caused any appreciable discomfort. The group first stopped on a dirt road near West Woodstock to see a colony of the rare North American male fern, *Dryopteris filix-mas.* Despite the fact that the colony had been threatened by road widening last year, a number of healthy plants were found along the road and up the bordering hillside. In the rich woods surrounding this colony, a number of other ferns and fern allies were found as well as hybrids between *D. filix-mas* and *D. marginalis.*

After this stop we had lunch at Ruth's Restaurant and then went on to the Summit Railroad Cut on the abandoned Rutland-Bellows Falls branch of the Rutland Railroad. This is a long, narrow cut through rock, and the walls are spotted with a surprising variety of ferns and other plants. Here many of the group saw more Slender Rock-brake than they had ever seen before. It was here that Mildred Faust coined a new name for a well-known fern, "The Briddle Braddle Fern." Everyone agreed that this was much more fascinating than the prosaic Brittle Bladder Fern.

From the Cut most of the cars returned to Wallingford, but some went on to Plymouth Lake to see the green spleenwort. After dinner that night, Mr. James E. Wilkinson, State Forester for the southern half of Vermont, gave a very interesting illustrated talk on forestry in his state which prompted many questions from the group.

Sunday was partly cloudy but warmer than Saturday. With our numbers somewhat depleted, we first visited an open, rocky hillside at East Dorset and saw a number of ferns such as purple cliff-brake and slender rock-brake. Before lunch a brief stop was made at Clarendon Gorge so that the group could see the three horsetails, *Equisetum hyemale, E. scirpoides,* and *E. variegatum* growing together.

Following lunch we congregated at Wallingford Inn and proceeded to Elfin Lake where we saw a beautiful quaking bog with an abundance of bog clubmoss. Here Dr. Correll had found quillwort growing in the shallows along the edge of the lake. Several people had never before seen these insignificant, grass-like fern allies.

The last stop of the foray was made at the farm of Mr. Henry Potter, one of the leaders. Here, the sight of several of the group crawling on hands and knees in a mowed field caused a good deal of hilarity among the upright members, as well as considerable fascination among people driving by. We were looking for the Adder's-tongue Fern, even though it was very late in the season for it. And we found it, so there! Mr. Potter had also collected a fascinating group of hybrid ferns, and many members had not seen most of these growing before.

Back at the Inn after dinner, three members showed slides. Dr. Mildred Faust showed several pictures taken on last year's foray in Oregon; Dr. L. K. Henry projected a number of slides of ferns we had seen during this foray; and Mr. Robert Aborn showed very good slides of Hawaiian ferns. Miss Jeannette Klute displayed several large color prints of her magnificent woodland photographs.

This brought to an end the 1963 Fern Foray. There had been sixty-four participants on all or part of the trips. Everyone expressed great appreciation for the excellent organization and leadership shown by Dr. Allison, Mr. Potter and Dr. Benedict and for Dr. Hauke's coordinating ability.

FERNS AND FERN ALLIES SEEN ON THE FERN FORAY

Polypodium virginianum
Gymnocarpium dryopteris
Thelypteris phegopteris
    noveboracensis
    palustris
Onoclea sensibilis
Matteuccia struthiopteris
Cystopteris bulbifera
    fragilis
Woodsia ilvensis
    obtusa
Polystichum braunii
    acrostichoides
Dryopteris cristata
    clintoniana
    goldiana
    filix-mas
    marginalis
    campyloptera
    spinulosa
    intermedia
    filix-mas × marginalis
    cristata × intermedia
    cristata × spinulosa
Athyrium pycnocarpon
    thelypterioides
    filix-femina
Asplenium ruta-muraria
    platyneuron
    trichomanes
    viride
Camptosorus rhizophyllus
Pteridium aquilinum
Adiantum pedatum
Cryptogramma stelleri
Pellaea atropurpurea
Dennstaedtia punctilobula
Osmunda cinnamomea
    claytoniana
    regalis
Ophioglossum vulgatum
Botrychium matricariifolium
    lanceolatum
    virginianum
    multifidum
    dissectum
    dissectum var. obliquum
Equisetum arvense
    sylvaticum
    fluviatile
    scirpoides
    variegatum
    hyemale
Isoetes echinospora
Lycopodium inundatum
    lucidulum
    obscurum
    flabelliforme
    tristachyum
    clavatum
    annotinum

The above list contains 57 species, one variety, and three hybrids. Forty-three species and the variety are ferns, 14 are fern allies, and all of the hybrids occur in the genus *Dryopteris*.

Members and friends participating in the Foray were as follows: Mr. Robert Aborn, Mrs. Percy W. Adams, Dr. and Mrs. Benjamin R. Allison, Mrs. Geoffroy Atkinson, Miss Helen M. Attridge, Mr. and Mrs. William A. Barnes, Dr. Ralph C. Benedict, Mr. Henry S. Blethen, Miss Frances W. Brewster, Mrs. Orvis K. Collins, Dr. Donovan S. Correll, Mrs. Howard Davis, Dr. and Mrs. Lewis Dickinson, Miss Ann L. Dunham, Mr. Frederick Dunlap, Mrs. Richard Dunlap, Mr. David L. Emory and his father, Dr. Mildred E. Faust, Dr. and Mrs. F. Gordon Foster, Dr. Paul E. Grattan, Miss E. Irene Graves, Mrs. Ronald S. Gray, Mrs. Alice N. Gobin, Miss Inez Hartsoe, Dr. and Mrs. Leroy K. Henry and son John, Dr. and Mrs. R. L. Hauke, daughters Katy and Nellie and Grandma Hauke, Dr. Donald G. Huttleston, Mrs. W. A. Kenzie, Miss Jeanette Klute, Mr. George S. Lee, Jr., Mr. Elwin F. Leysath, Dr. and Mrs. Robert S. Lommasson, daughter Carol and son Timothy, Dr. and Mrs. Ray Martin, Dr. Jewel Moore, Miss Mary Murphy, Mrs. H. W. Newton, Mrs. Gladys H. Nourse, Miss Elsa Potter, Mr. L. Henry Potter, Miss Ruth A. Reed, Mr. and Mrs. Alex D. Reid, Mrs. A. E. Scherrer, Miss Anna E. Scudder, Miss Eva Sobol, Miss Olive Stacey, Mrs. Harold Stillwell, and Mr. and Mrs. W. W. Willis. —DONALD G. HUTTLESTON, *Longwood Gardens, Kennett Square, Pennsylvania.*

GROWING BERRY BLADDER FERN.—For some years we have had a bed of Berry Bladder Ferns, *Cystopteris bulbifera*, in a semi-shaded spot in a slight hollow. Here they have multiplied happily. When we dig up the larger ones, we find many bulblets (black) with the outer shell just partially cracked. If these are planted in black humus barely an inch or maybe a half-inch deep, and the humus then mulched with old straw, little green fronds soon appear. It takes some years for these to grow to maturity.—MARIE SPERKA, *Woodland Acres Nursery, Route 2, Crivitz, Wisconsin.*

AN APPEAL FOR HELP.—During recent months it has become increasingly apparent that many papers published both in the United States and abroad that would be of interest to members of the American Fern Society have not been reviewed or listed in the *Recent Fern Literature* section of the Fern Journal. The task of checking through the numerous journals and publications from various laboratories and institutes in an attempt to search out such titles is too great a one for a single individual to attempt. In order to provide a somewhat more adequate coverage, the Editor will appreciate a card or note from any member who sees a paper or book that he or she thinks would interest other pteridologists. Just note the name of the author, the title of the book or article, and if the latter, the name, volume, and pages covered in the article, followed by the date of its appearance. Such offerings will be collected, evaluated for the relationship between interest and the space available in the Journal, and a selected list published in an ensuing number of the American Fern Journal.

Authors who publish such papers in other journals can further help by sending two copies of a reprint of such a paper to the Editor. If the paper is of sufficient length and interest, an attempt will be made to find an impartial reviewer, whose critique will be published when printing schedules and space permits.—I. L. W.

American Fern Society

ANNUAL MEETING IN 1964:—The annual meeting of the American Fern Society will be held at the University of Colorado in Boulder, with other Adherent Societies of the American Institute of Biological Sciences. The AIBS meetings begin August 23 and run through the 28th. Plans are being made for two sessions, one in the forenoon and one after the annual luncheon, for the presentation of contributed papers. Our society will probably cooperate with one or more other societies in sponsoring symposia of mutual interest.

Each member of the Fern Society wishing to present a paper at Boulder should send the following information to Mrs. Lenette Atkinson, 415 South Pleasant Street, Amherst, Massachusetts, not later than May 15th: title of paper, time required for its presentation (10 to 20 minutes), size and kind of projection equipment needed, if any. Please send in your title promptly, because late requests for a place on the program may have to be denied.

No summer meeting is complete without a field foray prior to or following the formal sessions, so a Foray will be planned and details will be included in the April–June issue of the Journal.

Report of the President for 1963

During August, just prior to the annual meeting in Amherst, the Society was represented at the Adanson Bicentennial Symposium at the Hunt Botanical Library of the Carnegie Institute of Technology in Pittsburgh, Pennsylvania, by the Society Librarian, Dr. Warren H. Wagner, Jr. His report appears in this issue of the Journal.

The annual foray sponsored by the Society was held in Vermont. Wallingford served as our headquarters site, and daily trips were made from there on August 23, 24, and 25. Dr. Richard L. Hauke made local arrangements and was largely responsible for handling many of the details of the largest foray we have had in recent years. Mr. Henry Potter of West Rutland, Vermont, deserves special recognition for leading the trips and providing direction to the very interesting fern habitats in the vicinity.

Besides being new to the duties of Secretary of the American Fern Society, Dr. Lenette R. Atkinson also had the added task of being local representative for our Society in planning the arrangements for our annual meeting held in conjunction with the AIBS meetings in Amherst, Massachusetts. She was assisted in this role by Mrs. Marion Rhodes. As program chairman Dr. Atkinson assembled a fine program of contributed papers that was given Tuesday, August 27, utilizing both the morning and afternoon sessions. Thanks are especially due also to the speakers for their excellent presentations. Between the formal sessions, the American Fern Society Luncheon was attended by 48 members and provided a welcome change of pace and time for general conversation and making several announcements. The American Fern Society also co-sponsored a symposium, "Systematics in the American Tropics," presented on Wednesday, August 28th.

In September I solicited a limited number of the members of the American Fern Society for contributions to provide and erect a display case for fern pictures in Fern Valley at the National Arboretum in Washington, D. C. The response was most gratifying to me, and generous on the part of contributors, for a fund of $93.00 was turned over to the group in charge at Fern Valley.

At a meeting of the Council of the American Fern Society in Amherst, it was decided that the Society should become an "Adherent Society" of the American Institute of Biological Sciences if our membership was willing to support this move by approving an increase in dues. Since the Society responded affirmatively in the annual election, our society, as of January 1, 1964, will have full rights and representation under the new constitution of the AIBS.

Special service to the Society has been rendered this year by John T. Mickel, who served as Judge of Elections, and by Professor Elmer A. Palmatier, who served as Auditor. I extend the Society's thanks to both of them.

It has been a distinct honor to me to serve as President of the American Fern Society, and I am sure the Society will prosper under the energetic leadership of my successor.

Respectfully submitted, ROBERT C. LOMMASSON, *President*

Report of the Secretary for 1963

With support from the President and the Treasurer, and with considerable aid from Dr. Huttleston, the past Secretary, I have come through the first year in office without receiving complaints. Or is everyone being polite?

Membership in the American Fern Society at the end of 1963 stands at 857. California still heads the list with the largest number of members, with New York a close second. There are 79 members outside the United States, distributed among 28 countries. We still have no members in Nevada, New Mexico, or North Dakota.

I regret to report the death of seven members during 1963: Mr. Peter Borree (1953), Mr. Thomas S. Constantine (1936), Mr. Lewis A. Dyer (1956), Mr. Andrew T. Skidmore (1950), the Reverend Jesse F. Smith (1949), Mrs. Ora M. Wilson (1957), and Dr. Walter Döpp (1951). Dr. Döpp was one of our distinguished overseas members. His extended researches on ferns produced two important contributions: an elucidation of the mechanics of apogamy and the discovery of a biologically active substance in thalli of the bracken fern that induces and hastens the formation of antheridia.

The annual meeting of the American Fern Society, held with the AIBS on the campus of the University of Massachusetts at Amherst, on August 27, was attended by well over 50 persons. Major assistance in arranging the program was given by Mr. Conrad Morton and by Mrs. Marion B. Rhodes. Their aid is gratefully acknowledged. The President of the Society, Dr. Robert C. Lommasson, presided at the formal sessions and at the luncheon. Titles of papers read follow in the order of presentation: "First century of Louisiana fern records," by Joseph Ewan; "Ferns and their habitats in Texas," by Donovan Correll; "Preliminary studies on the fern flora of Oaxaca, Mexico," by John T. Mickel; "Recent data on ferns of Georgia," by Wilbur Duncan (read by title); "County distribution of ferns and fern allies of Rhode Island," by Dorothy Crandall; "Contributions toward a morphological classification of fern spores," by Gerhard Kremp; "Sporogenesis in *Pteris cretica* with special reference to the cytoplasmic inclusions," by Norman Marengo; "On the rhizophore of *Selaginella*," by T. R. Webster and T. A. Steeves (read by Mr. Webster); "The *Polypodium virginianum* complex," by A. Murray Evans; "Fern gametophytes and developmental plant physiology," by John Miller; "Antheridium formation in ferns—a model for the study of developmental change," by Ulrich Naf; "Morphological effects of ultraviolet radiation on prothalli of *Onoclea sensibilis*," by Larry Estes (read by R. C. Lommasson); "Eastern American spreading woodferns, *Dryopteris campyloptera* and *D.* '*dilatata*,'" by Warren H. Wagner, Jr. (a timely paper as those on the foray saw some of these ferns); "The genus *Cyathea* (*sensu lato*) in Malaysia," by R. E. Holttum (read by W. H. Wagner, Jr.). Miss Clara Hires had a fine exhibit concerned with fern indusia and other structures in the exhibit hall.

On Wednesday afternoon, August 28, the American Fern Society, the American Society of Plant Taxonomists, and the Systematic Section of the Botanical Society of America cooperated in sponsoring a symposium on "Plant Systematics in the American Tropics," with Mildred Mathias presiding. Three papers were presented during this symposium: "The present state of knowledge and current field explorations," by Richard S. Cowan; "Opportunities for evolutionary studies," by Herbert G. Baker; and "Facilities for student training and research," by Walter H. Hodge.

All members of the Council were present at a meeting August 26. The Council decided to have an attractive membership card printed, to be sent to each new member, with a statement of the purpose and history of the Society. It was suggested that Mr. Conrad V. Morton be asked if he would serve as a Clearing Officer for exchange requests among members of the Society, for both living and herbarium specimens. Happily, Mr. Morton has accepted this responsibility. In view of the increasing number of requests for our membership list for various uses, it was voted to deny use of the American Fern Society membership roster for solicitation purposes.

One of the distressing duties of the Secretary is to deny requests from organizations or individuals who wish loans of fern specimens for exhibition purposes. I suggest that careful consideration be given to some method for complying with such requests. Such a move would promote one of the aims of the Society: to spread information about ferns.

Respectfully submitted, Lenette R. Atkinson, *Secretary.*

Report of the Treasurer for 1963

I am happy to report that the Society remains solvent. Thanks to the constitutional amendments passed in 1962 we were able to remove many delinquent members from the rolls without having to carry them in arrears for an extended period. This saves postage and copies of the *Journal.*

A major expenditure this year was for reprinting back numbers of the *Journal* that were out of print. We are now in a position to again supply complete sets of the *Fern Journal.* Because of this and the cost of reprinting, I have increased the book value of our holdings, thus increasing the Society's assets.

The cost of reprinting, much larger than our cash account could cover, was met with funds from the Una Weatherby Fund. This raised the question of the distinction between that fund and the Reserve Fund. It was decided in the Council meeting at Amherst that in the absence of a definite difference between them the monies from the Reserve Fund could be combined with the Una Weatherby Fund. This will be done as of January 1, 1964.

The amendments passed in 1963 have not yet become effective, but the future looks good. The budget for the *Journal* will be increased in 1964, enabling greater coverage of topics of interest to members. Continued association with the American Institute of Biological Sciences will enable the American Fern Society to retain its prestige in professional botanical circles. I hope that the necessary increase in dues will not cause an appreciable drop in our membership, and urge that any member deeply interested in the Society who finds this increase an insurmountable financial burden will let me know.

The Society's application for tax-exempt status under Internal Revenue laws, which was dependent upon passage of one of the amendments to our constitution, has been filed. When it is approved you will be notified, and gifts to the Society will be deductible in preparing personal income tax returns. Hopefully, this will encourage more people to make gifts or bequests to the American Fern Society.

The financial report for the year follows:

Receipts

Cash on hand, January 1, 1963			$1,070.25
Membership dues			
Arrears and Renewals	$1,337.35		
Sustaining	430.00		
New	244.50		
Advance payments	94.57		
Life	100.00		
		$2,206.42	
Subscriptions			
Current and Arrears	247.00		
Advance payments	495.80		
		742.80	
Sale of back numbers		813.14	
Sale of reprints		312.87	
Gifts		452.76	
Fern Valley Fund		93.00	
Extra charges, Journal articles		188.00	
Advertising		14.00	
Transfer from Weatherby Fund		2,362.54	
Miscellaneous		8.05	7,193.58
			$8,263.83

Disbursements

American Fern Journal			
Vol. 52, No. 4	$ 773.59		
Vol. 53, No. 1	992.73		
Vol. 53, No. 2	658.34		
Vol. 53, No. 3	738.93		
		$3,163.59	

Reprints	259.43	
Envelopes and printing stationery	157.20	
Treasurer's expenses	120.74	
Secretary's expenses	90.00	
Shipping and handling back numbers	60.73	
Editor's expenses	47.20	
Life Membership Fund	100.00	
Reprinting back numbers	2,362.54	
A. I. B. S. membership	200.00	
Fern Valley Fund	93.00	
Miscellaneous	11.58	6,666.01
Cash on hand, January 1, 1964		$1,597.82

Statement December 31, 1963

Assets

Cash in Industrial National Bank	$1,597.82	
Cash in Greenpoint Savings Bank		
Bissell Herbarium Fund	815.59	
Life Membership Fund	1,198.92	
Reserve Fund	2,232.81	
Una Weatherby Fund	1,213.62	
Accounts Receivable	45.86	
Inventory, American Fern Journal	5,560.00	
Library	396.00	
		$13,060.62

Liabilities

Advance dues collected	$ 94.57		
Advance subscriptions collected	495.80		
		$ 590.37	

Fund Balances

Bissell Herbarium Fund	815.59	
Life Membership Fund	1,198.92	
Reserve Fund	2,232.81	
Una Weatherby Fund	1,213.62	
General Fund	7,009.31	
		$13,060.62

Respectfully submitted, RICHARD L. HAUKE, *Treasurer.*

Report of the Auditing Committee

I hereby certify that I have seen the books and accounts of Dr. Richard L. Hauke, Treasurer of the American Fern Society, Inc., and have obtained confirmation of the correctness of the Society's balances on hand as set forth in detail in the accompanying report of the Treasurer.

ELMER A. PALMATIER, *Auditor.*

Report of the Judge of Elections

The results of balloting for officers of the American Fern Society are as follows:

For President	
Donovan S. Correll	330
Rolla M. Tryon	1
Warren H. Wagner, Jr.	1
Edgar T. Wherry	1
For Vice-President	
Donald G. Huttleston	328
David L. Emory	1
Richard L. Hauke	1
A. C. Jeremy	1
Dale M. Smith	1
Rolla M. Tryon	1
For Treasurer	
Richard L. Hauke	329
John T. Mickel	1
Warren H. Wagner, Jr.	1

I therefore declare the following candidates elected to office: Donovan S. Correll, President; Donald G. Huttleston, Vice-President; Richard L. Hauke, Treasurer.

The four amendments to the Constitution were voted on as follows:

Under Article III, delete Section 2 from the Constitution.

For..........................320 Against.......................... 7

Under Article III, change Sections 2, 3, and 4 to increase admission fee and annual dues from $2.50 to $4.00; change Section 4 to increase the sustaining membership from $5.00 to $8.00; change Section 5 to increase life membership from $50.00 to $80.00

For..........................299 Against.......................... 39

Under Article IV, Section 3, add "Program Chairman for the Annual Meeting" to the duties of the Vice-President.

For..........................330 Against.......................... 6

Under Article V, add new sections 3 and 4 to fulfill legal requirements as to a non-profit organization.

For..........................334 Against.......................... 4

I therefore declare these amendments to the Constitution of the American Fern Society approved by the membership and now in force.

Respectfully submitted, JOHN T. MICKEL, *Judge of Elections.*

Report of the Librarian and Curator for 1963

In the present report I shall deviate somewhat from custom and refer the reader to an earlier statement (THIS JOURNAL, **52**: 52–54. 1962.) to express the general picture of activities in the Society's Library and Herbarium. I wish to describe here instead an important botanical meeting.

During August the Adanson Bicentennial Symposium was held at the Hunt Botanical Library of the Carnegie Institute of Technology in Pittsburgh. It was my pleasure to be invited to represent the American Fern Society on this occasion. Although many members of the Society are probably familiar with the Hunt Library, a few words about it may be of interest.

More than 60 years ago, when she was a girl in her teens, the late Mrs. Rachel McMasters Miller Hunt began her now famous collection of botanical books, paintings, and prints, supplemented by letters and portraits of distinguished botanists. In 1961 the Hunt Library was formally opened in an excellent new building on the campus of the Carnegie Institute, where not only the significant collections will be cared for, but bibliographic research in botany will be fostered through the Hunt Foundation. This work is under the administration of George H. M. Lawrence, the Director, plus the directors of the Hunt Foundation and an advisory committee of six botanists from several countries. In addition to the research carried out by the staff and visitors to the Library, various other projects are supported, including the Hunt Facsimile Series, in which rare and often unavailable botanical works will be reproduced; the Hunt Monographic series, for the publication of new botanical investigations emphasizing historical aspects of the field; and the Bibliographica Huntiana, described as a "new Pritzel for the period of 1735-1850." It seems especially timely that this important establishment has been so efficiently organized so recently, now that the academic world and the educated public at large have become very strongly concerned with the history of science. In botany the historical aspects are of special operational significance in the day-by-day work because of the necessity to establish a stable nomenclature for plants based upon the principle of priority and in accordance with our International Code of Botanical Nomenclature.

It is appropriate too that it was the Hunt Library which celebrated the bicentennial of the publication of Michel Adanson's *Familles des Plantes*, one of the landmarks in the literature of plant sciences. Michel Adanson (1727-1806) was a French botanist and naturalist, whose name is much in the scientific limelight currently because of his philosophical conceptions of the nature of systematics. How do we evaluate taxonomic relationships? How are species grouped? Genera, and so on? Adanson argued for the use of all characteristics, all the information available about plants. His ideal methodology would be based upon not just a few characteristics (in ferns, for example, just the sorus and sporangium) but on all that we can learn about the plants. Furthermore, the idea that we do not know the relative "value" of characteristics and therefore should treat all data (e.g., roots, stems, leaves, spore-cases, epidermis—everything) as *equal* seems to come from Adanson, whose ideas must have seemed heretical to some of his colleagues.

Currently, with the appearance of the electronic computer as a tool in taxonomy, a whole new school of botany—"Numerical Taxonomy" or "Quantitative Adansonianism"—is apparently arising, and much of the philosophical groundwork traces back to Adanson. I am sure that many of the delegates and registrants at the Symposium found the purely historical papers of great interest, as I did. Out of the eight major talks that were presented (some in French, some in English), I was personally most inspired by the lecture on "Mathematics and classification from Adanson to the present" by Peter H. A. Sneath of the Medical Research Council in London, in which the influence of Adanson was analyzed from the perspective of the present world.

The program of the Adanson Bicentennial involved an exhibition of Adansoniana, the above-mentioned Symposium papers (held on the two days, August 18 and 19), a visit to the Carnegie Museum, and a Banquet. Botanists representing many viewpoints and backgrounds came together for the occasion. Each of the participants, undoubtedly, found the event a most stimulating experience, and I am grateful to the American Fern Society for being chosen as one of the delegates of the 18 botanical societies represented.

Respectfully submitted, WARREN H. WAGNER, JR., *Librarian and Curator.*

NEW MEMBERS

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Copy for a number of the Fern Journal goes to the printers before the 15th of the third month prior to the date of issue; before the middle of January, April, July, and October. Requests for change of address can not be published in the Journal until the *following* number if they reach the Editor after these deadlines.

NOTICE OF COLORADO FERN FORAY

Plans are being made for an American Fern Society field foray to be held prior to our annual meeting at the University of Colorado, Boulder, August 23-28, 1964. It is planned to have the foray in some area of Colorado approximately August 19–22. Details will be given in the next issue of the Journal as well as in a future issue of the AIBS *BioScience*.

Suggestions to Contributors to the American Fern Journal

1. Authors of papers submitted to the *American Fern Journal* should consult the *Style Manual for Biological Journals* (1960) and be guided by its examples.

2. The "name-and-year" system for bibliographic references will, except in exceptional cases, be used. (See Literature Cited below for an example).

3. Authors are encouraged to use the journal abbreviations set forth by Schwarten and Rickett (1958, 1961).

4. Abbreviations of names of herbaria will be those listed by Lanjouw and Stafleu (1959).

5. Reports of chromosome numbers will not be accepted unless documented.

6. The use of footnotes and tabular matter should be kept to a minimum.

7. All manuscripts submitted for publication should be typed, *double-spaced,* and have ample margins.

8. Reprints should be ordered when galley proof is returned to the Editor. An order blank will be included with the galley proof.

Literature Cited

American Institute of Biological Sciences, Committee on Form and Style of the Conference of Biological Editors. 1960. Style Manual for Biological Journals. American Institute of Biological Sciences. Washington, D. C. 100 p.

Lanjouw, J., and F. A. Stafleu. 1959. The Herbaria of the World. Index Herbariorum, Regnum Veg. **15**: 1-249.

Schwarten, L., and H. W. Rickett. 1958. Abbreviations of Titles of Serials Cited by Botanists. Bull. Torrey Club **85**: 277-300; 1961. Supplement I. Ibid. **88**: 1-10.

VOL. 54 APRIL-JUNE, 1964 No. 2

American Fern Journal

A QUARTERLY DEVOTED TO FERNS

Published by the

AMERICAN FERN SOCIETY

CONTENTS

The American Fern Society

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American Fern Journal

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An illustrated quarterly devoted to the general study of ferns, owned by the American Fern Society, and published at 3110 Elm Ave., Baltimore 11, Md. Second-class postage paid at Baltimore, Md.

Matter for publication should be addressed to Ira L. Wiggins, Dudley Herbarium, Stanford University, Stanford, California.

Subscription $4.50, exclusive of agency handling fees; sent free to members of the American Fern Society (annual dues, $4.00; sustaining membership, $8.00; life membership, $80.00). Extracted reprints, if ordered in advance, will be furnished authors at cost, plus postage.

Back volumes $3.00 each; single back numbers 75 cents each; Cumulative Index to vols. 1-25, 25 cents. Ten per cent discount on orders of six volumes or more.

Changes of address, applications for membership, subscriptions, orders for back numbers, and other business communications should be addressed to the Treasurer, Dr. Richard L. Hauke, Department of Botany, University of Rhode Island, Kingston, Rhode Island. Members and subscribers should allow two months for changes in address to take effect.

LIBRARIAN AND CURATOR OF THE HERBARIUM

Dr. W. H. Wagner, University of Michigan, Ann Arbor, Mich.

A regular loan department is maintained in connection with the library and herbarium. Members may borrow books and specimens at any time, the borrower paying all postal or express charges. The pages of the Journal also are open to members who wish to arrange exchanges; a membership list is published at intervals, to assist those interested in obtaining specimens from different localities.

American Fern Journal

Vol. 54 | April-June, 1964 | No. 2

Development of the Stelar Cylinder in the Rhizome of Bolbitis and Egenolfia

Surjit Kaur

Bolbitis and *Egenolfia* are Lomariopsidoid ferns of doubtful systematic position, relegated to the Aspidiaceae by most pteridologists (Ching, 1940; Copeland, 1947). They are small or medium sized ferns with dimorphic leaves, acrostichoid distribution of sporangia and dorsiventral epigeal rhizomes which may either be short creeping or long and sometimes climbing vertically on supports. During the course of a morphological investigation of some species of *Bolbitis* and *Egenolfia* it was observed that the characteristic dorsiventral type of solenostele of the rhizome (Holttum, 1954; Nayar, 1960) develops from the juvenile protostele in an unusual manner in these genera. The common type of development of solenostele from the solid cylindrical protostele in ferns by the formation of a central shaft-like pith connected to the cortical tissue through leaf gaps, is described by many workers (Bower, 1935; Gwyne-Vaughan, 1901). A variation of this type of development is reported in *Danaea* (Brebner, 1902). The present observations are based upon ten species of *Bolbitis* viz., *B. costata* (Wall.) Ching, *B. crispatula* (Wall.) Ching, *B. deltigera* (Wall.) C. Chr., *B. diversifolia* (Bl.) Schott, *B. heteroclita* (Pr.) Ching, *B. presliana* (Fée) Ching, *B. semicordata* (Moore) Ching, *B. subcrenata* (Hook. et Grev.) Ching, *B. subsimplex* (Fée) Ching, *B. virens* (Wall.) Schott and five species of *Egenolfia* viz., *E. appendiculata* (Willd.) J. Sm., *E. asplenifolia* (Bory) Fée, *E. helferiana*

Volume 54, No. 1, of the Journal, pp. 1–56, was issued April 15, 1964.

(Kze.) C. Chr., *E. sinensis* (Bak.) Maxon and *E. vivipara* (Hook.) C. Chr. The observations were made by cutting serial transverse sections of young and adult rhizomes and foliar buds, and making drawings with a camera lucida, from which the stelar pattern is reconstructed to scale. These are then compared with the stelar cylinders obtained after prolonged boiling in strong KOH solution.

STELAR CYLINDER OF THE ADULT RHIZOME

The stelar cylinder of the adult rhizome in *Bolbitis* and *Egenolfia* is a hollow cylinder pierced on the dorsal surface by two alternating, closely set rows of large, prominently overlapping leaf gaps (Fig. 4-l), which dissect the stelar cylinder into a broad, gutter-shaped, root-bearing, ventral vascular strand (Fig. 4-d). In some species more than two rows of leaves are developed at maturity and then the dorsal strand is pierced by one or two rows of leaf gaps. Vascular connections to each leaf (each leaf trace, Fig. 4-f) consist of many cylindrical vascular bundles originating in succession from the lateral margins towards the abaxial end of the leaf gap. Vascular connection to a vegetative bud (Fig. 4-b) is associated with each leaf trace on its abaxial side, and a root trace (Fig. 4-r) originates along with the bud traces (either fused with the bud trace or sometimes independently) in all the species.

DEVELOPMENT OF STELAR CYLINDER OF RHIZOME

The juvenile rhizome has a solid, cylindrical, centrally placed vascular strand (Fig. 1-A). Leaf traces are single cylindrical bundles originating from the dorsal surface as superficial branches, unaccompanied by a leaf gap. Vegetative buds are absent. As the plant grows, the rhizome increases in thickness and the successive juvenile leaves increase in size. The stelar cylinder expands and successive leaf traces become alternately placed on either side of the dorsal median line (Fig. 1-B). Between the two rows of leaf traces a longitudinal groove is formed, which becomes progressively deeper and wider as the rhizome elongates. Later, each juvenile leaf is supplied by two vascular bundles originating from the opposite margins of the median groove (Fig. 1-C). The stelar cylinder expands considerably and the dorsal groove becomes more and more prominent till the stele is gutter-shaped, and later the margins of the gutter approach each other and fuse, forming a hollow cylinder with the cortical parenchyma forming a central pith (Fig. 1-D). One or two elongated lacunae (Fig. 1-p) may occur laterally on the stelar cylinder. Soon the dorsal surface of the stelar cylinder opens as a leaf gap (Fig. 1-l) and a set of vascular strands (usually two or three on either side of the gap) are given off to a leaf, the leaf in question being markedly larger than the previously formed ones. Vascular connection to a vegetative bud and the accompanying root (Fig. 1-b & r) is usually associated with this leaf trace on its abaxial side as in the adult condition. Vascular connection to the next leaf in succession is established in a similar way by the formation of a gap close to the first gap on one side. Thereafter, leaves are formed alternately in closely placed rows, and their gaps are prominent and considerably overlapping so that the dorsal median region of the vascular cylinder appears like a zigzag narrow meristele (Fig. 1-d) connecting the two margins of the gutter-shaped ventral region (Fig. 1-v).

STELAR CYLINDER OF FOLIAR BUDS

Foliar buds are characteristic of most species of *Bolbitis* and *Egenolfia*. These buds occur on the dorsal surface towards the apex of the terminal pinna (in some species on the lateral pinnae also), replacing one of the main lateral veins of the lamina. In many cases these buds strike root and grow into young plants while still attached to the parent leaf. The vascular bundle entering the base of the rhizome of these young plants is a simple, cylindrical, solid strand (Fig. 2-A) resembling the protostele of the juvenile rhizome. Soon it expands considerably, becomes flattened and later gutter-like (Fig. 2-B), with its concavity facing the lamina of the parent leaf (ventral sur-

FIG 1. STELAR CYLINDER OF YOUNG RHIZOME OF BOLBITIS SUBCRENATA. FIG. 2. STELAR CYLINDER OF FOLIAR BUD OF THE SAME. FIG. 3. STELAR CYLINDER OF FOLIAR BUD OF EGENFOLIA APPENDICULATA. FIG. 4. A PORTION OF THE VASCULAR CYLINDER OF THE RHIZOME OF B. SEMICORDATA. A—CYLINDRICAL PROTOSTELE; B—DEVELOPMENT OF DORSAL GROOVE ON STELAR CYLINDER; C—FORMATION OF MULTIPLE TRACES TO LEAF; D—FORMATION OF HOLLOW CYLINDRICAL STELE; E—ADULT CONDITION OF STELE. l = LEAF GAP, f = LEAF TRACE, b = BRANCH TRACE, r = ROOT TRACE, d = DORSAL VASCULAR STRAND, v = VENTRAL VASCULAR STRAND, p = LACUNA.

face of the daughter rhizome). The margins of the gutter-like stele approach each other and fuse (Fig. 2-D) forming a hollow cylinder which usually develops one or two elongated lacunae generally on the opposite side (dorsal surface of the daughter rhizome). A large leaf gap (Fig. 2-l) is formed dorsally, opening up the stelar cylinder, and a pair of leaf trace bundles (Fig. 2-f) originates, one from either lateral margin of the gap. The leaf gap next in succession originates lateral to the first gap and successive leaf gaps are formed in alternate succession dissecting the vascular cylinder into a broad, ventral strand and a narrow dorsal one as in the adult rhizome (Fig. 2-E). In *Egenolfia* a vascular connection to the first leaf of the daughter plant originates before the stelar cylinder becomes siphonostelic. The protostelic vascular cylinder entering the bud becomes gutter-shaped, with its concavity facing the dorsal side (Fig. 3-B) and one or two vascular bundles are given off from either margin to supply the first leaf. Soon afterwards the margins of the gutter unite to form the hollow, cylindrical stelar cylinder (Fig. 3-D) but generally an elongated dorsal lacuna (Fig. 3-p) is formed close to the point of fusion of the margins. After the formation of a hollow cylindrical stelar cylinder the adult condition is reached by the development of large leaf gaps in two alternating closely placed rows on the dorsal surface, but bud traces do not occur associated with the leaves though a root trace (Fig. 3-r) often is attached abaxially to each leaf trace.

Thus the stelar cylinder of the adult rhizome of *Bolbitis* and *Egenolfia*, whether developing from the protostele of a vegetative bud or the juvenile sporeling, is formed by flattening of the solid cylindrical protostele, accompanied by upward curving of the margins of the flattened strand and their final merging to form a hollow cylinder. The pith is connected to the cortical tissue and is clearly cortical in origin.

I am grateful to Prof. K. N. Kaul, who has taken keen interest in this work. I am obliged to Dr. B. K. Nayar under whose guidance this work was carried out. Thanks are due to

Shri P. C. Roy who has helped in the preparation of figures.

LITERATURE CITED

BOWER, F. O. 1935. Primitive land plants. Macmillan & Co., London.

BREBNER, G. 1902. On the anatomy of *Danaea* and other Marattiaceae Ann. Bot. **16:** 517-552.

CHING, R. C. 1940. On natural classification of the "Polypodiaceae." Sunyatsenia, **5:** 201-268.

COPELAND, E. B. 1947. Genera Filicum. Waltham, Mass.

GWYNNE-VAUGHAN, D. T. 1901. Observations on the anatomy of solenostelic ferns. I. *Loxsoma.* Ann. Bot. **15:** 71-98.

HOLTTUM, R. E. 1954. Flora of Malaya, **2:** Ferns. Singapore.

NAYAR, B. K. 1960. Morphology of two Indian species of *Bolbitis.* Jour. Indian Bot. Soc. **39:** 259-277.

PTERIDOLOGY LABORATORY, NATIONAL BOTANIC GARDENS, LUCKNOW, INDIA.

A New Species of Pyrrosia from India

PRAKASH CHANDRA

During a fern collecting tour of northeastern India, organized by the National Botanic Gardens (Lucknow) in May and June, 1961, I collected a narrow-leaved species of *Pyrrosia* in Manipur. The specimen did not tally with any of the species described previously. It was sent to Professor R. C. Ching (Peking Academy of Science), who confirmed that it is new, and suggested the name *Pyrrosia nayariana*, in honor of Dr. B. K. Nayar in recognition of his contributions towards a better understanding of the phylogeny of ferns, especially of the Indian species of *Pyrrosia*.

PYRROSIA **nayariana** Ching et Chandra, *sp. nov.*

Rhizoma breviter repens 2–3 mm. crassum, radicibus fasciculatis nigris firmis, dense paleatum, paleis peltatis lanceolatis 2–3 mm. longis dentatis; folia conferta lineari-oblanceolata 15–20 cm. longa, vix. 1.0 cm. lata, sessilia vel subsessilia, apice acuta, basi gradatim attenuata, supra glabra, hydathodis punctatis in apice venulis ultimis liberis, subtus dense tomentosa, pilis stellatis triformibus, inferioribus densis ramis elongatis gracilibus glomeratis, superioribus floccosis ramis brevibus latis cymbiformibus, alteris ramis gracilibus acicularibus; folia fertilia saepe paullo angustiora quam sterilia, soris subtus ubique praedita, soris in 2 vel 4 lineis costae utrinque latere; sporangii annulus ex 16–20 cellulis compositus; sporae monoletae, extine verrucoso.

Type in the herbarium of the National Botanic Gardens, Lucknow, India, sheet No. 47,967, collected at Imphal, Manipur, India, at about 795 meters elevation, May 12, 1961, by P. Chandra (no. 74310). Isotype in the Botanical Institute, Academia Sinica, Peking, China.

Pyrrosia nayariana (Fig. 1) grows in small epiphytic clumps on trunks and branches of trees in the plains. The fleshy rhizome is 2–3 mm. in diameter, short, branched, and enveloped by much-branched clusters of fibrous roots which form spongy masses attached to the substratum. The paleae (Fig. 3) are elongate-lanceolate, densely covering the rhizome, light brown in color, and peltate with an ovate basal region and a short, cylindrical stalk. The apex of the palea is acuminate and crowned by a simple or branched, deciduous glandular hair; the margin is dentate. The developmnt of the palea is as described earlier (Chandra, 1962; Nayar, 1961). Structurally, the rhizome is similar to that of *P. flocculosa* and *P. mollis* (*P. fissa*), but slender sclerenchyma strands, up to 16 cells thick, are irregularly distributed in the pith and inner cortex (Fig. 4). These strands are composed of very thick-walled, dark brown cells, with occluded lumen and prominent pit-connections in the walls. The cortical sclerenchyma sheath is 4–6 cells thick and golden brown in color. The vascular cylinder of the rhizome (Fig. 5) is a loose reticulum composed of many cylindrical vascular bundles, as in other species of *Pyrrosia* (Nayar, 1961). Leaf-traces to successive leaves originate alternately on either side of the dorsal, median vascular bundle. Branching of the vascular bundles and the fusion of nearby branches is very common. Three slender branches, originating from the dorsal median vascular bundle and a bundle lateral to it, supply each leaf (Fig. 5 1). The first-formed branch (usually from the median vascular bundle of the rhizome) forks once and forms the pair of abaxial bundles of the stipe. Compli-

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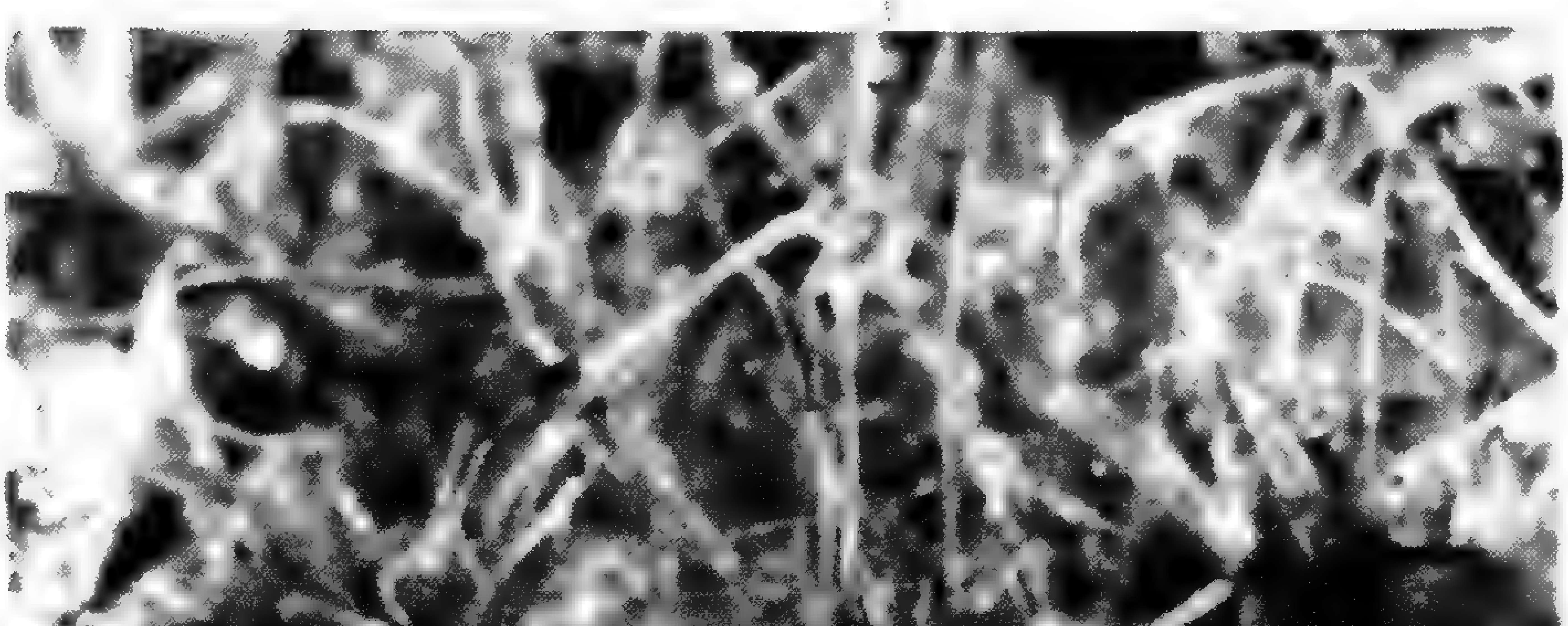

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cated vascular anastomoses occur before the separation of the leaf traces. Branches of the rhizome are associated with the leaves, and many are dormant. Each branch is supplied by a solitary vascular trace (Fig. 5 b), which originates along with the vascular connections to the leaf, as in *P. flocculosa* (Nayar, 1961). The leaves are articulated to short phyllopodia, the articulation being composed of a saucer-shaped pad of small parenchyma cells, as in *Drymoglossum* (Nayar, 1957). Peltate paleae cover the phyllopodium but paleae are absent on the leaf. The leaves are crowded, subsessile, and linear-oblanceolate (Fig. 1). The lamina is thick, leathery, glabrous on the upper surface, and densely covered by stellate hairs beneath (Fig. 2). A dense felt is formed by nearly hyaline, thin hairs with very long, more or less thin-walled, coiled, slender, frizzly arms (Fig. 6), which are entangled to form the dense felt. Above this layer are two types of hairs intermingled; one with short, broad, dark brown, boat-like, crowded arms (Fig. 7) and the other of a lighter color and bearing few, long, slender, needle-like arms (Fig. 8). Prominent, pitlike depressions representing foliar hydathodes occur on the upper surface. The venation of the lamina (Fig. 9) is fundamentally similar to that of many species of *Pyrrosia* described by Nayar (1961). The midrib is prominent, and bears alternately placed, loosely arranged, immersed, lateral veins. The latter are at an angle of 30–40° with the midrib and are connected by three (or four) secondary branches at right angles to them, resulting in a row of elongated, rhomboidal areoles. The secondary veins bear two or three, free-ending, short, tertiary branches on the side facing away from the midrib. Most of these tertiary branches subtend hydathodes on the upper surface of the lamina. Each stoma is encircled by a single epidermal cell. The fertile leaves are similar to the sterile ones in structure and venation. The sori are punctiform and distributed over all of the under side of

FIGURE 1. PYRROSIA NAYARIANA CHING & CHANDRA. FIGURE 2. STELLATE HAIRS ON UNDER SURFACE OF LEAF.


1 mm.
1 mm.
v
sc
c
s
l
r
a
3
4
l
b
b
5
d
6
200 µ
7
mr
m
9
2 mm
10
100 µ
8
200 µ

the leaf, directly above the apices of the tertiary veinlets. The sporangia are long-stalked. The annulus is 16–20 cells long. The spores (Fig. 10) are monolete (bilateral), plano-convex in equatorial view, ovate in polar view, and 61 $\times$ 86 $\times$ 62 μ (P $\times$ E_1 $\times$ E_2). The laesura is thickened. The exine is golden brown and densely verrucose, the protuberances being small and more or less uniformly distributed.

Pyrrosia nayariana resembles small-leaved specimens of *P. mollis* (*P. fissa*). In the latter the annulus of the sporangium is 20–24 cells long and the spores are more rounded (54 $\times$ 86 $\times$ 54 μ) and smooth-walled, whereas the annulus is 16–20 cells long in *P. nayariana* and the spores are verrucose and conspicuously larger.

I am grateful to Professor K. N. Kaul, Director, National Botanic Gardens, for his keen interest in this work, and to Dr. B. K. Nayar under whose guidance this work was done. Thanks are due to Dr. R. C. Ching for kindly confirming the identification and suggesting the specific name, and to C. V. Morton for the Latin diagnosis.

LITERATURE CITED

CHANDRA, PRAKASH. 1962. Development of the peltate palea in Polypodiaceae. Current Science **31**: 477-479.

NAYAR, B. K. 1957. Studies in Polypodiaceae—IV, *Drymoglossum*. Jour. Indian Bot. Soc. **36**: 169-179.

———. 1961. Studies in Polypodiaceae—VIII, *Pyrrosia*, Jour. Indian Bot. Soc. **40**: 164-183.

NATIONAL BOTANIC GARDENS, LUCKNOW, INDIA.

FIGURES 3—10. STRUCTURAL DETAILS: 3. PALEA; 4. TRANSVERSE SECTION OF RHIZOME, SHOWING SCLERENCHYMA AND VASCULAR BUNDLES; 5. VASCULAR STRUCTURE OF A PORTION OF THE RHIZOME (ROOTS OMITTED); 6—8. FOLIAR HAIRS; 9. VENATION PATTERN; 10. SPORE, EQUATORIAL VIEW. (A = STALK OF PALEA; B = BRANCH TRACE; C = OUTER CORTEX; D = DORSAL MEDIAN VASCULAR BUNDLE; L = VASCULAR CONNECTION TO LEAF; M = LEAF MARGIN; MR = MIDRIB; R = ROOT; S = SCLERENCHYMA STRANDS; SC = CORTICAL SCLERENCHYMA SHEATH; V = VASCULAR BUNDLE).

Notes on the Hawaiian Fern Genus Adenophorus

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The majority of the Hawaiian representatives of the fern family Grammitidaceae have recently been interpreted as representing a single endemic genus (Copeland, 1947). This concept is not entirely new. As early as 1824, in a short report describing some new plant genera collected during Freycinet's voyage around the world, Charles Gaudichaud (1824) published a description of the genus *Adenophorus*[1] in which he included three species. Two of these species had been described earlier Kaulf. (*Adenophorus minuta* Gaud.). The third species, *Adenophorus bipinnata* Gaud.) and *Polypodium hymenophylloides* Kaulf. (*Adenophorus minuta* (Gaud.). The third species, *Adenophorus tripinnatifidus* Gaud. was described here for the first time. This genus as originally described included those Hawaiian grammitids with pinnatifid or bipinnatifid pinnae, bearing glandular epidermal hairs and possessing glandular-stipitate paraphyses in the sori.

Evidently as a result of nomenclatural complexities, Desvaux (1827) later proposed the new name *Amphoradenium* for the described species of *Adenophorus,* and also provided a new epithet for *Adenophorus tripinnatifidus* in honor of Gaudichaud (*Amphoradenium gaudichaudii* Desv.). Clearly, however, the correct name for this group of grammitids when treated as a genus is *Adenophorus* Gaud. *Amphoradenium* is a synonym of this name. *Amphoradenium*, however, is the name that was adopted for this genus by Copeland (1947), who also made numerous new combinations.

Investigation shows that, according to Copeland's concept of the genus, *Adenophorus* includes two distinct groups of species.

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[1] The name *Adenophorus* had been published earlier by Desvaux (1808) in a list of names without any description. According to Article 12 of the Code of Nomenclature (Montreal) this earlier name has no status under the code.

The first group is characterized by having elongate creeping rhizomes, remote fronds, pinnate-pinnatifid to pinnate-tripinnatifid blades, with an irregular epidermal layer bearing numerous appressed, usually unicellar, reddish-brown glandular hairs which are oriented so that they point to the apex of the ultimate blade segment or lobe. The second group includes the species with short, erect or ascending rhizomes closely invested by the crowded stipes, simple, pinnatifid or pinnate blades, with a smooth epidermis bearing scattered uniseriate, simple or more frequently branched, erect hairs. In the first group belong *Adenophorus hymenophylloides* Hook. and Grev., *A. tamariscinus* Hook. & Grev. (as *tamarisci*), *A. tripinnatifidus* Gaud., *A. hillebrandii* (Hook.) K. A. Wilson[2] and *A. abietinus* (Eaton in Mann) K. A. Wilson.[3]

The second group includes *Adenophorus sarmentosus* (Brack.) K. A. Wilson,[4] *Adenophorus haalilioanus* (Brack) K. A. Wilson[5] and *Adenophorus pinnatifidus* Gaud.

The presence of clavate glandular paraphyses in the sori is the single morphological character that unites these two groups of Hawaiian grammitid ferns.

The distinctness of these two groups raises the problem of the generic validity of *Adenophorus.* Considering only the Hawaiian species of the Grammitidaceae, it might be suggested that each one of the two groups merits generic status. The great similarity of the species within each group argues strongly in favor of their close relationship. The degree of relationship between the two groups, however, is not clearly established. Convincing evi-

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[2]ADENOPHORUS **hillebrandii** (Hook.) K. A. Wilson, comb. nov. Basionym: *Polypodium hillebrandii* Hook., Sp. Fil. **4:** 228, tab. 279. 1864.

[3]ADENOPHORUS **abietinus** (Eaton in Mann) K. A. Wilson, comb. nov. Basionym: *Polypodium abietinum* Eaton in Mann, Proc. Am. Acad. Arts and Sci. **7**[5] 219. 1867.

[4]ADENOPHORUS **sarmentosus** (Brack.) K. A. Wilson, comb. nov. Basionym: *Polypodium sarmentosum* Brack. U. S. Explor. Exped. Bot. **16:** 8, 9. 1854; *pl. 2, fig. 3.* 1855.

[5]ADENOPHORUS **haalilioanus** (Brack.) K. A. Wilson, comb. nov. Basionym: *Polypodium haalilioanum* Brack. U. S. Explor. Exped. Bot.**16:** 5, 6. 1854; *pl. 1, fig 4.* 1855.

dence could be presented in favor of treating these ferns as two separate genera.

This situation is not uncommon throughout the entire family Grammitidaceae. There seems to be general agreement that the genus *Xiphopteris* is polyphyletic and, although easily recognizable, an artificial grouping. The assemblage of ferns placed in the genus "*Ctenopteris*" (the name is illegitimate) includes numerous groups of ferns. The interrelationships of these ferns is very poorly understood. *Prosaptia* is another grammitid genus which is probably polyphyletic. Problems similar to those in "*Ctenopteris*" are also evident in the large genus *Grammitis*. Clearly, a detailed study of the entire family is needed in order to establish clearer, more natural genera.

Until such a study is undertaken I consider it best to retain these convenient, although most likely artificial genera.

LITERATURE CITED

BRACKENRIDGE, W. D. 1855. *In* C. Wilkes, U. S. Expl. Exped. 1838-1842. Vol. 16.

COPELAND, E. B. 1947. Genera Filicum. Waltham, Mass.

DESVAUX, N. A. 1808. Sur les genres *Thorea* et *Lemanea,* de M. Bory de Saint-Vincent. Jour. Botanique Appliquée **1**(2): 121-125.

————. 1827. Prodrome de la famille des fougères. Mem. Soc. Linn. Paris. **6**: 171-337.

GAUDICHAUD-BEAUPRE, C. 1824. Descriptions de quelques nouveaux genres de plantes recueillies dans le voyage autour du monde. Ann. Sci. Nat. Bot. Zool. **3**: 507-510.

HOOKER, W. J. 1863-64. Species Filicum. Vol. 4. London.

KAULFUSS, G. F. 1824. Enumeratio Filicum. Lipsiae.

MANN, H. 1867. Enumeration of Hawaiian plants. Proc. Am. Acad. **7**: 143-235.

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New Combinations in Lycopodium

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About ten years ago, the U. S. National Museum lent a large number of unnamed specimens of tropical American Lycopodiums to Dr. W. Herter, the noted authority on the Lycopodiaceae. Dr. Herter found a number of new species among these collections, which he published in two papers, under the generic name *Urostachys* Herter.

The generic name *Urostachys*, dating from 1922, is antedated by two or three older names for the same concept.[1] However, it does not seem to me either necessary or desirable to split up the genus *Lycopodium*, which certainly seems to be natural, although with plants as old as these and which offer so few characters it is hard to be sure. But I agree with Boivin,[2] that if one begins to split up *Lycopodium* it will be necessary to recognize not just two genera but five or more, which is surely extreme, considering the inadequate present state of our knowledge of the gametophytes, life history, and anatomy of the species.

Apparently, this group of *Lycopodium* is rich in species, for most of those described by Herter seem to be well founded. Many of the specific epithets chosen by Herter are fanciful, derived from the names of mythical personages (*cassandrae*, *dianae*, *poseidonis*) or stars (*arcturi*, *capellae*, *stellae-polaris*, *crucis-australis*) or both (*castoris*), but why not? There are too many humdrum *hirsutums* and *acuminatums*.

In order to refer in identification lists and otherwise to the various new species described by Herter based on material in the U. S. National Herbarium, I propose the following new combinations:

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[1]See Hans Peter Fuchs, Urostachys nomen genericum conservandum?", Verh. Naturf. Ges. Basel **66**: 33–48. 1955.

[2]Bernard Boivin, "The Problem of Generic Segregates in the Form-Genus Lycopodium," Amer. Fern Jour. **40**: 32-41. 1950.

LYCOPODIUM **arcturi** (Herter) Morton, *comb. nov.*
Urostachys arcturi Herter, Rev. Sudamer, Bot. **10:** 118. 1953.
LYCOPODIUM **arthurii** (Herter) Morton, *comb. nov.*
Urostachys arthuri Herter, op. cit. 114.
LYCOPODIUM **bonae-voluntatis** (Herter) Morton, *comb. nov.*
Urostachys bonae-voluntatis Herter, *op. cit.* 112.
LYCOPODIUM **buesii** (Herter) Morton, *comb. nov.*
Urostachys buesii Herter, *op. cit.* 126.
LYCOPODIUM **capellae** (Herter) Morton, *comb. nov.*
Urostachys capellae Herter, op. cit. 114.
LYCOPODIUM **cassandrae** (Herter) Morton, *comb. nov.*
Urostachys cassandrae Herter, *op. cit.* 116.
LYCOPODIUM **castoris** (Herter) Morton, *comb. nov.*
Urostachys castoris Herter, *op. cit.* 111.
LYCOPODIUM **chamaeleon** (Herter) Morton, *comb. nov.*
Urostachys chamaeleon Herter, Amer. Fern Jour. **48:** 82. 1958.
LYCOPODIUM **costaricense** (Herter) Morton, *comb. nov.*
Urostachys costaricensis Herter, *op. cit.* 83.
LYCOPODIUM **crucis-australis** (Herter) Morton, *comb. nov.*
Urostachys crucis-australis Herter, Rev. Sudamer. Bot. **10:** 119. 1953.
LYCOPODIUM **cuatrecasasii** (Herter) Morton, *comb. nov.*
Urostachys cuatrecasasii Herter, *op. cit.* 123.
LYCOPODIUM **dianae** (Herter) Morton, *comb. nov.*
Urostachys dianae Herter, *op. cit.* 116.
LYCOPODIUM **ewanii** (Herter) Morton, *comb. nov.*
Urostachys ewanii Herter, *op. cit.* 126.
LYCOPODIUM **hystrix** (Herter) Morton, *comb. nov.*
Urostachys hystrix Herter, *op. cit.* 120.
LYCOPODIUM **innocentium** (Herter) Morton, *comb. nov.*
Urostachys innocentium Herter, *op. cit.* 127.
LYCOPODIUM **killipii** (Herter) Morton, *comb. nov.*
Urostachys killipii Herter, *op. cit.* 128.
LYCOPODIUM **leptodon** (Herter) Maxon, *in sched., comb. nov.*
Urostachys leptodon Herter, *op. cit.* 120.
LYCOPODIUM **macbridei** (Herter) Morton, *comb. nov.*
Urostachys macbridei Herter, *op. cit.* 115.
LYCOPODIUM **poseidonis** (Herter) Morton, *comb. nov.*
Urostachys poseidonis Herter, *op. cit.* 122.
LYCOPODIUM **socratis** (Herter) Morton, *comb. nov.*
Urostachys socratis Herter, *op. cit.* 117.
LYCOPODIUM **stellae-polaris** (Herter) Morton, *comb. nov.*
Urostachys stellae-polaris Herter, op. cit. 121.

LYCOPODIUM **trachyloma** (Herter) Maxon, *in sched., comb. nov.*
Urostachys trachyloma Herter, *op. cit.* 113.
LYCOPODIUM **ulixis** (Herter) Morton, *comb. nov.*
Urostachys ulixis Herter, *op. cit.* 115.

Herter's reasonably good work was not duplicated by that of his student Hermann Nessel, whose book "Die Bärlappgewachse" added little to our knowledge of the group. However, some of the species described by Nessel are good, and one of them is rather common in the Andes of Colombia:

LYCOPODIUM **wohlberedtii** (Nessel) Morton, *comb. nov.*
Urostachys wohlberedtii Nessel, Repert. Sp. Nov. Fedde **39:** 69. 1935.

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Some Hints for the Fern Culturist[1]

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The culturing of ferns in all of its phases is of intense interest to many of our members. One of the most challenging aspects of this hobby is raising ferns from spores and bringing the sporelings to maturity. A few of the more important articles on this subject are those by Hires (1940), Benedict (1955) Kleinschmidt (1952, 1957), Boydston (1958). Fliflet (1961) summarizes much of the former material on growing ferns from spores, and there is very little new that can be added.

Fern enthusiasts might, however, be interested in a new substrate for spore culture. The name of this material is *Turface*. It is a ground, calcined, clay product designed as a soil amendment to loosen soil, stimulate root growth and for similar gardening uses. It is manufactured by the Wyandotte Chemical Corporation, J. B. Ford Division, Wyandotte, Michigan. Currently it is sold in 50-pound bags but it is my understanding that it is soon to come out in smaller quantities and sold through chain stores. Spores can be sown on any reasonable substrate, of

[1]Contribution No. 63-1 from the Department of Botany and Plant Pathology, Michigan State University. Photograph by Phillip Coleman.

course. For example, one can hardly surpass oak soil (Kleinschmidt, pers. comm.) for many ferns. The very rough nature of a bed of *Turface*, however, seems to provide varying microeco-

FIGURE 1. CULTURE OF PROTHALLIA AND YOUNG SPOROPHYTES IN FLASK. FIGURE 2. YOUNG SPOROPHYTES IN POT COVERED WITH PLASTIC FREEZER BAG.

logical niches for spores and we have had very good luck with the material so far. As seen in figure 1, we have been placing the *Turface* in small flasks. We soak the medium in a modified Knutson's nutrient medium (almost any other will do), and then sterilize the flask in an autoclave for about 30 minutes. The spores are then sown through the mouth of the flask. One should have spores of known origin (uncontaminated) to begin with and Kleinschmidt's method (1957) of sterilizing the fronds before all of the spores have been shed is an excellent one. This precaution will largely prevent contamination by unwanted fern spores and also reduce fungal contamination. The sexual phase or gametophytes will develop from the spores if conditions are right. Usually one is only desirous of obtaining the sporophytes and one small trick here usually or frequently overlooked is to water the mass of prothallia from above (distilled water will do) so as to ensure fertilization and the development of the sporophyte. It should be mentioned in this connection that growing ferns in a closed flask largely eliminates as much watering as found in the potted soil method. One can tell when the clay needs watering by noting its color, which changes with varying percentages of water.

When the sporophytes are about an inch high, they are ready for transplanting. They can be spaced in pots or flats after removal (by shaking or by long forceps) from the flasks. This stage has always proven to be a hazardous one and many sporelings die. A way to ensure success with the transplanting and to force the plants along, is to place the pots of transplants (in moist soil) in a plastic freezer bag, label, using a wooden label, and close the top of the bag with a rubber band (fig. 2). The humid atmosphere in the bag offsets transplant loss and, each bag, acting as a miniature greenhouse, causes the plants to grow much faster than they ordinarily would.

LITERATURE CITED

BENEDICT, R. C. 1955. Aids to Spore Culture. Amer. Fern Jour. **45**: 60-64.

BOYDSTON, KATHRYN 1958. An Amateur Plants Fern Spores. Amer. Fern Jour. **48**: 1-18.

FLIFLET, THORLEIF 1961. Growing Ferns from Spores. Amer. Fern Jour. **51**: 113-127.

HIRES, CLARA S. 1940. Growing Ferns from Spores on Sterile Nutrient Media. Jour. N. Y. Bot. Gard. **41**: 257-266.

KLEINSCHMIDT, W. F. 1952. Growing Ferns from Spores. Amer. Fern Jour. **42**: 117-124.

——— 1957. A Method of Preparing Spores for Fern Cultures. Amer. Fern Jour. **47**: 95-98.

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Ethnobotanical Uses of California Pteridophytes by Western American Indians

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Utilization of pteridophytes by Western American aborigines played a minor but very interesting role in their lives. Most of the pertinent information is scattered. This paper attempts to summarize much of this information.

The species known to have been used by the western North American Indians north of Mexico are discussed below. The botanical nomenclature is according to Munz (1959).

LYCOPODIUM CLAVATUM L. Club-moss. Although there is no evidence for use of this species by western Indians, Frye (1934) reported its spores were collected for dusting on open raw wounds and chafed infants. The spores are very fine and light, which enables them to repel water and prevent stickiness. *Lycopodium selago* L., a related species in the northwest was used by Indians as an intoxicant. The stem was chewed and the juice swallowed. It is said that three plants produced a mild intoxication whereas eight plants stupified the user.

EQUISETUM ARVENSE L. Common horsetail. The major use of the horsetails was as an abrasive in polishing bows and arrows (Murphey, 1959). However, it was sometimes dried and burned and the ashes used on sore mouths. The Lower Chinook Indians of Washington gathered, peeled and ate raw the stems of early reproductive shoots (Gunther, 1945).

EQUISETUM HYEMALE L. var. ROBUSTUM (A. Br.) A. A. Eat. Medical uses of this plant included treatment of the prostate gland with infusions made from dried material taken orally (Romero, 1954). Washington Indians boiled the stems and washed their hair to get rid of vermin. Infusions of boiled stems and willow leaves were given to girls to regulate the menstrual period. The Makah ate the reproductive shoot heads for diarrhoea and used the root juice as an eye wash (Gunther, 1945). Karok Indians used the stalk as an abrasive to sharpen the edge of mussel shells used in cleaning fish and to polish arrows. Schenck & Gifford (1952) reported that infusions were used to cleanse priests in the Karok's First Salmon Ceremony.

EQUISETUM KANSANUM Schaffn. Hot infusions were drunk for backaches. Cold infusions were used as a lotion. This species was also used in the Waterway Ceremony of the Kayenta Navajo.

EQUISETUM LAEVIGATUM A. Br. Hopi Indians dried and ground stems and mixed this with corn meal to make a mush used for food and in preparing ceremonial bread (Castetter, 1935).

EQUISETUM TELMATEIA Ehrh. Giant horsetail. Portions of the root stalk were cooked and eaten by the Cowlitz Indians of Washington. Stems were also used for polishing and scouring and as fodder for horses.

ADIANTUM CAPILLUS-VENERIS L. Venus-hair fern. Kayenta Navajo used infusions as treatment for bumblebee stings and centipede bites, and for insanity. It was also smoked in the Lifeway Ceremony. Romero (1954) reported some California Indians used this species in treating menstrual irregularities.

ADIANTUM JORDANII C. Muell. California maidenhair. The most interesting use for any fern is that which Chesnut (1902) reports for this species. The Indians of Mendocino County valued the smooth black midribs for keeping and enlarging earring holes.

ADIANTUM PEDATUM L. var. ALEUTICUM Rupr. Five-finger fern. Despite its wide distribution this plant was only limitedly used. Its black shiny midrib coverings were a main component for making designs on baskets by many tribes (Balls, 1962; Merrill, 1923). Washington Indians soaked the fronds and used the infusions on the hair. The fronds were chewed for sore chest and stomach trouble and to stop bleeding from wounds. For the latter reason it was sometimes carried with war parties. Ashes of the fronds were rubbed on the hair to produce shiny black braids. Schenck & Gifford (1952) reported that the fern was used for decoration in the Jump Dance dress of the Karok Indians.

PELLAEA MUCRONATA (D. C. Eat.) D. C. Eat. Bird's-foot fern. Infusions of the frond were drunk as a tea for both medical and pleasurable reasons by the Luiseno Indians (Sparkman, 1908). The Minok used the tea to stop nose-bleeds and to purify the blood (Barrett & Gifford, 1933).

PELLAEA sp. (P. ATROPURPUREA in Romero, 1954). When steeped this fern produced a delicious ephedra-like tea to flush the kidneys and tone the blood. In summer it was used to prevent sunstroke.

PITYROGRAMMA TRIANGULARIS (Kaulf.) Maxon. Gold-back fern. This species was chewed by the Minoks for treating toothaches. It was also applied in mitigating the afterpains of childbirth by the Karok. Sometimes its midribs were substituted for those of the maidenhair fern in basketry. Chestnut (1902) reported that the fronds were slapped on clothing by children to make temporary gold colored prints. [This practice is *still* followed by white children!—Ed.]

PTERIDIUM AQUILINUM (L.) Kuhn var. LANUGINOSUM (Bong.) Fern. Brake or Bracken fern. The bracken fern was perhaps the most widely used fern in California. In basketry untreated roots provided the only brown coloring for designs (Merriam, 1955). Frequently these were blackened by heating in water, the degree of coloring depending on the length and temperature of the hot-water treatment. The Karok cleaned salmon on beds of the fern and used the fronds for wrapping tobacco. Some

California tribes cut and cooked the young sprouts to obtain a rich flavored oil and starch. Wittrock & Wittrock (1942) reported that rhizomes were used by many tribes as an important food. The white heart was roasted until it resembled the dough of wheat. This was relished as a nutritious but pungent foodstuff. Young sprouting shoots were also used in preparing soup, or were eaten raw (Yanovsky, 1936). Baked rhizomes could be stored for later use. The Quinault Indians of Washington were said to have used the fibers of the rhizome for making string (Gunther, 1945). They also made a fern-paste bread from the pulp. The Indians of Mendocino County used the large fronds for beating down grass fires and lining berry baskets (Chestnut, 1902). It was also used as a diuretic for horses.

ATHYRIUM FILIX-FEMINA (L.) Roth. var. SITCHENSE Rupr. Lady-fern. Roasted rhizome centers, roots, and new shoots were eaten by Washington Indians. The fronds were also used to wipe fish after cleaning. Boiling rhizomes produced a tea which was drunk to ease body pains. Boiled stem infusions were taken to ease labor pains.

DRYOPTERIS DILATATA (Hoffm.) Gray. Wood-fern. Pounded roots of this species were applied to cuts and frond infusions were used as a hair wash. The rhizomes were sometimes baked and eaten.

DRYOPTERIS FILIX-MAS (L.) Schott. Male-fern. The only recorded use for this fern is as a vermifuge (Wittrock, 1942).

POLYSTICHUM MUNITUM (Kaulf.) Presl. Sword-fern. Rhizomes were peeled and baked in pits with salmon eggs and eaten. The fronds were sometimes used to line the baking pits or to serve as racks for drying berries. The Quilente and Cowlitz Indians made mattresses from them. Medicinally, the young curled fronds were chewed raw and swallowed for sore throats or tonsilitis or to facilitate childbirth. Infusions of the frond were sometimes placed on sores and boils. Boiled rhizome infusion was said to cure dandruff. The sporangia were put on burns.

Sword fern fronds were used in a game to determine long wind. Leaflets were touched or torn off beginning at the bottom of the frond and certain words were spoken for each. The winner was the one who reached the highest point on the frond in one breath (Schenck & Gifford, 1852).

BLECHNUM SPICANT (L.) With. Deer-fern. Fronds were only used in case of emergency by lost children or to prevent thirst on long journeys. Infusions of the leaves were drunk for general ill health. Green fronds were eaten for lung trouble, stomach distress, and colic.

WOODWARDIA FIMBRIATA Sm. in Rees. Chain fern. Root fibers were used in basket designs either naturally colored or dyed red. The Luiseno Indians used infusions from the roots to relieve pain from injuries. In basketry the midrib of the frond contained two fibers which were stripped and handled like lengths of yarn. Sometimes they were dyed with alder bark or with moss to a burnt orange.

POLYPODIUM CALIFORNICUM Kaulf. California Polypody. Chesnut (1902) reported that juice of the rhizome was rubbed on sores for healing and on the body to treat rheumatism. Root extracts were sometimes used as an eyewash.

POLYPODIUM GLYCYRRHIZA D. C. Eaton. Licorice fern. The rhizome of this plant was roasted and chewed as treatment for coughs. The Cowlitz crushed and boiled the rhizome and mixed it with fir needles to treat measles.

DENNSTAEDTIA PUNCTILOBULA (Michx.) Moore. Romero (1954) erroneously reported this eastern fern from the mountains of California. Its only use was in treating tuberculosis and other lung diseases by drinking oil extracts from the root. The identity of this plant is unknown but it is not the species above.

Of the almost 85 species of ferns and fern allies occurring in California less than one-fourth are known to have been utilized by western American Indians. Upon close examination of the species discussed in this paper, most are found to be restricted in range to the cismontane and other mesophytic regions of the coastal and southwestern states. However, the majority of

Indian tribes covered in this study inhabit these regions.

Uses of ferns by desert tribes has been restricted to a few of the many species occurring in their region. The Hopi Indians of north central Arizona, for example, used only *Asplenium trichomanes* and *Equisetum laevigatum* (Whiting, 1939). Elmore (1944) found no pteridophytes being used by the Navajo, although they did have a name for *Cheilanthes feei.* Wyman & Harris (1951) reported two ferns used by the Kayenta Navajo.

By contrast, Indians of more mesophytic regions made more varied use of a greater number of ferns. Schenck & Gifford (1952) listed eight species used by the Karok of Humboldt County. Chesnut (1902) said six species were utilized by Mendocino County Indians and Gunther (1945) found ten species being used by Indians of western Washington.

None of the species listed was a major constituent of a tribe's sustenance except perhaps *Pteridium aquilinum* var. *lanuginosum* which was valued as food and for less important uses. Although a few of the remaining species were important in a utilitarian manner most of them were luxuries.

LITERATURE CITED

BALLS, E. K. 1962. Early Use of California Plants. Univ. of Calif. Press, Berkeley.

BARRETT, S. A. & E. W. GIFFORD. 1933. Minok material culture. Bull. Publ. Museum City of Milwaukee, Wisc.

CASTETTER, E. F. 1935. Ethnobiological studies in the American Southwest. 1. Uncultivated native plants used as sources of food. Bull. Univ. New Mexico Biol. Ser. **4:** 1–62.

CHESNUT, V. K. 1902. Plants used by the Indians of Mendocino County, California. Contr. U. S. Nat. Herb. **7:** 295–422.

ELMORE, F. H. 1944. Ethnobotany of the Navajo. Monogr. School Am Res. Santa Fe, No. 8.

FRYE, T. C. 1934. Ferns of the Northwest. Metropolitan Press, Portland, Ore.

GUNTHER, ERNA. 1945. Ethnobotany of Western Washington. Univ. Wash. Publ. Anthropol. **10:** 1–61.

MERRIAM, C. H. 1955. Studies of California Indians. Univ. of Calif. Press, Berkeley.

MERRILL, RUTH E. 1923. Plants used in basketry by the California Indian. Univ. Calif. Publ. Am. Archaeol. and Ethnol. **20**: 213–242.
MUNZ, P. A. 1959. A California Flora. Univ. of Calif. Press, Berkeley.
MURPHEY, EDITH. 1959. Indian Uses of Native Plants. Desert Printers, Inc., Palm Desert, Calif.
ROMERO, J. B. 1954. The Botanical Lore of the California Indians. Vantage Press, New York.
SCHENCK, SARA M. & E. W. GIFFORD. 1952. Karok ethnobotany. Anthropol. Rec. **13**: 377–392.
SPARKMAN, P. S. 1908. The culture of the Luiseno Indians. Univ. Calif. Publ. Am. Archaeol. and Ethnol. **8**: 187–234.
WHITING, A. F. 1939. Ethnobotany of the Hopi. Bull. Museum Northern Ariz. No. 15.
WITTROCK, MARION & G. L. WITTROCK. 1952. Food plants of the Indians. Jour. N. Y. Bot. Gard. **43**: 57–71.
WITTROCK, MARION. 1942. Medicines from plants. Jour. N. Y. Bot. Gard. **43**: 76–86.
WYMAN, L. C. & S. K. HARRIS. 1951. The ethnobotany of the Kayenta Navajo. Univ. New Mexico Publ. Biol. No. 5.
YANOVSKY, E. 1936. Food plants of the North American Indians, U. S. Dept. Agr. Misc. Publ. No. 237.

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Phytogeography of Selaginella douglasii

GEORGE NEVILLE JONES

This western North American species has a restricted geographical distribution, being known with certainty only in Washington, Oregon, and Idaho. From time to time it has been attributed to both California and British Columbia, but there seems to be no available evidence that it has ever been found in either of those places. My attention was drawn to this matter by the critical monographic work of Alston (1955), who pointed to certain ambiguities in statements dealing with its geographical range.

According to the classification of Alston & Walton (1938) *Selaginella douglasii* belongs in the subgenus *Stachygynandrum*, series *Decumbentes.* It was described first as *Lycopodium ovalifolium* by Hooker & Greville (1829), but this binomial was invalid when published because Desvaux had applied it to a different species earlier. In 1831 Hooker & Greville renamed the plant *Lycopodium douglasii,* and it appeared under this name in Hooker's *Flora Boreali-Americana* (1840). Spring (1843), the monographer of *Lycopodium* and *Selaginella,* included it with *Selaginella* as "24. S. douglasii (Lyc.) Hook. et Grev.," the "Lyc." standing for *Lycopodium.* Originally Hooker based the species on a collection by David Douglas. One hundred and forty-one years later this plant is known to occur only near the type locality along the Columbia River, and in one disjunct area in northern Idaho, some three hundred miles northeastward.

The reports of *Selaginella douglasii* as a Californian species originated apparently with D. C. Eaton, who in the *Botany of California* (1880) wrote that it occurs "Probably in Northern California." Other later published reports of this nature include those by Clute (1905) who wrote, "It is reported to grow in northern California, Oregon, Washington, and British Columbia." Piper (1906) gave the range as "Washington to California." Piper & Beattie (1915) correctly gave simply, "On wet rocks, local; abundant in the Cascade Gorge of the Columbia River." Maxon in Abrams (1923) gave the range as British Columbia and northern Idaho to California, and Jepson (1923) wrote, "Damp shades, n. Cal.; n. to B. C." Peck (1941) attributed this plant to "Moist rocky slopes in the shade, abundant on the south side of the Columbia River Gorge; B. C. to Calif., east to Idaho." Munz (1959) merely mentioned *S. douglasii* as "reported from n. Calif." The continued ascriptions of *S. douglasii* to California are remarkable because there is no other species of *Selaginella* north of Mexico that resembles *S. douglasii.* D. C. Eaton (1880, p. 350) commented that it is "more like some tropical forms than any of the northern species." There is now strong presumptive evidence that *S. douglasii* occurs not nearer than about 240 miles north of California.

The reports of *S. douglasii* from British Columbia also are remarkably persistent. The first came from Baker (1887), who wrote, "Hab. British Columbia, Oregon, and Washington Territory. A well marked species." Alston (1955) noted that this seemed to have arisen through confusion with the Columbia River, and added, "Hooker wrote 'Columbia, Douglas' on the Kew sheet, and Baker has added 'British.'" It may be observed that the town of Vancouver is on the Columbia River in the state of Washington, while the capital city of British Columbia bearing the same name is situated on the mainland of British Columbia. Hieronymus (1902) attributed *S. douglasii* to "nordamerikanisch Columbien und in Oregon," presumably referring to the western Canadian province of British Columbia. Another possible cause for ascribing *S. douglasii* to British Columbia may have resulted from confusing it with *S. selaginoides* (L.) Link, which Henry (1915) listed from "Selkirks and Rockies, Ucluelet [Vancouver Island, British Columbia], Ounalashka [Unalaska, Aleutian Islands]." There apparently is no evidence that *S. douglasii* occurs naturally in British Columbia or elsewhere in Canada.

Relevant references to *Selaginella douglasii* include the following:

Selaginella douglasii (Hook. & Grev.) Spring, Bull. Acad. Sci. Belg. **10**: 138, 1843; Mém. Acad. Roy. Belg. **24**: 92, 1850.—Eaton (1880, p. 350); Baker (1887, p. 47); Hieronymus (1902, p. 689); Clute 1905, p. 160); Piper 1906, p. 87); Piper & Beattie (1915, p. 14); Maxon (1923, p. 46); Jepson (1923, p. 42); Peck (1941, p. 57); Tryon (1949, p. 422); Alston (1955, p. 238); Munz (1959, p. 23).

Lycopodium ovalifolium Hook. & Grev., Icon. Fil **2**: *t. 177.* 1829, non Desv., 1827. "Hab. In oris occidentalibus Americae septentrionalis. Dom. Douglas."

Lycopodium douglasii Hook. & Grev. in Hook., Bot. Misc. **2**: 396. 1831.—"Hab. Near springs in woody places, N. W. America, *Douglas.*—An extremely distinct and well-marked species, which I have never received from any collector except *Mr. Douglas.*" (Hook, Fl. Bor. Am. **2**: 268. 1940.)

(?) *Lycopodium denticulatum* sensu Wilks, Jour. David Douglas 145, 1914, non Linn.

Type: Abundant in moist places on the hills near Grand Rapids, Columbia River above Vancouver, Sept. 1825, *Douglas* 482.

WASHINGTON

COWLITZ COUNTY: Kalma, *Hemphill* (K).

SKAMANIA COUNTY: Cape Horn, *Piper 4965* (ILL, WS); *Suksdorf 2647* (WS); *T. J. Howell*, June 1887 (MO); Castle Rock (Beacon Rock) *Suksdorf 8475* (WS); east side of Beacon Rock, near summit, shady rocky situation, *J. W. Thompson*, July, 1956 (WTU).

OREGON

CLACKAMAS COUNTY: Shady banks of Eagle Creek, May 20, 1928, *J. W. Thompson 4259* (MO, OSC, WTU); moist fir woods, on logs, mossy ground, etc., Eagle Creek, *M. W. Gorman 5115* (WTU); Milwaukie, May 1881, *Thomas Howell* (OSC, ILL), *T. Howell* 695 (WS); above Estacada, Aug. 1914, *M. E. Peck* (MO, WTU).

HOOD RIVER COUNTY: Herman Creek trail, Aug. 15, 1915, *L. N. Goodding* (OSC), Aug. 15, 1930, *S. B. Locke* (OSC); Columbia Gorge, Apr. 10, 1943, *Helen M. Gilkey* (OSC); Bridal Veil, Columbia River Gorge, *G. N. Jones 8767* (ILL, MO); wet rocks, McCord Creek, Columbia River Gorge, *G. N. Jones 10091* (ILL).

MULTNOMAH COUNTY: Damp shaded rocks near Bonneville, *Suksdorf 832* (BM, WS); common in mixed forest of *Pseudotsuga* and *Acer*, on rocks and tree trunks, elev. 600 feet, Oneonta Gorge Trail, two miles east of Multnomah Falls, *A. N. Stewart 7496* (OSC); on mossy basaltic banks, Sheppards Dell, south side of Columbia River, *C. L. Hitchcock 20110* (WTU); shaded slopes above Wahkeena Falls, Columbia River, *Ivan Buddenhagen 6* (OSC); on rocks on trail to falls, Wahkeena Falls, Sept. 12, 1951, *L. Jones & F. Nicol* (OSC); on moist sunny cliffs, Cornell Road, Portland, *L. F. Henderson 1217* (OSC); vicinity of Portland, *William Palmer 1492* (WTU); Portland, *Godman 342* (BM); damp shaded bank, McClay Park, Portland, June 15, 1915, *M. A. Flinn* (OSC); rocky places by spring just beyond Corbett, *J. W. Thompson* 2979 (WTU); Multnomah Falls, *J. W. Thompson 4192* (WTU), *4973a* (WTU), *11368* (MO, WS, WTU).

COUNTY UNKNOWN: Columbia River, near spring in wood, *Douglas* (K); abundant in moist places on the hills near Grand Rapids, Columbia River above Vancouver, Sept. 1825, *Douglas 482* (ex Wilks); banks of the Columbia, *Lobb* (BM); banks of the Columbia River, western Oregon, *T. J. Howell 245* (MO).

IDAHO

CLEARWATER COUNTY: Granite cliffs along the Clearwater River, 5 miles south of Orofino, *W. H. Baker* 13979 (ID).

IDAHO COUNTY: Wet sandy soil, South Fork, Clearwater River, *R. J. Davis 8401* (IDS, WS); on moist rocks in deep shade, about 25 miles west of Elk City on the South Fork of the Clearwater River, *C. L. Hitchcock 20362* (WTU); Selway Falls, *H. J. Rust 2595c* (ID); on moist cliffs, south side of Selway River, 20 miles southeast of Lowell, *J. H. Christ 18262* (WS); shaded rock cliff, Selway Falls, *J. H. Christ 2595* (ID); Selway Falls, *H. C. Aase 1774* (BM, MO, WS); *Ownbey & Ward 3131* (WS); Three Devils Camp, *Daubenmire 4526* (WS); Three Devils Camp Ground, four miles west of Lowell, *W. H. Baker 14804, 14526* (ID); southeast of Harpster, *Daubenmire 47144* (WS); on cliffs along Lochsa, one mile east of Lowell, *J. H. Christ 12081* (ID); rocky cliffs near Deadman Creek on the Lochsa River, *Young* (BM).

NEZ PERCE COUNTY: Moist wooded slopes along the Clearwater River, five miles east of Spalding, *W. H. Baker 6459* (ID).

LITERATURE CITED

ALSTON, A. H. G. 1955. The heterophyllous Selaginellae of continental North America. Bull. Brit. Mus. (Nat. Hist.) Bot. **1**: 219-274.

——— & J. WALTON. 1938. Lycopodiinae, in F. Verdoorn, Manual of Pteridology, pp. 500-506. The Hague.

BAKER, J. G. 1887. Handbook of the fern-allies. London.

CLUTE, W. N. 1905. The fern allies of North America north of Mexico. New York.

EATON, D. C. 1880. Pteridophyta, in S. Watson, Botany of California, **2**: 329-352.

HENRY, J. K. 1915. Flora of Southern British Columbia. Toronto.

HIERONYMUS, G. 1902. Selaginellaceae, in Engler & Prantl, Nat. Pflanzenf. **1**(4): 621-715.

HOOKER, W. J. 1840. Flora Boreali-Americana, vol. 2. London.

———& R. K. GREVILLE. 1829–31. Icones Filicum. vol. 2. London.

JEPSON, W. L. 1923. A manual of the flowering plants of California. Berkeley.

MAXON, W. R., IN L. R. ABRAMS. 1923. Selaginella, in Illustrated Flora of The Pacific States **1**: 46-50. Stanford.

MUNZ, P. A. 1959. A California flora. Berkeley.

PECK, M. E. 1941. A manual of the higher plants of Oregon. Portland.

PIPER, C. V. 1906. Flora of the state of Washington. Contr. U. S. Nat. Herb. **11**: 87.

———— & R. K. BEATTIE. 1915. Flora of the Northwest Coast. Pullman.

SPRING, A. 1843. Enumeratio Lycopodinearum. Bull. Acad. Sci. Belg. **10**: 138.

————. 1850. Monographie de la famille des Lycopodiacées. Mém. Acad. Roy. Belg. **24**: 92.

TRYON, ALICE. 1949. Spores of the genus Selaginella in North America north of Mexico. Ann. Missouri Bot. Gard. **36**: 413-432, *f. 1-32 on pl 23-30.*

WILKS, W. 1914. Journal of David Douglas. London.

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Retention of Viability in Lyophilized Spores of the Fiddlehead Fern, Matteuccia pensylvanica[1]

W. G. BARKER AND R. G. WHITE

For many years, residents of New Brunswick, Canada, have used young tender rolled fronds of *Matteuccia pensylvanica* as a table vegetable. In recent times, this use has assumed such economic importance that curled fronds are now gathered in the spring as a fresh crop, or are commercially processed either by freezing or canning. There has been no attempt at raising them commercially. Instead, they are harvested with difficulty from their wild habitat in shaded places along rivers and streams, mostly by Indian laborers. Because of the increasing importance of this crop, one of us (R.G.W.) has undertaken to study the propagation and management of these plants on a regularized basis.

[1]Contribution No. 128 from the Research Station, Canada Department of Agriculture, Fredericton, New Brunswick.

There is a somewhat sparse literature on the handling of fern spores. However, it has been noted (Bold, 1957) that spores of *Osmunda* spp. must be sown shortly after they mature. Further, Campbell (1887) reported that *Onoclea* sp. spores begin germination within a very few days and therefore grow rapidly to form the prothallus. On the other hand, Bailey (1915) reported that these organs, properly stored, can be kept alive for long periods. No statement could be found concerning the possibility of lyophilization, although similar techniques had been effectively employed in the preservation of ginkgo pollen (Tulecke, 1954) (but not the pollen of *Pinus palustris* Mill.) (Hesseltine & Snyder, 1958) and in various fungal diaspores (Mehrotra & Hesseltine, 1958). In consequence, it was decided to obtain this information with respect to this fern species.

Spores were collected September 23, 1962, as they matured in the wild. They were shaken free of the parent frond and placed in flasks of a Virtis Macro freeze-dry apparatus and frozen quickly by partial submersion in a mixture of dry ice and ethanol. Subsequently they were freeze-dried under vacuum imposed by a Duo-seal pump for 8 hours. They then were placed in bottles and stored at —20° C. in desiccators over Drierite crystals.

Following one and three month storage, the lyophilized spores were sown in several media: well rotted leaf mold, a mixture of peat, sand and soil, and in sterilized sphagnum. In every instance, the spores germinated readily and produced vigorous thalli. Both plantings have developed the sporophyte generation and are growing well. There has been no apparent drop in the viability of the lyophilized material.

Spores of the fiddlehead fern, *M. pensylvanica*, can undergo lyophilization and retain viability after storage for three months. How extended a storage period can be realized by this technique will be determined. It is not known at present whether this procedure will have application in the commercial growing of the fiddlehead fern. However, it may be of enhanced interest should it be demonstrated that other fern spp., especially those difficult to store, will survive this process.

LITERATURE CITED

BAILEY, L. H. 1915. Standard Cyclopedia of Horticulture, Vol. III. The MacMillan Co., London.

BOLD, H. C. 1957. Morphology of Plants. Harper and Brothers. New York. 669 pp.

CAMPBELL, D. H. 1887. II. The Development of the Ostrich Fern, *Onoclea struthiopteris*. Memoirs Boston Soc. Nat. Hist. IV. 17-52.

HESSELTINE, C. W. and F. B. SNYDER. 1958. Attempts to Freeze-dry Pine Pollen for Prolonged Storage. Bull. Torrey Bot. Club. **85:** 134-135.

MEHROTA, B. S. and C. W. HESSELTINE. 1958. Further Evaluation of the Lyophil Process for the Preservation of Aspergilli and Penicillia. Appl. Microbiol. **6:** 179-183.

TULECKE, W. R. 1954. Preservation and Germination of the Pollen of Ginkgo Under Sterile Conditions. Bull Torrey Bot. Club. **81:** 509-512.

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Shorter Notes

FERNS AND FERN ALLIES ON BONAVENTURE ISLAND, QUEBEC.—Bonaventure Island off the Gaspé Peninsula has long been a mecca for ornithologists, and it was to study sea birds that I visited that island from July 5–25, 1946. The richness of the flora and a spell of inclement weather were instrumental in my obtaining a reasonably complete collection of the pteridophytes of the island and a small collection of flowering plants, many of them not mentioned by Adams in his preliminary list of the plants of the island.[1]

The flowering plants and one set of the pteridophytes were deposited in the herbarium of the University of California at Berkeley and the remainder in the herbarium of the University of Michigan. Of the 29 pteridophyte species collected, only three (*Pteridium aquilinum, Thelypteris phegopteris,* and *Equisetum*

[1]Adams, J. 1940. A Preliminary list of the plants of Bonaventure Island. Canadian Field Nat. **54:** 7-9.

sylvaticum) were listed by Adams[1] and five others (*Dryopteris filix-mas, Osmunda cinnamomea, Botrychium lunaria, B. matricariifolium,* and *Selaginella selaginoides*) were reported from the island by Scoggan.[2] Because of the paucity of published records of pteridophytes from this island and the desirability of a guide to the habitats and relative abundance of these plants, I wish to put the results of this collection on record. I am endebted to Dr. W. H. Wagner, Jr., for his encouragement and help with the manuscript. An annotated list of the species found follows.

POLYPODIUM VIRGINIANUM L. Not uncommon; a thriving colony was found growing with *Empetrum* on a shaded boulder in mixed woodland.

PTERIDIUM AQUILINUM (L.) Kuhn. Found sparingly in open meadows.

CRYPTOGRAMMA STELLERI (Gmelin) Prantl. Fairly common on rock ledges. Some plants were found which appeared to be the hosts of a species of rust.

ASPLENIUM VIRIDE Hudson. A single colony of several plants of this species was found on a limestone ledge by a stream deep in coniferous forest. Some fronds measured up to seven inches in length.

ATHYRIUM ANGUSTUM (Willd.) Presl. Fairly common in wet ground in openings in the coniferous forest.

GYMNOCARPIUM DRYOPTERIS (L.) Newm. Common under conifers.

THELYPTERIS PHEGOPTERIS (L.) Slosson. Abundant under conifers.

DRYOTERIS CAMPYLOPTERA Clarkson. Abundant in recently cut-over areas in the coniferous forest where it grows waist-high with other disturbance indicators as *Ribes* and young birch. Its appearance in disturbed areas parallels that of *Pteridium aquilinum* in many areas to the south.

DRYOPTERIS INTERMEDIA (Willd.) Gray. Uncommon under conifers.

CYSTOPTERIS BULBIFERA (L.) Bernh. Not uncommon in moist parts of the coniferous forest and on shaded rock ledges.

CYSTOPTERIS FRAGILIS (L.) Bernh. Fairly common in coniferous forest.

DRYOPTERIS FILIX-MAS (L.) Scott. Uncommon in coniferous forest. A particularly large plant was found in the bottom of a small temporary stream near its head.

POLYSTICHUM BRAUNII (Spenner) Fee. Uncomon in moist coniferous forest.

MATTEUCCIA STRUTHIOPTERIS var. PENSYLVANICA (Willd.) Morton. Al-

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[2]Scoggan, H. J. 1950. The flora of the Bic and the Gaspé Peninsula, Quebec. Nat. Mus. Canada Bull. 115. pp. 1-399.

though very common on the mainland, this species was only encountered on the island in a few wet places in thin coniferous forest.

OSMUNDA CINNAMOMEA L. var. CINNAMOMEA and

OSMUNDA CLAYTONIANA L. both fairly common in wet openings in the forest.

BOTRYCHIUM LUNARIA L., B. MATRICARIIFOLIUM A. Braun, and B. SIMPLEX Hitchcock. Many scattered colonies of all three in open meadows, growing with moss, *Iris*, and *Polygonum viviparum*.

BOTRYCHIUM VIRGINIANUM L. Rare. A colony found growing in partial shade in a small clearing in the coniferous forest.

EQUISETUM ARVENSE L. Common in wet meadows.

EQUISETUM PRATENSE Ehrhart. One colony found growing with *E. arvense* in a damp meadow.

EQUISETUM SCIRPOIDES Michx. A colony found growing in tufts on stumps in cleared ground.

EQUISETUM SYLVATICUM L. var. MULTIRAMOSUM Fern. Very common, replacing *E. arvense* in moist areas in coniferous forest.

LYCOPODIUM ANNOTINUM L. Uncommon; collected in man-made clearing in coniferous forest.

LYCOPODIUM CLAVATUM L. and L. LUCIDULUM L. Uncommon in coniferous forest.

LYCOPODIUM OBSCURUM L. Rare. Two small plants were found in coniferous forest.

SELAGINELLA SELAGINOIDES (L.) Link. A good-sized colony was found in an open bog, where the species grew on small stumps in company with *Parnassia* and *Drosera*.

ROBERT W. STORER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

A NOTE ON ELAPHOGLOSSUM CRINITUM.—A number of years ago during one of my frequent botanizing trips to Cuba I spent some time at the "rest house" of the Hermanos de la Salle high up on the peak of Loma del Gato. This verdant mountain, one of the tallest in Cuba, lies not far from Santiago. Because of the extensive botanical activities of the Brothers of the Colegio de la Salle, both in Santiago and in Havana, its flora is reasonably well known. Especial attention was paid, by several of the noted Cuban botanists, to its extraordinary fern flora, which ranges into the hundreds of species, and includes a remarkable number of endemics.

The entire upper third of Loma del Gato—which means "Hill of the Cat,"—is covered by a dense forest. Constant very high humidity, coupled with frequent heavy rains throughout the year, create conditions which are ideal for the development of ferns. A variety of immense, graceful tree ferns is found here, virtually every tree-trunk is heavily clothed with dozens of different kinds of epiphytic ferns, and the moist ground under the trees is generally a solid sheet of other ferns in almost overwhelming quantities and kinds. In sunny places where the indigenous trees and shrubs have been disturbed, *Gleichenia* and *Dicranopteris* take over in almost impenetrable thickets.

In such a pteridologist's paradise, I felt uncomfortably aware of my failings and wished that I knew more about the intricacies of fern determination. But I did find, among others, one particular species of fern which was known to me, since it is a famous one which has long been prized by connoisseur collectors in all parts of the world. This was the strange Elephant-Ear Fern, *Elaphoglossum crinitum*.

Widely distributed in the West Indies, Mexico, and portions of Central Amrica, this remarkable fern is a common species in the summit forests of Loma del Gato, and has also been found on a few additional peaks in southeastern Cuba, such as Gran Piedra, Pico Turquino, etc. It has, in the past, been known as the type of a separate genus, *Hymenodium*, but Copeland and others consider this to be referable to the polymorphic group *Elaphoglossum*.

The initial specimens of this Elephant-Ear Fern (its very heavy, russet-hairy fronds certainly do look somewhat like pachyderms' ears!) which I found were growing in a habitat which was characteristic of all those encountered. It was perched in regular array on fallen, partially rotting, moss-covered logs in the darkest shaded spots in the forest. Though I found occasional sporelings on the bases of mossy tree-trunks (even those of the lovely Palma justa, *Euterpe globosa*), no mature plants were found other than on the fallen and deteriorating logs.

Growing with the *Elaphoglossum,* in considerable profusion, were creeping colonies of the very delicate and delightful *Rhipidopteris peltata,* which has long been one of my personal favorites of all ferns, even though I cannot successfully maintain it here in my Coconut Grove garden.

The hirsute covering of this *Elaphoglossum* varies from russet-brown to almost black, forms of the latter appearing rather as if they were dead, instead of living organisms. The fertile fronds are shorter-stalked than the sterile ones, smaller, and paddle-shaped; they bear a solid mass of sporangia on their undersides and are very distinctive, though seemingly rarely produced in the wild.

According to expert fern-growers, this Elephant-Ear Fern does well in a friable rich compost under high humidity at all times, though over-watering should be avoided. I would assume, from having seen the plants in the wild, that enough water should be given them at the roots to keep them constantly moist, but the mossy logs on which they perch would also afford them adequate drainage even in nature.

Though *Elaphoglossum crinitum* is a spectacular fern which has long been in cultivation, I am interested to find that in D. G. Huttleston's recent valuable "Fern Sources in the United States" (THIS JOURNAL **52**: 97-109. July-Sept. 1962), it is not listed. If it is available in this country, I would be most anxious to hear of a source.—ALEX D. HAWKES, *Coconut Grove 33, Florida.*

OBSERVATIONS ON THE SENSITIVE FERN: SUPPLEMENT.—Last year in my paper "Observations on the Sensitive Fern," I asked the question, "What is the critical period during which destruction of vegetative leaves will induce primordia of sporophylls to change their course of development?" (THIS JOURNAL **53**: 97. 1963). A simple experimental test of plants in a ten foot square at Pilot Knob indicates that, at least in this case, twenty days is long enough.

On June 16th the large vegetative leaves of the selected area were mowed off with a machete. Some small leaves, arising from tiny branches or young sporelings, were left untouched. Adjoining this area there flourished more extensive stands of *Onoclea* growing under similar conditions, but left undisturbed.

On July 6th, observations showed at least twenty specimens which could be classified as *Onoclea sensibilis* forma *obtusilobata*. Only normal types of sporophyls were observed in the adjoining, unmowed plot. Most of the intermediate leaves in the experimental plot were of the twice-pinnate type with which the name "*obtusilobata*" is usually associated. A few were not two-pinnate; their lateral divisions were narrowly linear and in this respect could be referred to as "lorinserioid."—RALPH C. BENEDICT, *Pilot Knob, New York.*

GROWING MOTHER FERNS.—I was interested in Mr. Morton's recent article on the Mother Ferns (*Asplenium bulbiferum* and *A. daucifolium*). I was surprised to hear that the little plantlets of this fern are ever difficult to grow. I have a plant of *A. bulbiferum* which I bought in this country. Its older fronds are weighted down with very large number of plantlets with little fronds up to about six centimeters in length. These plants drop off, and they litter my greenhouse. If I remove them from the frond I find them very easy to grow, if they are not taken too young. As I am not much more than a beginner at growing ferns and have no special skill, I am sure that anyone could grow my plantlets. My fern has two types of fronds; some intermediate fertile fronds have narrow ultimate segments, marginal sori, and bulbils on the upper surface.

I am interested in Australian ferns, which I grow from spores, when kind friends send me any. I wish I could see some of your American ferns. You must have a bewildering variety.[1]—M. I. TETLEY, *Valley Howe, Cartmel, Grange-over-Sands, Lancashire, England.*

[1] Following the receipt of this communication, I wrote to Miss Tetley asking if she would like to receive spores of American ferns, and she replied that she would be very happy to have them, especially spores of temperate ferns that would be likely to be hardy in Lancashire.—C.V.M.

Recent Fern Literature

THE DEVELOPMENTAL ANATOMY OF ISOETES, by Dominick J. Paolillo, Jr., Illinois Biological Monographs, No. 31. University of Illinois Press, Urbana, 1963. $2.50 paper, $3.50 cloth. 130 pp., including 19 plates.—This recent book of interest to many pteridologists has come to my desk. It is a handsome book, well-printed and bound and of pleasing format. In addition to the general introductory sections there are three parts to the work headed "The Shoot," "The Root-Producing Meristem," and "The Apical Meristem of the Root." Each section consists of a review of literature, observations, and discussion, plus a summary and conclusions. The literature reviews are quite detailed. The observations consist of careful descriptions of structure as seen in serial sections. Perhaps anatomical descriptions are by nature difficult to follow, but at times it does seem that the author could have found some way to make this less laborious.

Considering the contents, the title of this book is misleading. It would be more aptly titled "Some aspects of the developmental anatomy of Isoetes," since it deals with only the relatively mature sporophyte, and does not include the leaf. In fact, in this reviewer's opinion, it would have been better published as a series of papers in a journal rather than as a book.

Such a highly specialized and detailed book as this one probably will not be added to many private libraries. But it is a contribution to pteridology and should certainly be part of any University library.—RICHARD L. HAUKE, *Department of Botany, University of Rhode Island, Kingston, Rhode Island.*

FLORA OF MISSOURI,[1] by Dr. J. A. Steyermark, contains a complete account of the ferns (49 species, including two introduced species and two admitted hybrids, in 24 genera) and fern-allies (13 species in four genera) of Missouri. The figures cited show

[1]Flora of Missouri, by J. A. Steyermark. pp. i-lxxxiii, 1-1725, *pl. 1-390.* 1963. Published by Iowa State University Press, Ames, Iowa, $18.50. By a strange oversight on the part of the printers, early copies of the book contain no date of publication. According to Iowa State University Press the date was November 12, 1963.

that Missouri is not so rich in ferns as some states, but nevertheless there are many interesting species. The treatment is modeled on Deam's famous "Flora of Indiana," and compares favorably with that monumental work. Like Deam, Steyermark has spent many years in the study of the flora of his state, and the results, in the keys and comments, indicate that the book is not a compilation but shows an intimate knowledge of the plants both in the field and in the herbarium. There are no descriptions, but the keys are unusually full and usable. Each species is accompanied by a map showing its distribution by counties. An initial key to the species is followed by a key based wholly on sterile material, which should be useful. The nomenclature in general follows that in Gleason's New Illustrated Flora. A few of the names are not in the form required or recommended by the Code of Nomenclature. According to Art. 73, note, the diaeresis should be used in the name *Isoëtes,* genitives from personal names such as Engelmann should be corrected to *engelmannii* (even though originally spelled "*engelmanni*") (Art. 73, Note 3), a terminal "y" is regarded as a vowel, and so *Cystopteris fragilis* var. *mackayii* should be corrected to "*mackayi,*" the double "i" being considered as an orthographic error, and finally *Athyrium thelypteroides* should be *thelpyterioides*, the original spelling, which cannot be considered an orthographic error since it is etymologically possible. The only misprint that I have noticed is an unfortunate one: On page 30 in the key to the species of *Asplenium* the species *A.* × *ebenoides* appears as "*A.* × *asplenioides.*" An observation of interest noted by Tryon in "Ferns and Fern Allies of Minnesota," p. 138, is that *Lycopodium selago* var. *patens* has stomata on both surfaces of the leaves, whereas in *L. lucidulum* the stomata are on the lower surface only. These species and their varieties are perplexing and little known. Since *Lycopodium* possesses very few characters, this one of the stomata may prove to be of importance. Of course, the major portion of the book is devoted to the flowering plants. Altogether, according to the summary on p. 1665, there are 799 genera and 2438 species treated, and in addition hundreds of subspecies, varieties, forms, and hybrids. Dr. Steyermark is certainly to be congratulated on a fine and scholarly piece of work, which is going to be permanently useful, not only to those working on Missouri plants but to systematic botanists in general.—C. V. MORTON

ARNOLD, CHESTER A. & LYMAN E. DAUGHERTY. 1963. The fern genus Acrostichum in the Eocene Clarno Formation of Oregon. Contr. Mus. Paleont. Univ. Mich. **18**: 205–227 (*6 pls.*).—A brief resume of the ecological requirements of ferns in this genus sets the background for speculation about the conditions under which the fossil materials were deposited and preserved. The descriptions of the petrifactions, which occur in chert, are excellent and the photomicrographs of the thin sections are superb. The paper is technical, but will be of interest to many of the Fern Society's members.

FABBRI, F. 1963. Primo supplemento alle Tavole Chromosomische Della Pteridophyta de Alberto Chiarugi. Caryologia **16**: 237–335.—Continuing the work done by Chiarugi. The discussion in this paper is in English.

HEVLY, RICHARD H. 1963. Adaptations of cheilanthoid ferns to desert environments. Jour. Arizona Acad. Sci. **2**: 164–175.—Contains some interesting and instructive ecological information.

NAYAR, B. K. 1963. Contributions to the morphology of Leptochilus and Paraleptochilus. Amer. Jour. Bot. **50**: 301–308.—Technical description of morphology and anatomy. Illustrated with line drawings and half tones.

NAYAR, B. K. & FARRUH KAZMI. 1962. Ferns of India. IV. Plagiogyria. V. Hemionitis. VI. Cheilanthes. VII. Actiniopteris. Bull. Nat. Bot. Gard. (Lucknow) No. 64, 67, 68, and 75, respectively. — Each part is bound as a small booklet that contains long descriptions, considerable morphology, keys to the species, and with halftone reproductions of varying quality showing different parts of the plants. Line drawings used to illustrate the morphology and anatomy are good. There is an index to the species and references to pertinent literature.

SCAMMAN, EDITH. 1962. The genus Eriosorus in Costa Rica. Contr. Gray Herb. No. **191**: 81–89.—A key to the five species, brief general descriptions, statement of range, synonymy, and citation of species are included. Line drawings are very good.

TRYON, ALICE. 1962. A monograph of the fern genus Jamesonia. Contr. Gray Herb. No. **191**: 109–197, plus index. –Includes a key to the species, distribution maps, halftones and line drawings to illustrate various critical features. This is an indispensable book for anyone dealing with the ferns of the Andes, the mountains of Central America and southern Mexico. One who has tried to determine a species of *Jamesonia* without it can fully appreciate the service Mrs. Tryon has rendered all pteridologists!

TRYON, ROLLA. 1962. Taxonomic Fern Notes. III. Contr. Gray Herb. No. **191**: 91–107.—Five short notes on systematics of various genera. Includes new a generic name, **Blotiella**, based on *Lonchitis* Kümmerle (not Linn.), and seven new combinations in *Blotiella*. It includes also one new species, *Doryopteris* **allenae**; a new combination in *Alsophila*, some clarification of the genus *Saccoloma* Kaulf., and a note about the type species described by Kaulfuss, including a reproduction of Kaulfuss' signature.

WESSELS BOER, J. G. 1962. The New World species of Trichomanes Sect. Didymoglossum and Microgonium. Acta Bot. Neerlandica **11**: 277–330.—A technical monograph carefully done.

SLATER, JAMES R. 1964. Fern distribution in Washington State. Occ. Papers dept. Biol. Univ. Puget Sound No. **27**: 242–257 + 2 unnumbered, double page tables.—Fifty-two taxa based on specimens examined, with county occurrences given under each, are recorded, and county records for 23 added taxa taken from the literature are included in the tables only. Small type and extensive use of abbreviations make use of the booklet slow at first. It will be of considerable value to visitors wishing to find a particular fern within the state of Washington.

Notes and News

THE BRITISH PTERIDOLOGICAL SOCIETY.—The objects of the Society are to study and encourage interest in the Ferns and Fern Allies. The British Fern Gazette, published annually by the Society, contains papers on the horticulture and taxonomy of ferns from all parts of the globe. Membership, including a subscription to the Gazette, is $2.00 per year. Further particulars may be obtained from the Hon. Secretary-Treasurer, J. W. Dyce, Esq., 46 Sedley Rise, Loughton, Essex, Great Britain.—ROLLA TRYON, *Gray Herbarium, Harvard University.*

DEATH TAKES NOTED PTERIDOLOGIST.—On March 16, 1964, Professor Edwin Bingham Copeland, prominent American authority on ferns, a world leader in the study of their classification, and an Honorary Member of the American Fern Society, died in Chico, California, a few months past his ninetieth birthday. All who knew him will remember his dry wit and the caustic turn of his comments when he encountered careless work. We will miss him from among the workers on ferns and as a stimulating personality.

PROFESSOR R. C. CHING AND THE STUDY OF FERNS IN CHINA.—During two weeks in October-November 1963 I was privileged to visit China as a guest of Academia Sinica. At Peking I met Prof. R. C. Ching, and found him in good health and still very actively concerned with fern taxonomy. He is 65, but still able to climb mountains and enjoy field work. Though there has been a delay in the intended program of publication of the new Flora of the People's Republic of China (of which the first volume issued, in 1959, contained the first part of Prof. Ching's account of the ferns) two new volumes have recently been issued, and Prof. Ching told me he expected his second volume to appear in 1964, with two or three more volumes in later years. His preliminary studies of the genera allied to *Thelypteris* and to *Athyrium* have recently appeared in Acta Phytotaxonomica Sinica (vol. **8**: 289–335, 1963; vol. **9**: 41–84, 1964).

Prof. Ching is head of the division of Taxonomy and Plant

Geography of the Botanical Institute of Academia Sinica. The herbarium, with a very good and up-to-date library, is housed in the main building of the Institute (formerly the Botanical Institute of the National Academy of Peking), with other divisions temporarily installed in neighboring smaller buildings.

At Canton I visited the Botanical Institute of Academia Sinica for South China, of which Prof. W. Y. Chun is head; in this Institute is the herbarium started by Prof. Chun in 1929 as part of Sunyatsen University. Near the Institute (and part of it) is a Botanic Garden of 100 acres, founded in 1958 and still in an active state of development. The garden has a recently established collection of about 100 species of native fern plants; Mr. C. H. Wang, who assisted Prof. Ching in the preparation of the first volume of his fern flora, is actively interested in this collection. Mr. Wang also went with me to a National Park 90 miles from Canton. This National Park includes 500 acres of natural forest, in which are many species of ferns, and also an area of pine plantation with grass-covered hillsides beyond it, on which reforestation is planned. I took some young fern plants from the forest (among them *Cyathea podophylla*, abundant in shady gullies) and *Brainea insignis* from the pine plantation. These plants have now started growth in the tropical fern house at Kew. Many trees in the National Park, near the paths, carry labels painted with their botanical names in roman letters. I was impressed by the competence and the enthusiasm of the staff of the botanic garden and the national park.—R. E. HOLTTUM, *Royal Botanic Gardens, Kew.*

A BOOK BARGAIN.—The remaining copies of the late Professor Jesse M. Shaver's fine book "The Ferns of Tennessee" are being offered for sale at the bargain rate of $5.00 each by his widow, Mrs. Daisy Shaver, 1706 Linden Avenue, Nashville, Tenn.

American Fern Society

COLORADO FERN FORAY AND ANNUAL MEETING

Two full-day field trips are scheduled for members of the American Fern Society. On Friday, August 21, Dr. William A. Weber will lead the foray from Boulder to Green Mt., Flagstaff Mt., White Rocks and the "Flatirons." On Saturday, August 22, Mrs. Ruth Ashton Nelson will lead the foray from Boulder to Rocky Mountain National Park. It will be possible to observe many of the ferns of Colorado on these two trips. Participants will *not* be permitted to collect botanical specimens.

Members who register with AIBS and plan to attend the foray will be housed in Kittredge Hall near the southeast corner of the campus of the University of Colorado (south of the Observatory). Members who do not plan to attend the meetings or do not expect to register with the American Institute of Biological Sciences are welcome on the foray, but they must arrange for their own housing. Those who do plan to register with the AIBS wil be sent forms for doing so if they will request them from Dr. Hauke.

There will be two sessions for presentation of papers, one in the morning and one in the afternoon on Monday, August 24. The annual meeting and luncheon will be held at noon the same day, at the University of Colorado.

If you plan to attend the foray and/or luncheon, please fill out the following and return as soon as possible to Dr. Richard L. Hawke, Department of Botany, University of Rhode Island, Kingston, Rhode Island.

I do ( ) or do not ( ) plan to attend the luncheon.

I plan to attend the foray, August 21-22. ....

There will be .... persons in my party.

I need transportation for .... persons.

I can provide transportation for .... persons.

I plan ( ) or do not plan ( ) to register with the AIBS and will ( ) or will not ( ) need forms for doing so.

Name .... Address ....

Preregistration and Housing Application

AIBS-Sponsored Meetings of Biological Societies

University of Colorado, August 23-28, 1964

Please type or print

Name ....

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Society of primary interest ....

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I plan to take the following field trips:

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....

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Roommate Request:

(Must accompany this form)

....

I will be accompanied by:
Name(s) & Relationship

(Give age of children)

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....

(Continued on next page)

Travel arrangements:

By plane at Denver ____________

By train at Denver ____________

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Expected time of Arrival

____
(Date & hour: Flight No.)

Departure from Boulder

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(Date & hour)

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I have arranged my own housing at ____________

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Premeeting housing ________ Special requirements ____________

____
(i.e., Health, etc.)

Note: (1) Please preregister prior to August 1, 1964.

(2) Registration Fee: $10.00 for AIBS members, $15.00 for non-members, $3.00 for students. $2.00 extra after August 1.

(3) Make check payable to "American Institute of Biological Sciences."

(4) Mail this form and check to: AIBS Registration, Room 508
2000 P Street, NW.,
Washington, D. C. 20036

Registration fee check in amount of $ ________ is enclosed.

Suggestions to Contributors to the American Fern Journal

1. Authors of papers submitted to the *American Fern Journal* should consult the *Style Manual for Biological Journals* (1960) and be guided by its examples.

2. The "name-and-year" system for bibliographic references will, except in exceptional cases, be used. (See Literature Cited below for an example).

3. Authors are encouraged to use the journal abbreviations set forth by Schwarten and Rickett (1958, 1961).

4. Abbreviations of names of herbaria will be those listed by Lanjouw and Stafleu (1959).

5. Reports of chromosome numbers will not be accepted unless documented.

6. The use of footnotes and tabular matter should be kept to a minimum.

7. All manuscripts submitted for publication should be typed, *double-spaced,* and have ample margins.

8. Reprints should be ordered when galley proof is returned to the Editor. An order blank will be included with the galley proof.

Literature Cited

American Institute of Biological Sciences, Committee on Form and Style of the Conference of Biological Editors. 1960. Style Manual for Biological Journals. American Institute of Biological Sciences. Washington, D. C. 100 p.

Lanjouw, J., and F. A. Stafleu. 1959. The Herbaria of the World. Index Herbariorum, Regnum Veg. **15**: 1-249.

Schwarten, L., and H. W. Rickett. 1958. Abbreviations of Titles of Serials Cited by Botanists. Bull. Torrey Club **85**: 277-300; 1961. Supplement I. Ibid. **88**: 1-10.

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American Fern Journal

A QUARTERLY DEVOTED TO FERNS

Published by the

AMERICAN FERN SOCIETY

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A regular loan department is maintained in connection with the library and herbarium. Members may borrow books and specimens at any time, the borrower paying all postal or express charges. The pages of the Journal also are open to members who wish to arrange exchanges; a membership list is published at intervals, to assist those interested in obtaining specimens from different localities.

American Fern Journal

Vol. 54 JULY-SEPTEMBER, 1964 No. 3

A Preliminary Chromatographic Study of Eastern American Dryopteris

RAINER W. SCORA AND WARREN H. WAGNER, JR.[1]

The use of chemical methods—especially serology, electrophoresis, and chromatography—is fairly new in plant taxonomy. In fact, our knowledge of chemotaxonomy is still so far in its embryonic stages that probably the significance of chemical data is not at all understood. The present investigation was made to determine what chromatographic results could be obtained from studying eastern American woodferns, *Dryopteris*. These ferns are among the best known in the United States cytogenetically, thanks to the work of Walker (1955, 1959, 1961, 1962) and are accordingly an ideal group to examine, especially because numerous hybrids are known. The work focused not only upon the species, but the interspecific hybrids as well.

The chromatographic method makes it possible to take extracts from different kinds of plants and to compare the individual compounds present. It has been found that species, varieties, and hybrids of plants and animals often show strikingly different chromatographic patterns (Alston and Turner, 1963).

The application of chromatography to flowering plants has been fairly widespread during the past few years, but such study of ferns has been slight. Recently Smith and Levin (1963) investigated the Appalachian Aspleniums chromatographically and found striking evidence in support of a theory of reticulate

[1]We wish to thank Dale J. Hagenah for supplying plants, Ara Paul for use of chromatographic equipment, and Katherine Lim Chen, for technical assistance. The research was made possible in part by NSF grant G-10846.

Volume 54, No. 2, of the JOURNAL, pp. 57–104, was issued June 25, 1964.

evolution for these plants. By the use of chromatography Fikenscher and Gibson (1962) compared phloroglucinol derivatives among the woodferns *Dryopteris intermedia, D. spinulosa, D. intermedia* × *spinulosa, D. clintoniana, D. clintoniana* × *goldiana, D. arguta, D. goldiana*, and *D. marginalis*. They concluded that the hybrids showed additive phenomena of the compounds present in the parent species. This kind of result did not prove to be the case in the present study, as will be described below.

MATERIALS AND METHODS

Plants of various species and hybrids were grown under essentially uniform conditions in Birmingham, Michigan, by Hagenah of the Cranbrook Institute of Science. On July 30, 1963, comparable leaves, all with sori present, were collected from each plant. Vouchers for each plant are deposited in the University of Michigan Herbarium. Leaf material of *D. goldiana* was taken from a natural habitat near Ann Arbor on July 31 and that of *D. clintoniana* × *spinulosa* from the University of Michigan Botanical Gardens on the same date; all others were provided from the Hagenah garden. Because of their special interest, the *D. spinulosa* and the *D. cristata* complexes were studied in two dimensions. (These and other hybrids were examined in one dimensional chromatograms also but will not be reported here.)

Mature, healthy fronds were cut finely and extracted for 30 hours in 1 percent methanolic 1N HCl. These extracts were condensed and 60 λ spotted on 46 × 57 cm. sheets of Whatman no. 1 filter paper. The two-dimensional descending method was employed, using N-butanol: acetic acid: water (at volume/volume ratio of 4:1:2) for the first separation of 20 hours and 1 percent HCl for the second dimension of four hours, both at 21°±1°C. The solvents were mixed six hours prior to use. Equilibration of the chromatographic chamber lasted five hours in both cases. All equipment and solvents were stored two days prior to use at the same temperature. The chromatograms were dried and inspected for position of the solvent fronts and position and intensity of compounds under short and long wave ultra-violet light. Of several chromogenic sprays tested, 2N KOH gave the best results and was used throughout. The chromatographic patterns were copied before and after spraying with differently colored wax pencils on sheets of clear acetate (Scora, 1964). These acetate sheets were then superimposed to show pattern deviations.

RESULTS

The smallest number of spots in the chromatograms was found in *Dryopteris campyloptera* × *intermedia,* and the largest number of chemical substances in *D. dilatata* × *intermedia* and in *D. clintoniana* × *goldiana*—a range from 6 to 16.

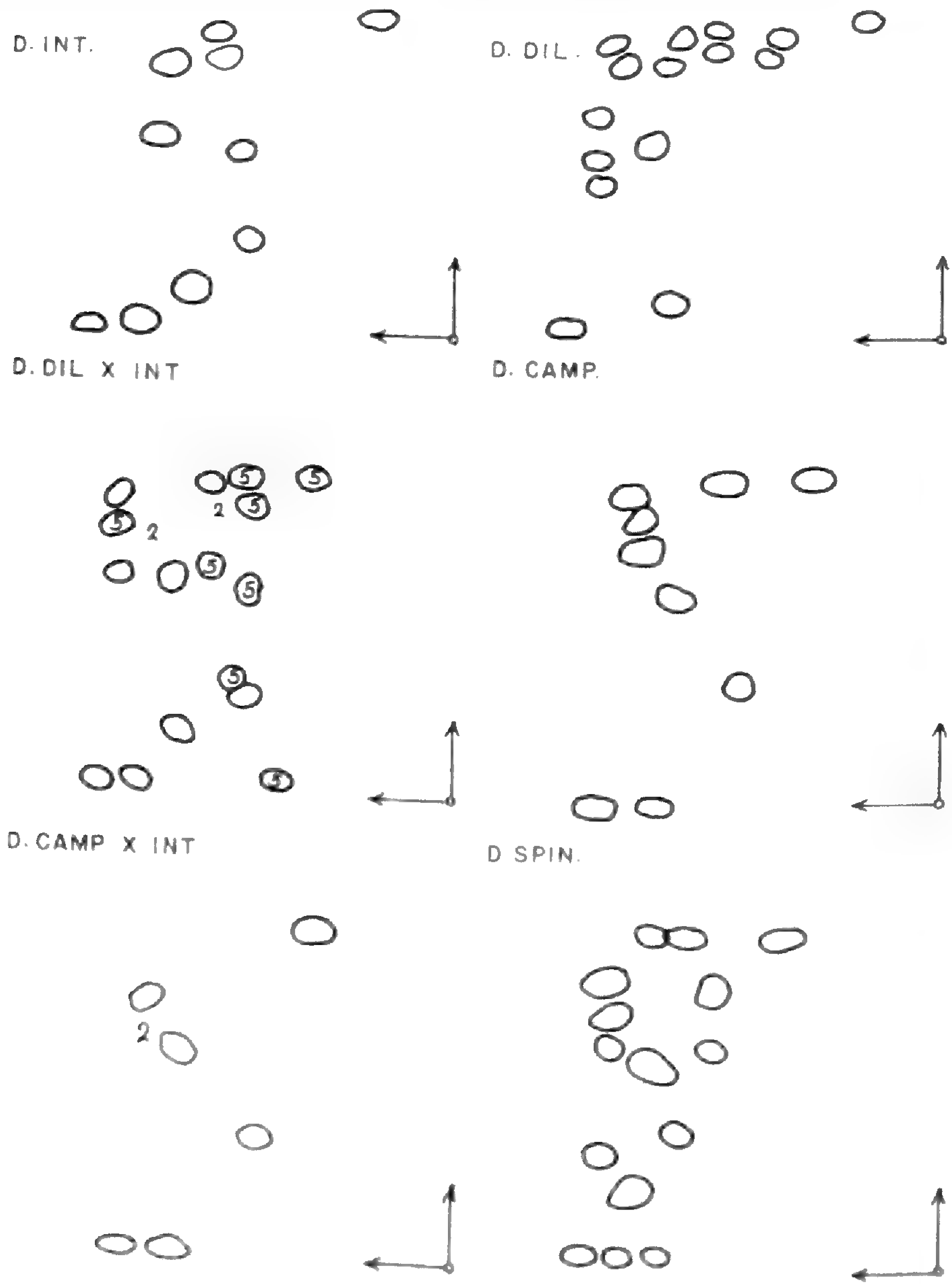
The effects of hybridization were striking, and all of the following situations were observed in our chromatograms:

1. Substance *present in both parents* and *present* in hybrid.
2. Substance *present in both parents* and *absent* in hybrid.
3. Substance *present in one parent* and *present* in hybrid.
4. Substance *present in one parent* and *absent* in hybrid.
5. Substance *absent in both parents* and *present* in hybrid.

The chromatographic entities that illustrate the second and fifth of these situations are marked by the corresponding numbers on the diagrams (Figs. 1–3).

The most striking chromatogram obtained is the one involving the hybrid of *Dryopteris dilatata* and *D. intermedia* (fig. 1). This hybrid, first reported by Wagner and Hagenah (1962), was found in the Huron Mountains of Michigan, and subsequently grown from an offset in company with the parents. One-dimensional chromatograms only were made of *D. dilatata* × *marginalis* and *D. intermedia* × *marginalis,* but these were different in nature from similar one-dimensional chromatograms of *D. dilatata* × *intermedia. Dryopteris dilatata* × *intermedia* shows all of the five situations listed above.

The most conspicuous result of this study is that wherever taxa of different polyploid levels are involved, the hybrid chromatograms usually tend to have more substances in common with the parent of higher ploidal level than with the one of lower level. This is shown by *Dryopteris campyloptera* (4X) × *intermedia* (2X); *D. intermedia* (2X) × *spinulosa* (4X)—(fig. 2); and *D. cristata* (4X) × *intermedia* (2X)—(fig. 2).



The one exception to this pattern is an unusual hybrid in-involving *Dryopteris clintoniana,* a hexaploid, and *D. spinulosa,* a tetraploid (fig. 3). In this plant the hybrid is unusual in showing more resemblance to the lower polyploid than to the higher. However, as has been found by Walker (1955, 1962) at least half of the genetic influence of *D. spinulosa* is probably already present as one of the three genomes of *D. clintoniana* (Walker, 1955, 1962). Thus the composition of *D. clintoniana* × *spinulosa* cannot be represented by the formula ABC plus DE, but rather AB*C* plus *C*D. Perhaps this genome homology between *D. spinulosa* and *D. clintoniana* is responsible for this turnabout in the pattern previously indicated (namely that the higher polyploid tends to have more influence than the lower).

DISCUSSION

It is clear from the results obtained in this study of members of the *Dryopteris spinulosa* and *D. cristata* groups that (1) fairly clear-cut differences exist between the species—as has been suggested by the previous work of Fikenscher and Gibson; and (2) interspecific hybrids by no means show clear-cut blending of parental patterns. The hybrid patterns are neither precisely intermediate, nor are they shown to be additive by the methods we used. If such a study as the present one had been made on only two parental species and a suspected hybrid, the worker might have concluded that the suspected hybrid was not a hybrid on the basis of the chromatic patterns even though it

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FIGURE 1. TWO DIMENSIONAL CHROMATOGRAMS OF *Dryopteris intermedia, D. dilatata, D. dilatata* × *intermedia, D. campyloptera, D. campyloptera* × *intermedia* AND *D. spinulosa,* AS SEEN IN LONG WAVE U/V LIGHT AFTER TREATMENT WITH 2N KOH. THE NUMBER 2 DENOTES POSITION OF SUBSTANCES PRESENT IN BOTH PARENTS AND ABSENT IN HYBRID. NUMBER 5 DENOTES "HYBRID CHARACTERISTIC SUBSTANCE" ABSENT IN BOTH PARENTS. HORIZONTAL ARROW INDICATES DIRECTION OF FIRST SEPARATION WITH N-BUTANOL: ACETIC ACID: WATER. ASCENDING ARROW INDICATES DIRECTION OF SECOND SEPARATION INVOLVING 1% HCL.

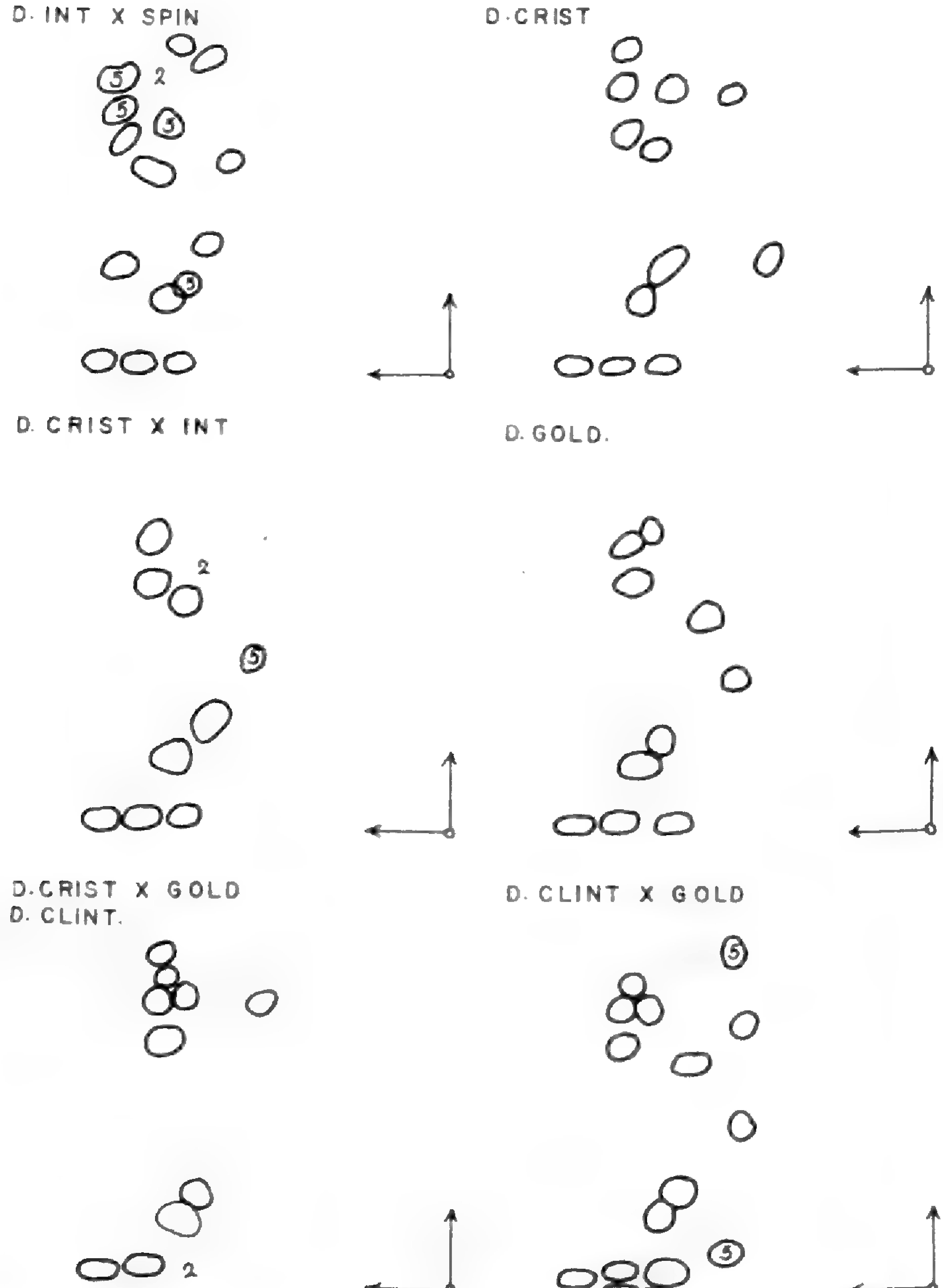

FIGURE 2. TWO DIMENSIONAL CHROMATOGRAM OF *Dryopteris intermedia* × *spinulosa*, *D. cristata*, *D. cristata* × *intermedia*, *D. goldiana*, *D. cristata* × *goldiana*, *D. clintoniana*, *D. clintoniana* × *goldiana*. OTHERWISE AS FIGURE 1.

were intermediate morphologically. A method like the present one, if used without reference to other data, might lead to serious errors. In the present instance a great deal was known about the plants involved through morphological and cytogenetic studies, and the chances were extremely small that the plants considered hybrids were not hybrids. The bulk of the specimens had been examined cytologically and found to have pairing behavior that confirms their hybrid origin; further, their morphology is intermediate between the suspected parents.

This research was carried out on single plants of each of the taxa involved. No test was made of whether or not each substance found in the basic species was wholly "species-characteristic" and there is no guarantee that the same chromatograms would be obtained with other biotypes or other clones of the species. If one were to argue that perhaps the chromatographic averages of many of the same hybrid combinations would be intermediate between the "averages" of the parents, then such data, as shown by the results here, at least, would be individually so variable as to be utterly useless as taxonomic criteria. However, the fact that we made two-dimensional chromatograms of eight hybrid combinations involving six different sexual species, and obtained essentially the same tendencies in practically all of

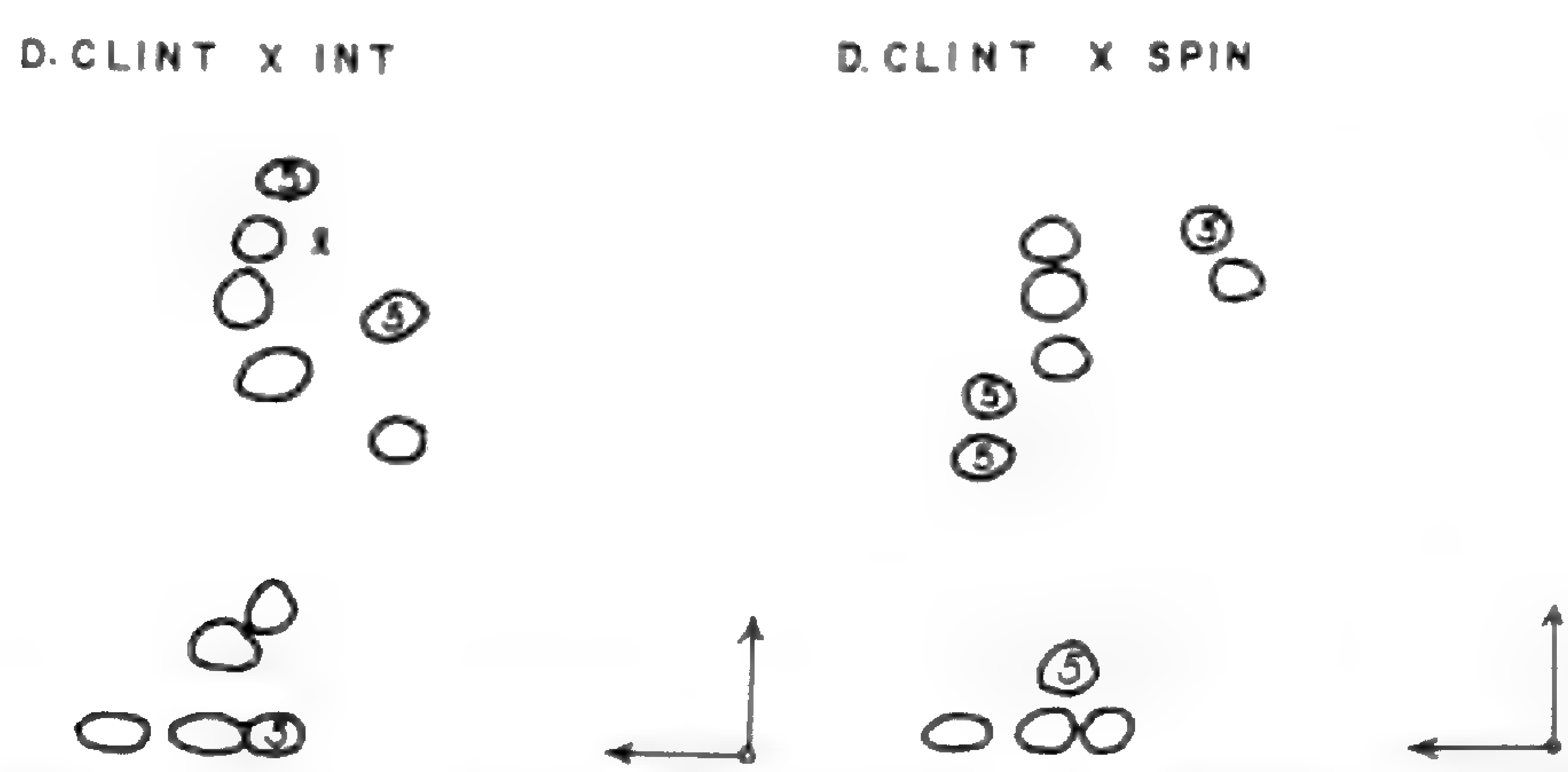

FIGURE 3. TWO DIMENSIONAL CHROMATOGRAM OF *Dryopteris clintoniana* × *intermedia* AND *D. clintoniana* × *spinulosa*. OTHERWISE AS FIGURE 1.

them (the sole exception being *D. clintoniana* × *spinulosa,* as explained above) indicates that the basic conclusions drawn from this work probably are reliable.

Why do the hybrids not show neatly intermediate or additive patterns of chemical compounds? Compounds which are present in one or both parents seem to disappear completely in the chromatograms of the hybrids. Or, even more surprisingly, wholly new spots apparently representing new substances not present in the parents, may appear. All this indicates that it is apparent that the biochemical reactions that lead to the formation of characteristic substances in the various woodferns differ from species to species. When hybridization occurs, the new biotypes may have "hybrid" reactions. These may take different forms, and unexpected changes may appear in the hybrids. For example, a dominant gene from one parent could prevent a reaction controlled by a recessive gene of the other parent from occurring, or the interaction of two different genetic systems controlling reactions may actually produce a substance different from any present in the parents, and a new spot might accordingly appear on the chromatogram. One disturbing possibility is that a very slight difference in a synthetic process such as adding or loosing a reactive group might make a radical difference in the chromatographic behavior of a substance. Therefore, chromatograms alone may not always give tangible evidence of whether or not a particular plant is of hybrid origin. Indeed, in some taxonomic groups it will perhaps become necessary to understand the genetics and detailed biochemistry of the parental and hybrid substances before patterns can be interpreted and evaluated.

LITERATURE CITED

ALSTON, R. E. AND B. L. TURNER. 1963. Biochemical Systematics. Prentice-Hall, Englewood Cliffs, New Jersey.

FIKENSCHER, LUCIE H. AND MELVIN R. GIBSON. 1962. Investigation of *Dryopteris* species. III. The occurrence of phloroglucinol derivatives in various American species of *Dryopteris*. Lloydia **25:** 196-200.

SCORA, R. W. 1964. The use of acetate sheets as records for chromatographic patterns. Jour. Chromatography **13**: 251.

SMITH, D. M. AND D. A. LEVIN, 1963. A chromatographic study of reticulate evolution in the Appalachian *Asplenium* complex. Amer. Jour. Bot. **50**: 952-958.

WAGNER, W. H., JR. AND DALE J. HAGENAH, 1962. *Dryopteris* in the Huron Mountain Club Area of Michigan. Brittonia **14**: 90-100.

WALKER, S. 1955. Cytogenetic studies in the *Dryopteris spinulosa* complex—I. Watsonia **3**: 193-209.

————. 1959. Cytotaxonomic studies of some American species of *Dryopteris*. Amer. Fern Jour. **49**: 104-112.

————. 1961. Cytogenetic studies in the *Dryopteris spinulosa* complex—II. Amer. Jour. Bot. **48**: 607-614.

————. 1962. Further studies in the genus *Dryopteris*: The origin of *D. clintoniana*, *D. celsa* and related taxa. *op. cit.* **49**: 497-503.

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Ferns Associated With Ultramafic Rocks in the Pacific Northwest[1]

ARTHUR R. KRUCKEBERG

The unique plant life on serpentine and other ultramafic rock types is a telling reminder to plant ecologists, taxonomists, and plant geographers of the significance of the edaphic factor in plant distribution. Endemism, ecotypic differentiation, serpentinomorphism, singular vegetational physiognomies, and "extralimital" distributions all contrive to make the floras of these magnesium-rich, calcium-poor areas fascinating and unique botanical areas (Krause, 1958; Whittaker, 1954). During the course of genecological and floristic studies on the plant life of ultramafic outcrops in the Pacific Northwest,[1] I have been struck by the highly predictable recurrence of and restriction to ultramafic soils of three fern species. *Polystichum mohrioides* (Bory) Presl var. *lemmonii* (Underw.) Fern. and *Cheilanthes siliquosa* Maxon

[1]Supported by a National Science Foundation Grant, G 10320.

are almost exclusively found on soils of ultramafic rock origin, while *A. pedatum* L. var. *aleuticum* Rupr. shows a strong preference for the same substrates. What follows, then, is a resumé of the occurrences of these "serpentinophytes" on ultramafics as compared with their nearly uniform absence on adjacent soils of other parent material origin. I have made field observations mainly in the state of Washington; a limited number of visits have been made to similar sites in Oregon, northern California, Montana, and British Columbia.

LOCATION AND DESCRIPTION OF SITES

The term "ultramafic" embraces all those rock types in which the elemental composition is largely silicates of iron and magnesium. The commonest lithological forms of ultramafics are the

FIGURE 1. INGALLS PERIDOTITE AND SERPENTINE IN FOREGROUND; IRON PEAK (HAWKINS GREENSTONE FORMATION) AT END OF RIDGE. NOTE ABRUPT LITHOLOGICAL CONTACT AT THAT POINT. THE THREE "ULTRAMAFIC" FERNS ARE COMMON ON THE NEAREST SLOPES.

igneous rocks, peridotite and dunite, and their metamorphic derivative, serpentine. Soils derived from such rocks are high in magnesium and low in calcium; probably a secondary biological effect is the common deficiency in nitrogen and phosphorus. Such soils are both unfit for agriculture and highly selective for native plant species. The vegetation often is sparse and yet of a unique floristic composition (Krause, 1958).

The ultramafics of Washington occur in three rather well-defined regions. The largest exposure is in montane portions of Kittitas and adjacent Chelan counties. The sites are all in the Wenatchee Mountains which form an easterly extending spur of the Cascade Range. The outcrops occur either as peridotite, dunite, or serpentine; exposures of the rock may be massive—of many square miles in extent—or very local. Old altered volcanics (greenstones), sedimentary rocks, gneisses and schists, as well as acid igneous granodiorite border or even interfinger with the ultramafics. The region is thus lithologically rich and complex (Pratt, 1958). The terrain is rugged, with steep slopes and high ridges that culminate in ultramafic peaks of from 5000 to 7000 feet altitude (Earl, Navaho, and Ingalls peaks). The clearest and most spectacular contact between ultramafic and non-ferromagnesian rock types is along upper Ingalls Creek where the east boundary of peridotite at the creek abruptly gives way to the massive granodiorite (acid igneous) of the Stuart Range.

All of the Wenatchee Mountains ultramafics occur in areas of coniferous forest. At altitudes from 2500 to 4000 feet, the forests consist of open stands of Douglas fir, yellow pine, and western white pine; this forest type grades insensibly upward into a mixture of subalpine fir, mountain hemlock, and whitebark pine (Fig. 1). The stands are invariably open, the barren slopes between the scattered trees lightly populated with grasses and forbs, some of which are highly characteristic of ultramafic soils (Fig. 2).

The next largest series of ultramafic occurrences in Washington is in the northwestern counties of Snohomish, Skagit, San

Juan, and Whatcom. The most outstanding of these is Twin Sisters Mountain, a westerly outlier of the northern Cascade Range; it is pure dunite, an igneous ultramafic composed primarily of the mineral olivine. Rock of similar origin occurs locally at low elevations to the west; Fidalgo Island and Cypress Island have the most extensive of this series of ultramafic outcrops.

The vegetation on the Twin Sisters dunite contrasts strikingly with that on the adjacent non-ferromagnesian parent materials. The luxuriance of the Humid Transition forest abruptly gives way to stunted Douglas fir, lodgepole pine, western white pine, and shrubby *Juniperus communis.* The insular ultramafics also support conifers, largely Douglas fir, beach pine, and *Juniperus scopulorum.*

FIGURE 2. TYPICAL SERPENTINE-BARREN SLOPE IN THE CONIFEROUS FOREST REGION OF WENATCHEE MTS. ALL THREE "ULTRAMAFIC" FERNS ARE FOUND ON THIS SLOPE.

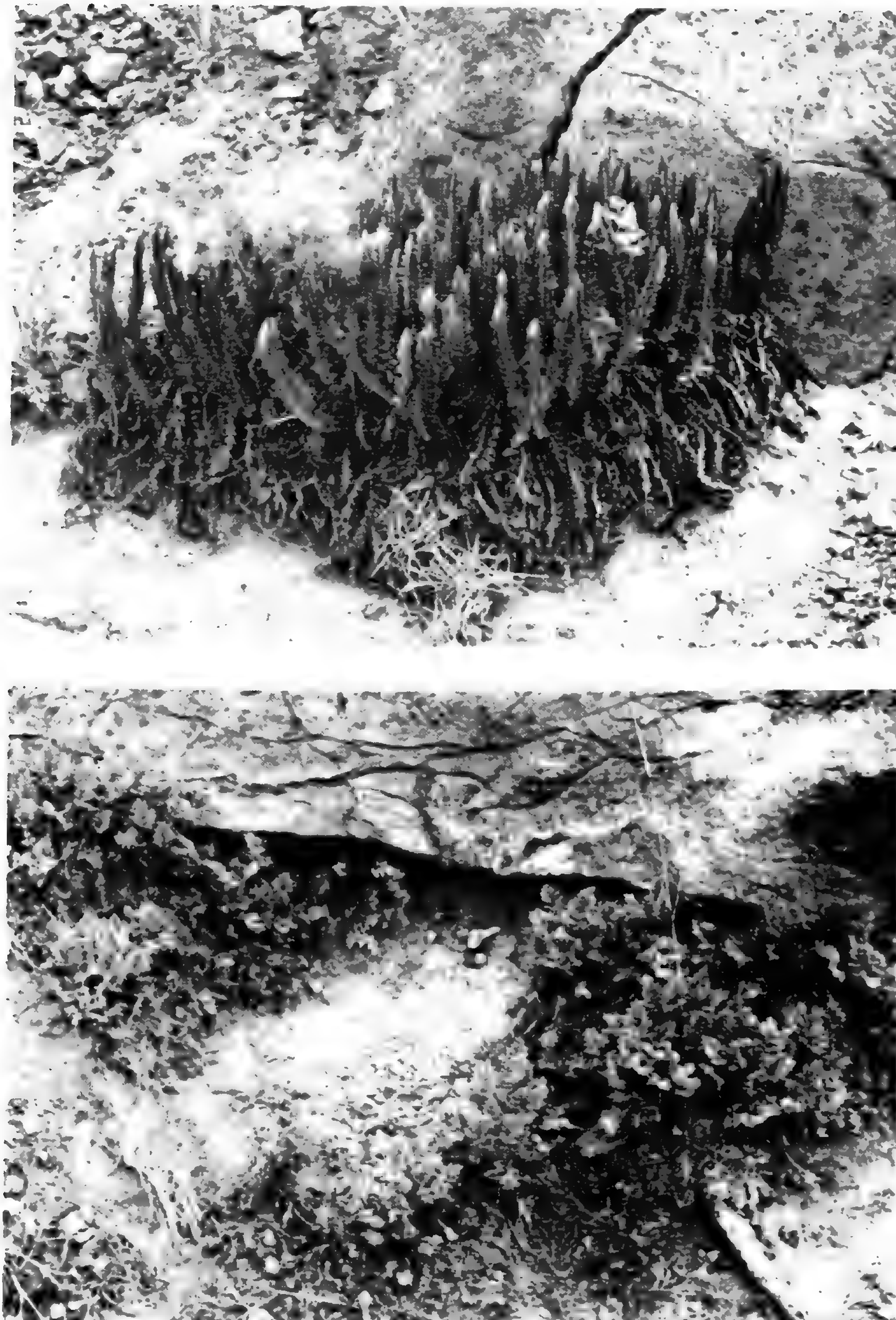

Figure 3. *Polystichum mohrioides* var. *lemmonii* (above) and *Cheilanthes siliquosa* (below) in crevices of massive peridotite boulders; at site of Fig. 2.

The third ultramafic region consists of widely separated small outcrops, east of the northern Cascades in Okanogan, Ferry, and Stevens counties of Washington. As yet, none of these sites has been visited by the author.

The coniferous forest on ferromagnesian substrata is by no means dense and continuous. The trees are largely stunted and widely spaced; often on steep, stony, serpentinized outcrops there are no trees present (Fig. 2). On such barren, continuously eroding slopes, as well as on talus, in rock fissures and on sparsely forested slopes, one is almost sure to find one or more of the three ferns so characteristic of our Pacific Northwest ultramafics.

OCCURRENCE AND DISTRIBUTION OF FERNS

The frequency and abundance of the fern species in question can be readily extracted from the phytosociological relevés that I have compiled. The floristic composition on ferromagnesian and non-ferromagnesian sites has been recorded for over sixty localities in the Pacific Northwest. The accompanying list of fern distributions presents sample abstracts from relevés recorded for two of the three ultramafic areas of Washington; a summary of all relevés for the Wenatchee Mountain area is also included. Wherever possible, fern records from adjacent non-ferromagnesian localities are given. The following abbreviations are used in the list:

Parent Material

S–ultramafic
NS–non-ultramafic
per.–peridotite
serp.–serpentine

Fern species

ADped–*Adiantum pedatum*
ADpal–*Adiantum pedatum* var. *aleuticum*
ATal–*Athyrium alpestre*
CHgr–*Cheilanthes gracillima*
CHsi–*C. siliquosa*
CRac–*Cryptogramma acrostichoides*
PYvh–*Polypodium vulgare* var. *hesperium*
POlo–*Polystichum lonchitis*
POmol–*Polystichum mohrioides* var. *lemmonii*
POsc–*Polystichum scopulinum*
PTaq–*Pteridium aquilinum*
WOor–*Woodsia oregana*
WOsc–*Woodsia scopulina*

Associates	LPP–Lodgepole pine
BP–Beach pine	LL–Lyall's larch
DF–Douglas fir	MH–Mountain hemlock
ES–Engelmann spruce	PP–Ponderosa pine
JUco–*Juniperus communis*	SAF–Subalpine fir
JUoc–*J. occidentalis*	WWP–Western white pine
JUsc–*J. scopulorum*	WBP–Whitebark pine

LIST OF FERN OCCURRENCES ON FERROMAGNESIAN AND NON-FERROMAGNESIAN SOILS

Locality	Parent material	Fern species	Topography and Associates
Kittitas-Chelan counties, Washington			
1. De Roux Forest Camp, n. fk. Teanaway River	S (per. & serp.)	POmol CHsi ADpal	Steep barrens surrounded by open slopes of DF, LPP, WWP, PP; ground layer of sparse forb-grass cover.
2. Upper Beverley Creek	S (per.)	POmol CHsi	Base of stable talus slope; scattered DF, SAF, WBP, and yew; low forb-grass layer.
3. Ingalls Lake trail	S (per. & serp.)	POmol CHsi PTaq	Steep, SW-facing slope of Teanaway-Turnpike ridge; open forest of SAF, WBP, LL, MH, and ES; subalpine forbs.
4. DeRoux-Boulder Creek trail	S (serp.)	POmol	Raw, barren outcrop of gentle slope, surrounded by closed forest of SAF and MH. Scant cover of endemic forbs.
Total fern occurrences on 29 ultramafic sites (number of occurrences): CHsi-20, POmol-19, ADpal-5, No ferns-4.			
5. Johnson Creek trail	NS (sandstone)	CHsi (rare) CHgr	Sparsely timbered (DF, PP), stable talus with scattered shrubs and forbs.
6. Beverly Creek trail	NS (sandstone)	WOsc	Lower edge of massive rock slide with widely scattered DF, SAF, WWP, PP, and shrubs; sparse grass-forb cover.

7. DeRoux-Boulder Creek trail	NS (sandstone)	CRac	Open forb-grass stony slope surrounded by forest.
8. Stafford Peak, 4100 ft.	NS (sandstone)	CHgr	Open grass-forb summit.
9. Standup Creek, 6500 ft.	NS (conglomerate)	CHgr	Top of high stony ridge; contacts S rock with CHsi and POmol.
10. Upper n.e.-facing slope of Jack Creek	NS (granodiorite)	CRac WOsc POlo ADped	Local granitic outcrop in massive peridotite block (this latter with POmol, CHsi, ADpal); much loose rock and rock crevices.
11. West-facing slope above Lake Cle Elum	NS (sandstone)	CHsi CHgr CRac WOor	Open rocky slopes with shrub - grass - forb cover. CHsi is remarkably common here.

Total fern occurrences on 21 NS sites (number of occurrences): CHgr-9, CRac-7, No ferns-6, ADped-5, CHsi-4 (but usually rare!), POmol-2 (on S-NS contacts!). WOor-1, WOsc-2, POsc-2, PYvh-2, POlo-1, ATal-1.

Snohomish-Skagit-Whatcom-San Juan counties, Washington

12. Upper Orsina Creek basin, Twin Sisters Mts., 4400′	S (dunite)	POmol CHsi	Dry morainic knolls near treeline, with "krummholz" LPP and SAF, heath and sparse forbs.
13. Upper Orsina Creek, Twin Sisters Mts., 3800′	S (dunite)	POmol CHsi ADpal	Steep talus of huge boulders with sparse conifer-forb cover.
14. Scheele Mine area, S. Fk. Nooksack River, 1800′	S (dunite conglom.)	CHsi PTaq	Steep bouldery slope; scattered stunted DF & LPP; ground layer either *Rhacomitrium canescens ericoides* (dense mats) or JUco and ericaceous shrubs).
15. Double Eagle Lakes, 3800′ (S-NS contact at V-shaped steep draw above lakes)	S (per.)	CHsi POmol ADpal	Steep rock ledges and faces; forbs and grasses in rock crevices
16. (Same as 15)	NS	CRac	Steep rocky slopes and walls; Alaska cedar, ericads, forbs and grasses.
17. Southeast tip of Cypress	S (dunite)	CHsi	Open balds and stony slopes

	Isl., 500′			with scattered DF, LPP, madrone, and JUsc. Heavy cover of grasses, forbs.
18.	Fidalgo Head, w. end of Fidalgo Isl., 50′	S (per.)	CHsi	Open sloping headlands with heavy moss - lichen - grass - forb cover; occas. stunted DF.
19.	W. slope of Sumas Mtn., 1000′	S (serp.)	CHsi	Open promontory on wooded w. slope, dwarfed DF, LPP, yew, and grass-forb cover on ledges and slopes.
Grant and Josephine counties, Oregon				
20.	Buck Cabin Creek, Grant Co.	S (serp.)	CHsi	Open steep stony outcrop surrounded by DF-PP forest; sparse grass - forb cover.
21.	Murderer's Creek, Grant Co.	S (serp.)	CHsi	Open stony slope with scattered DF, PP, JUoc, and grass-forb cover.
22.	Baldy Mtn., Grant Co. 7634′	S (per.)	CHsi	Massive outcrops and talus on n.-facing slope of summit; rich grass-forb cover.
23.	Strawberry Lake, Grant Co. (ca. 5 mi. e. of #22)	NS (volcanics)	None!	Rock outcrops on w. shore of lake; herb layer luxuriant but poor in spp.
24.	Road to Galice, Josephine Co.	S (serp.)	CHsi	Raw serp. cliffs above Rogue River.
Trinity county, California				
25.	Deer Lake, Trinity Alps	S (serp.)	POmol	Open rocky slopes with scattered MH and WWP.
British Columbia				
26.	Christina Lake	S (serp.)	CHsi WOor	Steep cliffs and talus bordered by DF forest
27.	Near Eholt	S (perid.)	CHsi	Local barren outcrop bordered by DF-LPP-larch forest
28.	Grasshopper Mountain, upper Tulameen River	NS (shale)	WOor	Outcrop and talus with sparse shrub and forb-grass cover

29. Same area as 28	S (perid.)	CHsi	Outcrop and talus with JUco and sparse grass-forb cover
30. Olivine Mountain, upper Tulameen River	S (perid.)	CHsi POsc	Steep talus with grass-forb and shrub cover
31. Piebiter Creek above Bralorne	S (dunite)	CHsi POsc CRac (rare!)	Barren local outcrop surrounded by dense brush and forest (on NS)
32. B. C. Nickel Mines above Choate	S (pyroxenite)	CHsi ADpal CRac	Open treeless talus bordered by MH and Alaska cedar

The high constancy and fidelity of *Cheilanthes siliquosa* and *Polystichum mohrioides* var. *lemmonii* for ultramafics in the Pacific Northwest suggests a close conformity of plant to substrate (Fig. 3). Only rarely does *C. siliquosa* occur on non-ultramafic outcrops, and I have yet to find *P. mohrioides* var. *lemmonii* on other substrates than ultramafics. On the other hand, the rather characteristic ferns of nearby non-ultramafic rock outcrops — *Cryptogramma acrostichoides, Cheilanthes gracillima, Polypodium vulgare* var. *hesperium,* and *Woodsia scopulina* rarely, if at all, grow on soil of ultramafic origin. Of the two species commonly found on ultramafics, *C. siliquosa* is the most frequent, and through a wide altitudinal range. It is at sea level in the San Juan Islands and on up to 4000 feet in the Wenatchee Mountains and even higher in Oregon and northern California. *P. mohrioides* var. *lemmonii,* however, does not occur below 3000 feet in the areas I have visited. We may invoke an explanation to account for narrow restriction of these ferns to ultramafics that has been exploited in connection with angiospermous serpentine endemics (Kruckeberg, 1951, 1954, and Walker, 1954). Survival on soils high in ferromagnesian minerals but deficient in calcium requires a physiological capability for efficient withdrawal of what little calcium is present and as well to accumulate other essential elements in low supply; failure to expand their range onto adjacent non-ferromagnesian soils may be due to the increased biotic (microbial and higher plant) competition encountered on more fertile soils. It should be possible to test the latter hypothesis in spore germination tests on the two soil types and in the presence of competition. Sporelings of *Cheilanthes siliquosa* frequently occur spontaneously on serpentine soils that I have used in the greenhouse for testing edaphic responses.

Dispersal and establishment of ferns with such a disjunct distribution and fastidious preference for substrate present a host of attendant problems. One is led to assume that spores of these "serpentinophytes" are widely dispersed or at least in a regionally broad "chain-mail" fashion, but only establish populations following germination on soils of ultramafic origin. The distribution of *C. siliquosa* spans the North American continent. The easternmost point in its distribution—Mount Albert on the Gaspé Peninsula—is a world-famous alpine serpentine area. In the known localities intervening between Quebec and the Pacific Coast states, I cannot find accounts of the substrate. The same species is common on serpentines of the Coast Ranges in California (personal observation), but apparently it is not restricted to ultramafics. It has been collected on granite in the Sierra Nevada and from other areas unlikely to have ultramafic substrates.

Polystichum mohrioides, as represented by variety *lemmonii* in the Pacific Northwest, appears to be exclusively on serpentine. Therefore I am suspicious of the granitic habitat ascribed to it by Maxon in Abrams (1923) and repeated by Munz (1959). The type of var. *lemmonii*—"near Mount Shasta"—could easily be on ultramafic rock; serpentine is common in the lithology of northwestern California. I can find no mention of substrate preference for the subantarctic and western South American congener, *P. mohrioides*,[2] though its unique bihemispheric distribution is frequently mentioned (Gams in Verdoorn, 1938, Christ, 1910).

Ferns which are characteristic on ultramafic rocks elsewhere

[2] Sr. José Diem, of Villa la Angostura, Neuquén, Argentina has informed me that "This fern prefers open or semiopen sites at the base of or in fissures in granitic rocks and other formations, but also is found in rather open woods and at the edges of arroyos where it has developed other varieties and forms."

in the world have intrigued botanists repeatedly through the years. The degree to which fern species are restricted to serpentine varies widely. Some are apparently true endemics at the species level, others are morphological and ecological variants of species possessing broader tolerance. Then some occurrences on serpentine are merely unusual range extensions wherein the ferromagnesian substrate somehow extends the distribution of a species. Still other species are apparently indifferent to changes in substrate; these have been called serpentine-wandering ubiquists ("serpentinvagen ubiquisten," Krause, 1958).

I have compiled in the following table a list of those ferns which are known to inhabit soils of ultramafic origin. The list includes species which show varying degrees of edaphic restriction, from endemics to ubiquists. This compilation undoubtedly will be incomplete; reports of additional instances of ferns inhabiting ultramafics will be welcomed by the author.

OCCURRENCES OF FERNS ON ULTRAMAFIC ROCKS ELSEWHERE IN THE WORLD

Asplenium adiantum-nigrum L. (incl. var. *cuneifolium*)	Sweden (Rune, 1957), Balkans (Krause & Ludwig, 1956), Italy (Messeri 1936, Pichi-Sermolli 1948)
A. adulterinum Milde.	Sweden (Rune 1957)
A. onopteris L. var. *davallioides* Heufl.	Italy (Messeri 1936)
A. ruta-muraria L. var. *brunsfelsii* Heufl.	Italy (Pichi-Sermolli 1948)
A. trichomanes L.	Japan (Kitamura 1950), Italy (Messeri 1936, Pichi-Sermolli 1948)
A. viride Huds.	Sweden (Rune 1953), but calcicole in Quebec (Scoggan 1950), Finland (Launamaa 1956)
Adiantum pedatum L. var. *aleuticum* Rupr.	Quebec (Scoggan 1950)
Cheilanthes siliquosa Maxon	Quebec (Scoggan 1950)
Ceterach officinarum Lam. & DC.	Italy (Messeri 1936, Pichi-Sermolli 1948)

Dicranopteris dichotoma (Thunb.) Bernh. (=*Gleichenia linearis* (Burm.) Clarke, var.)	Japan (Kitamura & Momotani 1952—probably of low fidelity)
Notholaena marantae (L.) R. Br.	Italy (Pichi-Sermolli 1948)
Polystichum scopulinum (D.C. Eat.) Maxon[3]	Quebec (Scoggan 1950, Rune 1953)
Polypodium vulgare L.	Italy (Messeri 1936)
Gymnocarpium robertianum (Hoffm.) Newm.	Japan (Yamanaka 1952)
Cryptogramma crispa R. Br. var. *japonica* Miyabe & Kudo	Japan (Kitamura 1952)
Pteridium aquilinum Kuhn var. *latiusculum* (Des.V.) Underw.	Pennsylvania (Wherry 1932)

LITERATURE CITED

CHRIST, H. 1910. Die Geographie der Farne. G. Fischer Verlag.

GAMS, H. 1939. Ökologie der extratropischen Pteridophyten. (in "Manual of Pteridology," ed by Fr. Verdoorn). M. Nijhoff.

KITAMURA, S. 1950. Serpentine flora near Sekinomiya, Prov. Tazima. Acta Phytotax. Geobot. **12:** 185-186.

————. 1952. Serpentine flora of Mt. Hayachine, Prov. Rikuchu, Japan. Acta Phytotax. Geobot. **14:** 177–180.

KITAMURA, S. AND Y. MOMOTANI. 1952. Serpentine flora of Island Sugashima, Prov. Shima, Japan. Acta Phytotax. Geobot. **14:** 118–119.

KRAUSE, W. 1958. Andere Bodenspezialisten. Encyclopedia of Plant Physiology **4:** 755–806.

KRAUSE, W. AND W. LUDWIG. 1956. Zur Kenntnis der Flora and Vegetation auf Serpentinstandorten des Balkans. 1. *Halacsya sendtneri* (Boiss.) Dorfl. Ber. Deutschen Bot. Gesell. **69:** 417–428.

KRUCKEBERG, A. R. 1951. Intraspecific variability in the response of certain native plant species to serpentine soil. Amer. Jour. Bot. **38:** 408–419.

————. 1954. Plant species in relation to serpentine soils. Ecology **35:** 267–274.

LOUNAMAA, J. 1956. Trace elements in plants growing wild on different rocks in Finland. Ann. Bot. Soc. 'Vanamo' **29:** 1–196.

MAXON, W. R., in ABRAMS, L. 1923. Illustrated Flora of the Pacific States. Vol. I. Ophioglossaceae to Aristolochiaceae. Stanford University Press.

MESSERI, A. 1936. La vegetazione delle roccie ofiolitiche di Monte Ferrato (Presso Prato.) Nuovo Giorn. Bot. Italiano, n.s. **43:** 277–372.

[3] *P. scopulinum* is occasionally found on or adjacent to ultramafics in the Pacific Northwest (Wagner & Kruckeberg, personal observation).

MUNZ, P. A. 1959. A California Flora. University of California Press.

PICHI-SERMOLLI, R. 1948. Flora e vegetazione delle serpentine e delle altre ofioliti dell'alta valle del Tevere (Toscana). Webbia **6**: 1–380.

PRATT, R. M. 1958. The geology of the Mount Stuart area, Washington. Unpubl. doctoral thesis, University of Washington, Seattle.

RUNE, O. 1953. Plant life on serpentines and related rocks in the north of Sweden. Acta Phytogeographica Suecica **31**: 1–139.

————. 1957. De serpentinicola elementen i Fennoskandiens flora. Svensk. Bot. Tidskrift **51**: 43–105.

SCOGGAN, H. J. 1950. The flora of Bic and the Gaspé Peninsula, Quebec. Nat. Mus. of Canada Bulletin No. 115 (Biological Series No. 39) 1–399.

WALKER, R. B. 1954. Factors affecting plant growth on serpentine soils. Ecology **35**: 259–266.

WHERRY, E. T. 1932. Ecological studies of serpentine-barren plants—I. Ash composition. Proc. Penn. Acad Sci. **6**: 32–38.

WHITTAKER, R. H. 1954. The ecology of serpentine soils: a symposium. I. Introduction. Ecology **35**:258–259.

————. 1954. The vegetational response to serpentine soils. Ecology **35**: 275–288.

YAMANAKA, T. 1952. Studies in the vegetation and the flora on serpentine. Res. Rep. Kochi Univ. **1**: 1–8.

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Rediscovery of Polypodium virginianum forma brachypteron (Ridlon) Fernald

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In 1921 H. C. Ridlon, of Bennington, Vermont, described *Polypodium vulgare* L. f. *rotundatum*, a peculiar, probably abnormal form, in which the segments of the blade are reduced to semicircular or deltoid lobes, toothed at the apex. It was soon found that the name f. *rotundatum* had already been used, so it was changed to f. *brachypteron* (Weatherby, 1921). Ridlon did not give the origin of the specimen upon which the form was based, except to say that it came from Vermont. He neglected to record if a type specimen had been preserved.

This has been a very rare form and nothing quite approaching it seemed to have been collected since its description until two fern enthusiasts collected it in Colchester, Vermont, on November 1, 1961, and on May 30, 1962. Their specimens came from a colony of 16 plants.

Dole (1937) gave the only definite data as to the type station. He wrote, "Rocks, Jamaica—type sta. 1919 (Ridlon)." It is surmised that Dole's information was based on his personal knowledge, of which he left no further written record. Other workers on our ferns, such as Weatherby (1921) and Fernald (1922) made no mention of the type station or of the type specimen.

In an endeavor to procure more data, and hoping to locate the type specimen, I wrote to various individuals and institutions. The replies produced no clue to a type. One correspondent, Mr. G. L. Kirk, advised that Mrs. Polly Ridlon Wilson was one of Ridlon's daughters and that she might have some information.

A letter to her inquired about the final disposition of the Ridlon herbarium and requested any information she might have pertaining to her father's collection of forma *brachypteron*. Mrs. Wilson replied as follows:

> "Unfortunately, I could not locate any correspondence nor even any notes regarding his study of this form of the Polypody. I do not know whether the station is still in existence, and I never had any knowledge of its exact location. However, tucked inside an old edition of *The Flora of Vermont* I came across two prints of the enclosed photograph. On the back of the duplicate he had printed: "Polypodium vulgare variety brachypteron (Ridlon)—Bloodsucker Pond, Jamaica, Vt."
>
> "My father's herbarium is now at Bennington College, and we might hope that the type specimen of this fern is there. . . ."

Bloodsucker Pond is a local name for Adam Pond, which can be found on the Londonderry, Vt., Quadrangle of the U. S. Topographic Survey map. Mr. Ridlon's daughter was unable to consult her father's herbarium until March 9, 1963. Concerning her search for the type specimen Mrs. Wilson wrote:

> "At last I have been in touch with Mr. Woodworth at Bennington College, and regret to report that there is no good news. I spent last Saturday carefully checking my father's herbarium there and am satisfied that there is no specimen *at all* of the form of Polypody which we are seeking.

"I am sorry to have to thus dash your hopes of finding it in Bennington. I had hoped and really expected to find at least something in connection with this. It seems as though it must have been preserved somewhere, but it is strange that you cannot locate it in any of the major herbariums where it might logically have been deposited."

The only documentary evidence of the type specimen seems to be the photograph mentioned above. This photograph has been reproduced and together with data pertinent thereto mounted on sheets for deposit in the herbaria at VT, US, GH, NEBC, Bennington College, and the herbarium of the American Fern Society. The discoverers of this form in Colchester, Vt., have offered to make available a few sheets from the new station for deposit in the aforementioned herbaria.

It should be mentioned that the distribution of this form, as given by Fernald (1950) was incorrect when published. He wrote, "—, very rare in w. Vt.,; —." It should have read, "—, very rare in s. Vt.; —."

The known occurrence of the forma is as follows: WINDHAM COUNTY: "Rocks, Jamaica—type sta. 1919 (Ridlon)." CHITTENDEN COUNTY: on rocks in Colchester Township, 16 plants observed growing with the typical form, *Mrs. Laurence P. Howe* and *Mrs. Oliver R. Eastman*, Nov. 1, 1961 (immature fronds), May 30, 1962, mature fronds).

LITERATURE CITED

DOLE, E. J. 1937. The Flora of Vermont. 3rd Revised Ed. Free Press, Burlington, Vt.

FERNALD, M. L. 1922. *Polypodium virginianum* and *P. vulgare*. Rhodora **24**: 141.

————. 1950. Gray's Manual of Botany. 8th Ed. American Book Co., Boston.

RIDLON, H. C. 1921. A new *Polypodium* from Vermont. Amer. Fern Jour. **11**: 46-48. *1 pl.*

WEATHERBY, C. A. 1921. A Correction. Amer. Fern Jour. **11**: 122.

————. 1937. A List of varieties and forms of the ferns of Eastern North America. Amer. Fern Jour. **27**: 51-56.

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Sporogenesis in Pteris cretica with Special Reference to the Cytoplasmic Inclusions

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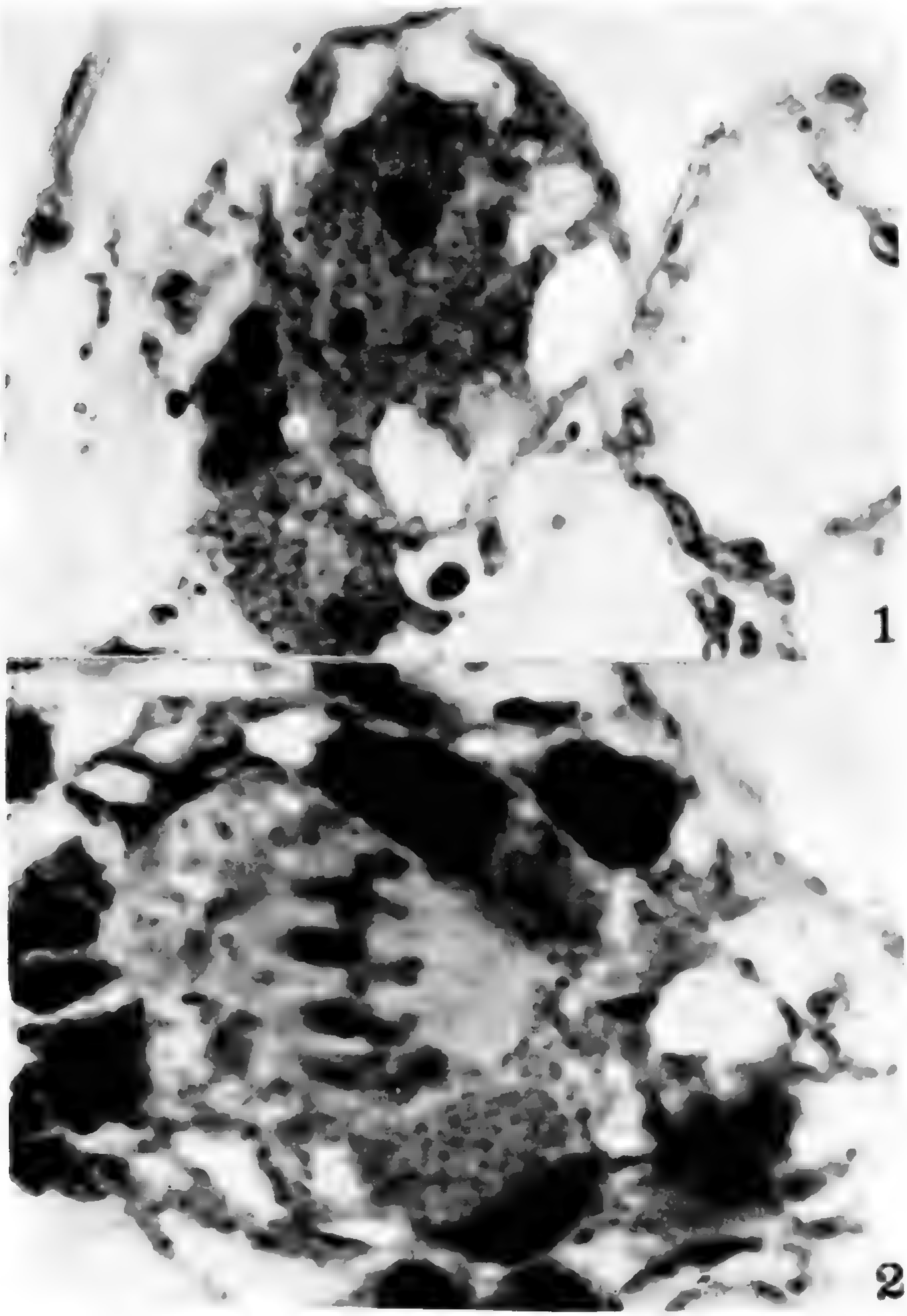
INTRODUCTION.—Studies dealing with the cytoplasmic inclusions during sporogenesis in polypodiaceous ferns have indicated that in at least three species, *Nephrodium molle* (Senjaninova 1927), *Onoclea sensibilis* (Marengo 1949) and *Polypodium virginianum* (Marengo 1959), cytokinesis of the spore mother cell results in the formation of a quartet of tetragonally arranged, and upon maturity, monolete, spores.

Adiantum hispidulum, a polypodiaceous fern bearing trilete spores was similarly investigated (Marengo 1962). In this species the cytoplasmic inclusions preserved by mitochondrial fixatives were found to be arranged, prior to cytokinesis, in a pattern of six planes marking the sites of the internal walls of the four tetrahedrally arranged spores arising from the spherical spore mother cell. The cytokinetic basis of tetrahedral symmetry in this species was thus found to be identical to that described in *Osmunda regalis* (Marengo 1954).

On the basis of the cytokinetic similarity of the maturation divisions of these two unrelated species, both producing trilete, tetrahedrally symmetrical spores, it was suggested that further studies might show in other species a similar sequence of events in meiosis, and thus possibly reflect a pattern of cytokinesis common to the production of all trilete spores, regardless of the taxonomic position of the species considered.

Through the courtesy of Dr. William Steere, material of *Pteris cretica* was made available at the New York Botanical Garden. This member of the Polypodiaceae produces typically and obviously trilete spores. It is the major object of this paper to describe the cytokinetics of the maturation divisions in this species and to compare them with previously described processes in *Osmunda regalis* and *Adiantum hispidulum*, and to clarify the suggestion that a common process and sequence hold for the production of all trilete spores.

MATERIALS AND METHODS.—Fertile leaf margin pieces under 5 mm in length were excised from greenhouse plants and im-



FIGS. 1-2. EARLY STAGES OF SPORANGIAL DEVELOPMENT. × 1578. FIG. 1. EARLY SPORANGIUM SHOWING INTERPHASE OF INITIAL SPOROGENOUS CELL PRIOR TO TAPETAL CELL FORMATION. FIG. 2. METAPHASE OF CENTRAL SPOROGENOUS CELL SURROUNDED BY EARLY TAPETUM.

mediately placed in fixative. To preserve the cytoplasmic inclusions, the material was fixed from twelve to twenty-four hours in a solution freshly prepared as follows (Huseby 1946): 10% Commercial formalin, 100 ml; Normal sodium hydroxide, 1 ml; Pyrogallol, 7 g.

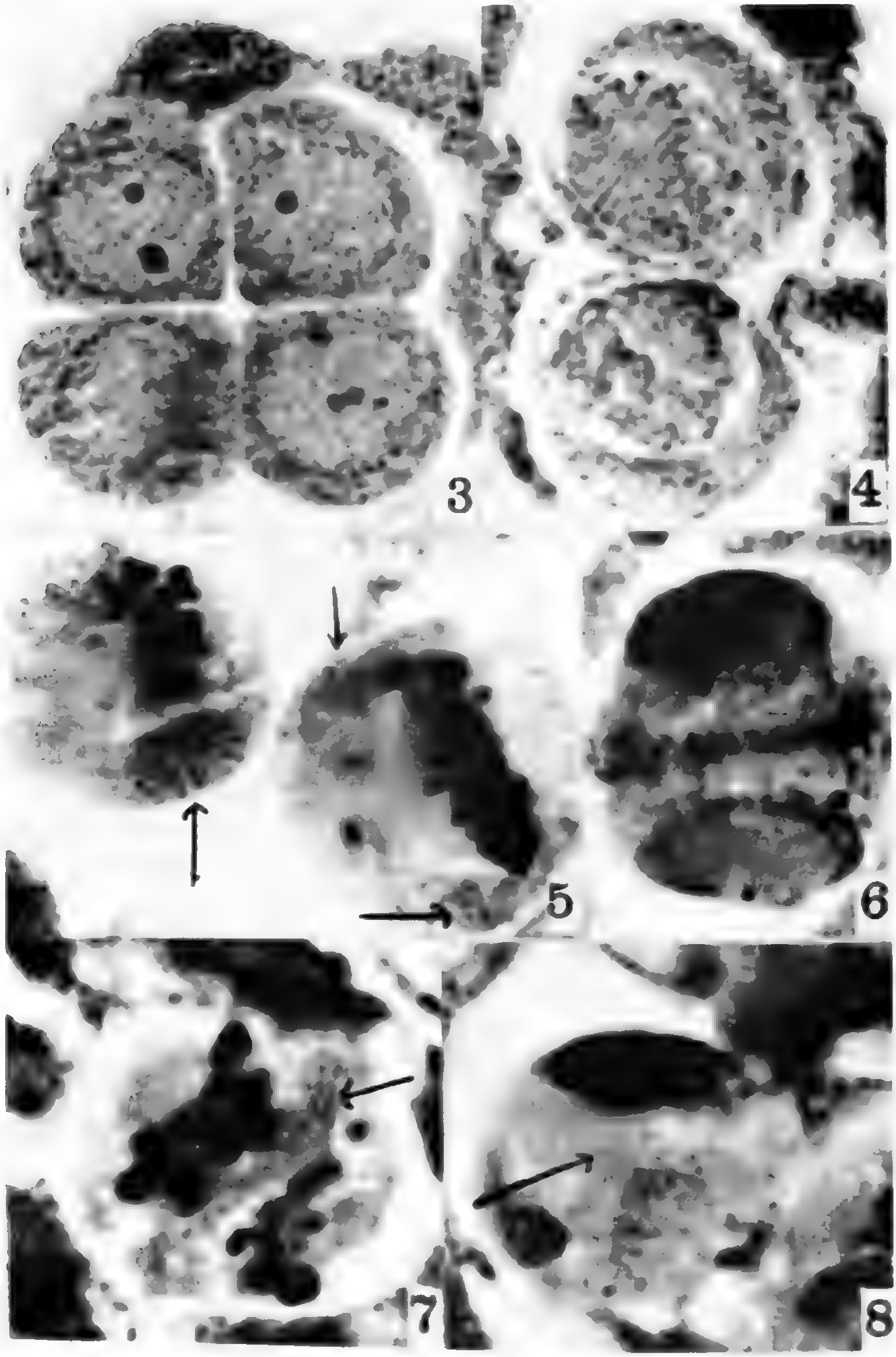
Pieces were rinsed briefly in running water, dehydrated with isopropyl alcohol and embedded in 56°–58° Fisher Tissuemat. Sections three microns in thickness were cut without difficulty.

Sections were mordanted twenty-four hours in 2 percent ferric alum, stained twenty-four hours in 0.5 percent hematoxylin and differentiated with microscopic observation in 2 percent ferric alum. Following a thirty-minute wash in running tap water, slides were dehydrated in isopropyl alcohol, counterstained with Orange G in clove oil, cleared in xylene and mounted in gum damar. Material similarly fixed and sectioned was stained with acid fuchsin and methyl green.

Observations and photomicrographs were made with a Bausch and Lomb Dynazoom microscope with a 97X achromatic objective; 4″ × 5″ negatives were obtained using a Brinkmann Model "U" photomicrographic camera with Kodak Royal Pan sheet film. Negatives were obtained also with Bausch and Lomb 35 mm photomicrographic camera, using Panatomic-X film.

OBSERVATIONS.—The mature spore of *Pteris cretica* bears a characteristic tri-radiate scar which marks the internal edges of the triangular spherical pyramid which originated as one of the four tetrahedrally symmetrical spores in the young quartet arising by meiosis from the spherical spore mother cell (Fig. 12). Its original pyramidal shape is obscured by enlargement and spore coat formation.

The early development of the sporangium is of the usual leptosporangiate type. A large sporogenous cell is separated at an early stage from the cells to become the sporangial wall (Fig. 1). This cell (Fig. 2) soon gives rise to tapetal cells and then to a central group of sporogenous cells. Prior to the maturation divisions, the sporogenous cells assume the rounded-



FIGS. 3-8. SPOREMOTHER CELLS IN VARIOUS STAGES OF MATURATION DIVISIONS. FIGS. 3-4 × 1429. FIGS. 5-8 × 1578. FIG. 3. YOUNG SPOREMOTHER CELLS IN INTERPHASE BEFORE MEIOSIS. FIG. 4. PACHYTENE STAGE, FIRST MEIOTIC DIVISION. FIG. 5. METAPHASE, FIRST MEIOTIC DIVISION. FIG. 6. INTERPHASE FOLLOWING FIRST MEIOTIC DIVISION. FIG. 7. METAPHASE OF SECOND MEIOTIC DIVISION. FIG. 8. TELOPHASE OF SECOND MEIOTIC DIVISION.

up shape of the young spore mother cell (Fig 3). The mitochondria of the spore mother cell in the interphase preceding maturation are small, granular or rod-like, and of uniform distribution throughout the cytoplasm.

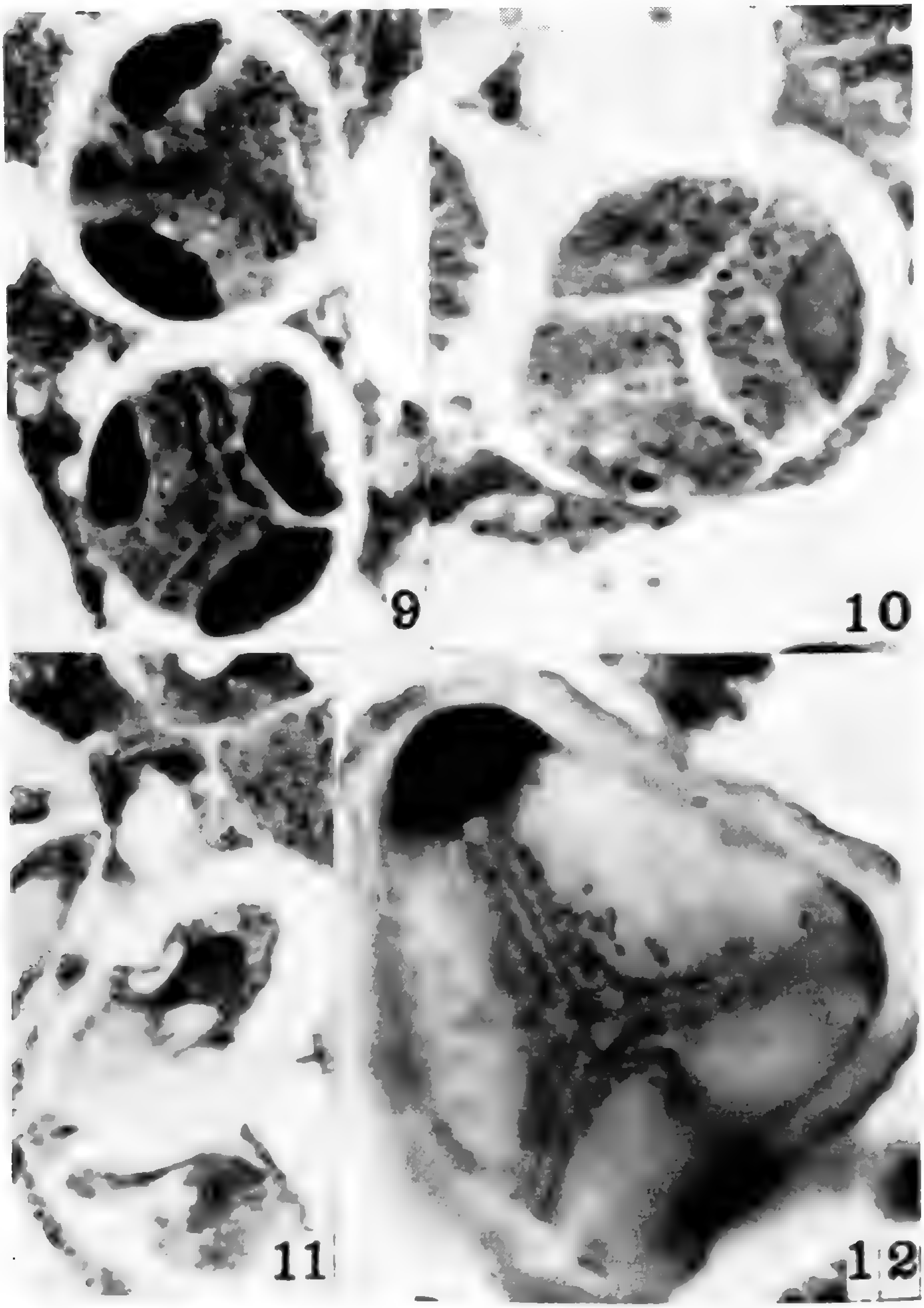
At the pachytene stage of the first meiotic prophase, the chromosomes are polarized into a "bouquet," with an accompanying polarization of the cytoplasmic inclusions. A small concentration is at the base of the bouquet and a larger mass at the opposite pole of the spore mother cell (Fig. 4).

At the metaphase of the first meiotic division, the cytoplasmic inclusions are almost completely localized in a ring or torus surrounding the metaphase plate. In a pole-to-pole section of this stage, this ring appears in cross section as a mass of granules at the edge of the metaphase plate (Fig. 5). As the first division proceeds, this ring of granules moves centrally into the spindle area. At the time of interphase following the first division this ring has been converted into a compact, flat disc interposed between the nuclei (Fig. 6). There is no indication of cytokinesis up to this point.

The first indication of cytokinesis appears at the metaphase of the second division. Favorable sections at this stage show the mitochondrial plate with a two-layered structure, suggesting that a cell plate has formed within it, although light microscopy has not as yet verified its presence (Fig. 7). By late telophase of the second division, a cell plate can be detected in favorable sections longitudinal to one of the second division spindles. This cell plate is formed completely independent of the mitochondrial localization which at this time assumes a folded structure, showing as a "V" in cross section (Fig. 8).

As the second maturation division is completed, the cytoplasmic inclusions are regularly arranged along all the internal walls of the newly-formed spores (Fig. 9). Prior to spore enlargement and quartet separation, these granules lose their localization and assume a uniform distribution in the cytoplasm of the young spore (Fig. 10).

It is difficult to properly fix and stain the young enlarging



FIGS. 9-12. SPORES FOLLOWING COMPLETION OF MEIOSIS. FIGS. 9, 11, 12 × 1429. FIG. 10 × 1578. FIG. 9. INTERPHASE IMMEDIATELY FOLLOWING COMPLETION OF SECOND MEIOTIC DIVISION. FIG. 10. SLIGHTLY OLDER QUARTET THAN FIG. 9. FIG. 11. ENLARGING SPORES. FIG. 12. MATURE SPORE SECTIONED AND SHOWING INTERNAL VIEW OF TRILETE SCAR.

spore. This difficulty may be associated with vacuole formation and spore coat deposition (Fig. 11). Stained sections through mature spores show the nucleus at one of the ends of the trilete scar, and numerous large granules along the scar itself (Fig. 12). The precise nature of these granules in the mature spore, and their genetic continuity with the mitochondria of the spore mother cell have yet to be established.

DISCUSSION.—The behavior of the cytoplasmic inclusions during the first meiotic division in *Pteris cretica* appears to be essentially like that observed previously in *Onoclea sensibilis* and *Adiantum hispidulum.* The arrangement of the late prophase chromosomes into a bouquet is accompanied by polarization of cytoplasmic inclusions comparable to the same stage in the other two species mentioned. The localization of granules into a compact plate between the interphase nuclei resulting from the first division is observed in the same stage in *Onoclea sensibilis* and *Adiantum hispidulum* as well as in *Osmunda regalis.*

In the two trilete species, *Osmunda regalis* and *Adiantum hispidulum,* there is no indication of cytokinesis or cell plate formation prior to the interphase after the second division, at which point the mitochondrial plates separating the nuclei are in two distinct layers. In *Pteris cretica* cytokinesis of the first meiotic division has started by the time the second division has reached metaphase. This is suggested by the two-layered structure of the mitochondrial disc formed following the first division. The completion of cytokinesis in *P. cretica* is accomplished by cell plate formation independent of any mitochondrial localization, and would suggest that in this species at least, this process and its relation to the establishment of tetrahedral symmetry of the spore quartet is not related to the distribution of the cytoplasmic inclusions during meiosis. In *Osmunda regalis,* prior to cytokinesis, the future internal walls of the spores appear to be delineated by mitochondrial plates. This suggests an inherent tetrahedral symmetry of the spore mother cell. The findings in *Pteris cretica* appear to support this idea, except that this symmetry is established independent of and unrelated to the cytoplasmic inclusions preserved by mitochondrial fixatives.

LITERATURE CITED

HUSEBY, R. A. 1946. Hydroxybenzene compounds as cytoplasmic fixatives. Proc. Soc. Exp. Biol. & Med. **61**: 122-125.

MARENGO, N. P. 1949. A study of the cytoplasmic inclusions during sporogenesis in *Onoclea sensibilis*. Amer. Jour. Bot. **36**: 603-613.

———. 1954. The relation of the cytoplasmic inclusions to the establishment of tetrahedral symmetry in the spore quartet of *Osmunda regalis*. Bull. Torrey Club **81**: 501-508.

———. 1959. The cytokinetic origin of the monolete spores of *Polypodium virginianum*. Bull. Torrey Club **86**: 259-263.

———. 1962. The cytokinetic basis of tetrahedral symmetry in the spore quartet of *Adiantum hispidulum*. Bull. Torrey Club **89**: 42-48.

SENJANINOVA, M. 1927. Chondriokinese bei *Nephrodium molle* Desv. Zeitschr. Zellf. Mikr. Anat. **6**: 493-508.

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Florida Strap Ferns and Their Culture

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The fern flora of the state of Florida is a remarkable one, the largest of that of any of the United States, insofar as I am aware. Of this assemblage, one of the most fascinating genera is that which contains the Strap Ferns, the genus *Campyloneurum*. Of the fifty or so species known to science (this genus is often included in *Polypodium*), four have made their way into our area, where one is a reasonably common indigene, while the others are definite and restricted rarities.

Campyloneurum phyllitidis is by far the most frequent and most widespread of the Strap Ferns here. Small, in *Ferns of Florida* (1931), notes it as occurring in "hammocks, lower two-thirds of the Florida peninsula and Florida keys." It is, however, not strictly an inhabitant of our marvelous hammocks, for I have encountered it on many occasions in cypress formations, and even in the strange areas bordering on the great mangrove swamps and buttonwood forests in the Everglades National Park.

This handsome fern is often called an epiphyte, but I have very infrequently found it—from many years' casual observation—growing under conditions which I would term precisely epiphytic. Rather, it in general prefers to form colonies (these often very extensive—and certainly very spectacular when one chances upon them unexpectedly) on fallen, partially decayed logs, these seldom far from perpetually standing water. It may also be found on the mossy trunks of old Pond Apples (*Anona glabra*) or Bald Cypress (*Taxodium distichum*) in spots which never dry up entirely, but I would consider this a definitely secondary habitat for the species here.

In several of the beautiful hammocks characterized by heavy stands of Wild Tamarind (*Lysiloma bahamensis*) in the Pinecrest region to the west of Miami, this *Campyloneurum* has rather well adapted itself to a semi-terrestrial habitat. Here it grows—with the largest colonies of our pretty Vine Fern (*Phymatodes heterophyllum*) which I have ever encountered in Florida—in the thick leafy humus under the varied trees. Glorious tree-snails (genus *Liguus*) are found here, too, as are far too many robust specimens of the vicious Catch-and-Hold-Back vine (*Pisonia aculeata*), so that botanizing in this region is always a challenge.

This Strap Fern, *C. phyllitidis*, is our largest native species of the genus, sometimes even approaching the grandeur of our scarce indigenous Bird's-Nest Fern (*Asplenium serratum*) with its erect or gracefully arching fronds to more than three feet in length. These are produced from a stout, creeping rhizome. They generally taper somewhat at each end, are glossy bright-green in color, and are frequently conspicuously irregular and wavy on the margins (though the sawteeth of the *Asplenium* are never normally present). Sori are typically produced in considerable quantities, in several irregular lines, on each side of the midrib.

I have succeded with *Campyloneurum phyllitidis* in my personal collection for many years, and consider it a very easy fern to grow. My specimens have come from a variety of regions in the wild, but all of them are cultivated in identical fashion—in proportionately large, very well-drained pots, in a compost made up of chopped osmunda fiber and fibrous loam in about equal parts. I find that they must have almost total shade to reach their full beauty, and the more moisture and humidity they receive the better they seem to like it. Any protracted period of drought sends them into a serious decline, from which they only very slowly recover. I have noted no serious pests with them, though on occasion a wayward slug will nip off a few of the juvenile sprouting fronds.

Several years ago I gathered a couple of smallish specimens of this fern in a swampy area some fifty miles from Miami, growing in close harmony with a stunted plant of *Phlebodium aureum,* and our odd "fossil plant," *Psilotum nudum,* on a large cypress tree. With a machete I managed to pry out of the crevice in the tree-trunk the entire interwoven mass, and upon my return home, quickly mounted it on a sizable slab of porous Guatemalan tree-fern fiber. This soon proved to be unwise of me, and I lost the *Psilotum* (a very touchy thing to transplant, in any event) and the larger of the Campyloneurums before I moved the entire apparatus into a pot with the above-noted mixture of osmunda and loam. This did the trick, and the two remaining ferns are still thriving at this date. From this, I would assume that our "epiphytic" *Campyloneurum* does not take well to the treatment normally afforded true epiphytes in our orchid and bromeliad collections.

The three other Campyloneurums native in Florida are, as I have already mentioned, all classed as definite rarities. These are *C. angustifolium, C. latum,* and *C. costatum.*

Campyloneurum angustifolium is noted by Small as having been "collected but once within the geographic limits of this work. . . It occurs in Timms Hammock, where it grows mostly on live-oak trees. It was discovered in Florida in 1903, and is widely distributed in the West Indies and in continental tropical America." I have collected what I assume to be this fern both in Cuba and in Nicaragua, in the first-named island on the marvelous "fern paradise" of Loma del Gato, in Oriente Province; in Nicaragua on the slopes of El Picacho, near Santa Maria de Ostuma (Hawkes, 1962). In both areas, it was invariably truly epiphytic, usually growing low down on very mossy trees, with a host of filmy-ferns (genera *Trichomanes* and *Hymenophyllum*) as close companions. I have not gathered it in Florida, though I have seen a very few specimens purported to have been collected in the great Fahakahatchee Swamp of the Big Cypress area. These were growing happily in pots—well-drained it must be assumed—in a compost of loose chunks of osmunda fiber, under the closest shade of a lath-house. This species has numerous fronds, rather closely arranged on the slender, fuzzy rhizome, which in large specimens arch to a length of almost 20 inches, with a width of only about ¼ inch. They are notably glossy (especially on the upper surface), and their frequent sickle-shaped form makes them unique among all native Florida ferns.

Campyloneurum latum (again according to Small) "has been found in Florida only in the Hattie Bauer Hammock in Dade County. It grows about lime sinks, both on the rock ledges and on the bases of trees around the sinks." I have recently seen cultivated specimens of it, growing in a fibrous medium which seemed to consist mostly of the "parts" of the fern itself, here in South Florida—these again purportedly from another locality, not one in Dade County—but I personally have never collected it nor grown it in my own garden. Darling (1962) has recently noted an unsuccessful search for this species near Homestead.

Small's comments on the fourth member of the genus, *C. costatum,* in Florida are, I believe, worthy of quotation: "This strap fern is very rare in our range, and, like *C. latum,* it has been found in only one locality. It is strongly characterized by the long slender tip of the leaf-blade and the obscure veins. The low hammock is the home of this fern. It is epiphytic and grows on trees, on logs, and on cypress knees. It was discovered in Florida in 1904. Outside of the United States it is known in the West Indies.

"It is not evident just how this fern escaped from the West Indies. The spores may have been carried by the wind or on the plumage of migratory birds. Where it began its career in Florda is another mystery. It may have been carried directly to its present isolated habitat in the Big Cypress Swamp or it may have started on the Florida Keys or in the Cape Sable region, and as it worked its way northward, died out in the rear of its course."

I have seen specimens of this Strap Fern relatively recently, ostensibly collected in the same Big Cypress area (Darling mentions it from the Fahakahatchee, near Copeland, in what is now the Collier County Park), growing happily in pots in osmunda fiber mixed with chopped tree-fern fiber. I have collected what I assume to be this species in eastern Cuba (near the summit of Gran Piedra), growing high in large, moss- and lichen-laden forest trees, in a welter of other epiphytic ferns, orchids, bromeliads, etc. It has not as yet made its way into my personal garden here in Coconut Grove, though I hope to acquire it eventually.

These are the fascinating and fabulous Florida Strap Ferns, the quartet of species comprising our indigenous representation of the unusual genus *Campyloneurum*.

LITERATURE CITED

DARLING, THOMAS, JR. 1962. More Florida Rarities. Amer. Fern Jour. **52**: 137-148.

HAWKES, A. D. 1962. Notes on the vegetation of Santa Maria de Ostuma, Nicaragua. Tropics Mag. **1**: 8-14. *figs. 6-8.*

SMALL, J. K. 1931. Ferns of Florida. New York.

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An American Species of Stegnogramma

KUNIO IWATSUKI

In my recent revision of the genus *Stegnogramma* s. lat., (Iwatsuki, 1963), I enumerated eleven species from the Old World and stated that the species of the New World were doubtfully included within my concept of that genus. After publication of that paper, C. V. Morton kindly offered me an opportunity to examine several American specimens having linear or oblong, exindusiate sori. Examining these specimens, I concluded that *Gymnogramma pilosa* Mart. & Gal. may better be considered an American representative of the genus *Stegnogramma,* and a new combination is proposed, as follows:

STEGNOGRAMMA **pilosa** (Mart. & Gal.) Iwatsuki, *comb. nov.*

Gymnogramma pilosa Mart. & Gal. Mém. Acad. Brux. **15:** 27, *pl. 4, fig. 1.* 1842; Liebmann, Vid. Selsk. Skr. V. **1:** 181. 1848.

Dryopteris pilosa (Mart. & Gal.) C. Chr., Ind. Fil. 284. 1905; Monogr. Dryopteris I. 196. 1913.

Thelypteris pilosa (Mart. & Gal.) Crawford, Amer. Fern Jour. **41:** 16. 1951.

Stegnogramma pilosa is most closely related to the wide-ranging *S. pozoi,* from which it is distinguished by the slightly yellowish color and the gradually narrowing lower portion of the frond. Pinnules are closer together in *S. pilosa* than in *S. pozoi,* though the hairs are not so densely crowded in the former species as in the latter. *Hinton 3467* (US) is peculiar in having glandular rather than setose hairs on the sporangia, and with very long hairs on the rachis sometimes exceeding 2 mm.

Stegnogramma pilosa is classified into three distinct varieties, vars. *pilosa, major,* and *alabamensis.* The known range of the species is from Mexico to Guatemala, var. *alabamensis* extending into Alabama. Among these three varieties, var. *major* seems to be the closest ally of *S. pozoi.* Transfer of *Gymnogramma pilosa* to *Stegnogramma* necessitates new combinations for the two varieties.

STEGNOGRAMMA PILOSA (Mart. & Gal.) Iwatsuki var. **major** (Fourn.) Iwatsuki, *comb. nov.*

Gymnogramme pilosa var. *major* Fourn., Mex. Pl. **1**: 73. 1872.
Thelypteris pilosa var. *major* Crawford, Amer. Fern Jour. **41**: 19. 1951.

STEGNOGRAMMA PILOSA (Mart. & Gal.) Iwatsuki var. **alabamensis** (Crawford) Iwatsuki, *comb. now.*

Thelypteris pilosa var. *alabamensis* Crawford, Amer. Fern Jour. **41**: 19. 1951.

It is rather difficult to give the differences between *Stegnogramma* and *Thelypteris* in a few words. One of the most distinctive features between them is the structure of the sori. In *Stegnogramma*, the sori are linear or oblong, exindusiate, sometimes extending along the veins and reticulate, the sporangia being setiferous. Among the species of *Thelypteris*, there are a few which have linear sori, exindusiate sori, or setiferous sporangia. Compared with the vegetative characteristics, however, the soral features of *Stegnogramma* are distinct. As known in many other fern phylons, such a large genus as *Thelypteris* presents a wide range of variation even in the soral characteristics. Another important feature of *Stegnogramma* is seen in the trichomes. All axes as well as laminar surfaces are covered with two kinds of hairs, the longer hairs and the shorter ones. In *S. pilosa*, the soral characters and those of the trichomes are quite identical with the same characteristics of the Old World species of *Stegnogramma*. Above these, we can safely add several other features which clearly indicate the generic status of this species, such as the constitution of fronds, especially the basal condition of lateral pinnae, the texture and color when dried.

Christensen (1913) included in his Sect. *Leptogramma* two other species, *Dryopteris dasyphylla* and *D. polypodioides.* I have not examined the former; this is a species described from cultivated material, the native locality being doubtful. The latter species has the same soral construction as that of *Stegnogramma*, but is distinct from this genus by features found in the trichomes, constitution of fronds, venation, texture, and so on. Except for the form of sori, *D. polypodioides* belongs to *Thelypteris*. In the frond form and texture, this species resembles such Old World species as the group of *T. crassifolia.*

There are a few other American species having linear, exindusiate sori. *Dryopteris ptarmica* var. *asplenioides* has such soral structure, although the type variety is distinct in having round sori with reniform indusia. The sori of *Thelypteris linkiana, T. gracilis, T. atrovirens* and others are also oblong and naked. The elongation of sori in the thelypteroid series is discussed critically in my recent paper on the morphology of that series (Iwatsuki, in ed.).

I wish to express my sincere thanks to C. V. Morton, whose kindness made possible this study.

LITERATURE CITED

CHRISTENSEN, C. 1913. A monograph of the genus Dryopteris. I. Vid. Selsk. Skr. VII. **10:** (196-198).

IWATSUKI, K. 1963. Taxonomic Studies of Pteridophyta VII. Acta Phytotax. Geobot. **19:** 112-126.

————. 1963a. Taxonomy of the Thelypteroid Ferns with Special Reference to the Species of Japan and Adjacent Regions I. General Considerations. Mem. Coll. Sci. Univ. Kyoto B. **30:** 21-51.

DEPARTMENT OF BOTANY, FACULTY OF SCIENCE, KYOTO UNIVERSITY, KYOTO, JAPAN.

Some New Name-combinations for Southeastern Ferns

EDGAR T. WHERRY

While several popular guides to the ferns of the northeastern states are available, the only broad treatment of those occurring farther south is Small's *Ferns of the Southeastern States,* which was published in 1938 and has long been out of print. The writer has accordingly undertaken to fill this need, and a book, *Southern Fern Guide*, is to be published soon. In its preparation several new name-combinations proved desirable. These are tabulated on page 346 of the book, but to render them fully valid, they are published herewith, accompanied by more extensive literature citations and discussion.

ASPLENIUM PUMILUM Sw. var. **anthriscifolium** (Jacq.) Wherry, *stat. nov*
Asplenium anthriscifolium Jacq., Collectanea **2:** 103. *Pl. 2, fig. 2–3.* 1788.

Because *A. pumilum* Sw. and *A. anthriscifolium* Jacq. intergrade in tropical America it has been usual to reduce the latter to synonymy under *A. pumilum* Sw. In Florida colonies, however, they are markedly distinct in habitat, cutting, and pubescence at all stages of development from first blade to fertile maturity. Their segregation at some taxonomic level is accordingly deemed desirable. Since their differences are not especially fundamental, that of variety is here proposed.

GONIOPHLEBIUM **triseriale** (Sw.) Wherry, *comb. nov.*
Polypodium triseriale Sw., Jour. Bot. Schrad. **1800**[2]**:** 26. 1801.
Polypodium brasiliense Poir., Encycl. Meth. **5:** 525. 1804.
Goniophlebium brasiliense (Poir.) Farw., Amer. Midl. Nat. **12:** 295. 1931. (Accepted by Small, 1938).

There is admittedly some doubt whether this American taxon is congeneric with the Asiatic one on which the name *Goniophlebium* was founded by Presl (1836). Having been "brought up" on Small's 1938 work, the writer is following his usage. Since the prior epithet of Swartz is now believed to apply to the same taxon as that of Poiret's, a new combination is needed.

GONIOPTERIS **sclerophylla** (Kunze) Wherry, *comb. nov.*
Aspidium sclerophyllum Kunze in Spreng., Syst. Veg. **4:** 98. 1827.
Dryopteris sclerophylla (Kunze) C. Chr., Biol. Arb. Tilegn. E. Warming 84. 1911.
Thelypteris sclerophylla (Kunze) Morton, Amer. Fern Jour. **41:** 87. 1951.

While the genus *Goniopteris* Presl (1836) has been accepted by such authorities as Christensen, Copeland, and Holttum, cogent arguments for denying generic status to such segregates have been presented by Morton (1963), who reduces this to *Thelypteris* subgenus *Cyclosorus* section *Goniopteris.* Although admitting that the intergradations of thelypteroid ferns over the world tropics justifies such an arrangement, the writer still feels that in the southeastern United States it is preferable to follow Small in recognizing minor groups as genera. The present taxon having been discovered in Florida since Small's day, a new combination is needed for it.

LEPTOGRAMMA PILOSA var. **alabamensis** (Crawf.) Wherry, *comb. nov.*

Thelypteris pilosa var. *alabamensis* Crawf., Amer. Fern Jour. **41**: 16. 1951.

The generic problems discussed in the preceding paragraph apply here as well. *Leptogramma* J. Smith (1842) is reduced by Morton (1963) to *Thelypteris* subgenus *Cyclosorus* section *Leptogramma*. Had the present taxon been known in the United States in Small's day, he would surely have accepted *Leptogramma* as a "good" genus and the combination *L. pilosa* (M. & G.) Underw. (1902). In any case, the writer favors doing this to make possible a simple key for use in the southeastern United States, contrasting the reniform-indusiate sori of *Thelypteris* with the sori formed by a streak of sporangia without indusium characterizing *Leptogramma*.

MICROGRAMMA **heterophylla** (L.) Wherry, *comb. nov.*

Polypodium heterophyllum L., Sp. Pl. 1003. 1753.

Polypodium exiguum Heward, Mag. Nat. Hist. II, **2**: 458. 1838.

Polypodium swartzii Baker in Hook. & Bak., Syn. Fil. 357. 1868.

Phymatodes swartzii (Bak.) Underw., Our Nat. Ferns, ed. 6, 84. 1900.

Phymatodes exiguum (Hew.) Underw., Torreya **3**: 18. 1903.

Phymatodes heterophyllum (L.) Small, Ferns Florida 81. 1932.

Microsorium heterophyllum (L.) Hawkes, Amer. Fern Jour. **41**: 52. 1951.

Craspedaria heterophylla (L.) Diddell, Amer. Fern Jour. **43**: 114. 1953. (As *C. heterophyllum*).

This taxon already having been renamed so many times, the proposal of still another combination seems regrettable. However, the writer can not but agree with Copeland (1947) that the genus *Microgramma* of Presl (1836) should be expanded to include *Craspedaria* of Link (1841) in that in view of their correspondence in all other respects, their difference in sorus outline (elliptical versus circular) is of no fundamental importance.

THELYPTERIS × **lindheimeri** (C. Chr.) Wherry, *stat. nov.*

Dryopteris normalis var. *lindheimeri* C. Chr., Danske Vid. Selsk. Skr. VII, **10**: 182. 1913.

Aspidium lindheimeri A. Br. ex C. Chr., loc. cit., as a synonym.

Thelypteris augescens var. *lindheimeri* (C. Chr.) R. P. St. John, in Small, Ferns SE. U. S. 241. 1938.

Dryopteris augescens var. *lindheimeri* (C. Chr.) Broun, Ind. N. A. Ferns 62. 1938.

This taxon combines the characters of *augescens* and *normalis* in such a way as to suggest a hybrid origin, which is confirmed by its abortive spores.

THELYPTERIS NORMALIS var. **harperi** (C. Chr.) Wherry, *comb. nov.*

Dryopteris normalis var. *harperi* C. Chr., Danske Vid. Selsk. Skr. VII, **10:** 182. 1913.

Thelypteris ovata R. P. St. John, in Small, Ferns SE. U. S. 230. 1938.

Thelypteris ovata var. *harperi* (C. Chr.) R. P. St. John, in Small, *op. cit.* 233. 1928.

Dryopteris ovata (R. P. St. John) Broun, Ind. N. Amer. Ferns 76. 1938.

Dryopteris ovata var. *harperi* (C. Chr.) Broun, Ind. N. Amer. Ferns 76. 1938.

LITERATURE CITED

COPELAND, E. B. 1947. Genera Filicum. pp. 247. *10 pls.* Waltham.

LINK, H. F. 1841. Filicum species in horto regio botanico Berolinensi cultae. pp. 179. Berlin.

MARTENS, M. & H. GALEOTTI. 1842. Mémoire sur les fougères du Mexique, et considérations sur la géographie botanique de cette contrée. pp. 99. *23 pls.*

MORTON, C. V. 1963. The classification of Thelypteris. Amer. Fern Jour. **53:** 149-154.

PRESL, K. B. 1836. Tentamen pteridopgraphia, seu genera filicacearum praesertim juxta venarum decursum et distributionem exposita. pp. 290. Prague.

SMITH, J. 1842. An arrangement and definition of the genera of ferns, with observations on the affinities of each genus. Hook. Jour. Bot. **4:** 38-70.

SWARTZ, O. 1788. Nova genera et species plantarum prodromus. pp. 152. Uppsala.

UNDERWOOD, L. M. 1902. American Ferns, IV. The genus Gymnogramme of the Synopsis Filicum. Bull. Torrey Club **29:** 617-634.

DEPARTMENT OF BOTANY, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA 4, PENNSYLVANIA.

Camptosorus rhizophyllus forma boycei C. L. Wilson

LEOPOLD A. CHARETTE

On 14 August 1934 Mr. Guy H. Boyce discovered a strikingly beautiful variation of *Camptosorus rhizophyllus* (L.) Link in the township of Highgate, Vermont, which was named forma *Boycei* by Wilson (1935) in honor of the discoverer. It differs from the species in having auricles deeply lobed, margins of fronds irregularly dissected, with obtuse teeth 1–3 mm long.

A search through literature (Broun 1938, Dole 1937, Fernald 1950, and Weatherby 1937) failed to disclose any previous or subsequent collection of this form. In late 1962 the writer was at the Gray Herbarium and in April 1963 at Yale University at which times specimens of typical *Camptosorus rhizophyllus* (L.) Link were studied. Two specimens among the collections at Yale University, from Connecticut, were found to be of this form. Surprisingly enough these had been collected 17 and 30 years prior to the form having been described and named.

The exact location of the type station had never been precisely recorded. Desiring to ascertain the present day status of the form I wrote to Mr. Boyce for first hand information. In his reply Mr. Boyce (1962) invited the author to visit him at his camp and further offered to act as guide to the station which he described as follows: "The place where we found the fern is some three miles from camp and quite close to the Canadian line, and rather hard to describe. . . ."

September 8, 1962 was the date agreed upon for visiting Mr. Boyce. On this date the author and Miss Marion L. Smith were personally guided to the colony from which the type collection had originated.

The station is located in an open woodland which has only light underbrush and is liberally strewn with large limestone boulders and outcrops. The woodlands are adjacent to a cow pasture and the cattle have a path which, unfortunately, passes very close to the colonies of this fern.

In the four colonies pointed out to us by their discoverer, the plants in all but one colony were growing at the base of boulders or shelving outcrops and in habit were characteristically closely appressed to the rocks which here seems to afford some protection from the passing cattle. In only one colony were the plants growing on the face or top of boulders. All the plants were in luxuriantly healthy condition.

The typical form of the Walking Fern is present, but in no case is it abundant. In a single colony only were the form and typical species growing intermixed, a factor which marks forma *boycei* as an artistocrat of its clan, displaying a preference for growing in pure stands. The colonies observed are rather small, with perhaps from 3 to 7 or 8 plants only in each. The woodlands in the immediate vicinity of the station present a notable absence of other ferns as the only other species noted was *Adiantum pedatum* L.

It is gratifying to report that this interesting form is thriving at its original station. At the request of Mr. Boyce and in the interest of conservation the exact location of the station is not being divulged.

LITERATURE CITED

BOYCE, G. H. 1962. 2-paged letter to L. A. Charette dated at Proctor, Vermont, 26 August 1962. Pringle Herbarium document No. 962-476-1.

————. 1963. 2-paged letter to L. A. Charette dated at Proctor, Vermont, 11 February 1963. Pringle Herbarium document No. 963-161-1.

BROUN, M. 1938. Index to North American Ferns. Lancaster, Pa.

DOLE, E. J. 1937. The Flora of Vermont. 3rd Ed. Burlington, Vt.

FERNALD, M. L. 1950. Gray's Manual of Botany. 8th Ed. New York.

WEATHERBY, C. A. 1937. A list of varieties and forms of the ferns of Eastern North America. Amer. Fern Jour. **27**: 20-24.

WILSON, C. L. 1935. A new form of the Walking Fern. Amer. Fern. Jour. **25**: 18. *1 pl.*

PRINGLE HERBARIUM, UNIVERSITY OF VERMONT, BURLINGTON, VERMONT.

Shorter Notes

ASPLENIUM × EBENOIDES R. R. SCOTT IN KENTUCKY.—Early in the winter of 1961, Dan Schreiber asked me to examine several fern specimens collected by one of his students, Donald Willoughby. Among the specimens, all collected in Madison County, Kentucky, were two fronds of a fern unknown to me. I thought they might be hybrids since they were different from ferns commonly found in the area.

The fronds were sent to C. V. Morton who identified them as *Asplenium × ebenoides* Scott, commonly called Scott's spleenwort or walking spleenwort. This is the rather rare hybrid between *Asplenium platyneuron* Oakes and *Camptosorus rhizophyllus* Link.

One frond had the general appearance of *A. platyneuron,* the common ebony spleenwort. The second looked quite different. Some of the pinnae were extremely elongated and resembled closely individual fronds of *C. rhizophyllus* in miniature, even to the somewhat irregular arrangement of the sori. Morton said these were the most robust plants of this hybrid he had ever seen.

Since only individual fronds of this fern had been collected it was hoped that the specimen could be relocated. Mr. Willoughby described the site of the original collection as a wooded slope near College Hill, Madison County. However, subsequent visits to the area failed to relocate the plant. The original collection is deposited in the United States National Herbarium.

It was first believed that this fern had not previously been reported from Kentucky since it was not included in the lists published by Reed (Castanea **23**: 1–13. 1961; op. cit. **26**: 94–96. 1961), and Smith (Castanea **24**: 48–50. 1959). However, a recent list of additions by Reed (Castanea **27**: 83–87. 1962) provides a clue to a previous record. Williamson's *Fern Etchings.* Ed. 2, illustrating all the species of ferns indigenous to the northeastern United States and Canada, published in Louisville, Kentucky, in 1879, contains several illustrations of ferns which he recorded from counties in Kentucky. Plate XVII shows *Asplenium ebenoides*. According to this source, "Professor Wildberger" collected *A. ebenoides* in Franklin County in 1878. Apparently this is the earliest published record for this hybrid in the state.

I wish to thank Conrad Morton for identifying the plant, and Donald Willoughby for giving the specimens to the National Herbarium.—THOMAS A. HUTTO, *Biology Department, School of the Ozarks, Point Lookout, Missouri.*

Recent Fern Literature

FLORA OF SOUTHEASTERN WASHINGTON AND OF ADJACENT IDAHO. 3rd Ed., by Harold St. John. Outdoor Pictures, Escondido, Calif. xxix, 1-583. 1 map, 11 figs. October 1963. $6.95.—The second edition, which appeared in 1956, included about 30 pages of addenda which have now been incorporated into the 3rd edition. The present book is essentially a facsimile reprint of the former editions with some additions and corrections. The sequence of families of angiosperms follows Engler & Prantl. Within each family the genera are arranged alphabetically, as are the species in each genus.

One of the notable features of the 3rd edition is a revised taxonomy of ferns, particularly in the delimitation of families along lines proposed by R. C. Ching, E. B. Copeland, R. E. Holttum, and others, although apparently these authors are not mentioned. There is no evidence of ordinal concept, but there are three classes, with Filicineae inserted between Lycopodineae and Equisetineae. The families of ferns begin with Ophioglossaceae and end with Marsileaceae, with the old "Polypodiaceae" represented by eight families. For one of these, the name Cheilanthaceae would have been preferable to Sinopteridaceae. The families are arranged in the key on p. xviii into two groups according to whether the rhizome is dictyostelic, protostelic or solenostelic.

The book is clearly printed and well-bound and will continue to be useful for identifying plants growing in southeastern

Washington and adjacent areas. The author is to be congratulated on having kept the book more or less up to date, and the publisher on having produced an attractive, handy volume.—G. NEVILLE JONES, *University of Illinois, Urbana, Illinois.*

FERN MATERIAL USED IN RESEARCH ON MORPHOGENESIS AND PHOTOPERIODISM.—For thirty years and more ferns have provided material for important research in fundamental problems of differentiation of tissues and organs. Leading work has been carried on in England by Wardlaw and his students and by Wetmore and his aides at Harvard. In a recent paper[1] DeMaggio and Wetmore reported successful excision and culture on nutrient media of young embryos of *Todea barbara,* an Australian member of the *Osmunda* family. When embryos that had become spherical, 5-7 days after fertilization of the egg, are used the embryo could be carried to independent growth, with a root-stem-leaf system, on the medium. With one-celled embryos, however, multicellular structures would be produced, but they were without tissue organization and resembled prothallia.

Another pair of experimenters[2] report the effects of exposure to red light on early stages of the prothallia of *Onoclea sensibilis.* Like most fern spores, those of *Onoclea* require light to germinate. When germinated spores are then placed in darkness, growth is in the form of a slender filament. Brief exposure to red light will increase the rate of growth (elongation) of these filaments to about the 12th day. Thereafter, the elongation rate is reduced by exposure to red light.—RALPH C. BENEDICT, *Pilot Knob, New York.*

JOE, BARBARA. Species of Dryopteris Cultivated in California. Baileya **11**(4): 117–130. Illus. 1963.—Provides a key, brief descriptions and good photographs of each of eight taxa.

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[1]DeMaggio, A. E. and R. H. Wetmore. Growth of Fern Embryos in Sterile Culture. Nature **191** (4783): 94-95. 1961.

[2]Miller, John H., and D. R. Wright. An Age-Dependent Change in the Response of Fern Gametophytes to Red Light. Science **134** (3490): 1629. (Nov. 17) 1961.

WAGNER, W. H., JR. Pteridophytes of the Mountain Lake area, Giles County, Virginia, Including Notes from Whitetop Mountain. Castanea **28**(4): 113–150. Illus. 1963.—A check list with copious notes on geographic distribution, ecology, and cytotaxonomy of the ferns and fern allies studied.

Notes and News

HARRY W. TRUDELL was born in Richmond, Virginia, May 2, 1879, but came to Philadelphia as a youth. Becoming an accountant, he was employed for many years by a large leather firm, and rose to the important position of Secretary. A nature enthusiast, he spent all available time outdoors, collecting both botanical and mineralogical specimens. He also took an active part in such organizations as the Philadelphia Botanical Club, which he served as treasurer for many years, and the Philadelphia and Pennsylvania Mineralogical Societies.

Friendly in manner and having a fine sense of humor, he was an ideal companion on field trips, and joined the writer on many searches for ferns. He was a member of the American Fern Society for 45 years. A hybrid between the Lobed and Mountain Spleenworts, which we found on the cliffs of the Susquehanna River in Lancaster County, Pa., was named *Asplenium trudellii* Wherry in his honor (Amer. Fern Jour. **15**: 49. *Pl. 4, figs. 4-5.* 1925).

He enjoyed superior health for 80 years, then was stricken with Parkinson's disease, and after gradually failing, passed away on January 26, 1964.

His collections of ferns and other plants have been placed in the herbarium of the Academy of Natural Sciences of Philadelphia and other similar institutions.—EDGAR T. WHERRY, *University of Pennsylvania, Philadelphia.*

EXPERIENCES IN RAISING FERNS FROM SPORES.—Two or three years ago I decided to try raising some ferns from spores, being stimulated by Mrs. Kay Boydston's article in the Fern Journal[1]

[1]Boydston, Kathryn. An Amateur Plants Fern Spores. Amer. Fern Jour. **48**: 1-18. 1958.

and by the existence of the Spore Exchange of the Fern Society. Mrs. Boydston kindly sent me some spores, and I decided to treat them according to her system, which seems to me the most practical of those I have read about. The spores were all sown at the same time in transparent plastic jars, with enough moisture, and placed in a well-lighted room, away from the direct sunlight. After two or three weeks some prothallia started to develop. But just then I had to be absent from home for two weeks, and on my return I found to my regret all the jars as dry as a bone, the prothallia all dead, and no new ones apparent. Unwilling to give up I sogged the whole mixture, put the whole ruined collection on a window sill in full sun, and hopelessly waited. In less than two weeks the fattest prothallia developed in all the jars. This shows that not all spores in a sowing develop at the same time. I let them grow under the same conditions until I was able to find time to transplant the plantlets into individual baby pots. I placed the pots in a sort of Wardian case, but since I do not have room for Wardian cases everywhere I selected only the best and strongest plants, which are now doing pretty well.

Some of my ferns are attacked by scale insects. When young these look like transparent oval-shaped drops about one or two mm long. Later they harden and become darker brown. They seem to start from the base of the plant and work their way upward, covering at last the segments of the fronds, the stems, and all. When crushed the shell bursts and the inside is whitish and sticky. The plants attacked as a rule suffer considerably, stop putting out new fronds, and lose all vitality. I have used fish soap and Blackleaf 40, and have rescued half of the plants treated, but on some this seems not to work. None of the nurseries I have asked can give me a satsifactory solution to this problem. It is a discouraging business. If we do not watch our plants carefully the scales spread very rapidly.[2]

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[2]Malathion is reported to be the most successful insecticide against scale insects. [C.V.M.]

My wife has about 200 varieties of plants growing inside the house—cacti, philodendrons, orchids, anthuriums, and so on, including a Christmas cactus (*Zygocactus truncatus*) hanging in a window where it gets all the sun it wants. One day I noticed something else showing besides the cactus. Of course the cactus was kept on the dry side, but there it was—a fern! In a few days another showed up and a third. I started picking them out and transplanting them into pots. Most of them turned out to be *Adiantum hispidulum*, of which I have a nice specimen in my fern collection. One was *Pellaea rotundifolia*, which I also have in my collection, and another I have not been able to identify yet. I have already given away four or five nice looking plants, and more are coming along.—NICHOLAS BARTHO, *RFD, Center Conway, New Hampshire.*

A CORRECTION.—In Wilson's paper on *Adenophorus* (Amer. Fern Jour. **54**: 68–70, 1964), line 9 on page 68 should read: (Kaulfuss, 1824), as *Polypodium tamariscinum* Kaulf. (*Adeno-* Remove the parenthesis just before, but not after "(Gaud.)." in line 11, to read: Gaud.).

AMERICAN FERN SOCIETY

An Open Letter from the President

Few scientific societies are so fortunate as ours is to have had included in its membership from its very beginning a large number of serious amateurs dedicated to the study of ferns as an avocation. It is significant that our charter membership included a number of non-professionals, some of whom later distinguished themselves in the field of Pteridology. One of these, C. E. Waters, a chemist in the National Bureau of Standards, wrote the first book on ferns to be illustrated with photographs of typical fronds, and especially, with enlarged photographs of the sori of different genera. Through the years, practicing scientists and interested amateurs, through Society membership, have forged a unified bond of common interest for the advancement of our knowledge of ferns and for the pleasure of working with them. This has been a healthy situation, and one that should be constantly encouraged.

With the increased amount of leisure that is becoming available to many of us because of shorter work time and longer vacation periods, the need for recreational interests is going to become more pressing. I do not know of any more pleasant way in which to spend one's free time than in studying and working seriously with our native plants, especially ferns. Also, the pleasure of getting out into the field with people of like interests has a strong fraternal appeal.

Coupled with the need for developing more avenues of recreational endeavor is the urgent need to assure that organizations such as ours, providing recreational outlets, be placed on a sound and permanent footing, so that they and their activities can be perpeutated for the enjoyment of future generations.

With the steadily mounting costs of publishing our Journal, a most important adjunct to our activities, and the future need to help support certain special publications in the field of ferns and fern allies, we should all give serious consideration to what we might be able to do personally for the Society. The American Fern Society has been fortunate in the past to have had some members who generously contributed materially to its progress and well-being. Such a one was Mr. C. A. Weatherby, who not only during his lifetime personally contributed substantially to the advancement of our Society, but who also left a generous gift to the Society in his will.

Among our members are doubtless some who now or in the future may wish to contribute generously to the support and perpetuation of our Society. I appeal to these individuals to keep in mind the future needs and welfare of the American Fern Society.—DONOVAN S. CORRELL.

American Fern Society

LIST OF MEMBERS

Aborn, Mr. Robert G., Box 323, Millington, New Jersey 1963
Ade, Dr. Ralph D., 2805 - 26th Street, Moline, Illinois 1946
Adkins, Mr. Eugene B., 2112 E. 60th St., Tulsa, Okla. 74105 1962
Akins, Mrs. Jesse C., 200 E. 9th St., Rome, Ga. 1964
Akutowicz, Mr. Frank, 2007 Harvey Road, Wilmington 3, Del. 1960
Alava, Dr. Reino, Dept. of Botany, University of Turku, Turku, Finland 1958
Albro, Miss Mary Stephanie, 29 Mosswood Road, Berkeley 4, Calif. 1958
Alexander, Miss Eva, 900 Graymont Ave. W., Birmingham 4, Ala. 1956
Alexander, Mrs. Leonore, 2104 Grant Ave., Redondo Beach, Calif. 1957
Allen, Dr. & Mrs. Edward P., 505 Ridge View Rd., Orange, Conn. 1949
Allen, Mr. Walter S., 2 Pool Road, New Haven, Conn. 1917
Allison, Dr. Benjamin R., 26 Ives Rd., Hewlett, L. I., New York 1950
Amason, Mr. Carl R., Route 3, Box 180, El Dorado, Arkansas 1963
Anderson, Prof. Lewis E., 2020 Sunset Avenue, Durham, N. C. 1952
Anderson, Mr. Roger F., Mich. Chr. Jr. College, 800 W. Avon Rd., Rochester, Michigan 1962
Andreas, Mr. Lee, Wisconsin State College, Stevens Point, Wis. 1953
Andrews, Prof. Henry N., Jr., Botany Dept., University of Connecticut, Storrs, Conn. 06260 1951
Artz, Miss Lena, Waterlick, Virginia 1948
Atkinson, Mrs. Geoffroy (Lenette), 415 South Pleasant St., Amherst, Mass. 1951
Attridge, Miss Helen M., 358 Longwood Ave., Boston 15, Mass. 1963
Atwood, Mr. Felix, 307 N. Sherman St., Ennis, Texas 1961
Aubrey, Mr. H., Angophora Crescent, Forestville N.S.W., Australia 1963
Bacon, Miss Catharine M., 183 Lancaster St., Albany 10, N. Y. 1954
Bain, Mrs. Carlton L., 23 Maple Street, West Roxbury 32, Mass. 1962
Baker, Miss Harriet E., 1927 Buckingham Rd., Los Angeles 16, Calif. 1941
Baker, Dr. William H., University of Idaho, Moscow, Idaho 1947
Baldwin, Prof. John, College of William & Mary, Williamsburg, Va. 1953
Ballard, Mrs. F. L., Jr., 149 Northwestern Ave., Philadelphia 18, Pa. 1958
Ballard, Mr. Francis, Royal Botanic Gardens, Kew, Richmond, Surrey, England 1944
Bange, Mr. M., 24 Rue Grenette, Lyon 2, France 1960
Barnes, Mrs. Albert C., Latch's Lane, Merion, Pa. 1926
Barnes, Mrs. William A., 2645 Edgewood Road, Utica 3, N. Y. 1944
Bartho, Mr. Nicholas, R.F.D., Center Conway, New Hampshire 1959
Barton, Mr. Ralph R., 517 E. Alder St., Brea, Calif. 1957

Bartsch, Mrs. Paul, Gunston Hall Road, Lorton, Virginia 1961
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LANJOUW, J., and F. A. STAFLEU. 1964. The Herbaria of the World. Index Herbariorum, Regnum Veg. **31**: 1–251.

SCHWARTEN, L., and H. W. RICKET. 1958. Abbreviations of Titles of Serials Cited by Botanists. Bull. Torrey Club **85**: 277-300; 1961. Supplement I. Ibid. **88**: 1-10.

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Edwin Bingham Copeland (1873-1964) and His Contributions to Pteridology

W. H. Wagner, Jr.[1]

The death of Professor Copeland in Chico, California, on March 16, 1964, marked the end of a distinguished botanical career not only of a leading pteridologist but an administrator, a teacher, a physiologist, and a tropical agriculturist. Of all of Dr. Copeland's contributions, his work on the ferns is best known, and his last publication was fittingly titled simply "Fern" (1964). He was recognized by the American Fern Society by election as an Honorary Member in 1948.

He was born on September 30, 1873, in Monroe, Wisconsin, and acquired his deep interest in botany from his mother, Alice Bingham Copeland. His father, a graduate of Cornell University, died when Edwin was only three. He grew up in Monroe, and when he reached college age he went to the University of Wisconsin in Madison, some thirty miles away. After his third year there he transferred to Stanford University where one of his purposes was to study under the fern authority, D. H. Campbell. When he graduated from Stanford in 1895, he left for Europe where he attended the University of Leipzig and the University of Halle, specializing in plant physiology. He completed his Doctor's degree at Halle in 1896 with a thesis on the influence of light and temperature on turgor.

After his return to the United States he held several positions in different American universities. In 1903, he left with his wife and young son for the Philippine Islands, where he remained for fourteen years. His first appointment in the Islands was as Sys-

[1] In preparing this biographical obituary I acknowledge the aid of Herbert F. Copeland, Conrad V. Morton, and Florence S. Wagner especially. Further notes on the life of Copeland and a complete bibliography are published in *Taxon*.

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FIG. 1. EDWIN BINGHAM COPELAND AT THE AGE OF TWENTY-FIVE

tematic Botanist in the Bureau of Science. In 1909 he founded the College of Agriculture of the University of the Philippines (for which he received a Doctor of Laws, *honoris causa* 40 years later). As Dean of the College he was deeply involved in academic administration and one would judge that when he returned in 1917 to the United States he was relieved to be his "own man." In fact, for nearly a decade after his return he lived as a leading rice grower in the area of Chico, Butte County, California, and effectively cut his connections with the academic life. By this time his family had grown to five children.

Not until 1927 did Copeland return to botanical research and administration, first as Associate Curator of the University of California (Berkeley) for four years, and then as Technical Advisor and Director of the National Economic Garden in the Department of Agriculture of the Philippine Government for four years. In 1935 he retired and became a permanent Research Associate of the Department of Botany of the University of California, thus entering a period of pure research on ferns that lasted nearly three decades. It was during this period that most American botanists remember him.

His appearance was striking. Although his height was average and his build slender, his eyes were sharp and penetrating and he always wore a mustache and goatee. The photograph (fig. 1) shows him as a young man of 25 when his hair was bright red. When I studied with him as a graduate student at Berkeley in the years 1946-50, his hair was pure white and he was bald on top. His bearing was dignified, alert, and authoritative.

Dr. Copeland was a heavy smoker of cigarettes, and one of our constant worries was that he might set fire to the building and destroy it, herbarium and all. Actually the waste basket into which he casually tossed his cigarette butts was metal; and I have often wondered whether he did not start the billowing smoke just to keep things lively. He had a wry sense of humor, and it was a delight to hear him tell a story. He was also absolutely forthright and he let the chips fall where they might. I recall with blushing the time I asked him to criticize my first attempt at a botanical Latin description. He read it over rapidly, scratched his head, and said "Are you fooling?"

No subject was too small or too large for his analysis and criticism. His lively, critical mind was always in action. Airplanes, new styles, politics, English grammar—all were objects of careful attention. Once Dr. and Mrs. Copeland decided to drive down to visit Dr. Campbell at Stanford University and invited me along. Dr. Copeland, 75 years old at the time, was driving along the freeway south of San Francisco at 80 miles an hour, simultaneously watching a helicopter soaring along to the east. Fascinated by the "whirlybird" he got so interested in it that he missed his turn completely and we ended up having to backtrack about five miles.

He always amazed us by his ability to sit down at his desk and write up descriptions of species, give historical references and so on, almost entirely from memory. He had a remarkably retentive mind and put down his thoughts in a laconic style that was anything but wordy. His letters, likewise, were crisp and he wrote many of them to his colleagues across the world including, over many years, such authorities as A. H. G. Alston (England), Carl Christensen (Denmark), R. E. Holttum (Singapore and England), W. R. Maxon (U. S.), Conrad V. Morton (U. S.), M. Tagawa (Japan), and Mme. Tardieu-Blot (France).

It would be impossible to review thoroughly all of the pteridological contributions of Dr. Copeland. During the course of his long career he described 35 new genera and some 600 new species of ferns. His personal herbarium (now at the University of Michigan, Ann Arbor) totals approximately 25,000 specimens. The published results of his work on ferns appeared over 62 years (1902-1964). In his bibliography the titles pertaining to notes, articles, reviews, monographs, and books on the ferns number nearly 120. The following comments will emphasize several of the high spots of his pteridological investigations, and the titles chosen for the literature cited will be only those which are pertinent.

One of Dr. Copeland's most interesting (and most often overlooked) papers was one of his earliest on the ferns—*The comparative ecology of San Ramon Polypodiaceae* (1907). His introductory statement in this article could have been written today, nearly six decades later:

> Contemporary biological science is working toward two ends, namely: (a) The reduction of the processes taking place in living things to understand reactions of chemistry and changes of physics; this is Physiology. (b) Assuming the existence of living things, the causal interpretation of the forms they assume and the elucidation of their relationships; this is Bionomics, sometimes called "Evolution." The application of principles established in the study of physiology to the problem of bionomics is called Ecology.

At this point in his research career, Copeland's interests were beginning to shift from "(a)" to "(b)." In the ten years prior to his San Ramon paper, practically all of his works were physiological, dealing with problems of tropisms, turgor, transpiration, and the mechanism of stomates. After 1907 nearly all of his writings were taxonomic, evolutionary, and ecological. In the San Ramon paper, 80 pages long, he investigated the origin and geographical affinities of the ferns of the area, the local environment and adaptations to it, and gave a systematic application of the results. This paper is of importance not only to students of the ecology of ferns, but it represents Copeland's first venture into the problem of fern evolution. We find here the germs of many of his ideas, some later amplified, others modified. His concepts at that time are summarized in an evolutionary diagram (pl. IV), which anticipated many of the ideas later expressed by F. O. Bower, Copeland himself, and a number of other workers.

The purely floristic-taxonomic investigations of E. B. Copeland dealt mainly with the Old World tropics — Philippines, southern China, Borneo, Sumatra, New Caledonia, New Guinea, Fiji, Raratonga, Society Islands, Hawaii, and so on; and they comprised the bulk of his floristic publications. He did, however, concern himself with New World ferns to some extent, and worked up, for example, the collections of Ynes Mexia from Brazil and Mexico. Most important herbarium materials from the New World tropics during the period of Copeland's research career were sent to the U. S. National Museum for identification. Copeland was the authority for the area he knew best. He received many specimens for study from such botanists and missionaries as Rev. Copland King (the materials collected in Papua); C. J. Brookes (Borneo); J. C. Moulton (northern Sarawak); M. l'Abbé U. Faurie and J. F. Rock (Hawaii); R. S. Williams, J. B. Steere, and D. L. Topping (Philippines); H. E. and S. T. Parks (Polynesia); S. F. Kajewski (Santa Cruz Islands); L. J. Brass (New Guinea); A. C. Smith (Fiji) and many others. He always felt a special indebtedness to Mrs. Mary Strong Clemens, who sent him extensive collections from both Borneo and New Guinea.

The major results of his floristic researches are embodied in several publications that appeared mostly during his later years. Among the most important are the fern floras of Fiji (1929c), Society Islands (1932b), New Guinea (1940, 1941a, 1947a, 1949a, 1949b, 1949c, 1952b) and the Philippines (in three volumes—1958, 1960a, 1960b). In bringing together his floristic knowledge he concluded that the ferns evolved in the Antarctic region and migrated from there into more northerly regions (1939a, 1939b). In view of the present evolutionary activity of the higher ferns he decided that "the period since the Miocene may be judged sufficient for the evolution of most of the existing species and a large part of the genera, and for their spread over any expanse of suitable land area the globe affords." He also came to the opinion that fern evolution leading to the forms of today took place chiefly in the tropics and that ferns migrated therefrom into the temperate zones. He was impressed by the abundance and diversity of ferns in the warm regions of the earth and cited a single mountain (Kinabalu) in Borneo where the fern flora comprises 437 species.

Much of Copeland's revisional work was woven into his floristic publications, but he did produce several significant monographic studies, of which that on the Hymenophyllaceae is the best known (1933, 1937, 1938, 1947b). His procedure in presenting this monograph was unusual in that he treated first all of the species of the traditional genus *Trichomanes,* following this by a similar treatment of *Hymenophyllum,* and then revised all of the species generically and divided the family up into 34 genera. For thus splitting the two classical genera of the filmy-fern family, Copeland received much criticism. In his defense he had already argued that those of his predecessors who had examined the family in detail equivalent to his own had come to the same conclusion about the need for many genera. Furthermore, as he pointed out, many species do not readily fall into either of the two traditional genera. For this reason, and the fact that there are approximately six hundred species of filmy-ferns to be dealt with in an over-all taxonomy, he argued that so long as the genera were natural it would be more convenient to recognize as many as he did. Twelve of his genera are more or less isolated from the others and are monotypic; of the others, the number of species range from several to 100 each, averaging *ca.* 20 species each. Pteridologists are today divided on whether or not to accept Copeland's generic treatment. Even in so large a fern flora as that of Malaya at least one worker has found that it has not proved convenient to recognize so many genera. The general reaction seems to be to uphold the two traditional categories *Trichomanes* and *Hymenophyllum* but to recognize Copeland's genera as subgenera.

The other large generic monographs of E. B. Copeland include *Leptochilus* (1928), *Plagiogyria* (1929), *Grammitis* (1951), *Xiphopteris* (1952a), and *Ctenopteris* (1956).

It is upon matters of broad evolution and classification of the Filicineae that Copeland's influence has been and will be felt the most. His tutelage under Douglas Houghton Campbell, combined with his own intimate knowledge and experience with perhaps as many species of ferns as any one who has ever lived, placed him in a unique position to evaluate the classification of ferns. It must be remembered that the taxonomy of ferns was fairly "settled" by the thorough work of Diels and others in *Die natürlichen Pflanzenfamilien,* and the valuable bibliographic source work of C. Christensen in *Index Filicum.* During the years approximately 1910 to 1930, the popular works of the Glasgow morphologist, F. O. Bower, called attention to the abundance of parallel and convergent evolution in the ferns. Nevertheless Bower himself still continued in the old tradition of emphasizing the sorus as the most fundamental criterion of fern relationships. (Copeland always felt that Bower's work suffered from lack of knowledge of broad fern diversity.) Although we find Copeland as early as 1907 discussing the evolutionary relationships of ferns (as noted earlier), it was not really until 1929 in his *Oriental Genera of Polypodiaceae* that his basic ideas became well established. He expressed his operational procedure in this way: "Systematic Botany today is dominated by two principles: 1. Its groups of plants, of generic or of whatever rank, *must* be natural in the evolutionary sense. 2. These groups *should* be convenient—easy to recognize and to define." He felt that "It is by its distinctive effort to interpret [evolutionary relationships] that systematic botany maintains the dignity of a science . . . ." and he was concerned not only with mere classification but also understanding and insight. The "Oriental Genera" is of interest in other respects too. For example, he used here a neat numerical way of expressing divergent relationships in a linear series (an idea based upon methods used in family genealogies and library catalogues) with unit numbers, 1, 2, 3, etc., the first figures the main branches, the second figures the secondary branches, and so on—for example: 125 Athyrium, 12521 Blechnum, 12522 Doodia, ... 1253 Asplenium, 125311 Ceterach, 125312 Pleurosorus.

With the encouragement of Ethel Faulkner Copeland, his wife, Dr. Copeland decided to summarize his conclusions regarding the taxonomic relationships of the ferns, an effort which culminated in the *Genera Filicum* (1947b). There, he put into practice his conclusion that the old "Polypodiaceae" was a catch-all for many different lines of evolution. He divided it into a number of families, so that the total of filicinean families was 19 in all. He later added a twentieth, the Grammitidaceae (1951). This division of the Polypodiaceae *sensu lato* resulted in the recognition of such segregates as Pteridaceae, Davalliaceae, Blechnaceae, Aspleniaceae, and Vittariaceae. The idea of breaking up "Polypodiaceae" had been anticipated seven years earlier by R. C. Ching (1940), who had recognized 33 segregates from what had been considered a single family (Copeland himself criticized this treatment in 1941). Since Copeland's *Genera Filicum* appeared, evidence is accumulating that he was probably too conservative if anything. Many workers today believe that his Pteridaceae and Polypodiaceae are too large and heterogeneous to represent natural assemblages of ferns.

Perhaps the major contribution of *Genera Filicum* was the active recognition that many soral types have arisen repeatedly in separate lines of fern evolution, and that the sorus is not so reliable an expression of relationships as had been thought, for example, by Diels, Christensen, and Bower. Such forms of sori as the "acrostichoid," "asplenioid," "gymnogrammeoid," "polypodioid," and "pteroid," have appeared convergently in independent groups. Such fern genera as *Elaphoglossum* (which he placed in Aspidiaceae), *Dictyoxiphium* (Aspidiaceae), *Diellia* (Aspleniaceae), and *Prosaptia* (Grammitidaceae) show soral structures that are strikingly different from their relatives as he interpreted them in his revision. It was in keeping with his basic philosophy, however, that relationships should be determined upon the *totality* of characters, whether or not a single feature or complex of features should be strongly divergent.

The influence of *Genera Filicum* may be measured in part by the number of floras which adopted the same or a modified form of his classification (over a dozen since 1947), and in part by the extent to which it has stimulated and augmented research. In many respects Copeland's treatment has been supported by new lines of evidence, as in the cytological findings of Irene Manton (1954, cf. especially Table 1, p. 176) and her followers. At about the same time that *Genera Filicum* appeared, another system of classification was published, namely that of R. E. Holttum (1946, 1949) and their differing viewpoints made research on fern classification especially timely and stimulating. In the fifties several other systems have been proposed, of which those of Alston (1956) and Pichi-Sermolli (1958) have been especially important.

Current thinking suggests some significant changes in the taxonomic concepts of *Genera Filicum*. For example, there is evidence now that Copeland's "Cyatheaceae" should include several of the genera that he included in his "Pteridaceae" (Holttum, 1963). The remainder of the family "Pteridaceae" should probably be divided into two separate families (cf. Manton, op. cit.). There is a strong question whether *Dipteris* and *Cheiropleuria* should be included in the Polypodiaceae *sensu stricto* (cf. Wagner, 1952; Wilson, 1959). On the other hand, it is possible that the largest of Copeland's families, the "Aspidiaceae" (comprising nearly 70 genera and 3,000 species) may have to be enlarged even more to include "Davalliaceae," "Blechnaceae," and "Aspleniaceae" if it is to be natural.

When one considers the vast labor involved in Copeland's extensive work on the ferns, it seems hard to believe that he also had time to be a teacher, a tropical agriculturist, and an administrator. Many botanists are not aware that he also succeeded in writing several books on non-pteridological subjects—"Elements of Philippine Agriculture" (1908), "The Coconut" (three editions, 1914, 1921, and 1931) and "Rice" (1924), and even a book on the principles of practical ethics entitled "Natural Conduct" (1928). Although he will probably be remembered most for his contributions to the knowledge of ferns, he was obviously a man of broad interests. Alert and in possession of his mental faculties until the end of his long life, as his age approached 90 years he became blind and could no longer work. In what was surely one of the last letters Dr. Copeland received in those final months, his good friend C. V. Morton wrote to him as follows: "You have the consolation of knowing that your name is in constant use by fern students the world over."

LITERATURE CITED

ALSTON, A. H. G. 1956. The subdivision of the Polypodiaceae. Taxon **5:** 23-25.

BOWER, F. O. 1923-28. The ferns, vols. I-III. University Press. Cambridge.

CHING, R. C. 1940. On natural classification of the family "Polypodiaceae." Sunyatsenia **5:** 201-268.

COPELAND, EDWIN BINGHAM, 1907. The comparative ecology of San Ramon Polypodiaceae. Philip. Jour. Sci. **2** (C): 1-76, *pls. 1-4.*

———— 1928. Leptochilus and genera confused with it. Philip. Jour. Sci. **37:** 333-416, *pls. 1-32.*

———— 1929a. The fern genus Plagiogyria. Philip. Jour. Sci. **38:** 377-417, *pls. 1-15.*

———— 1929b. The oriental genera of Polypodiaceae. Univ. Calif. Publ. Bot. **16:** 45-128.

———— 1929c. Ferns of Fiji. Bishop Mus. Bull. **59:** 1-105, *pls. 1-5.*

———— 1932a. Brazilian ferns collected by Ynes Mexia. Univ. Calif. Publ. Bot. **17:** 23-50, *pls. 1-8.*

———— 1932b. Pteridophytes of the Society Islands. Bishop Mus. Bull. **93:** 1-86, *pls. 1-16.*

———— 1933. Trichomanes. Philip. Jour. Sci. **51:** 119-280, *pls. 1-61.*

———— 1937. Hymenophyllum. Philip. Jour. Sci. **64:** 1-188, *pls. 1-89.*

———— 1938. Genera Hymenophyllacearum. Philip. Jour. Sci. **67:** 1-110, *pls. 1-11.*

———— 1939a. Fern evolution in Antarctica. Philip. Jour. Sci. **70:** 157-189.

———— 1939b. Antarctica as the source of existing ferns. Proc. Sixth Pacific Sci. Congr. **4:** 625-627.

———— 1940. Oleandrid ferns (Davalliaceae) of New Guinea. Philip. Jour. Sci. **73:** 345-357, *pls. 1-10.*

———— 1941a. Gleicheniaceae of New Guinea. Philip. Jour. Sci. **75:** 347-361, *pls. 1-6.*

———— 1941b. Tropical American ferns. Univ. Calif. Publ. Bot. **19:** 287-339, *pls. 36-66.*

——— 1941c. Comment on natural classification of the family Polypodiaceae by R. C. Ching. Sunyatsenia **6:** 159-177.
——— 1947a. Cyathea in New Guinea. Philip. Jour. Sci. **77:** 95-125, *pls. 1-15.*
———1947b. Genera filicum, the genera of ferns. Chronica Bot., Waltham, Mass. 247 pp., *pls. 1-10.*
——— 1949a. Pteridaceae of New Guinea. Philip. Jour. Sci. **78:** 5-41, *pls. 1-6.*
——— 1949b. Aspleniaceae and Blechnaceae of New Guinea. Philip. Jour. Sci. **78:** 207-229, *pls. 1-6.*
——— 1949c. Aspidiaceae of New Guinea. Philip. Jour. Sci. **78:** 389-475, *pls. 1-44.*
——— 1951. Grammitis. Philip. Jour. Sci. **80:** 93-271, *pls. 1-6.*
——— 1952a. The American species of Xiphopteris. Am. Fern Jour. **42:** 41-52; 93-110.
——— 1952b. Grammitidaceae of New Guinea. Philip. Jour. Sci. **81:** 81-119, *pls. 1-10.*
——— 1956. Ctenopteris in America. Philip. Jour. Sci. **84:** 381-473, *pls. 1-16.*
——— 1958. Fern Flora of the Philippines. Vol. 1. Pp. 1-191. Bur. of Printing, Manila.
——— 1960a. Fern Flora of the Philippines. Vol. 2. Pp. 193-376. Bur. of Printing, Manila.
——— 1960b. Fern Flora of the Philippines. Vol. 3. Pp. 377-557. Bur. of Printing, Manila.
——— 1964. Fern. Encyclopedia Britannica **9:** 191-195, *pls. 1, 2.*
Holttum, R. E. 1946. A revised classification of the leptosporangiate ferns. Jour. Linn. Soc. (Bot.) **53** (no. 350): 123-158.
——— 1949. The classification of ferns. Biol. Rev. **24:** 267-296.
——— AND U. SEN. 1961. Morphology and classification of the tree ferns. Phytomorphology **11** (4): 406-420.
MANTON, IRENE AND W. A. SLEDGE. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. Phil. Trans. Roy. Soc. London, ser. B (Biol.) **238:** (no. 654): 127-185.
PICHI-SERMOLLI, RODOLFO E. G. 1958. The higher taxa of the Pteridophytes and their classification. Acta Univ. Upsaliensis **1958** (6): 70-90.
WAGNER, W. H., JR. 1952. Types of foliar dichotomy in living ferns. Am. Jour. Bot. **39:** 578-592.
WILSON, KENNETH A. 1959. Sporangia of the fern genera allied with Polypodium and Vittaria. Contr. Gray Herb. **187:** 97-127.

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Observations on Drought Resistance in Selaginella densa Rydb.

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INTRODUCTION.—During a recent study of *Selaginella densa* Rydb., the Prairie Club Moss, it was noted that this plant has a remarkable ability to survive conditions of extreme drought. The purpose of this paper is to record some observations made on a small mat of *S. densa* in the laboratory, and to make some remarks about drought resistance in this species. According to Maximov (1935), drought resistance can be defined as "the capacity of plants to endure drought and to recover readily after permanent wilting, with the minimum of damage to the plant itself." In the xerophytic species of *Selaginella* there is no outward appearance of permanent wilting. Probably the the best evidence of reaching the permanent wilting point in these species is the tight folding of the leaves next to the stem (Daubenmire, 1959). He further stated that it is important to distinguish plants which can really endure drought (that is, plants which are drought resistant) from those which merely escape or evade drought (e.g. desert ephemerals). Drought resistance has been described for several mosses and liverworts as well as for *Selaginella.*

Campbell (1930) noted that among the California species of the Marchantiaceae, many dry up during the summer and are revived with the coming of rains in autumn. In these species, *Fimbriaria californica*, *Targionia hypophylla*, and *Cryptomitrium tenerum*, to cite a few examples, the growing point and neighboring tissues of the thallus survive. Richards (1932) described examples of drought resistance among mosses. Leaves of *Tortella inclinata* were air-dried for eighty weeks at room temperature and survived, and those of *Grimmia pulvinata* survived sixty weeks in a desiccator at 20 degrees centigrade. Stems and buds of these species were found to be even more resistant to drying. Shuster (1955) reported a case in which material of the liverwort *Riccia atromarginata* from Texas had been revived after one year and three months of drying. Growth was evident five days after the material had been moistened, and the plants continued to grow in a greenhouse for nearly a year.

Certain species of *Selaginella* also exhibit drought resistance, the most familiar example being *S. lepidophylla,* commonly called the Resurrection Plant. Leclerc du Sablon (1889) noted the capacity of this species to withstand prolonged periods of desiccation, the plant remaining in a tight rolled-up ball in the dry state. After the application of water, it unrolls, the branches take on a green color, and growth resumes. Uphof (1920) concluded that about six per cent of the then-known 580 species of *Selaginella* are xerophytes. He discussed the anatomical features of this small group of species as well as the possible mechanism by which the cells of these plants protect their protoplasm during drought. Finally, Tyron (1955) reported that part of a mat of *S. densa* var. *densa* that had been stored for six months as an herbarium specimen grew after being planted and watered.

HABIT AND ECOLOGY.—*S. densa* is considered to be an ally of *S. rupestris,* resembling this species very closely. However, *S. densa* is usually more western in its range, occurring from southwestern Manitoba to southern Alaska, and south to Texas, Arizona, and northern California (Tryon, 1955). It grows in the form of dense mats, with short, decumbent branches. The shoot possesses a helical phyllotaxy. The branching pattern is terminal and unequal, resulting in one shank being slightly smaller than the other. Four-angled cones or strobili arise at the ends of the branches. These grow in an upright position and may reach a length exceeding one centimeter. The cones contain both microsporangia and megasporangia, the sporangial arrangement fitting Pattern I in the scheme set forth by Horner and Arnott (1963). In this pattern, there is a basal zone of megasporangia above which is a zone of microsporangia.

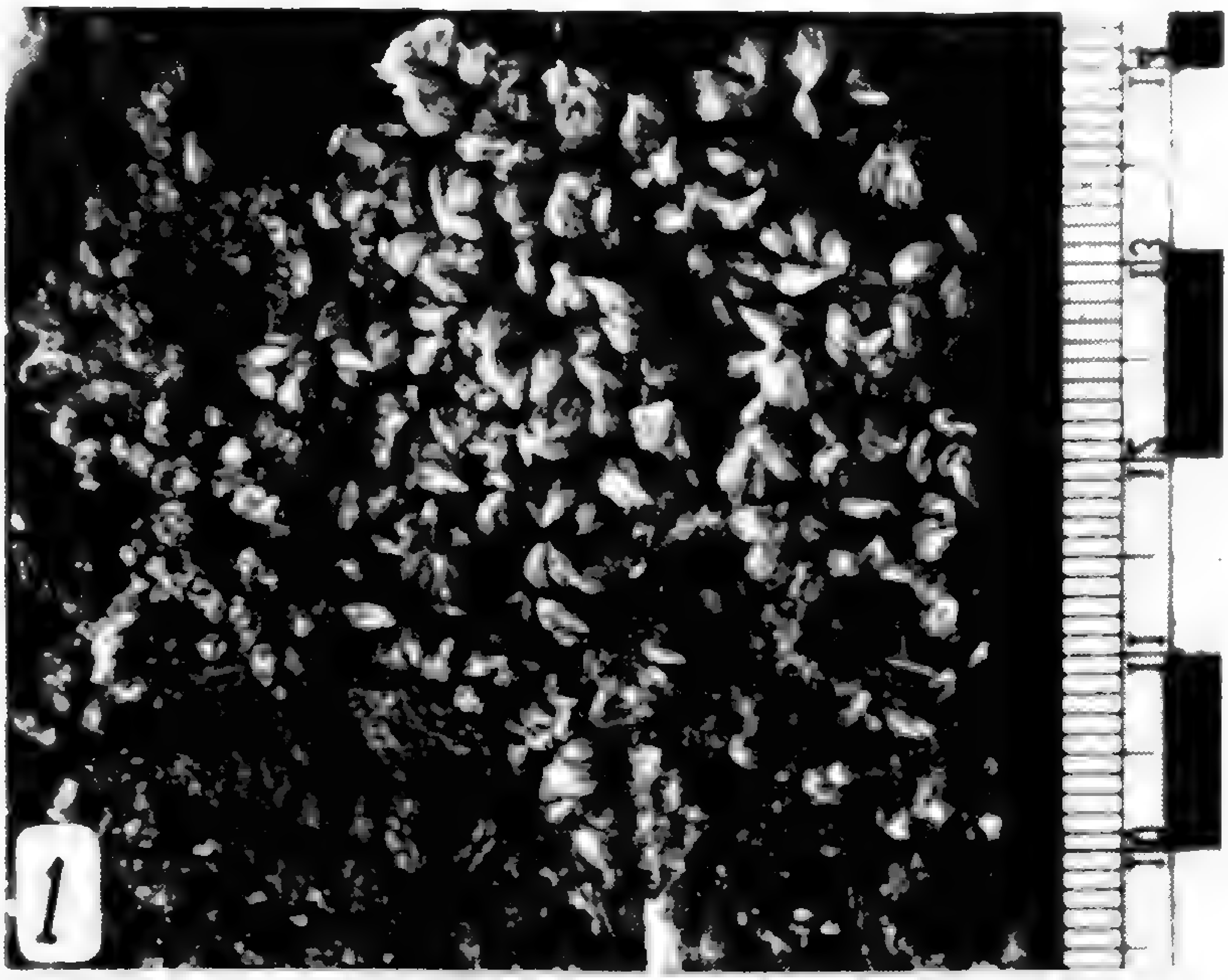
On the Saskatchewan prairie, *S. densa* must be considered an important part of the vegetation, covering up to twenty-five per cent of the soil surface in some areas (Coupland, 1950). This species grows in relatively open places where it is subjected to the extremes of a severe continental climate. During much of the year the Saskatchewan prairie gets little precipitation (Table 1). During prolonged dry periods the mats are composed of dormant shoots having a dull grayish-green color and non-living shoots which exhibit an ash-gray appearance. In the dormant state the leaves, each with a long white awn on the tip, are closely appressed to the stem (fig. 1). It has been suggested by Uphof (1920) that these awns serve to reflect sunlight away from the plant as well as to protect the growing point of the stem.

In the field it was observed that the dormant aspect described above changes literally overnight if any amount of moisture becomes available to the plant. In the field after a rainfall, the grayish-green color gives way to a more luxuriant dark green, giving the previously dormant mats the appearance of active growth. On the other hand, the ash-gray color of the dead stems noted above does not change. In the active shoots, the leaves are no longer closely appressed to the stem, but lie at an angle to the axis. The appearance of a healthy and actively growing mat of *S. densa* is seen in fig. 2.

Table 1. Precipitation in Saskatoon, Saskatchewan, Canada (60 year average). Data courtesy of Physics Department, University of Saskatchewan

	Inches		Inches
Jan.	0.56	July	2.36
Feb.	0.53	Aug.	1.73
Mar.	0.59	Sept.	1.38
Apr.	0.74	Oct.	0.78
May	1.37	Nov.	0.55
June	2.54	Dec.	0.51
		Total	13.64

EXPERIMENTAL OBSERVATIONS.—In September, 1960, a sod containing a mat of *S. densa* was brought into the laboratory for observation and study. A piece of this clump that was not



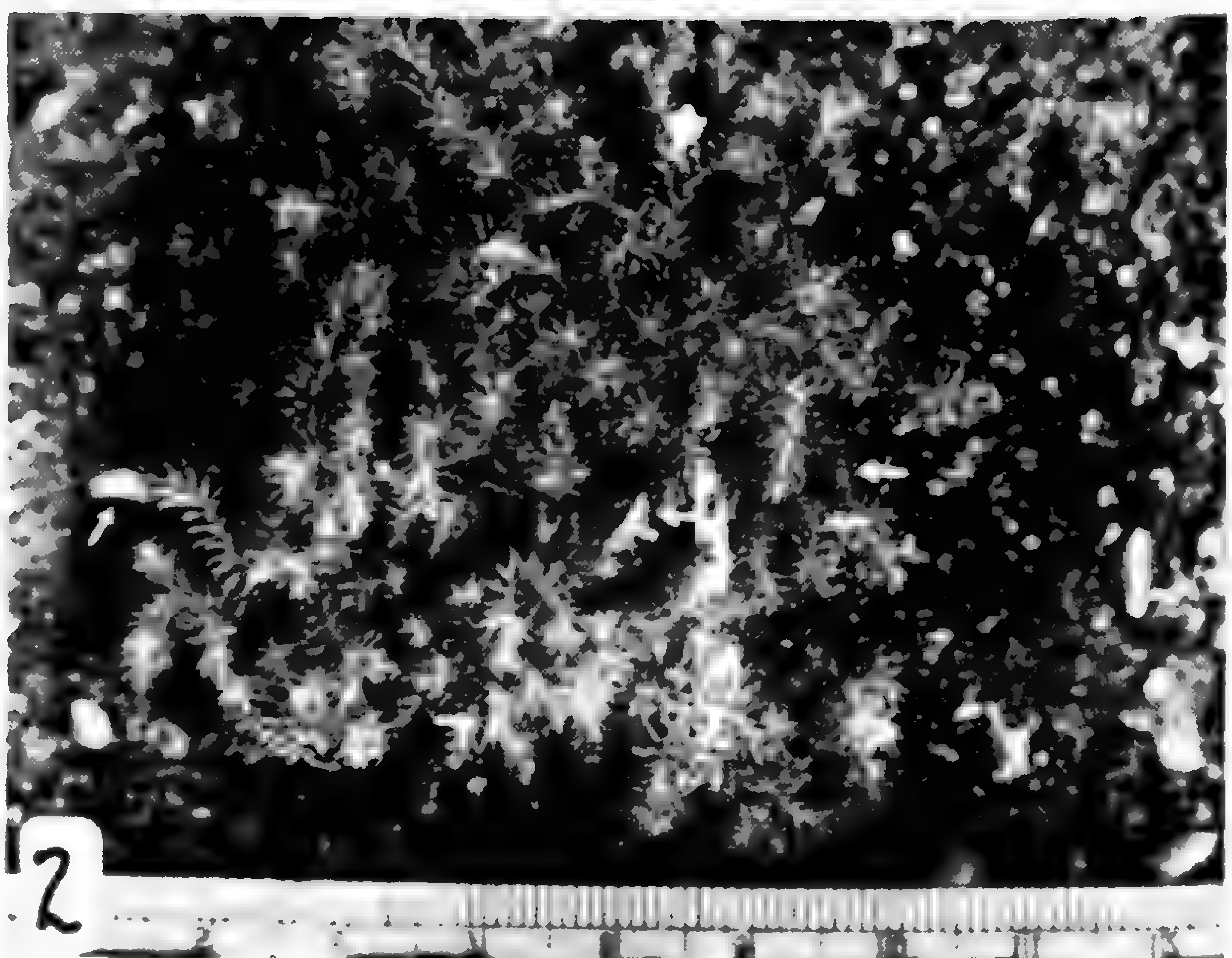


FIGURE 1. DORMANT MAT OF S. DENSA. SCALE IN CENTIMETERS. FIGURE 2. THE SAME MAT 2 MONTHS AND 27 DAYS AFTER INITIAL WATERING. ARROWS INDICATE CONES. SCALE IN CENTIMETERS.

used was placed on a shelf where it lay without moisture for two years. Several times during this period small pieces of the clump were removed and watered. In a few hours the dormant shoots took on the aspect exhibited by actively growing shoots. Having observed this interesting phenomenon, it was decided to test the ability of the remaining mat of dormant *S. densa* to survive a more prolonged period of dessication.

On June 17, 1963, about two years and nine months from the date of original collection in 1960, the remaining clump of *S. densa* was photographed in its dry state (fig. 1). It was then placed in a shallow dish of tap water. After two hours a change was noticeable. In some of the shoots the leaves no longer clasped the stem, but had spread and turned green, exhibiting the revived condition. The next observations were made nineteen hours after the application of water, and it could be seen that the whole mat (except the ash-gray non-living material) had the appearance of active growth. The small clump was planted in fine sand in a clay pot, placed near an eastward facing window, and watered daily. Fig. 2 shows the mat almost three months after it had first been watered. Growth is clearly evident by this time, the best evidence being the production of cones, which were absent from the original mat. At the present time several of the cones are in various states of development; some have completely shed or are currently shedding their spores, while others exhibit sporangia at different states of maturation. At certain times during this project the clump has become dry, and a return to the dormant condition has resulted. However, with the addition of water, the mat of *S. densa* has always revived quickly with no apparent damage to the plant—further verification of the drought resistance of this species.

DISCUSSION.—Tryon (1955) pointed out that, in general, the allies of *S. rupestris* are restricted in their distribution to open habitats, which are frequently xeric. He further stated that they are able to persist in such areas because of their ability to survive desiccation. In his opinion, this ability lies in the physical and chemical properties of the contents of the cells. Such an explanation is supported by field observations on *S. densa.* In one particular site near Saskatoon, Saskatchewan, abundant sporelings at all stages of development were encountered. Over fifty locations of sporelings (or in some cases small groups of sporelings growing together) were marked with stakes, and periodic checks have been made over a period of one year and three months. It is clear from the observations made so far, that these sporelings, no matter how small (fig. 3), can survive the long periods of droght. Their fragile construction suggests that the ability to resist drought lies in some physiological mechanism of the cells themselves.

Such a mechanism has not as yet been explained for xerophytic Selaginellas, but certain information suggesting possible mechanisms should be mentioned. Leclerc du Sablon (1889) early suggested that there is a reserve substance in the cells of

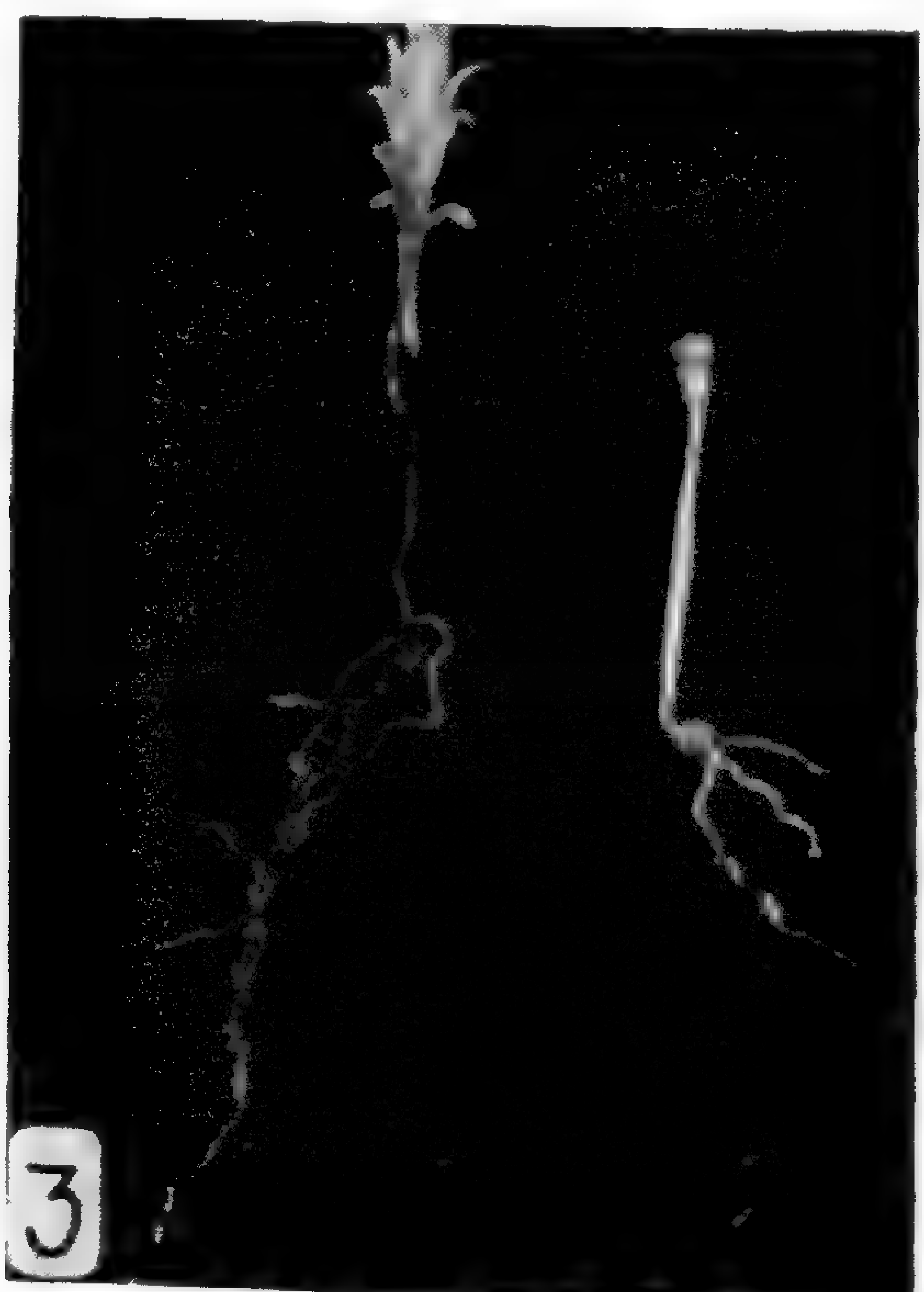


FIGURE 3. SPORELINGS OF S. DENSA. × 4.5.

S. lepidophylla which he thought might be responsible for the resistance of this plant to desiccation. He compared the appearance of the dense opaque protoplasm of the cells to what one sees in cells of cotyledons or in the endosperm cells of certain seeds.

In a paper dealing mainly with anatomical features of xerophytic species of *Selaginella*, Uphof (1920) concluded that the main question arising from his study is that of the protection and behavior of the protoplast of the cells under conditions of extreme drought. In cutting sections for microscopic examination, Uphof noticed many large oval-shaped droplets, which were found to be oil, coming from the open cells. During plasmolysis of the cell, the oil droplets fuse to produce larger ones. Uphof suggested that when the cells lose water, a film of oil is formed around the vital parts of the cell, preparing the cells for dormancy during periods of drought. He noted that neither mesophytic species (e.g. *S. galeottii*) nor xerophytic Selaginellas grown under conditions of abundant moisture produce oil. Evans (1958, 1959) found that in certain filamentous algae which are able to survive drought, the vegetative cells become modified with accumulations of oil. Other changes that he noted for these cells are thickened walls and mucilaginous sheaths.

In a recent work by Iljin (1957), possible mechanisms by which cells in general resist desiccation were noted. Iljin reported that, according to numerous workers, species of plants living in dry habitats have smaller cells than plants of moist habitats. Mosses, lichens, algae and other lower plants adapted to dry locations were cited as having cells of small volume. Uphof (1920) noted this feature for the xylem elements and cortical cells of xerophytic species of *Selaginella*. Iljin suggested that smaller cells suffer less damage under conditions of desiccation. When a cell loses water from the vacuole, the opposite walls are caused to approach one another so that the desiccated cells may become separated. In larger cells, there would be a greater readjustment of the walls to each other and more possibility of damage than in smaller cells.

The authors wish to express their appreciation to Dr. M. V. S. Raju and Mr. Norman Ferrier for aid in photography. They also wish to express their indebtedness to Mr. Ted Cooper for assistance in laboratory and field work and to Dr. William C. Steere for his helpful suggestions. This investigation was supported by a grant from the National Research Council of Canada.

LITERATURE CITED

CAMPBELL, D. H. 1930. The Structure and Development of Mosses and Ferns. MacMillan Co. New York.

COUPLAND, R. T. 1950. Ecology of Mixed Prairie in Canada. Ecol. Monog. **20**: 271–315.

DAUBENMIRE, R. F. 1959. Plants and Environment. (2nd Edition). John Wiley and Sons, Inc. New York.

EVANS, J. H. 1958. The Survival of Freshwater Algae during Dry Periods. I. An investigation of the Algae of Five Small Ponds. Jour. Ecol. **46**: 149–167.

————. 1959. The Survival of Freshwater Algae during Dry Periods. II. Drying Experiments. Ibid. **47**: 55–71.

HORNER, H. T., JR. and H. J. ARNOTT. 1963. Sporangial Arrangement in North American Species of *Selaginella*. Bot. Gaz. **124**: 371–383.

ILJIN, W. S. 1957. Drought Resistance in Plants and Physiological Processes. Ann. Rev. Plant Physiol. **8**: 257–274.

LECLERC DU SABON. 1889. Sur la Reviviscence du *Selaginella lepidophylla*. Bull. Soc. Bot. de France **35**: 109–112.

MAXIMOV, N. A. 1935. The Plant in Relation to Water. (2nd Edition). English Translation. Allen and Unwin Ltd. London.

RICHARDS, P. W. 1932. Ecology. In Verdoorn, Fr. (Editor). Manual of Bryology. Martinus Nijhoff. The Hague. pp. 367–395.

SCHUSTER, R. M. 1955. Boreal Hepaticae, a Manual of the Liverworts of Minnesota and Adjacent Regions. II. Ecology. Amer. Midl. Nat. **57**: 203–299.

TRYON, R. M. 1955. *Selaginella rupestris* and Its Allies. Ann. Mo. Bot. Gard. **42**: 1–99.

UPHOF, J. G. TH. 1920. Physiological Anatomy of Xerophytic Selaginellas. New Phytol. **19**: 101–131.

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Southwest Vacation

THOMAS DARLING, JR.

In November 1961, after six consecutive years of fern exploration in Florida, I decided to visit the Southwest, concentrating on Arizona, with a brief visit to New Mexico.

Preliminary investigation of the possibilities of finding interesting ferns at this season of the year proved discouraging. A letter from Dr. Walter S. Phillips, Head of the Department of Botany, University of Arizona, had this to say:

"I have your letter regarding fern hunting in Arizona. This is a problem that is very difficult to answer. I am sure that if I went out with you for two weeks we might be able to locate some of the plants in which you are interested, but it would be a long and rather arduous trip which entails considerable walking through rough country and some cliff climbing.

"Ferns in Arizona are not nearly as easy to find as they are in your eastern area. There are several difficult things about this time of year for a trip like you are planning.

"If I were to advise you on coming out here to see ferns, I certainly would not recommend this time of year. After a wet summer, the last of August or the first of September is a good time, or better still after a wet spring. Even our desert ferns are hard to find most of the time, as they curl up and dry.

"One of the best guides that I know of is Leslie N. Goodding who lives in St. David, Arizona. He is a retired botanist and an excellent fern man. He loves to go on trips and I think would be glad to guide you. When he was in my office the other day, however, he said, 'This is not the time of year to see ferns!'"

On November 4th I flew to Phoenix, Arizona, and the next day telephoned Mr. Goodding that I would go to southern Arizona fern hunting if he considered it worth while. He said that if I wished to make a trip to Sycamore Canyon near the Mexican border, he would act as guide. Furthermore, he believed that the ferns would be in good condition following recent rains.

I boarded a south-bound bus, spent Sunday night in Tucson, and early Monday met Mr. Goodding at the University of Arizona. We used his car, and reached our destination before noon.

Sycamore Canyon lies only a few miles north of the border, its southern reaches extending into Mexico. The Arizona section of the canyon is within the Coronado National Forest. I was impressed by the wild beauty of Sycamore Canyon with its colorful pinnacles of eroded rock. Mr. Goodding, a man in his early eighties, led me a merry chase up the steep gorges of side canyons and scrambled along rock walls wherever it was possible to obtain a foothold.

An ardent naturalist and conservationist, my companion had written two articles about this area (1946, 1961). During my visit he pointed out many rare plants, shrubs and trees, some of which grew almost exclusively in this canyon, such as the Alamo Lotus and the Goodding Ash.

As for the main object of my search, ferns of the Southwest, in a few brief hours we came upon more than a dozen species. With the single exception of the beautiful Venus'-hair Fern, *Adiantum capillus-veneris,* all were new to me. The Adiantum was seen to best advantage in a cave-like overhang along the trail, carpeting the entire roof and sides with its delicate growth.

Probably the most conspicuous and striking of all was the relatively rare *Phanerophlebia auriculata,* sometimes called the Trailing Fern, locally plentiful on cool damp cliffs. The genus *Cheilanthes* (Lip Fern) was represented by *C. wootonii, C. lendigera, C. lindheimeri,* and *C. eatonii* forma *castanea. Pellaea longimucronata,* the sharp-pointed cliff brake so common in the Southwest, was abundant. Less common was *Bommeria hispida,* with its generally triangular outline and pubescent lower surface. Only young sterile fronds were in evidence.

I was especially interested in trying to locate two rare and interesting species of *Asplenium, A. exiguum* and *A. palmeri,* both known from Sycamore Canyon. The former is one of the rarest ferns in the United States, found in but one other locality in Arizona and in no other state. It was described from specimens collected in the Himalaya Mountains, and also has been found in China and Mexico. Its curious geographical distribution remains unexplained. Although Mr. Goodding had originally discovered

A. exiguum in this locality, he was unable to relocate it during our visit. Exploring a side canyon, however, I was delighted to find *A. palmeri* in the rock crevices high up the cliffs. At first I thought this little plant was only the common *A. resiliens,* but closer inspection revealed the recurved fronds and proliferous tips that distinguish *A. palmeri*.

At the time of my visit Mr. Goodding was greatly concerned about the future of Sycamore Canyon. Overgrazing has resulted in heavy runoff during rainy periods, accompanied by soil erosion and damage to some of the rarest plants. Due to the efforts of Mr. Goodding and others, the Forest Service has recently declared Sycamore Canyon a scenic area. The objective of this classification is to maintain the canyon as nearly as possible in an undisturbed condition, but allowing use of the area. Approach roads, trails, picnic grounds and parking areas will be located so as not to disturb the natural environment, but at the same time provide for some public use. It is hoped that in the future Sycamore Canyon will be treated in many respects like one of our National Parks. Collection of plants, animals and minerals will be strictly prohibited.

Back in Tucson later that week I arranged to go on a fern expedition in the Santa Catalina Mountains with Dr. Walter S. Phillips. In a single day, comprising two separate trips, he showed me a surprising number of ferns typical of the Southwest. Snow already covered the upper slopes of Mt. Lemmon, closing the trail to the area where *Asplenium septentrionale* had been found, making search for this curiosity out of the question.

In the morning we concentrated our attention on a small canyon just north of Tucson in the foothills of the Santa Catalinas. Here the rather common gray-green *Cheilanthes lindheimeri* was found in the same neighborhood with the rarer and delicately graceful *C. wrightii*. It was especially interesting to see *Notholaena standleyi* and *Pityrogramma triangularis* growing side by side in this locality. Although to a layman these ferns may superficially resemble one another (the fronds of each showing a white or yellow powdery effect on the under surface), the Gold Fern is more triangular in appearance and the *Notholaena* pentagonal or star-shaped. Here also two fern allies were seen growing together, carpeting the nearby rocks, *Selaginella rupincola* and *S. arizonica*. The entire area was filled with various species of cacti, and as I backed away from an interesting specimen to take a photograph, thereby making posterior contact with another prickly plant, Dr. Phillips gave me one of the primary rules of the desert: "Never back up without looking around first!"

After lunch we set forth on the second phase of our fern hunting expedition, a visit to the Molino Basin Area in the Santa Catalina Mountains. En route we skirted the Saguaro National Monument, famous for its forest of giant cactus *Carnegiea gigantea,* limited in distribution to southern Arizona, in northern Mexico, and a few plants in California.

At Molino Basin, in addition to ferns which I had seen previously elsewhere, *Notholaena* was well represented. It was an experience to find *N. aurea* (dull green above, with golden undersurface), *N. grayi,* and *N. sinuata,* frequently intertwined with a species of sharp-spined yucca. *Cheilanthes covillei* and mature fronds of *Bommeria hispida* were locally plentiful.

In Phoenix I rented a Comet "compact" which I drove some 1600 miles on an eleven-day trip via the Painted Desert, Petrified Forest, Grand Canyon, Bryce and Zion National Parks in southern Utah, to Las Vegas, Nevada. On this part of the trip my main objective was sightseeing, but some unusual botanical adventures still remained.

Having missed the opportunity to see *Asplenium septentrionale* near Tucson, I decided to search for this oddity along the Mogollon Rim southeast of White Oak Canyon where the rock spleenwort was reported to be locally plentiful. Early on November 10th, with not a cloud in the sky and relatively warm weather for that time of year, I left Cottonwood, Arizona, for the Rim Road. Beyond Camp Verde the going became difficult. With a steep winding mountain road looming ahead, it was mid-afternoon before I reached my destination. At Long Valley I noticed the first evidence of snow, but at the approach to the Mogollon Rim Road I realized that the trip was probably a wild goose chase. Motorists were returning from the area with chains and pessimistic reports. "The road is impassable," they told me. "The snow is several feet deep!" Determined to botanize at least the nearest likely area, I drove eastward a short distance, skidding frequently en route, to Baker Butte at an elevation of over 8,000 feet. Leaving my car just off the highway, I climbed up a snow-covered road to the fire tower from which I obtained a fabulous view over the Tonto Basin and the surrounding lowlands. On the rocks nearby was the cliff brake, *Pellaea ternifolia*, var. *wrightiana.* Search for *Asplenium septentrionale* proving unsuccessful, I returned to the car and slithered back to Long Valley.

After a visit to the ghost town of Jerome, where copper fortunes were once made and lost, then on to Sedona with its colorful buttes and movie-like atmosphere, I drove northward up Oak Creek Canyon to Flagstaff. Immediately on arrival, Veterans Day, I called Chester Deaver of the Botany Department at Arizona State College, hoping to enlist his aid in discovering the extremely rare *Asplenium adiantum-nigrum,* a European species found in the United States only from northeastern Arizona, northeastern Colorado and southern Utah. It has been found in very limited occurrence on the south face of Elden Mountain, four miles northeast of Flagstaff. Mr. Deaver told me that he had never seen this rare fern on Mt. Elden, but would be glad to join me in a search for it the following afternoon.

Sunday morning dawned clear and cold. Planning an advance expedition on my own, I arose early and journeyed to the base of Mt. Elden, feeling confident of finding *A. adiantum-nigrum* after reading Dr. Wherry's account of its occurrence in this locality (1941).

Having arrived at the general area, I realized that it covered a far greater area than I had bargained for. It was like looking for a needle in a haystack. Selecting the easternmost approach, I picked my way precariously up the mountainside. Halfway up the steep cliff, with the sun at my back, I detected a cave-like formation with dark shadowy floor. Since ferns frequently grow in such a locality, I ventured close to the cave's entrance, reaching up to touch the roof with the tips of my fingers. Suddenly a sixth sense made me freeze in my tracks. Immediately ahead I detected a sheer drop-off! Lying flat and peering over the edge of the abyss, I looked into an apparently bottomless chasm. My enthusiasm for an independent search ended abruptly!

That afternoon, with Mr. Deaver as guide, I again ventured up Mt. Elden. This time we chose the western side of the south face, threading our way laboriously up the steep rocky wall. *Cheilanthes feei* was in evidence on exposed ledges along the route. Near the summit we reached a moist shady cul-de-sac where high vertical cliffs prevented further progress. Here the presence of the Male Fern (*Dryopteris filix-mas*) and the Maidenhair Spleenwort (*Asplenium trichomanes*) indicated (according to Dr. Wherry's notes) that *Asplenium adiantum-nigrum* might be in the near vicinity. Since none was to be seen, however, and since we had reached an impasse, we reluctantly had to give up the search. Our visit to Elden Mountain was none too soon, as the region was blanketed with heavy snow the following day.

Journeying eastward, I visited the Petrified Forest and Painted Desert in a young blizzard, making the loop circuit and spending two nights at Winslow, Arizona, en route. Tuesday evening I reached the Grand Canyon and planned to make the descent to the bottom the following day.

Bright and early the next morning I was driven to Yaki Point, the beginning of the extremely steep but spectacular South Kaibab Trail. I was anxious to make this trip on foot, rather than by mule train, so that I would be free to botanize and take pictures independently en route. Some six hours, eight miles and about one hundred color photos later, after crossing the suspension bridge, I reached Phantom Ranch on the north side of the Colorado River. Although the desert plants had been most intriguing, there had been little of pteridological interest along the trail.

After spending the night at the ranch, I left early the next morning on the steep eleven-mile climb back to the South Rim via the Bright Angel Trail. Near the intersection of the latter with the South Kaibab Trail I spotted a small patch of *Cheilanthes parryi* on a rocky ledge, one of the few ferns seen during my expedition into the Grand Canyon. Shortly before dark I reached the South Rim just after a severe snowstorm set in which lasted all night and into the next morning.

Several days later, after visiting Glen Canyon and Bryce Canyon National Park, I spent a few hours at Zion National Park in southern Utah. Although I realized that this was one of the places where *Asplenium adiantum-nigrum* had been found many years ago, I realized that my chances of locating it during a quick visit were practically nil. Dr. Wherry wrote (1941): "Then it [*A. Adiantum-nigrum*] was found in Zion Canyon, Utah; but on visiting that National Park in 1940 I was unable to find anyone who knew on which of the myriad cliffs it occurs."

I made the usual photographic tour of Zion Park, then followed the self-guiding nature trail to Canyon Overlook. At one point I left the main trial to explore an interesting side canyon. Looking up at the high cliffs above, I detected an evergreen fern that looked from a distance suspiciously like *Asplenium adiantum-nigrum*, but it was too far out of reach and an attempt to venture closer from above ended in frustration. Unable to erase the possibility from my mind, however, I stopped at headquarters before leaving and gave details of the location to the young naturalist on duty. Although just an off-chance that this fern might actually prove to be the extremely rare *A. adiantum-nigrum*, I suggested that a more thorough search might well be justified, and that in any event I would appreciate receiving a specimen for identification.

Early in February 1962, after I had nearly forgotten the incident, I received a letter from Carl Jepson, Chief Park Naturalist. He explained that bad weather and numerous duties had prevented earlier search, but went on to say that he believed they had located the side canyon I mentioned. He continued, "Enclosed are some pieces of a frond knocked from a fern growing about twenty feet above the floor of the canyon at its head. According to the keys in Kearney and Peebles' Arizona Flora, this fern appears to be the one in question, i.e., *Asplenium adiantum-nigrum.* A brief search was made for more of this fern, but none was found. We hope that later investigations will establish its habitats and occurrence more accurately. We certainly do appreciate your bringing this fern to our attention, for it was one that we had not seen before. We would like very much for you to confirm the identification."

I lost no time showing the fragments, fully mature specimens, to C. V. Morton at the National Herbarium, Smithsonian Institution, who immediately agreed that the plant was indeed *Asplenium adiantum-nigrum.* He further said that judging by the size of the fragments the original plant must be unusually large for the United States, although it frequently attains luxuriant stature in Europe.

From Zion National Park I drove to Las Vegas, Nevada, where I turned in my car, then flew to Albuquerque, New Mexico, where I again rented an automobile. There was still one fern which I was anxious to see, but which so far had eluded me—*Asplenium septentrionale,* the curious little Forked Spleenwort which I had missed at Mt. Lemmon and Baker Butte in Arizona.

A study of herbarium specimens at the University of New Mexico at Albuquerque indicated that *A. septentrionale* had been found in the vicinity of Las Vegas, New Mexico. Informed that Dr. R. G. Lindeborg of New Mexico Highlands University in Las Vegas knew the location of this rarity, I called him long distance and arranged a field trip. The next morning I drove north to Santa Fe and reached Las Vegas about noon.

Dr. Lindeborg and I set forth in the mid-afternoon, heading for a box canyon nine miles southwest of Las Vegas. The trip involved rather a long hike from the point where we left the car to our ultimate destination, an extensive area of flat rock outcrops containing occasional fissures. In one particular crevice, my guide informed me, grew a small patch of *Asplenium septentrionale,* but it could easily be overlooked since the other crevices were barren. We spent several hours searching to no avail, and as darkness approached Dr. Lindeborg had some doubts whether our quest would be successful. Soon afterwards, however, he called out that he had discovered the elusive ledge, and there in a crevice below the flat rock surface was a small but luxuriant growth of *A. septentrionale.* Not far distant *Cheilanthes eatonii* was fairly abundant. On the return trip to the car we encountered a driving sleet storm which stingingly pelted our faces. That evening I drove back to Albuquerque over treacherous roads.

After spending Thanksgiving with relatives on a ranch in Quemado, New Mexico, I returned to Albuquerque, turned in my rented car and flew back to Washington after a most enjoyable vacation in the Southwest, which included some memorable fern discoveries.

LITERATURE CITED

GOODDING, LESLIE N. 1946. A hidden botanical garden. Jour. N. Y. Bot. Gard. **47:** 86-96.

————. 1961. Why Sycamore Canyon in Santa Cruz County should be preserved as a nature sanctuary or natural area. Jour. Ariz. Acad. Sci. **6:** 113-115.

WHERRY, EDGAR T. 1941. Asplenium adiantum-nigrum in Arizona. Amer. Fern Jour. **31:** 97-100.

3809 LARNO DRIVE, ALEXANDRIA, VA.

Shorter Notes

FERNS IN THE FLORISTS' TRADE IN 1964.—Some months of getting my exercise by hiking among the canyons of Manhattan had indicated that ferns were much scarcer than formerly as florists' merchandise. Most commonly seen were the ersatz types made from plastic which ranged from small fronds having some characteristics of polypody and Christmas fern cutting to a larger, more divided pattern. Two lines of enquiry recently took me to the wholesale florists area: What kinds of living fern plants were available? What was the status of the cut fern leaf trade?

Of living plants, I found only five forms of *Nephrolepis*. None of these was accurately named. Two were of special interest. One consisted of thrifty stiff-leaved plants of the wild sword fern, *N. exaltata*. The dealer spoke disparagingly of these as "Florida plants, imported for the chain store trade." The other was the cultivar, "Scottii," forty years ago one of the most widely grown of the Boston Fern series but missing from the collection recently sent to the University of Michigan. In retail shops I have seen at least one other cultivar in the Boston Fern series and have learned that retailers may receive plants directly from growers and wholesalers in the metropolitan area.

My enquiries led me to the Kervan Company on West 28th Street. There I had the good fortune to find as general manager, Mr. Harry Hyatt, whom I had last seen as a biology student of mine in Stuyvesant High School over 42 years previously. He had begun work in the Kervan store as errand boy after graduation from high school.

Four kinds of fern are represented in the cutleaf trade today. The most abundant is the "fancy fern" *Dryopteris intermedia* which is collected in Vermont. While question has been raised from time to time whether the extensive trade in this fern might be endangering its existence, the fear has never seemed justified and the present status of collection and demand remove even the slightest risk. In recent years, Mr. Hyatt assured me that the use of this fern had declined to no more than one tenth of the former volume. Demand has also decreased for leaves of the Pacific coast "sword fern," *Polystichum munitum,* which, like the fancy fern is a cold storage item.

The other two kinds are picked and used fresh. The most expensive is the splendid "California Woodwardia" or "Giant Chain Fern," *Woodwardia fimbriata,* with leaves over four feet long and one and one-half feet wide. It can be ordered on a given day and received in New York the next by air freight. The fourth is the leather fern, *Polystichum* (*Rumohra*) *adiantiforme,* native in the West Indies and in southern Pacific areas. Several Florida dealers raise it, and the wiry, shiny, three-pinnate leaves, offer no serious problem in storage.—RALPH S. BENEDICT, *Pilot Knob, New York.*

Notes and News

BOSTON FERN COLLECTION FINDS A NEW HOME.—In March 1964, the collection of Boston Fern varieties and related types which had been assembled at the Brooklyn Botanic Garden, beginning in January 1914, was shipped air freight to the Botanical Garden at the University of Michigan, Ann Arbor. It will be available for research studies under the direction of W. H. Wagner, Jr., Professor of Botany and Curator of the Fern Herbarium.

The collection was started at the Brooklyn Botanic Garden in connection with preparation of a revision of the section on ferns for edition two of L. H. Bailey's *Cyclopaedia of Horticulture.* Beginning about 1895, commercial growers had introduced dozens of new varieties obtained as bud mutations from the Boston Fern. There was no adequate literature covering their characteristics or their derivation. In 1914 a period began when visits were made to practically every U. S. grower who had introduced a new variety, and many variants of the Boston Fern were obtained and housed at the Brooklyn Botanical Garden. From a few square feet of bench space, the collection expanded to several sections in the greenhouse, with outside lath-shaded space used during some summers. Eventually the collection included cultivars and wild species of *Nephrolepis* from botanical gardens and commercial growers in Europe as well as in the U. S., together with a number that originated at the Brooklyn Botanic Garden.

The collection shipped to the University of Michigan consists of forty types which comprise all but a few of the most significant forms obtained during the years of study. The missing variants will be sought and sent along later, if found.

Acknowledgements have been made in various publications for the aid which made possible the assembling and study of the *Nephrolepis* collection through the years since 1914. These included particularly Dr. C. Stuart Gager, Director of the Brooklyn Botanic Garden during his incumbency. Grateful acknowledgement is made now to the present Director, Dr. George S. Avery, and to his staff for continued maintenance of the collection and for the final work in preparing and shipping it to the University of Michigan.—RALPH C. BENEDICT, *Pilot Knob, New York.*

DR. W. C. DRUMMOND, a member of the American Fern Society since 1956, died recently. An alumnus of St. Louis University, Dr. Drummond practiced dentistry in East St. Louis, Illinois. After his retirement 31 years ago he moved to Los Angeles, California, where he became interested in horticulture, and especially in ferns. He was one of the founding members of the Los Angeles Fern Society and its President for a number of years. Under his leadership the Society prospered and is now the largest local fern group in the United States.

Dr. Drummond assisted in setting up the Fern Dell in Griffith Park, Los Angeles, particularly in preparing the fern exhibit in the Fern Dell Nature Museum. This educational display shows 140 fern specimens that were collected, pressed, and identified by Dr. Drummond and mounted in 5 by 10 foot permanent cases. For this work he was honored in 1958 by Los Angeles civic leaders. Dr Drummond's fern library consisting of over 250 books, many of them rare, has been presented by his widow, Mary Hazel Drummond, to the University of California (Los Angeles) Biomedical Library, where it will be available for consultation by interested persons.

PROFESSOR EDGAR T. WHERRY was honored on September 10, 1964, his 79th birthday, at a reception in The Academy of Natural Sciences, Philadelphia, when Cranbrook Institute of Science, Bloomfield Hills, Michigan, bestowed upon him the Mary Soper Pope Award. This award was established to recognize persons who have made distinguished contributions in the field of plant science. His was the 10th award.

The ceremonies were attended by about 150 persons gathered chiefly from the Philadelphia area, but with representatives from Massachusetts, North Carolina, and Michigan.

Professor Warren H. Wagner, Jr., was chairman of the Mary Soper Pope Award Committee. Other members were Dr. William Campbell Steere and Dr. Warren P. Stoutamire.

American Fern Society

FERN FORAY

The fern foray began at 9 A.M. Friday, August 21, when 24 members assembled in front of Kittredge Hall, the dormitory at the University of Colorado, Boulder, where most were rooming. After driving barely out of Boulder to the beginning of the Mesa Trail, we walked up the trail to the Flatirons where we did a considerable amount of rock-hopping. We came to see *Asplenium septentrionale* which grew sparsely in the rock crevices. We also saw a beautiful colony of the Male Fern as well as other species. This area belongs to the City of Boulder which is attempting to preserve it in its natural state.

Returning to the cars, we drove back to the campus where we broke for lunch. In the afternoon we drove eight miles northeast of Boulder to White Rocks, an impressive formation of cliffs where the horizontal surfaces are marked off in an unexplained turtleback design of geometric shapes resembling the plates on a turtle shell. This area belongs to Mr. and Mrs. Bruce Weiser who are preserving it and who were kind enough to allow our visit. Here we saw *Asplenium adiantum-nigrum, Cheilanthes feei,* and *Equisetum hyemale,* and a number of interesting flowering plants. We were also interested in seeing the ubiquitous pigeon or Rock Dove nesting on the cliff ledges as it formerly did in its native Europe. Too bad most of them have abandoned their natural way of life.

Returning to Boulder we drove a few miles up Boulder Canyon, stopping along the way to see two Selaginellas, *S. underwoodii* and *S. weatherbyana.* We turned off on a dirt switch-back road which climbed the wall of the canyon and onto Falstaff Mountain where we saw *Cheilanthes fendleri* and other ferns. This first day's foray was interestingly and ably guided by Dr. William Weber.

On Saturday we assembled at 7:30 and drove to Bear Lake in Rocky Mountain National Park where we were met by Mrs. Ruth Ashton Nelson and Mr. Gilbert Culter who led us on the wonderful climb past Bear Lake, Nymph Lake, and Dream Lake to over 10,000 feet elevation. Mrs. Nelson was familiar with the plants of the area, having written books on them, and Mr. Culter, the Park naturalist, furnished us with much general information on the park. During the walk, fifteen species of ferns and fern allies were seen, only five of which duplicated those seen the first day. Notable among these were *Isoetes bolanderi,* a new record, growing in Nymph Lake, *Lycopodium annotinum, Botrychium lunaria, Dryopteris disjuncta,* another new record, and *Athyrium alpestre* which was observed at Dream Lake and higher.

After a late lunch in a park picnic area, the group broke up with some driving up Trail Ridge Road mainly for the view, though they did see *Cystopteris fragilis* growing in crevices at 12,150 feet.

Thirty persons participated in all or part of the foray, and this was felt to be a good number in view of the location and the fact that several regulars were attending the Botanical Congress in Scotland. Many were surprised that, in such an arid region, as many as twenty-four species, subspecies and varieties of ferns and fern allies were seen during the two days.

Members participating in the foray were Mr. Robert Aborn (Penna.), Dr. and Mrs. William H. Baker (Idaho), Dr. and Mrs. Ralph H. Benedict (Illinois), Dr. and Mrs. Donovan S. Correll, Charles and Selena Correll (Texas), Mr. and Mrs. Lawrence Dillon (Texas), Mr. Frederick Dunlap (Missouri), Mr. David L. Emory (Penna.), Dr. E. S. Ford (Florida), Dr. and Mrs. L. K. Henry (Penna.), Dr. Walter H. Hodge (Maryland), Dr. Donald G. Huttleston (Penna.), Mr. and Mrs. James Leach (New York), Mr. and Mrs. Blake Saunders (Colorado), Dr. and Mrs. Ira L. Wiggins (California), Mr. and Mrs. Walter W. Willis (Ohio), Mr. Robert Willis (Connecticut), Dr. William A. Weber, Mrs. Ruth Nelson and Mr. Gilbert Culter, our leaders, from Colorado.

Ferns and fern allies seen on the trip were: –*Asplenium adiantum-nigrum*, *Asplenium septentrionale* (Forked Spleenwort), *Athyrium alpestre* var. *americanum* (Alpine Ladyfern), *Athyrium filix-femina* (Ladyfern), *Botrychium lanceolatum* (Lance-leaf Grapefern), *Botrychium lunaria* var. *lunaria* (Moonwort), *Botrychium lunaria* var. *minganense*, *Botrychium matricariifolium* subsp. *hesperium* (Matricary Grapefern), *Cheilanthes feei* (Slender Lipfern), *Cheilanthes fendleri* (Fendler Lipfern), *Cryptogramma acrostichoides* (Parsley Fern), *Cystopteris fragilis* (Fragile Bladderfern), *Dryopteris dilatata* (Mountain Woodfern), *Dryopteris disjuncta* (Oak-fern), *Dryopteris filix-mas* (Male fern), *Pteridium aquilinum* var. *pubescens* (Bracken Fern), *Woodsia mexicana* (Mexican Woodsia), *Woodsia scopulina* (Rocky Mountain Woodsia), *Equisetum hyemale* (Scouring-Rush), *Isoetes bolanderi* (Bolander Quillwort), *Lycopodium annotinum* (Stiff Club-moss), *Selaginella densa* (Compact Spikemoss), *Selaginella underwoodii* (Underwood Spikemoss), *Selaginella weatherbyana* (Weatherby Spikemoss).

D. G. HUTTLESTON, *Longwood Gardens, Kennett Square, Penn.*

REGISTRATION FOR A. I. B. S. MEETINGS.—Some members of the American Fern Society, who were not individual members of the A. I. B. S., were displeased when A. I. B. S. personnel at Boulder refused to accept their applications for housing unless they also paid the registration fee ($15.00 if application was made prior to August 1, $17.50 if made later) to attend the entire series of meetings. The Council of the Fern Society considered the matter at its regular Annual Meeting, August 23.

The Council agreed that the registration fee seems excessive for one who plans to attend only the Fern Foray and/or the sessions of the Fern Society. Therefore, the policy of the Council with regard to attendance and payment of registration fees will be that it recommends compliance with the A. I. B. S. scheme when practical. But it believes non-members of A. I. B. S. may arrange for their own housing in a motel, hotel, or private home in the vicinity of the annual meetings, and may attend the Foray and/or the formal sessions of the Fern Society without registering for the whole series of meetings.

Owing to an editorial error the Honorary Members of the American Fern Society were not listed in Vol. 54, No. 3 of the Journal. They are given here, with the Editor's apologies!

Honorary Members

Benedict, Dr. R. C., Pilot Knob, N. Y. (First joined)	1905
Looser, Dr. Gualterio, Casilla 5542, Santiago, Chile	1928
Manton, Prof. Irene, Department of Botany, The University, Leeds, England	1927
Stokey, Prof. Alma G., Emeritus, Dickinson House, South Hadley, Mass.	1949
Wherry, Dr. Edgar T., Botany Department, University of Pennsylvania, Philadelphia 4, Pa.	1918

It was impossible to make last minute changes in addresses after the list of members had been set in type. Consequently, known errors occur. The Editor will appreciate having any and all errors detected in this list brought to his attention. A note or post card will be sufficient, and corrections will be made as early as possible.—I. L. W.

Index to Volume 54

ERRATA

Page 40, line 3: For "clifi" read "cliff."
Page 57, line 18: For "Gwyne" read "Gwynne."
Page 63, line 18: For "developmnt" read "development."
Page 68, line 9: See page 154.
Page 68, line 10: for "bipinnata" read "bipinnatus."
Page 68, line 11: For "minuta" read "minutus."
Page 69, line 4: For "unicellar" read "unicellular."
Page 70, line 9: For "is" read "are."
Page 70, line 17: For "1855" read "1854."
Page 78, line 25: For "Chestnut" read "Chesnut."
Page 79, line 12: For "Chestnut" read 'Chesnut."
Page 85, line 3: For "1940" read "1840."
Page 89, line 12: For "Mehrota" read "Mehrotra."
Page 90, line 5 from bottom: for "*Polystichium*" read "*Polystichum.*"
Page 96, line 22: For "*thelpyterioides*" read "*thelypterioides.*"
Page 98, line 19: For "*Dorypteris*" read "*Doryopteris.*"
Page 124, line 25: For "*brunsfelsii*" read "*brunfeslsii.*"
Page 125, line 13: For "Des.V" read "Desv."
Page 146, line 28: For "pteridopgraphia" read "pteridographiae."
(Corrections in the List of Members will appear in Volume 55).

American Fern Journal

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A regular loan department is maintained in connection with the library and herbarium. Members may borrow books and specimens at any time, the borrower paying all postal or express charges. The pages of the Journal also are open to members who wish to arrange exchanges; a membership list is published at intervals, to assist those interested in obtaining specimens from different localities.

American Fern Journal

VOL. 55 | JANUARY-MARCH, 1965 | NO. 1

Preliminary Studies in the Cytotaxonomy of the Dryopteris villarsii (Bell.) Woynar Complex in Europe

G. PANIGRAHI

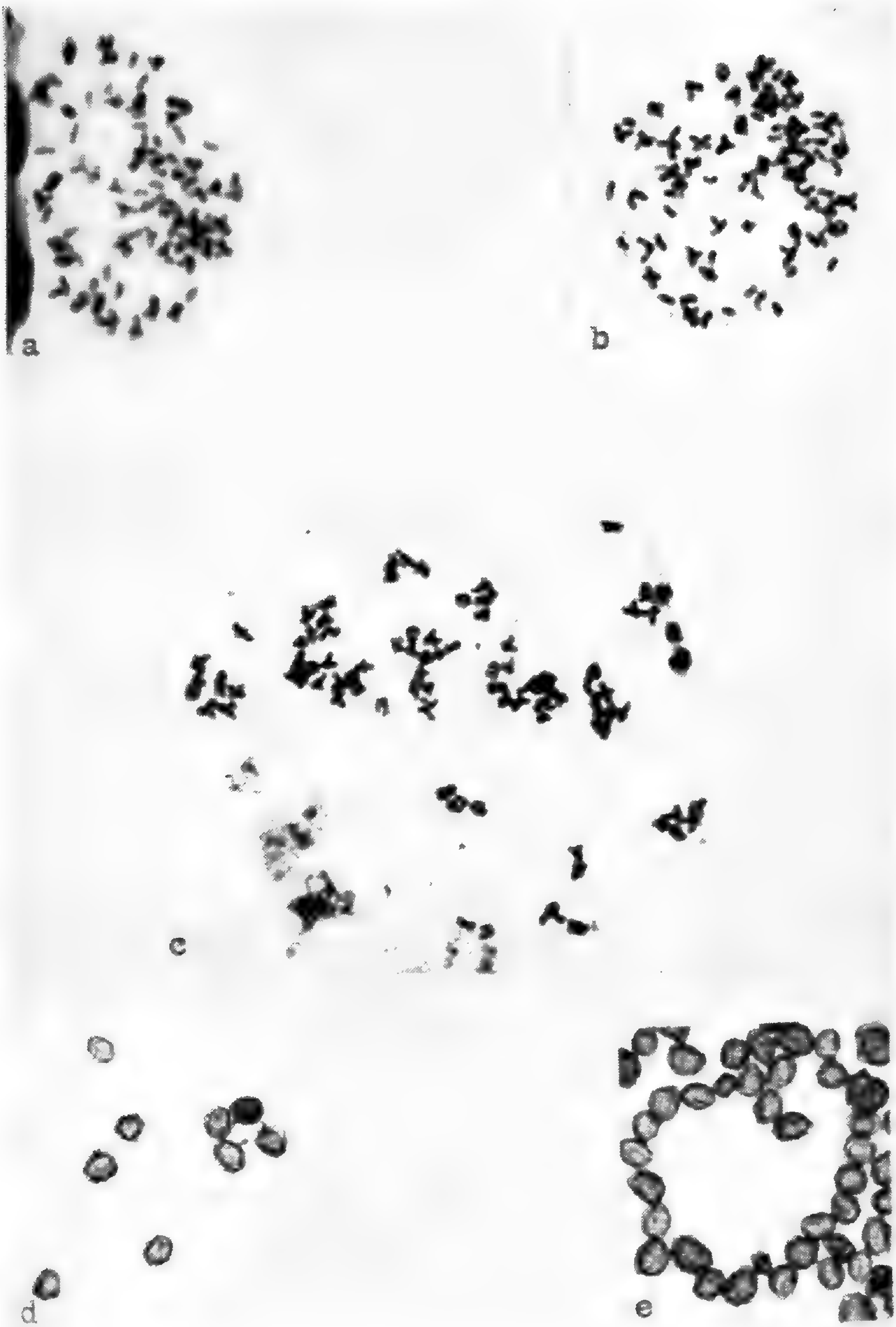
The discovery of diploid forms with $n = 41$ and tetraploid forms with $n = 82$ (Figs. 1c, 4c) in *Dryopteris villarsii* (Bell.) Woynar (Manton, 1950) raised interesting cytological and taxonomic problems. The relationship of the exclusively tetraploid forms with restricted distribution in the British flora with diploid alpine forms in Switzerland and France needed study to throw light on the past history of *D. villarsii* in Britain, as suggested by Manton (1955).

MORPHOLOGY OF CYTOTYPES

A diploid stock plant from France had fronds nearly tripinnate, green, herbaceous; lowest pair of pinnae not reduced, or only slightly so; pinnae fewer and more crowded than in the tetraploid, those of adult fronds ascending; pinnules with larger number of teeth (12–13), with a corresponding number of bifurcate veins ending short of the margin; stipe and rachis scaly (Fig. 3b); spores small, 40.3 μ broad by 48.6 μ long (Fig. 1d).

On the other hand, tetraploid plants from the Pennines in England had fronds bipinnate only, straw-colored, stiff; lowest pinnae reduced (Fig. 3c), occasionally equal to subbasal pair; pinnae more numerous than in the diploid form, almost at right angles to rachis; pinnules much less toothed (3–5), with veins equally prominent, some of them bifurcating and running to the margin; stipe and rachis scaly; spores larger, 53.5 μ long, 44.6 μ broad (Fig. 1e).

It should be noted that the characters ascribed above to the cytotypes are based on only one plant of each, and I am not sure


a
b
c
d
e

that all of them are constant for each cytotype. Nor do I know how much these characters vary with age, habitat, seasonal fluctuations and edaphic conditions. The venation may be a more or less constant character, and with the size of spores, may serve as a character of some taxonomic value. I have no clue as to whether the tetraploid form occurs in the continental flora, although I have positive evidence that the British population of the species is tetraploid, and that the diploid form occurs in both Switzerland and France (Manton, 1950).

EXPERIMENTAL HYBRID

With a view to establishing the genetic relationships between the two cytotypes, the British tetraploid form was crossed with the French diploid (Panigrahi, 1954). As a result of about 25 attempts in each direction, only one F_1 triploid hybrid was produced artificially with the tetraploid as the female parent. The hybrid showed pronounced heterosis (Fig. 2c) and was intermediate morphologically between its parents (Fig. 2a). Although it had bipinnate fronds, the serration of the pinnules and the number of teeth on a pinnule were like those of its female parent. The disposition of the pinnae on the rachis was like that of its male parent. It became sporangiferous in 11 months from the date of crossing, but it was sterile and formed only abortive spores. Study of its meiosis showed 33 bivalents and 57 univalents; no multivalents were seen. (Two meiotic cells are illustrated in Figs. 1a, 1b, 4a, and 4b).

The formation of 33 bivalents indicates homologous pairing between 33 chromosomes of each parental genome, the remaining 57 from both gametes forming univalents in the absence of their homologous partners. Since $n = 41$ in the genus *Dryopteris*, there is therefore some, although apparently not complete, homol-

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FIG. 1. a AND b: PHOTOMICROGRAPHS OF CYTOTYPE OF F_1 TRIPLOID HYBRID SHOWING $33_{II} + 57_{I}$. c: CYTOTYPE OF TETRAPLOID FROM GREAT BRITAIN WITH 82_{II}. d: SPORES FROM DIPLOID PLANT. e: SPORES FROM TETRAPLOID PLANT. (a, b, c, $\times$ 800; d, e $\times$ 80).

ogy between the chromosomes of the diploid and the tetraploid forms. There is no suggestion of autopolyploidy in the British tetraploid.

DISCUSSION

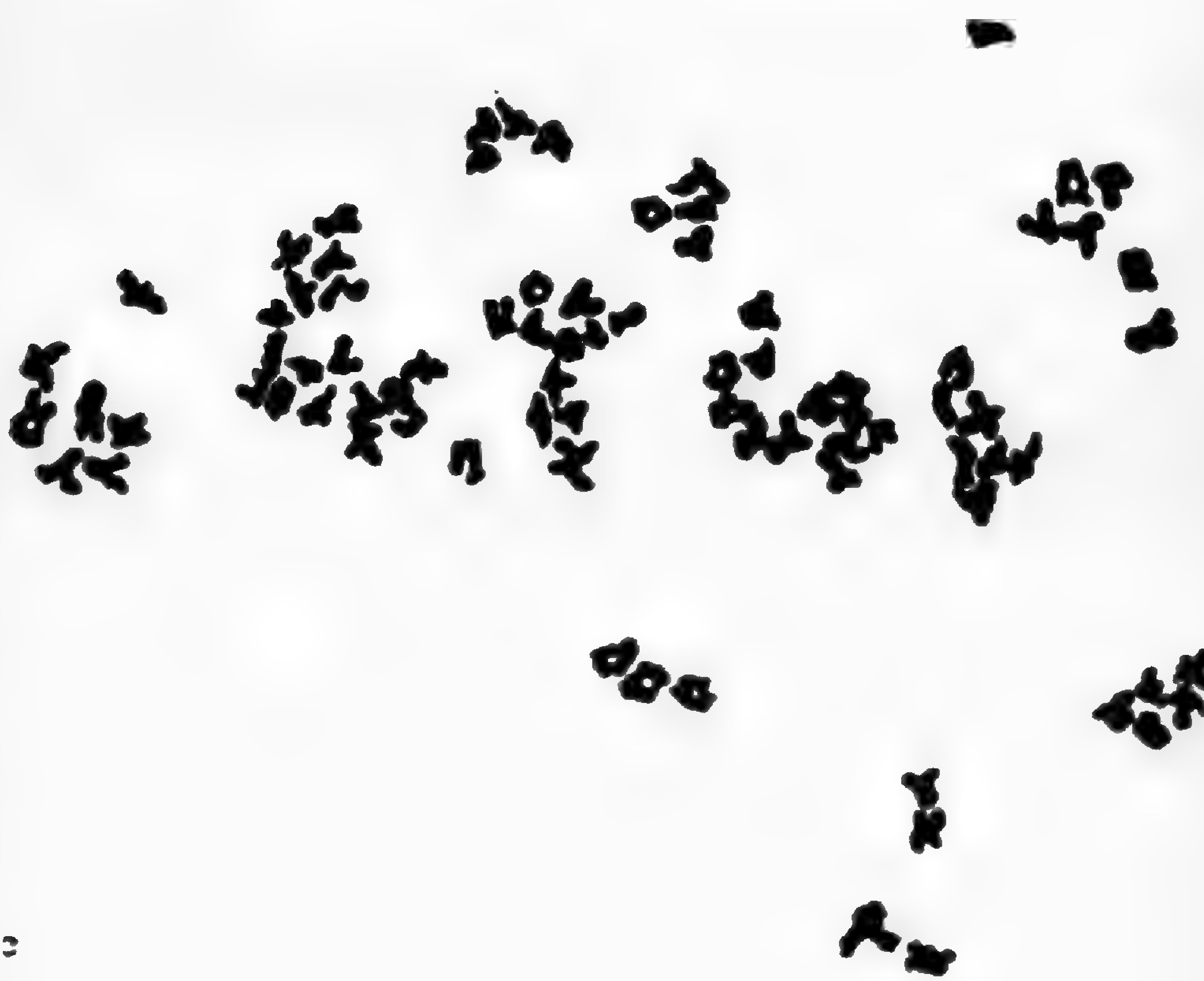
These findings raise important nomenclatorial points which

FIG. 2. FRONDS FROM YEAR-OLD SPORELINGS: a: FROM TETRAPLOID SPORELING. b: FROM DIPLOID SPORELING. c: FROM F_1 TRIPLOID HYBRID. (ABOUT 4/5 NAT. SIZE).

FIG. 3. FERTILE FRONDS FROM ADULT PLANTS. a: FROM F_1 TRIPLOID HYBRID. b: FROM DIPLOID PLANT. c: FROM TETRAPLOID PLANT. (ABOUT 2/5 NAT. SIZE).

a

b



c

may be pursued profitably a little further. Bellardi (1792) founded *Polypodium villarsii* on material collected from the plateau of St. Nicolai on Mt. Cenis along the Italian-French border, 45.2° N., 6.8° E., and described his plants as having "frondibus bipinnatis, alis horizontalibus, foliolis serratis, dentibus aristatis saepe bifidis." It is from this type locality that my diploid stock plant came. Comparison of the description of the diploid cytotype with Bellardi's description given above shows some discrepancies, whereas the description agrees well with the tetraploid cytotype, which may mean that both the diploid and tetraploid forms occur at the type locality and that Bellardi's description was based on a tetraploid rather than on a diploid plant. It might, however, mean that it was drawn from a young diploid plant that had bipinnate fronds, or that Bellardi's description is broad enough and vague enough to include both diploid and tetraploid cytotypes. Which alternative is the more probable I cannot say.

We may further note that Hoffmann (1795) founded *Polypodium rigidum* apparently on continental material, but did not specify the locality from which his plants came. However, his description of the species (viz. "fronde bipinnata; pinnulis ovato-lanceolatis incisis; laciniis conniventi 2–3-dentatis, stipite paleaceo, colore ex flavescente viridi" etc.) fits the morphological characters of the tetraploid from Britain. It is clear, therefore, why all British taxonomists with the exception of Clapham, Tutin, and Warburg (1952) have described British materials as Hoffmann's *P. rigidum* (such as *Lastrea rigida, Aspidium rigidun, Dryopteris rigida*, etc.). But the latter authors call the British species *D. villarsii* (Bell.) Woynar, and cite *rigida* as a synonym.

FIG. 4. DIAGRAMS OF PHOTOMICROGRAPHS OF CYTOTYPES ILLUSTRATED IN FIG. 1. a: AND b: CHROMOSOMES OF F_1 TRIPLOID HYBRID SHOWING 33 PAIRS IN BLACK AND 57 UNIVALENTS IN OUTLINE. c: CHROMOSOMES OF TETRAPLOID PLANT SHOWING 82 BIVALENTS. (× 1600).

In view of the allotetraploid nature of the British form, it will be necessary to treat the two cytotypes as two taxonomically different species if the morphological characters present in my stock plants also characterize the populations in the wild. In such a case the specific epithet *villarsii* (or *villarii*) of Bellardi may be used for the diploid form if there is no tetraploid form in the type locality for *Polypodium villarsii* Bellardi. The specific epithet *rigida* on the other hand may be used for the British form if only the tetraploid form is cytologically established elsewhere on the continent. If the tetraploid is found also in the type locality of *D. villarsii*, this will be the correct name for the British form and another name has to be provided for the diploid species.

This nomenclatorial problem and past history of the British form need more extensive investigation of material from the European continent.

Grateful thanks are due Professor I. Manton, F. R. S., The University, Leeds, for supervision and guidance.

LITERATURE CITED

BELLARDI, L. 1792. Appendix ad Floram Pedemontanam. Augustae Taurinorum, p. 255.

CLAPHAM, A. R., T. G. TUTIN, and E. F. WARBURG. 1952. Flora of the British Isles. Cambridge.

MANTON, I. 1950. Problems of cytology and evolution in the Pteridophyta. Cambridge.

———. 1955. Contributions of the tropical ferns to understanding of the British Flora. "Species studies in the British Flora." London.

PANIGRAHI, G. 1954. Cytogenetic and taxonomic studies on certain species of tropical ferns. Ph.D. Thesis. Leeds University, England.

WOYNAR, H. 1918. Betrachtungen über *Polypodium austriacum* Jacq. Österr. Bot. Zeit. **67**: 268.

BOTANICAL SURVEY OF INDIA, ALLAHABAD, INDIA.

Abortion of Spores and Sporangia as a Tool in the Detection of Dryopteris Hybrids

W. H. WAGNER, JR. AND KATHERINE LIM CHEN[1]

It is practically axiomatic that interspecific and intergeneric hybrids in ferns are, with rare exceptions, "sterile." The situation found by Trevor Walker (1958) in certain hybrids of *Pteris* remains our only example of interspecific hybridization that yields fertile progeny directly. Because sterility is otherwise so nearly universal among fern hybrids, it seems desirable to describe some of the signposts of this condition. What is meant by "sterile hybrids" requires explanation, because there have been some misunderstandings. The mere absence of sori, for example, is not necessarily diagnostic for hybridity. So far as has been determined, fern hybrids have just as many sori as do normal species. Species as well as hybrids both tend to lack sori when growing under conditions unusual for the plants involved, such as exceptionally deep shade and especially wet, rich substratum. The point is that production of sori and of sporangia *per se* are not inhibited in interspecific crosses, so that a hybrid plant which is unable to reproduce itself may nevertheless be abundantly soriferous. A more serious problem, as will be exemplified by alleged "hybrids" described and figured by Crane (1953) and Tryon (1942) to be discussed below, involves misinterpretation of the criteria for the detection of hybrids. We hope, therefore, that the following notes and illustrations will prove useful to those who are engaged in clarifying the variations and taxonomy of American woodferns, *Dryopteris*.

DETECTION OF HYBRIDS

Interspecific crossing usually expresses itself in terms of what is traditionally called "abortion." There are all degrees of abor-

[1] Research supported by National Science Foundation Grant G-10846. We wish to thank the persons who have contributed specimens and field assistance to this research, especially D. J. Hagenah, A. Murray Evans, E. T. Wherry, and C. V. Morton.

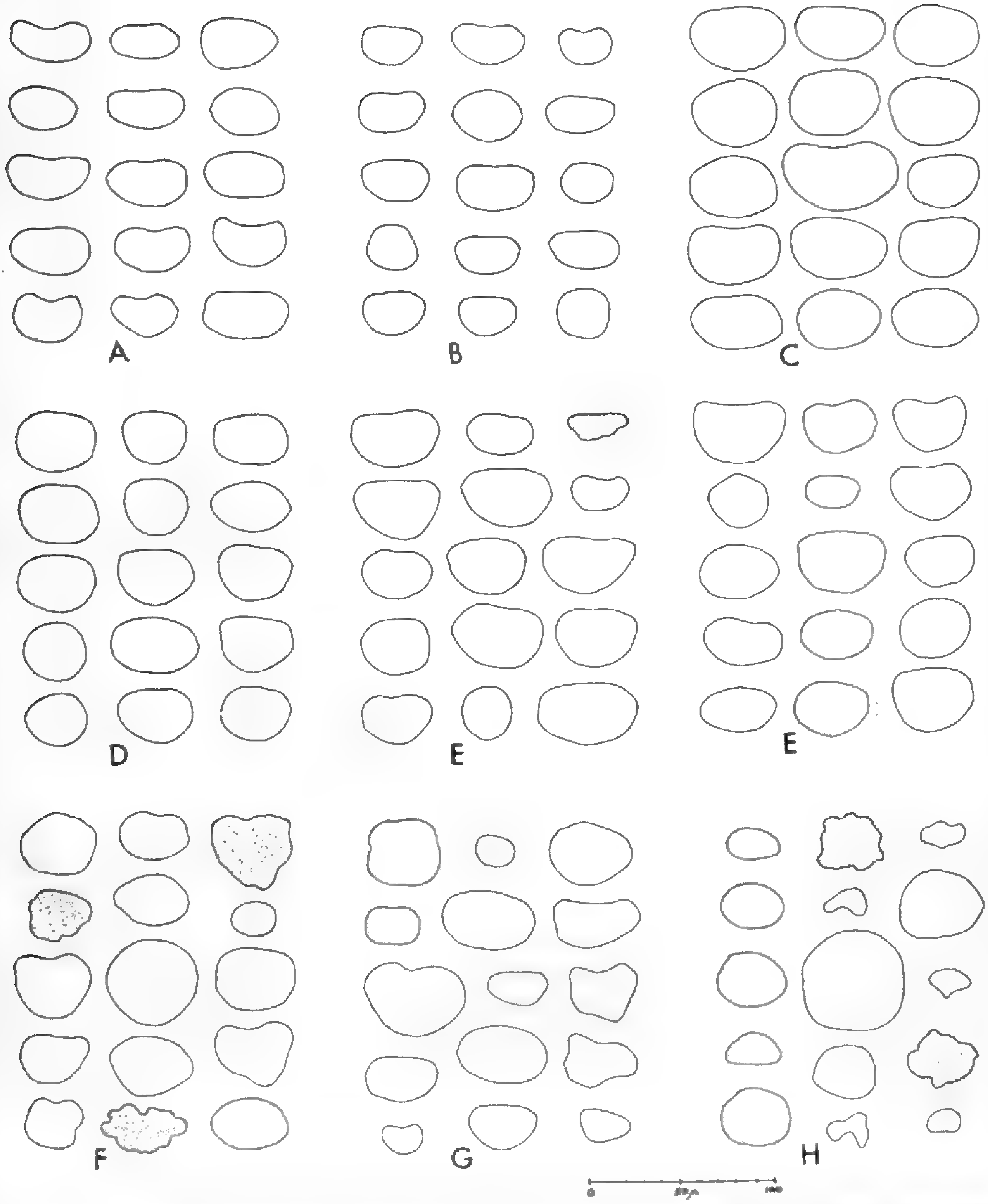


FIG. 1. A-E, EXOSPORE OUTLINES OF NORMAL SPECIES EXCEPT FOR SHADED SPECIMENS IN WHICH EXOSPORE COULD NOT BE SEEN. A. DRYOPTERIS WHERRYI, 63172J. B. D. GOLDIANA, 63167F. C. D. CRISTATA, IRWIN'S WOODS, VOUCHER, WAGNER S.N. D. D. FILIX-MAS, CRANE 54144 (AFS). E. D. FILIX-MAS, DUTTON 2108 (NEBC). F-H, EXOSPORE OUTLINES (EXCEPT SHADED SPECIMENS) OF INTERSPECIFIC HYBRIDS. F. D. CRISTATA × MARGINALIS, ROSA AND WAGNER 76. G. D. CLINTONIANA × GOLDIANA, TUSCOLA COUNTY, MICH., D. J. HAGENAH (MICH). H. D. FILIX-MAS × MARGINALIS, ALPENA SINK, MICH., HAGENAH H-27. (UNLESS OTHERWISE INDICATED ALL SPECIMENS DEPOSITED IN MICH, AND NUMBERS OF W. H. WAGNER).

tion—from the state of only a few defective spores to the condition in which all of the spores appear to be distorted and inviable, and the spore-cases themselves fail to mature normally. Normal species usually have at least some abortive spores (as shown in Fig. 1, E); and sterile hybrids usually have at least a few spores that appear normal (Fig. 1, G). Experienced field workers can usually tell with a good hand lens (15x or 20x), or sometimes even with the naked eye, whether a plant shows spore or sporangial abortion, at least in the genus *Dryopteris*. The sorus often appears darker in color in hybrids as a result of the presence of numerous deformed spores with blackened walls and because the majority of sporangia fail to open and appear darker than a corresponding mass of normal sporangia from which the spores have already been discharged. The mature sorus of a hybrid, no matter what its size, usually seems to be more compactly constructed than in normal species, with the sporangia appearing as more or less globular objects tightly grouped together. When the sporangia are later examined under the compound microscope it is seen that even those capsules which developed to full size contain spores of various sizes and shapes. Such irregular spores, when scattered on an appropriate growth medium, germinate in extremely low percentages or not at all If a few prothallia are obtained from them in culture, these will generally be peculiar in form and fail to complete their growth or to reproduce the plant. The signs of abortion will be described in detail below.

The phenomenon of spore abortion may be traced back to the process that produces the spores. This process is described in detail in familiar cytology and genetics books (e.g., Sharp, 1943, pp. 216-219) so needs no repetition here. The important point is that in hybrids the chromosomes tend to be distributed irregularly to the young spores, and the spores differ genetically among themselves. Under the microscope one can tell, even in very young spores, that they are abortive. Often the sporangium dies as a whole at a stage of early spore development. When the spore-cases do reach their full size and do discharge their contents, the spores are highly irregular.

The assignment of interspecific hybrid status to a plant found in nature should not rest alone on whether the spores are abortive. There is always the possibility that an individual of a normal species had been damaged by sudden environmental changes which injured the developing sorus, or that the plant was genetically abnormal in the first place and that abortion was due to some peculiar internal factor. Hybrid status should be assigned first and foremost on the basis of intermediacy. During recent years botanists have become more and more familiar with the basic species of *Dryopteris* in temperate North America, thanks to such workers as R. C. Benedict, E. T. Wherry, and Stanley Walker. We now know the ranges of the species and their normal spectra of variation to a high degree. And where populations of two well known species grow together intermixed in the same habitat and an unusual plant is found which unquestionably combines the characters of the associated species, there is no reason not to interpret the plant as a cross. Presumably all or most of the species differences between the parents are multigenic, involving many interacting factors. If they cross, their hereditary factors influence each other in such a way as to produce intermediacy in all or most characteristics. Hybrids which closely resemble one or the other parent in all their characters would not only be unlikely, they would be extraordinary.

Hybrids in *Dryopteris* are practically all first generation crosses since the vast majority are sterile and unable either to breed with themselves or with other plants. Thus crosses in these ferns are expected to be almost exactly intermediate in most of their characteristics because recombination of parental traits or backcrossing is not likely. Only when the cross is a hybrid between a 4× species (in which the chromosome number is 164) and a 2× species (with the usual diploid condition of 82 chromosomes) do we expect the situation to be otherwise. In the latter case, the hybrid will still be intermediate between its parents, but its characteristics will tend to be inclined toward the $4\times$ species. For example, the well known *D.* $\times$ *boottii*, although obviously a compromise between its parental characters, resembles its $4\times$ parent (*D. cristata*) more than its $2\times$ parent (*D. intermedia*).

The actual steps involved in the detection of an interspecific hybrid found in nature usually follow this pattern:

(1) Recognition that the majority or all of the characteristics of the plant in question are intermediate between those of two distinct and well-understood species.

(2) Observation that the sori contain abortive sporangia and spores.

(3) Determination that the chromosomes, when studied in cytological preparations under the compound microscope, do not behave normally in the process of spore production.

It is easy enough to state that no taxon has been "demonstrated" to be of hybrid origin unless the same kind of plant has been produced experimentally under controlled laboratory conditions. This is true, of course—and in questionable situations the artificial production of a hybrid is mandatory. However, the array of knowledge of hybridization among ferns now available is so extensive that the basic patterns and principles may be considered as firmly established. So many cases, indeed, have been experimentally confirmed that one can say with considerable certainty that if the three criteria given above are met, the specimen in question is with very little doubt an interspecific cross. In most cases, moreover, it is entirely sufficient to meet only criteria (1) and (2).

However, precautions must be observed. In the present study of the authors involving a survey of the natural occurrences of wild hybrids in *Dryopteris* in the United States, we have sometimes been misled in making interpretations. Others have likewise come to erroneous conclusions. Accordingly, the problems of recognition of hybrid abortion will be examined in more detail, to be followed by specific examples.

RECOGNITION OF ABORTION

To greater or lesser degrees one uses in the field the following points as aids in determining hybridity: indusial texture, sporangial size, sporangial dehiscence, sporangial bow (so-called "annulus") thickening, and spores. The latter two characters are best studied under the compound microscope. However, a good 15× or 20× hand lens may often reveal the necessary information about all of these characters at the time of collection if the light used to illuminate the sori is bright and the specimen is held in the full rays of the sun. The spores can frequently be scattered by pressure from a fingernail and observed on the leaf surface around the sorus.

In some groups of *Dryopteris* the indusia tend to appear more or less the same whether the specimen is a hybrid or a normal species. In the complex of *D. filix-mas*, *D. goldiana*, and *D. mar-*

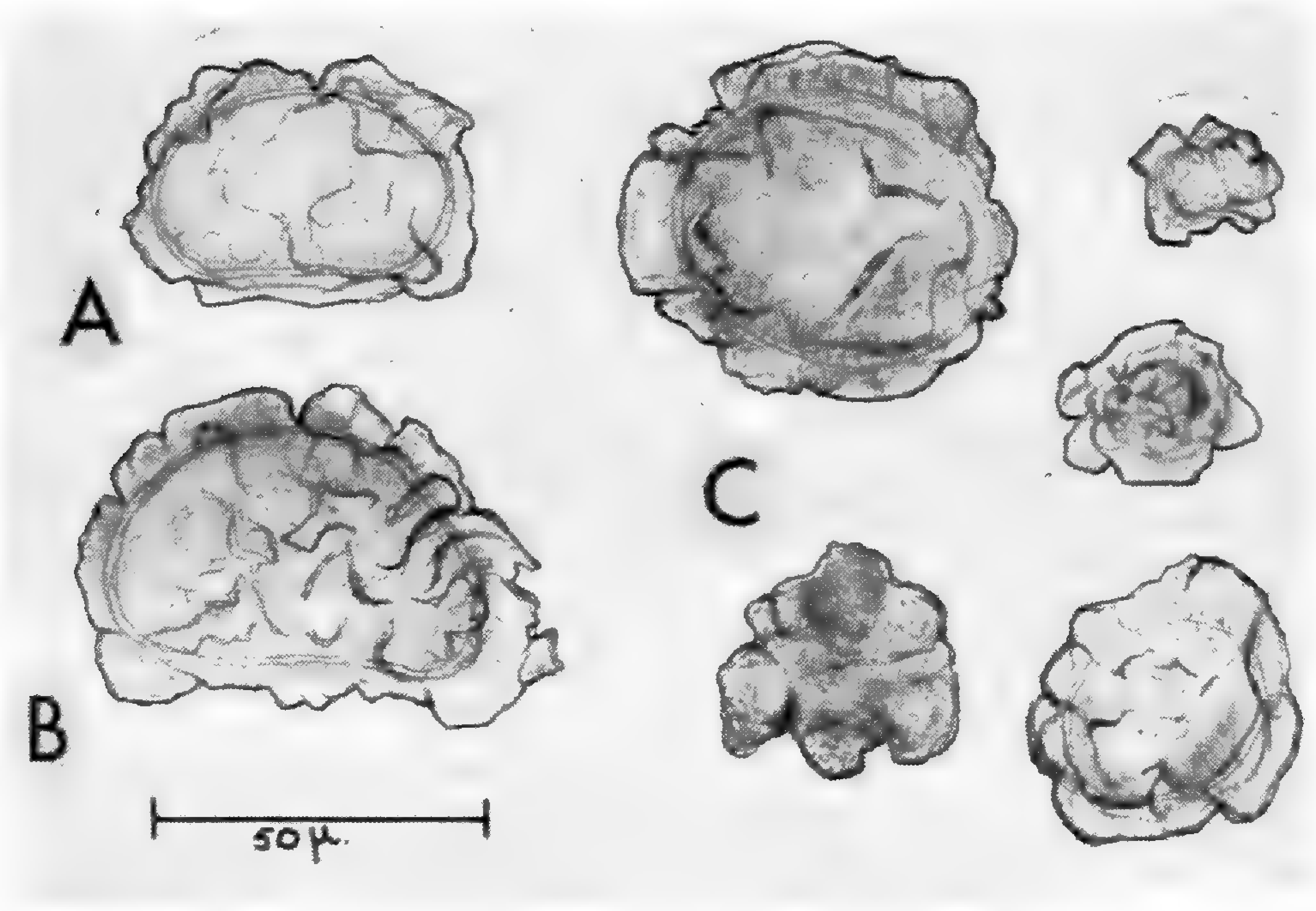


FIG. 2. HALFTONE DRAWINGS OF SPORES. A. DRYOPTERIS CELSA (NOTE OUTLINE OF EXOSPORE WITHIN PERISPORE), WAGNER 8234. B. D. CLINTONIANA SARGENT IN 1957. C. D. × LEEDSII (NOTE THAT IN 3 OUT OF 5 SPORES, THE EXOSPORE CANNOT BE DISTINGUISHED), WAGNER 63172 AND WHERRY.

ginalis, however, we find that there seems to be a tendency for the indusia of the hybrids to become rigid and persistent, with a more or less dark pigmentation, especially as observed in August and September during the latter half of the season. The parents tend to have more papery indusia which may or may not fall off; if they persist, the indusia are more or less curled and the now discharged normal sporangia are conspicuous, radiating in all directions from the receptacle of the sorus. The hybrid sporangia, on the other hand, are inclined to be tightly clustered and only partially exposed in a ring under the margins of the stiff indusia.

The sporangia in all of the hybrids which we have examined tend to average smaller, roughly two-thirds or less the size of those of the parents. What this means is probably that the same process of abortion which influences the spore development, as described above, extends to the behavior of the whole spore case. When a certain percentage of the spores within die, the whole sporangium stops development altogether. Associated with this smaller size of the capsules is a failure of dehiscence and discharge, so that the sporangia are mostly unopened. The dehiscence of the spore cases is usually absent except for some of those around the periphery of the sorus. In normal species, in contrast, dehiscence is the rule except for a central small group of sporangia near the receptacle which tend to remain rudimentary. The majority if not all of the sporangia in a hybrid thus remain unopened even at the end of the season, while at the same time the majority of sporangia in a typical species are opened and have released their spores. One must be warned, however, that early in the growth season, even the spore-cases of normal species are closed, even if there are young viable spores within. Not until the sporangium is mature will the capsule rip open to release the spores, and this may take until late June or July.

As might be expected from the foregoing, the sporangial bow (the string of cells along the side and top of the capsule which activates the opening and discharging mechanism) is imperfectly developed in hybrid spore-cases as a rule. In terms of the component cells, this means that the process of secondary thickening which characterizes the cells of the bow is curtailed sooner or

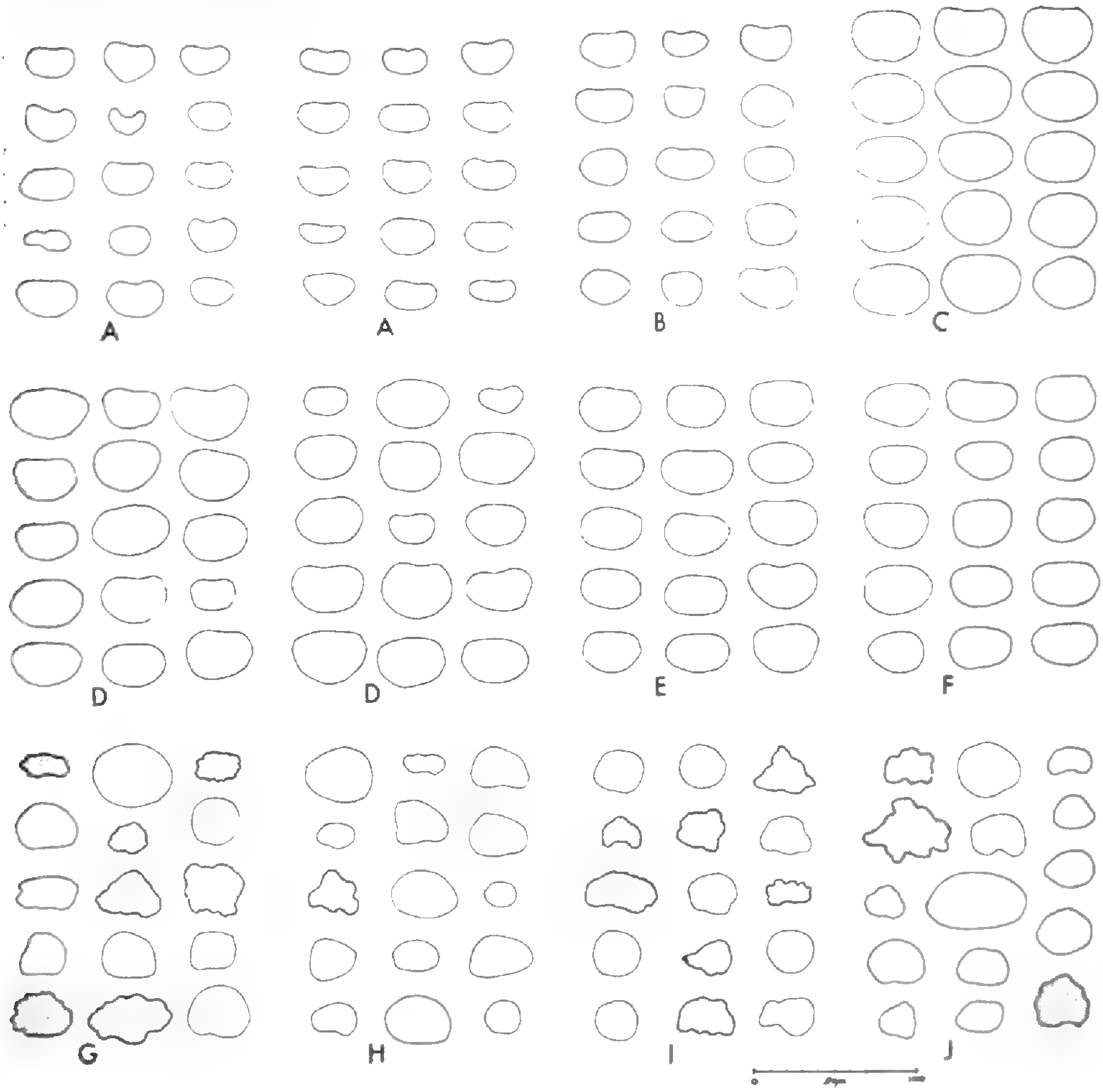
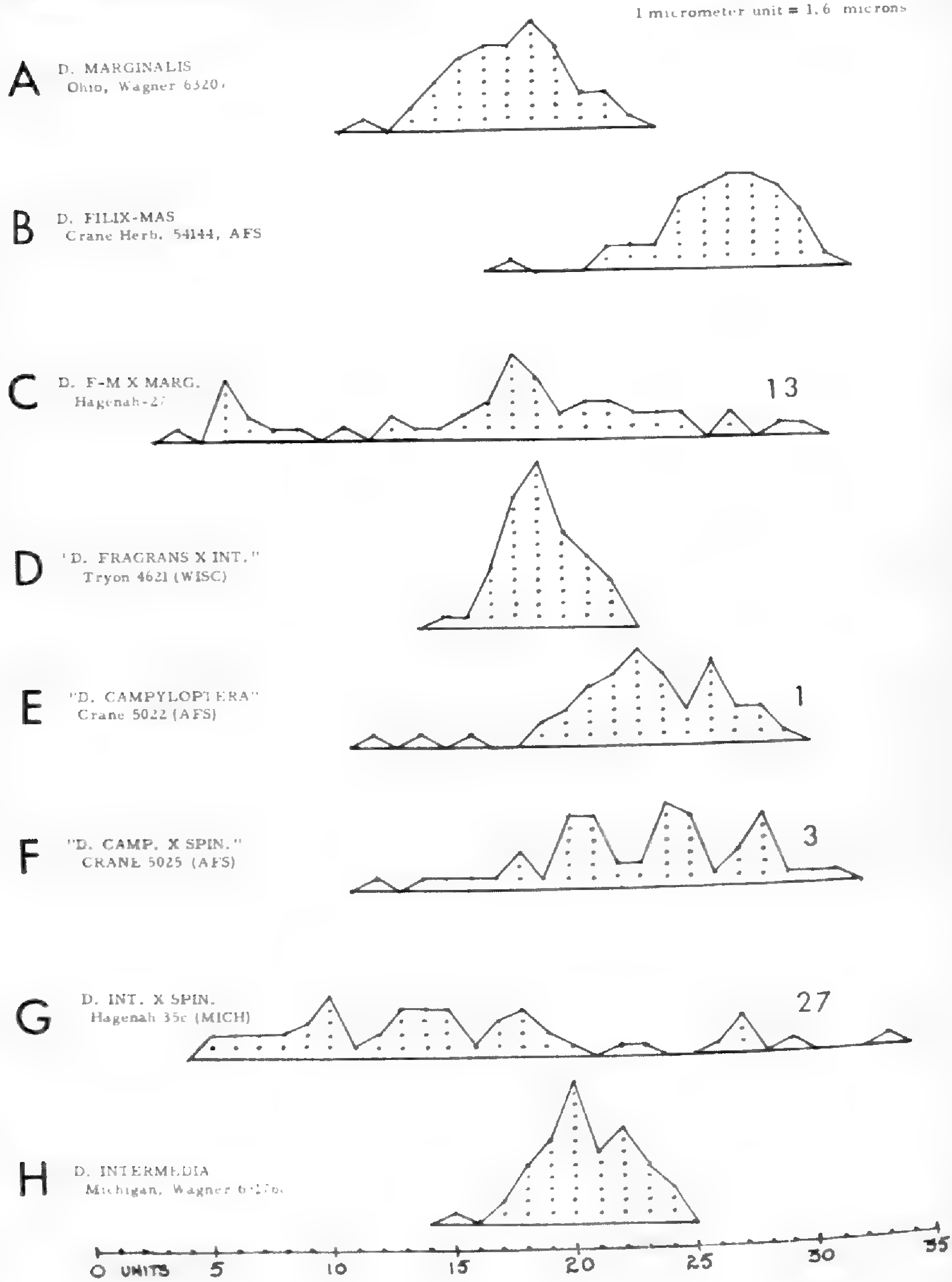


FIG. 3. A-F, EXOSPORE OUTLINES OF NORMAL SPECIES EXCEPT FOR SHADED SPECIMENS IN WHICH EXOSPORE COULD NOT BE SEEN. A. ALLEGED "D. FRAGRANS × SPINULOSA VAR. INTERMEDIA," TRYON AND TRYON 4621 (WISC). B. D. INTERMEDIA, 63159E. C. D. FRAGRANS, FLOYD HERB. 2118 (AFS). D. "D. CAMPYLOPTERA × SPINULOSA," CRANE 5025 (AFS). E. "D. CAMPYLOPTERA" (= "D. DILATATA"), CRANE 5022 (AFS). F. D. SPINULOSA, 63165B. G-J, SPORES OF INTERSPECIFIC HYBRIDS INVOLVING D. INTERMEDIA AND D. SPINULOSA (EXOSPORES ONLY, UNLESS SHADED). G. D. INTERMEDIA × SPINULOSA, MICHIGAN, HAGENAH H-35C. H. D. DILATATA × INTERMEDIA, HURON MTS., MICHIGAN, HAGENAH H-20. I. D. CRISTATA × SPINULOSA, ROSA AND WAGNER 103. J. D. CRISTATA × INTERMEDIA, HURON MTS., MICH., HAGENAH H-2A. (UNLESS OTHERWISE INDICATED ALL SPECIMENS DEPOSITED IN MICH AND NUMBERS OF W. H. WAGNER).

later, so that under the compound microscope the thickening of the cells is seen as less than that of normal sporangia, and many of the sporangia do not seem to be provided with a secondary wall layer at all. Hybrids commonly show the lateral walls of the sporangial capsules to be covered internally with more or less numerous aggregations of globules of blackish or dark-brown substance. Such materials are rarely seen also to some extent in normal sporangia, but they become abundant and striking in the sporangial walls of many hybrids.

The abortive spores have various shapes and sizes, and all the forms are mixed together in the same spore-cases (Fig. 2, C). Many of them are very dark in color, even with bright illumination under the compound microscope. The outer jackets or "perispores" which surround the exospores are often much more irregularly crested than usual. The contents of many hybrid sporangia contain numerous small undefined blackened objects, some of them probably very imperfectly developed spores, others related to the globular materials mentioned above. Normal spores can be measured easily by determining the exospore dimensions as seen through the transparent, jacketing perispores (cf. Fig. 2). The advantages of measuring the exospore dimensions rather than the perisporial jacket are obvious. The perispore is extremely rugose, but the exospore is smooth. The exospore is the smooth and immediate boundary of the spore protoplast, so it gives a good measure of the volume of the living cell within. Even in young sporangia, so long as the spores have separated and the exospores have reached their normal dimensions, it is possible to make measurements, even though the later-developed perispores have not yet been laid down. Unfortunately, in hybrids it is often impossible to make out the exospores within, if the perisporial coverings have formed, so that the drawings and measurement data in this article are not exactly comparable between hybrids and species. We have tried to indicate this in Figures 1 and 3 (which were designed only to show exospores) by tracing the entire spore outline of the opaque spores, including perispore, and then shading the entire outline. In Figure 3, for example, G, H, I, and J contain outlines of *whole spores including perispores* because we could not make out the exospores within.



To illustrate the appearance of samples of normal species and hybrids of *Dryopteris*, the figures were prepared by scraping the sori into hot lactic acid and drawing the first fifteen spores in outline under a camera lucida. The perispores were not drawn (except as indicated above) but only the boundaries of the actual protoplast as represented by the exospore. To indicate the measurements of exospores in Fig. 4, 50 spores each of the plants involved were measured with an eyepiece micrometer at 450 × magnification. The slides were mostly diaphane mounts.

If frequency histograms of maximum exospore length are plotted, the sizes of normal spores of sexual species tend to approximate rather steep normal curves (cf. Fig. 4, A, B, H) of variation, with the majority of spores close to the numerical mean. Spores which are abnormal, either much larger or much smaller than the median, will tend to stand out. Sterile hybrid spores will tend, on the other hand, to have much broader curves (cf. Fig. 4, C, G). (Many hybrid spores cannot be measured at all, of course, and this is indicated in Fig. 4 by the number at the right of each histogram. Each histogram therefore contains the first *measurable* spores).

Maximum exospore length by itself is not sufficient to express completely the situation, however, because there are at least two other factors involved in abortion—outline (cf. Figs. 1 and 3), and exospore definition (as shown by the stippled spores in which the exospore cannot be distinguished by an ordinary light microscope). The major abnormalities of the morphology of

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FIG. 4. FREQUENCY HISTOGRAMS OF EXOSPORE LENGTHS IN DRYOPTERIS. 50-SPORE SAMPLES, WITH NUMBER OF UNMEASURABLE (OPAQUE OR OTHERWISE) SPORES ENCOUNTERED DURING TABULATION INDICATED AT RIGHT OF EACH HISTOGRAM. EACH DOT REPRESENTS ONE SPORE. A. D. MARGINALIS, OHIO, WAGNER 63207 (MICH); B. D. FILIX-MAS, VERMONT, CRANE 54144 (AFS); C. D. FILIX-MAS × MARGINALIS, MICHIGAN, HAGENAH H-27 (MICH); D. ALLEGED "D. FRAGRANS × INTERMEDIA," WISCONSIN, TRYON AND TRYON 4621 (WISC); E. "D. CAMPYLOPTERA" (= "D. DILATATA"), MINNESOTA, CRANE 5022 (AFS); F. PUTATIVE "D CAMPYLOPTERA × SPINULOSA," MINNESOTA, CRANE 5025 (AFS); G. D. INTERMEDIA × SPINULOSA, MICHIGAN, HAGENAH H-35C (MICH); H. D. INTERMEDIA, MICHIGAN, WAGNER 63176C (MICH).

sterile hybrid spores in *Dryopteris* as known to us may be summarized as follows:

(1) *Size:* Range large, with abnormally large numbers of unusually small spores present (cf. Fig. 4).

(2) *Shape:* Some spores not typically "bean-shaped," but either spherical, twisted, square, or triangular (cf. Figs. 1 and 3).

(3) *Color:* Some spores not transparent enough to enable definition of the exospores within (shaded objects in Figs. 1 and 3). (Non-measurability of exospores may be due also to (2), when the spore is so twisted as to obscure the internal structure.)

In a series of interesting papers, Crane (1955, 1956, 1960) presented much of value to our understanding of spore diversity in American *Dryopteris.* However, in these papers one cannot obtain a clear idea of the quantitative conditions involved because, in general, single spore specimens were selected to illustrate the taxa. The curves and drawings presented in this paper should help to allay this deficiency, and make it possible for a student to have an operational basis for ultilizing abortion of spores and sporangia as a tool in the detection of *Dryopteris* hybrids.

As shown in Fig. 1, A-E, the spores of presumably normal species are rather conspicuously uniform in outline and size. Occasionally there is a somewhat larger one (Fig. 1, C, middle), occasionally a smaller one (A, bottom row). Sometimes (although rarely) we find a small, dark "spore" like that so frequently seen in hybrids in which the exospore cannot be seen at all through the irregular, pigmented perispore, as shown in the shaded object in the top of the third column of Fig. 1, E. It is our impression that reproductive polyploid species (4×, 6×, such as *D. campyloptera* and *D. clintoniana*) often show somewhat more irregular spores than diploids, although we have as yet no statistics to support this.

In Fig. 1, F-H, are shown 15-spore samples of three hybrids, *D. cristata* × *marginalis* (F), *D. clintoniana* × *goldiana* (G), and *D. filix-mas* × *marginalis* (H). These spores show much greater irregularities, of course, than we would expect in normal species. The histogram in Fig. 4, C, illustrates the size variation of a 50-

spore sample of *D. filix-mas* × *marginalis*. The most extreme condition includes very large, nearly spherical spores; more or less normal-appearing spores; and many very tiny spores—as well as opaque objects in which the exospore cannot be distinguished. Some other illustrations of spore abortion may be found in Wagner and Boydston (1958, Fig. B, and 19), Morzenti (1962, Fig. 2), and Wagner (1962, Fig. 1, C). The following descriptions will illustrate the application of spore abortion data to the detection of *Dryopteris* hybrids.

EXAMPLES

1. Some "hybrids" involving *Dryopteris filix-mas*: It has become widely recognized over the past three or four decades that wherever *D. filix-mas* co-exists with *D. marginalis* in Vermont, Ontario, and northern Michigan, numerous crosses may be expected. There seems to be little or no barrier to hybridization between these species in nature, and the situation is quite unlike most other species pairs when they occur together. After observing numerous herbarium collections of so-called "*D. filix-mas*" we have come to the conclusion that many of them are actually hybrids that have been overlooked. Why taxonomists have failed to recognize that these collections are actually *D. filix-mas* × *marginalis* is related, we believe, to two factors: (a) *Dryopteris marginalis* is one of the most abundant and familiar of the woodferns of eastern North America, and practically every field botanist is familiar with its variations. *D. filix-mas*, on the contrary, is a rarity, highly localized in a few localities. Its variations are not well known to most field botanists. Thus any hybrid plants will tend to be referred to the less familiar, rare taxon. (b) *D. filix-mas* is a tetraploid species, with 164 chromosomes (possible formula $A_1A_1A_2A_2$), but *D. marginalis* is a diploid, $2\times=82$, (BB). Not surprisingly, therefore, the interspecific crosses (A_1A_2B) tend to simulate *D. filix-mas* more than *D. marginalis*. The displacement of sori in the hybrids toward the margin of the segments that we would expect from the influence of *D. marginalis* is not so strong as to be a precisely intermediate con-

dition; the soral position is accordingly somewhat more like *D. filix-mas* than *D. marginalis.*

We recommend that field workers and herbarium botanists re-examine their specimens of "*D. filix-mas*" carefully for specimens showing traits in the direction of *D. marginalis.* Suspicious specimens should be examined for spores. The spore data gives an excellent test, for all of the now numerous hybrids we have studied in the field under natural conditions have shown remarkably irregular and variable spores (cf. Fig. 4, A, B, and C; Fig. 1, D, H).

Our studies of *D. filix-mas* lead us to the conclusion that considerably more work is needed to understand the variations of eastern American populations of this species. For example, in our joint investigations with Dale J. Hagenah, we have found circumstantial evidence that unusual temperature conditions that "burn off" the early leaves of the season by freezing lead to the formation in this species of peculiar fronds, sterile and fertile, characterized by much broader and more deeply divided pinnae and segments. These injured specimens are very confusing because they are so unlike the ordinary narrow form of *D. filix-mas.* Some are so divided as to suggest hybridization with *D. intermedia* in their morphology, but at least one striking specimen illustrating such strong division had normal spores of *D. filix-mas.* It should be noted that most of the unusually broad and dissected specimens of the latter description show damage to the frond tip, involving incompletely developed and abbreviated segments.

A very robust specimen kindly lent for our study by the New England Botanical Club was annotated in Mr. C. A. Weatherby's handwriting as "Dryopteris goldiana × ?" and by someone else as "× filix-mas?." When we examined the spores, however, we found no special evidence that the plant was of hybrid origin. A 30-spore sample showed only slightly more irregularity (Fig. 1, E) than a more typical specimen of *D. filix-mas* (cf. Fig. 1, D); and the majority of the spore-cases have dehisced in the normal way. We interpret this specimen, therefore, not as a hybrid but another of the forms of *D. filix-mas.*

2. Some "hybrids" involving *Dryopteris intermedia*: Our "fancy fern" or "evergreen woodfern," *D. intermedia,* is the most important species in the eastern part of North America in terms of breadth of range, abundance, and economic value. It is known to hybridize with practically every other species of woodfern with which it grows. On October 19, 1963, the senior author in company with Dale J. Hagenah, A. Murray Evans, and Herman Becker, studied a woodfern locality in Kalamazoo Co., Michigan (T4S, R12W, n. side of sect. 20, swamp along "W" avenue), which is strongly recommended to students of this genus. Here such species as *D. clintoniana, D. cristata, D. goldiana, D. intermedia,* and *D. spinulosa* grow in luxuriance, and many hybrids are found as well as variations of the basic species. Crosses of *D. intermedia* with *D. clintoniana, D. cristata,* and *D. spinulosa* are common and are readily found over a large part of the swampy woods. While studying these hybrids we found a colony of a peculiar fern that resembled *D.* × *boottii* (*D. cristata* × *intermedia*) but which seemed more dissected and more like *D. intermedia* than usual.

In the Great Lakes region, *D. spinulosa* and *D. intermedia,* the two most common "spinulose" ferns, develop narrow-leaved forms that more or less resemble *D.* × *uliginosa* and *D.* × *boottii,* the respective crosses of these species with *D. cristata.* Figure 5 shows the typical broad form of *D. intermedia* from the Kalamazoo County locality beside fronds from the apparent "hybrid" in question. Our later study of the peculiar plant showed that if the details of cutting were compared carefully, the narrow-leaved plant matched *D. intermedia* in spite of its frond outline. Furthermore, its spores are entirely normal. Thus a specimen which we might have carelessly identified as the hybrid *D.* × *boottii* turned out in fact to be one of the narrow-leaved extremes of *D. intermedia.* The narrowness of the fronds of this form is genetically fixed, as evidenced by the fact that it grows side-by-side and completely intermixed with the more typical, broad form.[2]

In 1942, Tryon published a "New Dryopteris Hybrid" involving what he called "*D. fragrans* and *D. spinulosa* var. *intermedia.*" His figure (1942, Pl. 8, Fig. 1) suggests a narrow form of *D. intermedia.* Materials of this "hybrid" sent to us for identification from the Herbarium of the University of Wisconsin provide an illustration of the need for careful study before publishing such interpretations. In spite of a rather elaborate description as summarized in a two-page chart (op. cit., pp. 82-83), the evidence is unconvincing. As the author himself wrote, his "hybrid" is "definitely more closely related to" *D. intermedia* than to *D. fragrans.* In our opinion the only possible character which might suggest *D. fragrans* is the narrowness of the leaf blade. But the actual shape of the frond is like *D. intermedia* only more narrowed. The alleged absence of "spine-tips" on the acute teeth is more apparent than real, and is due to the immaturity of the fronds which had not yet completed their foliar growth at the time of collection (July 4, 1940).

Obviously, because of the season, the sporangia of this specimen were young and undehisced. In fact, the perisporial jackets of the spores were not yet formed. However, by merely placing the sporangia in lactic acid, the exospores (which were fully developed) were separated out easily, and they proved, as expected, to be entirely normal. Tracings of 30 exospores of the supposed "hybrid" were compared with a random sample of 15 each from *D. intermedia* and *D. fragrans* in Fig. 3 (cf. A with B and C). The spores of the "hybrid" are obviously more like *D. intermedia* than *D. fragrans.* Frequency histograms (Fig. 4, D and H) confirm their essential identity. Accordingly, the citation of this "hybrid" by Wherry (1961) must be revised. Although *D. fragrans* × *intermedia* may possibly be found or synthesized in the

[2] Since the above was written we have determined the chromosomes of the narrow form to be normal, with $n = 41$ pairs at meiosis, as in typical *D. intermedia.*

future, this interesting biotype has still not been described validly to our knowledge, and has yet to be obtained.

3. Some "hybrids" involving *D. dilatata*: Recently it was pointed out that there are two taxa passing under the name "*D. dilatata*" in the eastern United States (Wagner and Hagenah, 1962). One of them, tentatively designated as "Lake Superior *D. dilatata*," is known to occur in the western Great Lakes region and is characterized by its very broadly ovate blade, the petiole nearly equalling the length of the midrib, the blade texture herbaceous, the scales narrowly triangular and dark-brown or chestnut in color. "Lake Superior *dilatata*" has not yet been found east of the Upper Peninsula of Michigan and the corresponding part of Ontario. The other taxon included in "*D. dilatata*," *D. campyloptera*, extends from eastern Canada to the Carolinas in the mountains, and is distinguished by its relatively narrower blade, shorter petiole, firmer texture, and broader, paler scales. The "Lake Superior *D. dilatata*" is a relatively large-spored diploid like *D. fragrans*, with $n = 41$. Eastern *D. campyloptera* has very slightly larger spores, but is a tetraploid with twice as many chromosomes, $n = 82$. It was hypothesized by Wagner and Hagenah (op. cit.) that the latter species might actually be an allopolyploid derivative of a hybrid between "*D. dilatata*" and *D. intermedia*.

Accordingly, in the summer of 1962, a field study was made of populations of *D. campyloptera* in the Mountain Lake area of Giles Co., Virginia, in the hope of finding examples of the hybrids between *D. campyloptera* and *D. intermedia*. If our hypothesis were correct, such hybrids should show that *D. intermedia* (AA) shares its species genome with one of the two genomes of *D. campyloptera* (AABB) and at spore production the chromosome behavior should conform to the formula AAB, i.e., 41 pairs (2 genomes of *D. intermedia*) and 41 singles (1 "*dilatata*" genome). This field experiment provided an excellent illustration of the use of spores in determining hybrids in the field and although described elsewhere (Wagner, 1963), the details will be repeated here.

As it turned out, the variations of *D. campyloptera* in southwestern Virginia were so extensive that the characters of *D. intermedia* and those of *D. campyloptera* seemed to run together. Practically every feature of *D. campyloptera* overlapped with *D. intermedia*, and at first we had considerable difficulty in separating the two species (cf. Wagner, op. cit., Table 1, and

FIG. 5. SPECIMENS OF DRYOPTERIS INTERMEDIA FROM KALAMAZOO COUNTY, MICHIGAN. A. BROAD FORM, WAGNER 63162A. B. NARROW "D. × BOOTTII-LIKE" FORM, 63159A AND C.

Figures 5, 6). Not until we hit upon the procedure of using the spores as a basis of identification, in fact, could we separate the *intermedia*-like plants of *D. campyloptera* from the other species. The method is highly recommended to all concerned with these plants. The spores of *D. campyloptera* are so much larger than those of *D. intermedia* that the difference can be immediately recognized under the microscope. The actual difference, as measured by the longest diameter of the exospore, is almost exactly 20 per cent.

Under the circumstances, the discovery of a hybrid between these two taxa turned out to be difficult. Every time we found what seemed to be an intermediate specimen, careful examination showed it to be an *intermedia*-like *D. campyloptera* or a very-broad, large *D. intermedia.* Finally we were forced to take a dissecting microscope into the field and examine literally hundreds of plants in the mixed populations. In this way we finally found what we sought. When we ultimately discovered the plants which had both morphological intermediacy combined with highly irregular, obviously abortive spores, we later confirmed in the laboratory that all of the presumed hybrids were in fact triploids with three genomes ($3\times = 123$) and at spore production there are 41 singles (presumably the unpaired chromosomes of "*D. dilatata*") and 41 doubles (the pairs of chromosomes of *D. intermedia*).

At present we know the following natural crosses among the "spinulose" woodferns of the eastern United States: *D. campyloptera* × *intermedia, D. dilatata* × *intermedia,* and *D. intermedia* × *spinulosa.* All three have been examined cytologically by S. Walker (1961), Wagner and Hagenah (1962), and Wagner (1963); and all three are being maintained as living plants for research purposes by D. J. Hagenah of the Cranbrook Institute of Science.

We were greatly interested in the plant which was figured by Crane (1953, Fig. IX, *Crane* 5025) as "*Dryopteris campyloptera* × *spinulosa,*" taken at Beaver Bay, Minnesota. The specimen preserved in the American Fern Society Herbarium was indistinguishable to us from forms of "Lake Superior *D. dilatata*" from that area (including *Crane* 5022, op. cit., Fig. VII, taken at the same time and place). Since *D. spinulosa* is a tetraploid species and "*D. dilatata*" is a diploid species, we would expect any hybrids to resemble *D. spinulosa* somewhat more than *D. dilatata* rather than the reverse. However, the pinnae and segments of the specimen of the "hybrid" in question are like those of the 2× species: The pinnae are finely divided, the segments more truncate, the angles of divergence wider, and the whole frond more open and ample—as in *D. dilatata*. The scales on the stipe are very dark, nearly blackish, rather than pale tan as in *D. spinulosa*. Nothing about the specimen suggested influence of *D. spinulosa*.

When the sori of the questionable specimen were examined the following facts were revealed: (a) the sporangia are all of full size: (b) all except those in the center have opened fully (as seen in the dry condition); and (c) the spores (as shown in the 30-spore sample in Fig. 3, D) are evidently normal, with only a few reduced ones. The spore abortion in this specimen is by no means comparable with that known in the hybrids of "spinulose" ferns listed above. Yet the plant, if it were truly the hybrid "*D. dilatata*" × *spinulosa*, would be expected to have the triploid chromosome condition and the spores should be equally abortive. Our measurements of 50-spore samples of the "hybrid" (*Crane* 5025) and the "species" (*Crane* 5022) gave remarkably similar frequency histograms that probably belong statistically to the same curve (Fig. 4, E and F).

There is probably no good reason, from what we know about these plants, why true hybrids between "Lake Superior *D. dilatata*" and *D. spinulosa* should not be found in the great Lakes area. They do occur together occasionally in wooded swampy places, and might be expected to generate some hybrids. Thus far, however, we have not seen any good evidence that such a cross has been found.

LITERATURE CITED

CRANE, FERN WARD. 1953. Spore studies in Dryopteris. I. Amer. Fern Jour. **43:** 159-169; 1955. II. Dryopteris celsa and D. separabilis, Ibid. **45:** 14-16; 1956. III. Ibid. **46:** 127-130.

——— 1960. A key to American Dryopteris based on characters of the perispore. Ibid. **50:** 270-275.

MORZENTI, VIRGINIA M. 1962. A first report on pseudomeiotic sporogenesis, a type of spore reproduction by which "sterile" ferns produce gametophytes. Ibid. **52:** 69-78.

SHARP, LESTER W. 1943. Fundamentals of Cytology. McGraw-Hill Book Co., New York.

TRYON, R. M., JR. 1942. A new Dryopteris hybrid. Amer. Fern Jour. **32:** 81-85.

WAGNER, W. H., JR. 1962. Cytological observations on Adiantum × tracyi C. C. Hall. Madroño **16:** 158-161.

———. 1963. Pteridophytes of the Mountain Lake Area, Giles County, Virginia, including notes from Whitetop Mountain. Castanea. **28:** 113-150.

——— AND KATHRYN E. BOYDSTON. 1958. A new hybrid spleenwort from artificial culture at Fernwood and its relationship to a peculiar plant from West Virginia. Amer. Fern Jour. **48:** 146-159.

——— AND DALE J. HAGENAH. 1962. Dryopteris in the Huron Mountain Club area of Michigan. Brittonia **14:** 90-100.

WALKER, STANLEY. 1961. Cytotaxonomic studies in the Dryopteris spinulosa complex.—II. Amer. Jour. Bot. **48:** 607-614.

WALKER, TREVOR G. 1958. Hybridization in some species of Pteris L. Evolution **12:** 82-92.

WHERRY, E. T. 1961. The fern guide. Doubleday and Co., Garden City, N. Y.

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A New Jamaican Cyathea

C. V. MORTON

A study of type specimens in the British Museum (Natural History) has shown that one of the Jamaican tree-ferns is currently passing under an untenable name, *Cyathea nigrescens* (Hooker) J. Smith. Since there is no published name available, the species is described below as new. However, the plant itself has been known for over 150 years; it is not uncommon in the Blue Mountains of Jamaica, where it appears to be endemic.

CYATHEA **hystricosa** Morton, *sp. nov.*

Caudex erectus usque ad 3.5 m. altus, hystricosus; stipites elongati usque ad 60 cm. longi, fusci, sublepidoti armati, spinis numerosis nigrescentibus saepe 10 mm. longis, basi valde paleacei, paleis rigidis fere subulatis lucentibus fuscis; lamina foliorum usque ad 2 m. longa, subtripinnata, coriacea, subtus plus minusve glauca, rhachibus fuscis puberulis basi paullo muricatis; pinnae usque ad 65 cm. longae et 20 cm. latae, lanceolatae, subsessiles, apice acuminatae, rhachillis basi muriculatis, furfuraceis supra sulcatis et hirsutis; pinnulae ca. 30-jugae, subsessiles, usque ad 9 cm. longae et 2 cm. latae, fere usque ad costam partitae, apice acuminatae, costa supra strigosa, subtus paleacea, paleis subbicoloribus atropurpureis margine pallido-marginatis lanceolatis, margine hinc inde nigrospinescentibus; segmenta 16-20-juga, 8-10 mm. longa, oblonga subfalcata obtusiuscula, integra, infima sessilia altera adnata, costulis supra glabris, subtus paleatis, paleis flavidis subbullatis et parcissime pilosis, pilis flavis sparsis; venae 9–12-jugae, basi furcatae; sori pauci, saepe 1- vel 2 (vel 3)-jugi, basales; indusia hemisphaerica membranacea persistentia brunnescentia cupuliformia, margine regularia integra, paraphysibus paucis.

Type in the herbarium of the British Museum (Natural History), London, collected in Jamaica by Wiles about 1805. (Morton photograph 8097).

This species has passed under the name *Cyathea nigrescens* (Hook.) J. Smith, e.g. in Maxon, No. Amer. Flora **16**: 74. 1909, and also in the Index Filicum. However, *C. nigrescens* is based on *C. arborea* (L.) J. E. Smith var. *nigrescens* Hook. (Sp. Fil. **1**: 17. 1844). Hooker divided *C. arborea* into two varieties, var. *α* *nigrescens* (of which *Polypodium arboreum* L. is cited as a synonym) and var. *β pallida* (based on *C. elegans* Hew.). Thus it is clear that var. *nigrescens* is only a varietal name for the typical variety, which should now be called var. *arborea,* and the species *C. nigrescens* (Hook.) J. Smith, which is based on the variety, becomes a straight nomenclatural synonym of *C. arborea* (L.) J. E. Smith. Hooker doubtless included several species in his concept of *C. arborea* var. *nigrescens,* for he cited specimens from Jamaica, Hispaniola, Martinique, St. Vincent, and Brazil, and possibly saw the one described above originally collected in Jamaica by Wiles, although this collection is not mentioned. The type of var. *nigrescens* must be the same as the type of *Polypodium arboreum* L., and this Wiles collection has nothing to do with that. It appears that the species represented by the Wiles collection has never been described under a tenable name, since when it has been recognized at all, it has always received the incorrect name *C. nigrescens.*

ADDITIONAL SPECIMENS EXAMINED:

JAMAICA: Beyond Vinegar Hill, vicinity of Cinchona, *Underwood* 3253. East of Cuna Cuna Gap, *Maxon* 9426, 9460. Maccasucker Bump, *Maxon* 9557. Stone Hole Bump, *Maxon* 9492, 9512. Gossamer Peak, *Maxon* 9219. Vinegar Hill, *Maxon & Killip* 827. John Crow Peak, *Maxon & Killip* 984. Morces Gap to Vinegar Hill, *Johnson* 1804. Trafalgar Gap, *Stoudt* 674. Pleasant Hill, *Harris* 7723 (BM; fide Maxon). Above Fort Stewart, *Purdie* (K; fide Maxon). Without specific locality: J. P. 46; *Sherring; Jenman; Hart* 80; *Home* (BM; fide Maxon); *Bancroft* (K; fide Maxon). So far as the labels indicate, this is a common species in the Blue Mountains at elevations between 725 and 1650 meters.

A note by John Smith on the type sheet in the British Museum reads: "Sir W. Hooker unites this and others under *C. arborea* (Plum. Fil. t. 1), differs essentially from this in the fronds separating from the stems as if articulate, leaving a clear rhomboid scar. This character is common to only a few species. In *C. nigrescens* and many others the lower portion of the stipes is permanent and forms the stem. I term this group *Cyathopteris* J. Sm. Sir W. Hooker relied implicity on his herbarium specimens. He scarcely ever took the living plant into view in drawing up his descriptions; such appeared to confuse him. If he had looked at the Garden representatives of this and *C. arborea* he would have paused before he united them as one species."

It is not possible to check Smith's observations regarding the "articulation" of the fronds from herbarium material; it is a fertile field for investigations in the wild. However, the species that he separated as "*C. nigrescens*" differs not only in this character but in several others, notably in the smaller darker scales of the caudex and stipe-bases (those of *C. arborea* being large and whitish), scaly secondary rhachises, yellow and only subbullate scales on the costules beneath (rather than white, bullate scales as in *C. arborea*), few pairs of sori, and especially a deeper indusial cup.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C.

The Gametophyte of Cystodium

LENETTE R. ATKINSON

One of the rare and little known ferns of the world is *Cystodium sorbifolium* (Sm.) J. Sm., a monotypic tree fern species of Malaysia. It is variously placed in taxonomic works, depending upon relationships postulated. The characteristics used are those of the sporophyte. Holttum (1963) includes *Cystodium* in his family Cyatheaceae, sub-family Cyatheoideae, tribe Dicksonieae, along with *Dicksonia* but says that more information is needed about this fern. Copeland (1947) places *Cystodium* as the third genus in his Pteridaceae, following *Thyrsopteris* and *Dicksonia*, and states that *Cystodium* is close to *Dicksonia* and to nothing else. Christensen (1938) places *Cystodium* tentatively in the family Dicksoniaceae, sub-family Dicksonioideae, as a probable derivative of *Dicksonia*. These authors, however different their views, agree on an affinity of *Cystodium* with *Dicksonia*.

Cystodium sorbifolium grows in wet lowland forests at elevations up to 1300 feet in contrast to tropical Malesian *Dicksonia* which grows in the high forest between 3300 and 9900 feet (Holttum 1963). A chromosome count from root tips, $2n = 112$, and at meiosis, $n = 56$ has been made recently at Kew Gardens, England (Roy and Holttum, 1965). This fern was collected in August, 1963, in New Guinea by R. E. Holttum, to whom I am indebted for the spores. Germination was excellent and the cultures grew well but slowly on peat in covered dishes.

The spore is tetrahedral, yellow in color and ornamented by a delicate but irregular network of ridges. The outer coat is fragile and parts of it crack and fall off on handling, yet it was two weeks after planting before the spore wall opened. Part, at least, of the reserve food is oil and a large droplet can be observed in the basal cell during the early stages of growth.

A filament of from 2–6 cells is produced, although often in later stages only one undivided cell is found at the spore end of the plate. Divisions in the terminal cell of the filament are oblique and an apical cell with three cutting faces is developed in a cordate plate. Some irregularity was observed in a few individuals: the apical cell may divide transversely, initiating an apical meristem at 4 weeks, or an apical cell may still be present in the thallus at 7 weeks.

The mature thallus (nine months) is characterized by a large unruffled wing and a heavy midrib 6–9 cells thick.

The first rhizoids contain chloroplasts which soon disappear. The wall is colorless and may remain pale or become golden brown with age. The rather short rhizoids are few and form behind the archegonia on the cushion.

No hairs of any sort have been seen.

It was 3 months before sex organs appeared. Antheridia were produced sparingly and were observed on small ameristic thalli growing among the rhizoids on larger thalli. The antheridium is of the less advanced type, that is, with a several-celled wall. Most, perhaps all, thalli in my cultures produced archegonia without having produced antheridia. The necks of the archegonia are massive with very little curvature.

DISCUSSION

The great difference between the gametophytes of 1) *Dicksonia* and the associated *Culcita* and *Cibotium* and 2) *Cyathea,* in the broad sense (Holttum 1963), is in the matter of hairs. Stokey (1930) found that the thallus of the Cyathea group bears hairs and that of the Dicksonia group does not. The hair develops from a special initial cut obliquely from the anterior face of a cell of the midrib at or near the notch. It becomes multicellular and is produced in numbers sufficient to be seen by the naked eye, at least in *Cyathea*. These are gametophytic structures and not associated with embryo formation or apogamy. *Dicksonia, Culcita, Cibotium* and now *Cystodium* are found to lack these hairs. Stokey reported minor differences between the two groups which are reflected also in *Cystodium*: the thallus is thicker and the antheridia are larger than those in *Cyathea*.

Thus morphological characteristics of the thallus of *Cystodium* suggest a close relationship with that of *Dicksonia.* The chromosome number, however, of *Cystodium*, $n=56$, does not agree with that of *Dicksonia,* since in the 5 species counted, $n=65$ (Brownlie 1957, 1961; Manton 1958, Roy and Holttum 1965). Nor does it fit that of the genera associated with *Dicksonia*: *Cibotium* counted in 2 species, $n=68$ (Manton 1958); *Culcita macrocarpa*, $n=66$-68 (Manton 1958). The chromosome number which comes closest to that of *Cystodium* is that of *Culcita* (subg. *Calochlaena*) *dubia* where $n=55$-58 (Manton in Holttum 1963).

It is perhaps too much to hope, in view of the great similarity among *Dicksonia* species, that a chromosome number nearer that of *Cystodium* will be found among the yet uncounted (about 22) species. The fact remains that the evidence from the gametophyte does not contradict an affinity of *Cystodium* to *Dicksonia*.

LITERATURE CITED

BROWNLIE, G. 1957. Cyto-taxonomic studies on New Zealand Pteridaceae. New Phyt. **56**: 207-209.

———. 1961. Additional chromosome numbers—New Zealand Ferns. Trans. Roy. Soc. N. Z. (Bot.) **1**: 1-4.

CHRISTENSEN, C. 1938. In Verdoorn's Manual of Pteridology.
COPELAND, E. B. 1947. Genera Filicum. Waltham, Mass.
HOLTTUM, R. E. 1963. Flora Malesiana, Ser. II Pteridophyta, pt. 2.
MANTON, I. 1958. Chromosomes and fern phylogeny with special reference to "Pteridaceae." Jour. Linn. Soc. London B. **56**: 73-90.
ROY, S. K. and R. E. HOLTTUM. 1965. New cytological records for *Cystodium* and *Dicksonia*. Amer. Fern Jour. **55**: 35-37.
STOKEY, A. G. 1930. Prothallia of the Cyatheaceae. Bot. Gaz. **90**: 1-45.

AMHERST COLLEGE, AMHERST, MASSACHUSETTS.

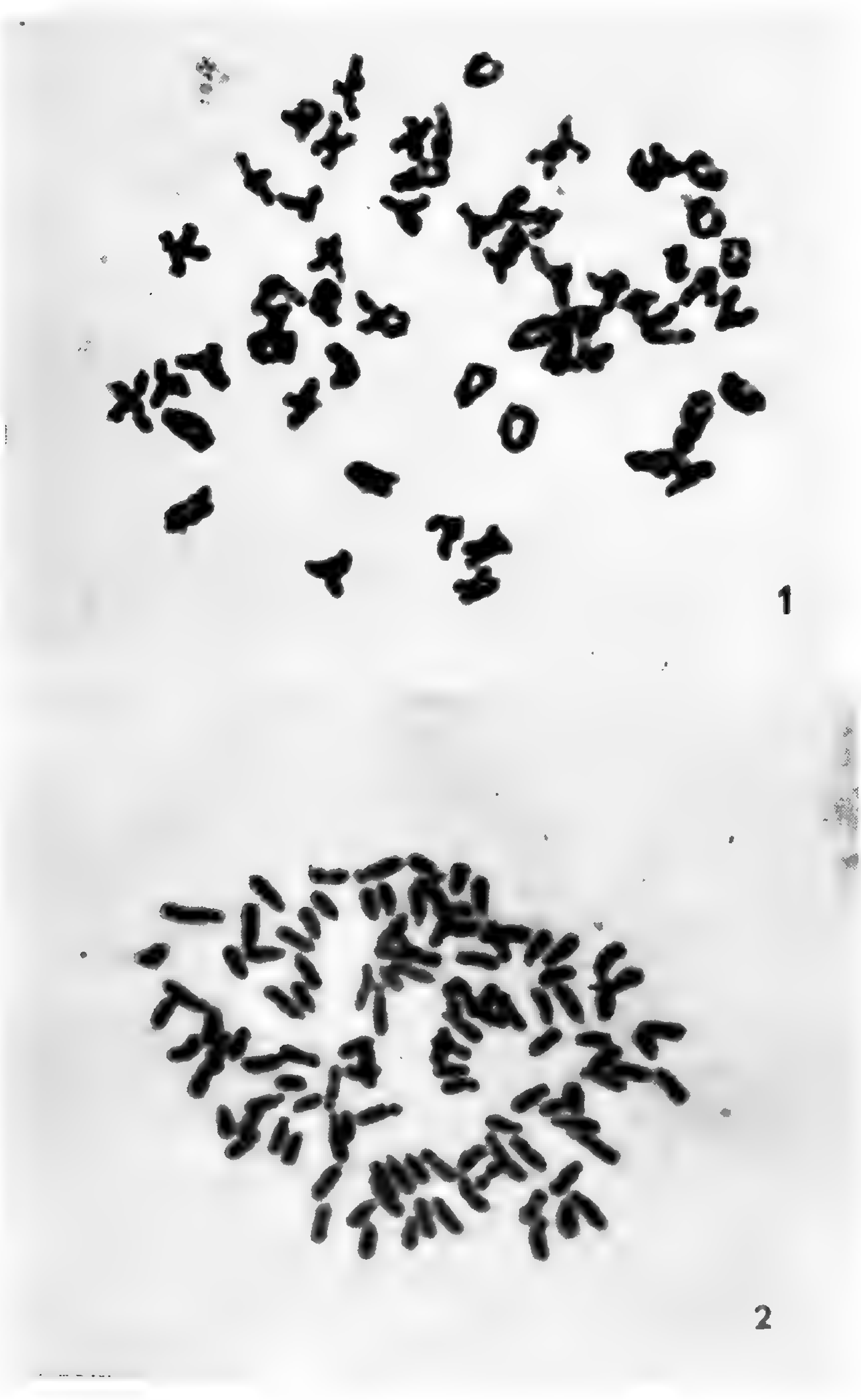
New Cytological Records for Cystodium and Dicksonia

S. K. ROY AND R. E. HOLTTUM

Young plants of *Cystodium* and *Dicksonia* were among collections made by Holttum in New Guinea in August, 1963, through the cooperation of the Division of Botany, Department of Forests, at Lae. Mr. J. S. Womersley kindly arranged for the despatch of the plants to the Royal Botanic Gardens, Kew, where they have made good growth. Roy has made cytological preparations from these plants.

Cystodium is a monotypic genus. Further notes upon it and references to previous literature are given in the accompanying paper on the gametophyte by Lenette R. Atkinson. *Cystodium sorbifolium* has been found in lowland forest in Sarawak, North Borneo, North Celebes, Ceram, and at many localities in New Guinea and neighboring smaller islands. Holttum found it common on steeply rising ground near two small streams. The stock is prostrate, covered with long hairs as in *Dicksonia;* the fronds may attain 250 cm in length. The young plants sent to Kew had fronds about 10 cm long; by July 1964 they had fronds about 50 cm long which were fertile.

Before fertile fronds were produced, Roy made cytological observations from root-tips; these were treated with paradichlorobenzene before fixation in acetic-alcohol, and then with snail enzyme to separate the cells. Clear preparations showing $2n=112$ resulted (Fig. 2). Subsequently, when fertile fronds were produced, preparations were made from sporangia at



CHROMOSOME COMPLEMENTS IN CYSTODIUM SORBIFOLIUM. FIGURE 1. DIAKINESIS SHOWING n=56 BIVALENTS. × 1000. FIGURE 2. ROOT TIP MITOSIS SHOWING 2n=112. × 1000.

meiosis, showing $n=56$ (Fig. 1). This result gives confirmation to the status of *Cystodium* as a genus distinct from *Dicksonia*. At the same time, there can be little doubt that, as judged by characters of the sporophyte, it is more nearly allied to *Dicksonia* than to any other genus. The difference in chromosome number between *Dicksonia* and *Cystodium* is very like the difference between the two subgenera of *Culcita* (66-68 for subg. *Culcita*, 55-58 for *C. dubia* in subg. *Calochlaena* which comprises the species of Malaysia, Australia and the Pacific; the approximate numbers are due in both cases to difficulty in obtaining satisfactory preparations). It would be not unreasonable to raise subg. *Calochlaena* to generic status.

Dicksonia hieronymi Brause grows at 4500-9500 ft. in mountain forest in New Guinea. A young plant in cultivation at Kew has yielded root-tip preparations showing $2n=130$. This agrees with the counts for three species in New Zealand by Brownlie, and for *D. arborea* (St. Helena, type species of the genus) in cultivation at Kew by Manton. It should be noted that *Dicksonia scabra* Wall., reported by Fabbri (1963) as a possible tetraploid ($n =$ c.123) is a species of *Dennstaedtia*, under which genus Fabbri gives further records.

LITERATURE CITED

FABBRI, F. 1963. Primo supplemento alle Tavole Chromosomiche delle Pteridophyta di Alberto Chiarugi. Caryologia **16:** 237-335.

KEW GARDENS, RICHMOND, SURREY, ENGLAND.

American Fern Society

ANNUAL MEETING IN 1965—The annual meeting of the Society will be held in conjunction with those of the American Institute of Biological Sciences at the University of Illinois, Urbana, Ill. The A. I. B. S. meetings are scheduled from August 15 to 20, and our formal meeting sessions, including the luncheon, will be held on August 16th. The American Fern Society will hold two or possibly three sessions for the presentation of papers, and may cooperate with other societies in sponsoring symposia.

A two day Fern Foray will be held in southern Illinois, on Friday and Saturday, August 13 and 14, leaving Sunday the 15th free to drive the 175 miles north to Urbana. Dr. Robert H. Mohlenbrock will be the leader of the Foray and he has suggested the following schedule:

Thursday afternoon, August 12th	Arrive in Carbondale
Thursday, 8:00 p.m.	Illustrated lecture
Friday, 8:00 a.m. to 5:00 p.m.	Field Trip
Friday, 8:00 p.m., August 13	Lecture
Saturday, 8:00 a.m. to 5:00 p.m.	Field Trip

Dr. Mohlenbrock writes as follows:—"The field trip should be divided into two full days to see the maximum number of ferns. I will also be happy to discuss other vascular plants encountered on the trip. I shall arrange a University bus for transportation and will equip myself with a battery-powered megaphone to describe the areas we drive through.

"Box lunches for the field trip may be purchased from the University cafeteria.

"There is a good possibility of finding 43 species of ferns and fern allies on the trip."

To register for the Foray, write direct to Dr. Robert H. Mohlenbrock, Department of Botany, Southern Illinois University, Carbondale, Illinois 62903. Tell him the number in your party, and whether you wish box lunches from the University cafeteria on the days of the Foray. This letter should reach Dr. Mohlenbrock by August 1st.

Request for motel or hotel rooms should be sent direct to the manager. The following, all in Carbondale, Illinois, are suggested: Franklin Hotel, Heritage Motel, Holiday Inn Motel, Plaza Motel, Uptown Motel. Write for reservations before August 1st if possible.

Report of the President for 1964

It is gratifying to be able to report that the Society is in good shape. The steadfast and energetic work of the various officers, and especially of the Editor-in-Chief of our Journal, is to be commended.

Our annual field foray preceding the American Institute of Biological Sciences meetings at the University of Colorado, August 23-28, was well-attended. We were most fortunate to have Dr. William A. Weber, who was also our local representative, and Mrs. Ruth A. Nelson, serve as our leaders. Dr. Weber guided us over the Flat-irons, some magnificent promontories above Boulder, where we saw several interesting ferns, including *Asplenium septentrionale,* and to several other choice areas in the vicinity of Boulder. Of especial interest were the great sheets of *Selaginella weatherbiana,* a species honoring Mr. C. A. Weatherby, that covered precipitous ledges in Boulder Canyon. Mrs. Nelson, assisted by a Park Ranger, guided us to some fine fern habitats in the Rocky Mountain National Park.

At the formal meeting in Boulder, on Monday, August 23, a fine program of contributed papers was given in the morning and part of the afternoon. Our Vice President, Donald Huttleston, who served as Program Chairman, had assembled some interesting papers for the occasion. The luncheon held at noon was attended by a small but enthusiastic group. Considering the fact that many of our professional members were unable to be with us at the meeting because they attended the International Botanical Congress held earlier in the month in Edinburgh, Scotland, we had a better attendance for all our functions than had been anticipated. The council also held its annual meeting in Boulder where various and pending items of business for the Society were dealt with.

During the year Dr. Warren H. Wagner, Jr., in addition to his several other duties for the Society, assumed the responsibility of being our representative to the Governing Board of the American Institute of Biological Sciences. He succeeded Dr. Walter H. Hodge, who is to continue as our representative to the American Association for the Advancement of Science.

The long-delayed publication of our membership roster was accomplished during the year. It evidences a strong Society and attests the sincerity and loyalty of its individual members. Our membership in 1964 remained essentially the same as that for 1963 although a substantial increase in dues occurred for the year.

It is hoped that every member read my "open letter," published in the July-September 1964 issue of the Journal, and, if so, that my appeal will not go unheeded. I omitted there the fact that since our Society has a tax exemption status with the Internal Revenue Service, all gifts to the American Fern Society are tax exempt.

Special service to the Society has been rendered this year by Dr. LeRoy K. Henry, who served as Judge of Elections, and by Professor Elmer A. Palmatier, who served as Auditor. The Society is indebted to both of them and appreciates very much their services.

I am sure that everyone is pleased that the Society bestowed upon Dr. Edgar T. Wherry an Honorary Membership. This is the very least it could do to show its appreciation to one who has been so magnanimous to the Society.

Recently, I felt a great personal loss in the death of Dr. H. L. Blomquist, a member of the American Fern Society since 1934, who was my good friend and major Professor when I attended Duke University many years ago.

It has been a distinct honor to me to serve as President of the American Fern Society during the past year and it is my desire to do my best to serve it well during the year 1965.

Respectfully submitted, DONOVAN S. CORRELL, *President.*

Report of the Secretary for 1964

The American Fern Society at the close of 1964 has 754 members living in all states of the union excepting Nevada, New Mexico and North Dakota, and in 27 countries outside the United States.

I regret to report the death during 1964 of eleven members (year in parentheses indicates date of joining the Society): Dr. W. C. Drummond (1956); Mrs. Gifford Ewing (1948); Mrs. W. S. Learned (1953); Mrs. Fay MacFadden (1953); Mrs. Elizabeth Sawyer (1961); two members of long standing—Mrs.

Arthur W. Doubleday (1928) and Mr. Henry Trudell (1919); three life members and members of long standing—Dr. H. L. Blomquist (1934) elected President of the Soicety in 1962, Mr. Francis Hunnewell (1915), Miss Gertrude Phair (1916); and the distinguished pteridologist and Honorary Member of the American Fern Society, Dr. E. B. Copeland (1948).

The annual meeting of the Society, held August 24 with the AIBS on the campus of the University of Colorado at Boulder, was attended by about thirty people. The president of the Society, Dr. Donovan Correll, presided at both the formal sessions and at the luncheon. A varied and interesting program was arranged by Dr. Donald Huttleston, Vice-President of the Society. Titles of papers follow in the order of presentation: "The gametophyte of *Cystodium* (Cyatheaceae)," by Lenette R. Atkinson; "Distributional records of the true ferns of Idaho," by William H. Baker; "Recent data on ferns of Georgia," by Wilbur H. Duncan; "Variation in *Equisetum* L.," by Richard L. Hauke (read by D. S. Correll); "Sporogenesis in *Cyrtomium falcatum*," by Norman P. Marengo and Mildred M. Marengo (read by Mrs. Marengo); "Leaf anatomy in some of the species of the genus *Cheilanthes*," by Paul Volz and Irving Knobloch (read by Paul Volz); "The phytogeography of some Galápagos Island ferns," by Ira L. Wiggins; "The phylogenetic position of *Anemia colimensis*," by John T. Mickel; "The log fern complex (*Dryopteris celsa* and its relatives) in eastern United States," by Warren H. Wagner, Jr.

Four of the five members of the Council were present at a meeting on August 23 when it regretfully accepted the resignation of Dr. Walter H. Hodge as representative of the American Fern Society to the Governing Board of AIBS. Dr. Warren H. Wagner has agreed to represent the Society for a four year term.

Respectfully sumbitted, LENETTE R. ATKINSON, *Secretary*.

Report of the Treasurer for 1964

The Society has finished another year in the black. The increase in dues caused some loss of membership, and as a consequence the receipts this year were not quite as high as anticipated. However, there was some increase over last year. With the increase in institutional subscription rates, effective January 1965, and with the increase in price of back issues, we can probably look forward to a further improvement in total receipts next year.

The Council decided to use some surplus cash-on-hand to reprint five additional back numbers of the Journal. This gives us a sufficient quantity of all numbers to meet the anticipated rise in orders for complete sets as new colleges open and college libraries expand. It is hoped that the sale of back numbers will be an increasing source of income for the Society, which in turn will be reflected in a larger number of pages in each year's issue of the Fern Journal.

Tax-exempt status was granted the Society by the Internal Revenue Service. This will permit members, of course, and others, to make gifts to the Society, and take income tax deductions in their own tax reports. It is hoped that this will bring about an increase in the number and in the size of bequests and gifts to the American Fern Society. At present, gifts to the Society consist mainly of the royalties on Dr. Wherry's "Fern Guide." However, these can be expected to decrease year by year, and something else must replace them for the Society to remain solvent.

Since this is to be my last year as Treasurer, thought must be given to a successor. I wish to repeat a suggestion made earlier, that a retired member of the Society who has had experience in some segment of the financial world volunteer his services!

The financial report for the year follows:

Receipts

Cash on hand, January 1, 1964		$1,597.82
Membership dues		
Arrears and Renewals	$1,939.02	
Sustaining	392.10	
New	230.70	
Advance payments	108.97	
Life	80.00	

		$2,750.79	
Subscriptions			
Arrears	6.15		
Current	235.30		
Advances	573.53		
		814.98	
Sale of back numbers		535.12	
Sale of reprints		260.52	
Gifts		382.22	
Extra charges, Journal articles		30.00	
Advertising		4.00	
Miscellaneous		3.11	
			4,780.74
			$ 6,378.56

Disbursements

American Fern Journal			
Vol. 53, No. 4	$ 869.21		
Vol. 54, No. 1	933.59		
Vol. 54, No. 2	825.64		
Vol. 54, No. 3	1,234.89		
		$3,863.33	
Reprints		324.91	
Envelopes, Mailing Journal		117.00	
Printing, Stationery		72.20	
Treasurer's expenses		127.41	
Secretary's expenses		102.44	
Shipping and handling back numbers		68.87	
Editor's expenses		5.92	
Life Membership Fund		80.00	
Reprinting back numbers		930.00	
A. I. B. S. membership		400.00	
Fern Foray		55.06	
Miscellaneous		10.51	6,157.65
Cash on Hand, January 1, 1965			$ 220.91

Statement December 31, 1964

Assets

Cash in Industrial National Bank	220.91

Cash in Greenpoint Savings Bank		
Bissell Herbarium Fund	850.76	
Life Membership Fund	1,330.67	
Una Weatherby Fund	3,595.23	
Accounts receivable	119,25	
Inventory, American Fern Journal	6,202.50	
Library	396.00	
		$12,715.32
Liabilities		
Advance dues	108.97	
Advance subscriptions	573.53	
Fund Balance		
Bissell Herbarium Fund	850.76	
Life Membership Fund	1,330.67	
Una Weatherby Fund	3,595.23	
General Fund	6,256.16	
		$12,715.32

Respectfully submitted, RICHARD L. HAUKE, *Treasurer.*

Report of the Auditing Committee

I hereby certify that I have seen the books and accounts of Dr. Richard L. Hauke, Treasurer of the American Fern Society, Inc., and have obtained confirmation of the correctness of the Society's balances on hand as set forth in detail in the accompanying report of the Treasurer. ELMER A. PALMATIER, *Auditor.*

Report of the Judge of Elections

The results of balloting for officers of the American Fern Society are as follows:

For President
- Donovan S. Correll 342
- Mildred Faust 1
- D. G. Huttleston 1

For Vice-President
- Irving W. Knobloch 337
- David Emory 1
- Wilbur Duncan 1

John Mickel 1
C. V. Morton 1
Thomas Pray 1
Kenneth Wilson 1

For Secretary

Lenette R. Atkinson 342

For Honorary Member

Edgar T. Wherry 339

I therefore declare the following candidates elected to office: Donovan S. Correll, President; Irving W. Knobloch, Vice-President; Lenette R. Atkinson, Secretary.

It is also my privilege to declare Dr. Edgar T. Wherry elected to Honorary Membership in the American Fern Society, Inc.

Respectfully submitted, L. K. Henry, *Judge of Elections.*

New Members

Mr. A. H. Arndt, Edelweiss Gardens, P. O. Box 66, Robbinsville, N. J.
Mrs. L. C. Bock, Jr., 823 Tanglewood Drive, Bryan, Texas 77803
Mrs. Eugene F. Bolduc, 2131 Vallejo St., St. Helena, Calif.
Mrs. M. J. Butler, 512 Fairway Drive, Aberdeen, Wash.
Mr. John R. Geary, Mount Shasta, Calif. 96067
Mrs. William Hebert, 223 E. Canterbury Drive, Stockton, Calif. 95207
Mrs. B. W. Heitkotter, 306 Irene St., Bakersfield, Calif. 93305
Miss Mary Howard, Box 345, Bolinas, Calif. 94924
Miss Juanita Norsworthy, Route 1, Stockton, Georgia
Mr. Norman B. Parsons, 91 Glengrove Ave., West, Toronto 12, Ontario, Canada
Mrs. Muriel Perz, 2141 West 29th St., Long Beach, Calif. 90810
Dr. Richard H. Sharrett, 1190 Park Ave., Plainfield, N. J. 07060
Mr. William R. Smith, 20 Old Millstone Lane, Lafayette, Calif. 94549
Mrs. Arthur Stucky, P. O. Box 306, Stateline, Calif. 95729
Mrs. Joseph T. West, 109 South County Line Road, Hinsdale, Illinois
Mr. Stillman Wright, 5822 Conway Road, Bethesda, Maryland 20034

Changes of Address

Miss Harriet E. Baker, 1508 Campbell Ave., Thousand Oaks, Calif. 95360
Mr. Richard A. Benedict, 63-145 Alderton St., Rego Park, N. Y. 11374
Mr. Fred C. Boutin, 605½ West Duarte Road, Monrovia, Calif.
Mr. Floyd L. Brown, P. O. Box 764, Clarksville, Tenn. 37041
Mrs. Kenneth L. Clarke, 1420 E. Orange Grove Ave., Orange, Calif. 92667

Mrs. Blanche E. Dean, 2242 Arlington Ave., Apt. 6, Birmingham, Ala. 35205
Miss Gertrude E. Douglas, 175 Jay St., Albany, N. Y. 12210
Mr. Dara E. Emery, c/o Santa Barbara Botanic Garden, 1212 Mission Canyon Road, Santa Barbara, Calif.
Dr. Mildred E. Faust, 1057 Lancaster Ave., Syracuse, N. Y. 13210
Mrs. John Zell Gaston, Box 57160, Webster, Texas
Dr. Richard Hevly, Dept. of Biology, Wisconsin State Univ., Superior, Wisc.
Dr. Herbert H. Hollinger, 212 Cleveland Road W., Huron, Ohio 44839
Mr. Ralph S. Hudson, Rt. 2, Box 1265, Nokomis, Florida 33555
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Pg. 162, line 10: For "Duforstrasse" read "Dufourstrasse"
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Pg. 167, following line 12: Insert, "McArthur, Mrs. W. E., 3547 Richmond St., Jacksonville, Florida 1964"

Pg. 167, line 3 from bottom: Delete entire line; insert in its place, "Marnier-Lapostolle, Mr. Julien, Jardin Botaniqué, St. Jean-Cap-Ferrat, France"

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Pg. 174, line 4: For "Tryon, Mrs. Alice F." read "Tryon, Dr. Alice F."

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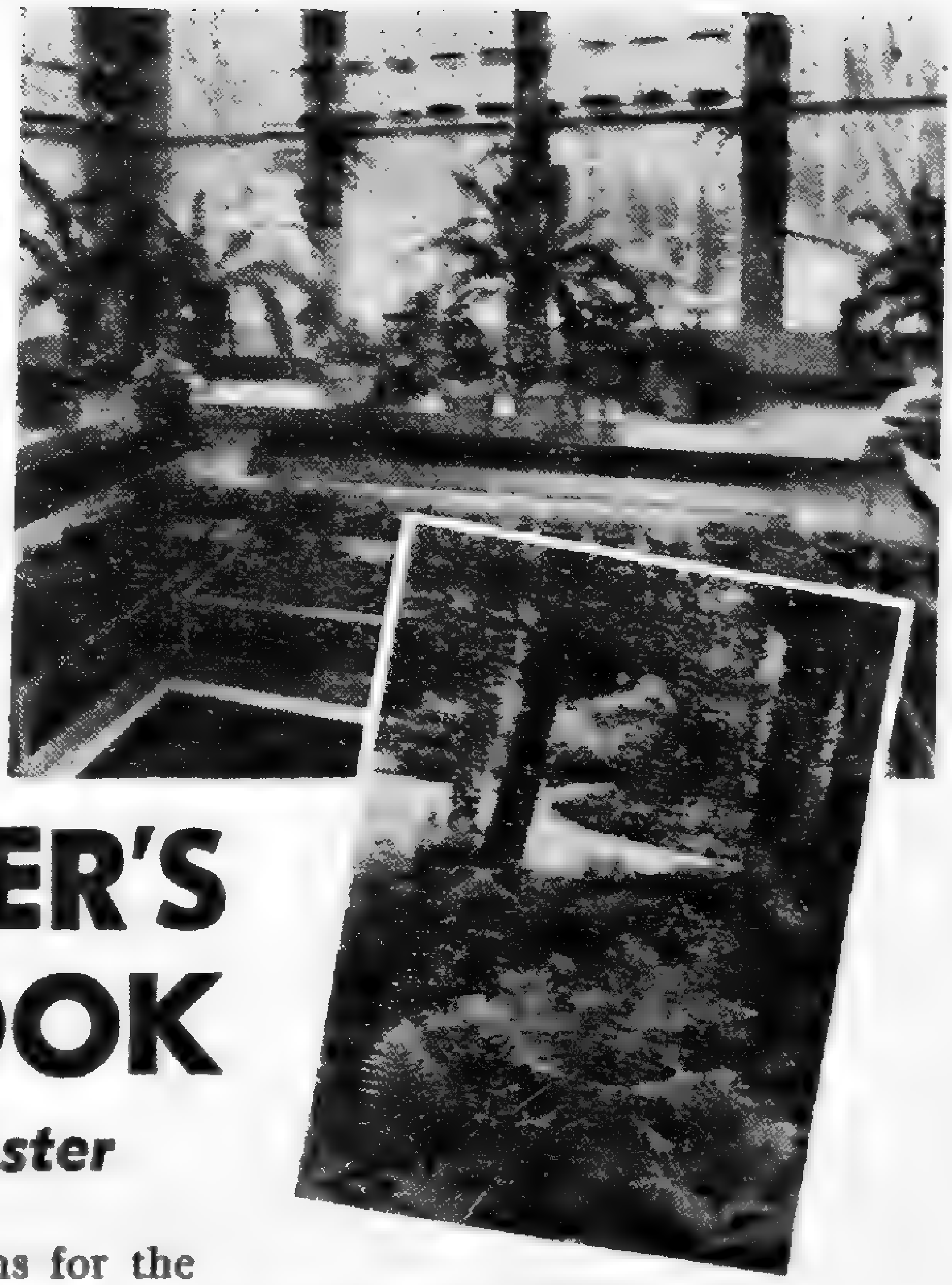

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Vol. 55 April-June, 1965 No. 2

American Fern Journal

A QUARTERLY DEVOTED TO FERNS

Published by the

AMERICAN FERN SOCIETY

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American Fern Journal

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A Parcel of Cameroon Ferns

ALICE F. TRYON

Botanically, Africa is one of the brightest of continents, for collectors and botanists from many nations have worked on the flora over 300 years. American botanists[1] have done relatively little in the area, but speed and convenience of modern travel grant new opportunities to see the unique vegetation of this continent. Our opportunity came with an invitation to attend the 50th Jubilee celebration of the National Botanic Gardens of South Africa, at Kirstenbosch, near Cape Town in South Africa. The program included a 3200 mile trip to the Cape Peninsula, the *Podocarpus* forest at Knysna, the Karroo deserts, and the eastern provinces of Natal and Transvaal. We combined with this a trip to Mount Kenya to observe the montane flora of east Africa. We made several trips out of Nairobi and camped on Mount Kenya with Dr. and Mrs. B. Verdcourt. His work is primarily on flowering plants but he has published also on mollusks and on some African species of *Adiantum*. We visited Cameroons Mountain, the highest land mass in west Africa, to sample the montane flora of west Africa. Schelpe (1951) published a paper in this journal on the Pteridophyta of Mount Kenya and is currently preparing a treatment on the ferns of South Africa. An account of the ferns of former French Cameroun has been published by Mme. Tardieu-Blot, H. Nicklès and

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[1] Two members of the American Fern Society have collected and studied west African plants. Mrs. Winifred J. Harley (1957) has published an illustrated Handbook of Liberian Ferns, and Prof. J. T. Baldwin traveled extensively in Liberia in 1947-48 and has published several papers on native and cultivated plants relating to his travels in West Africa.

Volume 55, No. 1, of the JOURNAL, pp. 1-48, was issued March 25, 1965.

H. Jacques-Felix (1949).

We collected on Cameroons Mountain during the last week of October and the first in November of 1963. To my knowledge, my husband, Rolla Tryon, and I have been the first American botanists to collect extensively on the mountain, although David Fairchild visited it on one of the Armour voyages in 1927. There are about 119 species of pteridophytes reported from the mountain and our collections, deposited at the Gray Herbarium and at Kew, include nearly half of them. The treatment on the Ferns and Fern-allies of West Tropical Africa, prepared by Alston (1959), which is a supplement to the second edition of the Flora of West Tropical Africa, has been my most useful reference and I have depended much upon it for ranges and records from Cameroons Mountain.

The Federal Republic of Cameroon is centrally located at the sinus on the west African coast. It is one of the newly independent countries formed from a British mandate, south of Nigeria and a somewhat larger French mandate, north of Gabon. The mountain is a few miles inland from the coast of the Gulf of Guinea. It is a massive form reaching 13,350 feet altitude with a somewhat elongated base about 28 by 30 miles. Meteorological observations are practically non-existent on the mountain itself but at the coast the monthly average temperature ranges between 70 and 90° F. Snow may occur on the upper slopes of the mountain but does not persist. Cameroons Mountain is in the belt of converging trade winds and an average annual rainfall of some 10 yards, one of the heaviest in the world, is reported at the coast near the mountain. At Buea, 3000 feet on the mountain, the average rainfall is 114 inches annually and 122 inches is reported for the summit. Cameroons Mountain is the only active member in the chain of volcanic mountains extending from Lake Chad, in interior Africa, through Cameroon, and out into the Gulf of Guinea to include the islands of Fernando Po, Principe, São Tomé and Annobon. The most recent eruption occurred in 1959. It is estimated that the eruptions began in the Cretaceous and about 300 cubic miles of material has been ejected. A Plio-Pleistocene basaltic layer about 1,000 meters thick caps the summit and slopes. Eight eruptions have been reported since 1800, the most spectacular of these was in 1922 when six craters erupted, forming a lava-flow 3000 feet wide which produced great clouds of steam as it entered the Gulf of Guinea.

There are some accounts of early Greek and Portuguese voyages down the west African coast as far as Cameroon but there is no formal record of explorations near the mountain until 1841. The first ascent was made by the botanist, Gustav Mann, of Hanover, sent out by the British Admiralty. He collected first on Fernando Po, and made the remarkable discovery of *Podocarpus* on the Island of São Tomé which was the first record of the Coniferae in west tropical Africa. Mann began his ascent of the mountain in December 1860 and part way up was met by the party led by the British explorer Richard Burton, the Baptist missionary Alfred Saker, and a Portuguese judge named Calvo. Together they reached one of the summit peaks, which they named Mount Albert, in January 1861. Mann botanized in the region for the next three years and collected about 3000 flowering species and these specimens came to the attention of Sir Joseph Hooker, Director of the Royal Botanic Gardens at Kew.

The vegetation of Cameroons Mountain is rather broadly delineated by R. W. J. Keay (1955) and includes the following three major vegetational zones. *Montane Forest* extends up to 6000 feet, the upper portion of which is covered for long periods by clouds and is characterized by many epiphytes. *Montane Woodland* occurs between 6000 and 8500 feet, is drier and much of the zone is occupied by grassland which has been affected by burning. Above this is a transition to *Montane short-grassland* occurring above 10,000 feet. The woodland grass areas are of much the same composition as the lower portion of the short-grassland. Our collections are from the southeastern side of the mountain, largely near Buea at an elevation of about 3000 feet, and following the road to the high frequency station at 8500 feet. In cleared areas and at the forest edge, around Buea epiphytes were abundant, especially on palm trunks, among them *Oleandra distenta*, *Polypodium (Phymatodes) Scolopendria* and *Asplenium hemitomum*. *Selaginella Soyauxii* was weedy in gardens and appeared especially aggressive in taro patches. *Pityrogramma calomelanos* var. *calomelanos*, an introduced American species, was planted as an ornamental and was spontaneous along road cuts. We also found it in areas apart from human habitation where it was well established and integrated in the native flora.

Our richest collecting was in a ravine about 200 feet above Buea. This was approached along the dry stream bed and was bordered by steep walls of volcanic rock with some open places affording growth of large trees and lianas. Three species of *Selaginella* occurred together in soil pockets in the rocks, *S. Kalbreyeri*, *S. versicolor* and *S. Vogelii*. Large plants of the latter had a distinctive, irridescent-blue overcast to the delicate sprays of leaves. Robust plants of *Tectaria camerooniana* grew in the humus near the stream bank and had leaves nearly two yards long. Another coarsely cut fern here was *Coniogramme africana* with leaves once pinnate and with less than 10 pinnae — each of these about 10 inches long—and pale, straw colored petioles. The genus is placed near *Pityrogramma* as the sporangia are exindusiate along the veins and the rhizome bears scales. It is peculiar in being almost exclusively Old World in distribution except for a species in Mexico. The most imposing fern in the ravine was *Marattia fraxinea*. Each plant had about a dozen leaves approximately eight feet tall with bright maroon colored petioles striped with white pneumatophores (ventilating tissues), arising from the massive rhizome. We also collected the rare orchid *Manniella Gustavii* in this ravine.

In open places in the forest at about 5000 feet we found a large colony of the tree fern *Cyathea Manniana* (Fig. 1). This is one of the species in which the base of the scales on the petioles and croziers become indurated into prickles and make collecting difficult. At the edge of the forest at 6000 feet we collected the large epiphyte *Drynaria Volkensii*. This is similar to *Platycerium* in habit—the old leaves persisting and forming humus upon which new portions develop. A second epiphyte, a small plant of *Asplenium*, had become established on the *Drynaria*. *Lycopodium ophioglossoides* also hung from the tree in long, lax, hanks.

In the montane woodland at 7800 feet we found *Anogramma leptophylla* and this is the first record of its occurrence in west Africa. It grew luxuriantly on bare soil under a rock ledge much as we found it on Loma Lachay, near Lima, Peru. It has a relatively wide distribution and Alston particularly noted its absence in west Africa. It might be easily overlooked, for plants usually grow under some rock shelter and mature ones are from 5 inches to less than an inch tall. Except for this and another species on Ascension Island, the species of *Anogramma* are wholly American. *Anogramma leptophylla* is reported to be diploid in New Zealand and tetraploid in the western Himalayas. The biology of the species may be unusual for it is reported to produce perennial gametophytes which can survive dry periods and produce lobes from which new sporophytes arise. In the grassland at 8500 feet there were numerous rocks with crevices and soil pockets in which leathery leaved *Dryopteris Pentheri* and *Athyrium Schimperi* were abundant and depauperate plants of *Pellaea quadripinnata* were less common.

A few species we collected apparently have not been reported from Cameroons Mountain. In addition to *Anogramma*, mentioned above, these are *Asplenium hemitomum* which grew on the trunk of an oil palm at 3000 feet, near Buea, *Ctenitis Barteriana* on a lava wall in the ravine above Buea, and also in the same locality, *Thelypteris cruciata*, which is not reported from Cameroon.

The first account of the flora of Cameroons Mountain was by Sir Joseph Hooker (1864). He was primarily interested in the geographic relationships of the species occurring above 5000 feet and observed that the montane flora is relatively poor; and that there is a preponderance of Ethiopian (Abyssinian) forms —most of the genera and over half of the species are natives of

(ABOVE). A GROVE OF TREE FERNS, CYATHEA MANNIANA IN RIGHT CENTER, IN A FOREST OPENING, NORTHWEST OF BUEA, AT 3200 FEET. TRUNKS ABOUT SIX TO TEN FEET HIGH. FIG. 2. (BELOW). ADIANTUM PHILIPPENSE ON A BANK NEAR MUTENGENE, AT 2000 FEET IN THE CAMEROONS.

Ethiopia. These and the other relationships he noted have been evaluated by Keay and considered still applicable. His observations on the poverty of the flora and its relationships with the flora of east Africa can be exemplified among the Pteridophyta.

In the following paragraphs I have taken up some of the floristic relationships mentioned by Hooker and to illustrate these I have cited examples mainly of the Pteridophyta we studied and collected in the Cameroons. There appear to be no endemic species on the mountain aside from a few, as *Asplenium Adamsii,* recently described from limited collections and which may prove to be more widely distributed. Frequent vulcanism resulting in extensive burning and the porous volcanic rocks which retain little moisture are undoubtedly factors affecting the poverty of the whole Cameroons Mountain flora. The lower altitude of Cameroons Mountain, about 6000 feet lower than the high eastern peaks, Kilimanjaro and Kenya, has also been considered in explanation of the more limited flora. The lesser height may have been critical during warm periods of the Pleistocene when the lower summits may have been too warm to support the montane vegetation.

The island of Fernando Po about 32 miles southwest of Cameroons Mountain has the nearest high mountain, reaching 9800 feet. Exell (1944) in his work on the islands in the Bight of Biafra drew some interesting comparisons with adjacent areas. He indicated that 160 species not on the other islands occur on both Cameroons Mountain and Fernando Po. One of these, *Polystichum fuscopaleaceum,* we found growing at 8500 feet on the mountain; it is also reported from Bamenda in the eastern Cameroon highlands. Others, such as *Blotiella* (*Lonchitis*) *gracilis, Pteris camerooniana* and *Nephrolepis pumicicola* have been reported from the Cameroons and some of the adjacent islands. The slightly richer pteridophyte flora of Fernando Po includes several species that are not on Cameroons Mountain, such as *Osmunda regalis,* which is widely distributed in Europe, Asia, North and South America and in eastern, southern and western Africa. It occurs in the eastern highlands near Bamenda in the Cameroon and on Fernando Po but it has not been reported from Cameroons Mountain.

The floristic relationship that Hooker remarked upon as strongest is with Ethiopia (Absyssinia). This, and relationships with the east African mountains, are shown by many genera of flowering plants and in the pteridophytes by *Coniogramme africana*, which also occurs in Kenya, *Diplazium zanzibaricum* from the east African mountains and Zanzibar, *Selaginella Soyauxii* which occurs eastward in Uganda and *S. versicolor* which extends from Sudan to Nyasaland in east Africa. Most of the species we collected on the mountain, among them, *Dryopteris Pentheri, Pellaea quadripinnata, Trichomanes borbonicum, Asplenium abyssinicum* and *A. aethiopicum*, occur also in eastern and southern Africa.

Some species we found on the mountain, as *Drynaria Volkensii, Polypodium (Phymatodes) Scolopendria* and *Asplenium unilaterale*, are widely distributed in the tropics of Africa and Asia. Comparative study of these plants throughout their range is much needed as shown by the work on the *Pteris quadriaurita* complex by Walker (1958). The name *Pteris togoensis* is used by Alston for the Cameroon plant of this complex although the relationship of American material is still a problem. Cytological reports have been made for some of the widely distributed species, such as *Cheilanthes farinosa*, which occurs in Asia, Arabia, east and west Africa, Malesia, Mexico, Central and South America, and plants from east Africa were reported to be diploid, tetraploid, and apogamous triploids. *Adiantum philippense* (Fig. 2) was reported to be an apogamous triploid in Ceylon and in south Africa, but has not been studied in other areas of Africa or Asia nor in Australia, Mexico, or Central America.

The distribution of disjunct species, particularly those showing relationships between Cameroons Mountain and Britain, interested Hooker. He examined the kinds of propagules produced by plants showing these relationships and found them to be structurally adapted for clinging or to have minute seeds. The manner of dispersal is one factor of these distributions. Specific ecological and climatic requirements of the plants are likewise involved for such epiphytes as *Lycopodium ophioglossioides*, pendulous on trees usually above 3000 feet, and *Trichomanes borbonicum* also on trees at higher altitudes, undoubtedly have particular growth requirements. Geological events, as Pleistocene glaciation which influenced migrations of floras, and the climatic changes of the period are additional critical factors. These problems of biogeography which concerned Sir Joseph Hooker and his correspondents, including Asa Gray and Charles Darwin, are still live topics. New information on rock magnetism, migration of land masses, topography of ocean bottoms and new records from the radiocarbon dating of fossil material provide additional data. The explanation and resolution of the problems of biogeography will be implemented by these but are also dependent upon our knowledge of the kinds and distribution of ferns, among other plants, and upon our knowledge of the plants on Cameroons Mountain, among other mountains.

LITERATURE CITED

ADAMS, C. D. 1957. Observations of the Fern Flora of Fernando Po. Journ. Ecol. **45**: 479-494.

ALSTON, A. H. G. 1959. The Fern-Allies of West Tropical Africa. Flora of West Tropical Africa. ed. 2. Suppl.

EXELL, A. W. 1944. Catalogue of the Vascular Plants of S. Tomé (with Principe and Annobon). British Museum. London.

HARLEY, W. J. 1957. Handbook of Liberian Ferns. Ganta, Liberia.

HOOKER, J. D. 1864. On the Plants of the Temperate Regions of the Cameroons Mountains and Islands in the Bight of Benin. Jour. Proc. Linn. Soc. [Botany] **7**: 171-240.

KEAY, R. W. J. 1955. Montane Vegetation and Flora in the British Cameroons. Proc. Linn. Soc. Lond. **165**: 140-143.

SCHELPE, E. A. C. L. E. 1951. The Pteridophyta of Mount Kenya. Amer. Fern Jour. **41**: 65-74.

TARDIEU-BLOT, M., H. NICKLÈS and H. JACQUES-FELIX. 1958. Contribution a la Flore et a l'Ècologie des Fougères du Cameroun. Etudes Cam. **2**: 81-112.

WALKER, T. G. 1958. Hybridization in some Species of Pteris L. Evolution **12**: 82-92.

GRAY HERBARIUM, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Cup Ferns (Dennstaedtia) Cultivated in California

BARBARA JOE[1]

The cup ferns cultivated in southern California are finely divided ferns of large to medium size, and sometimes are used as background foliage. Little known to the gardening public, they may be recognized by the characteristic cup-like marginal structures on the under side of the fronds. The sporangia are borne within these cups. With the exception of *Dennstaedtia punctilobula*, a temperate North American species, all are tropical species.

Once these plants are established in gardens they require little care except watering. Today they are most frequently found in older gardens where they were planted before the era of philodendrons and other foliage plants of present popularity. The Huntington Estate in San Marino, California, has a well established bed of *D. davallioides* in its Japanese tea garden. Dennstaedtias rarely are found in the nursery trade and plants are primarily acquired through the generosity of fern gardeners. New plants are started easily from division of a mature plant. Some gardeners object to the wide-creeping habit of *D. cicutaria* and *D. davallioides*. However, I have found them easy to control by occasionally pulling them out of trespassed areas. During the winter months these plants undergo a period of rest. They are at their best in the spring and summer months. Although capable of withstanding more abuse than many other ferns, their requirements are basically the same; shade, a moist friable soil, some protection from wind, and fairly good drainage. It is doubtful if these ferns would survive in areas with long cool winters.

Dennstaedtias in general are large to medium sized ferns with creeping, branched, hairy rhizomes. The fronds usually are broadest at the base and may be once to four times pinnate. The veins are free, forked, and on fertile fronds bear sori at their tips. The indusium and leaf-margin form a cup-like structure

[1] Mrs. Barbara Joe Hoshizaki.

holding the sorus. There are about 70 species native to the tropics and one species native in temperate areas.

The following key distinguishes the species known to be cultivated in California.

Hairs present on upper surface of frond; surface not glossy; axis on upper surface of tertiary pinnae not flanked by an herbaceous pleat-like wing:

Many of hairs on under surface gland-tipped; frond narrowly deltoid to lanceolate, bipinnate-pinnatifid ....*D. punctilobula*

Hairs not gland-tipped; frond deltoid, tripinnate-pinnatifid:

Hairs densely concentrated in rachis groove; frond dull green, to 15 dm. long; rhizome 12 cm. in diameter or more, in cultivated plants mostly wide-creeping on surface of soil ....*D. cicutaria*

Hairs more or less evenly distributed over surface of rachis; frond medium green, to 1 m. long; rhizome 5-6 mm. in diameter, creeping beneath surface of soil . *D. davallioides*

Hairs essentially absent from upper surface of frond; surface glossy; axis on upper surface of tertiary pinnae flanked on each side by pleat-like wing almost perpendicular to leaf surface .. . *D. bipinnata*

DENNSTAEDTIA BIPINNATA (Cav.) Maxon. (*D. adiantoides* (Willd.) Moore)

Rhizome about 6 mm thick or more, short-branched beneath the surface of the soil; frond deltoid, 1 m. long, tripinnate; larger tertiary pinnae pinnatifid into 5–7 lobes, each lobe apically toothed, the axis on upper surface of tertiary pinnae (or unit bearing the ultimate segment) flanked on both sides by a herbaceous pleat-like wing continuously to the next axis; surfaces of fronds essentially glabrous, glossy above; sori cylindrical to subcylindrical, borne in sinues of ultimate segments.

American tropics, including southern Florida. Semi-hardy. Semi-evergreen.

This fern is distinguishable from the other three species by the glossy foliage and the small pleat-like wings on the upper surface of the tertiary axes (Fig. 1).

DENNSTAEDTIA CICUTARIA (Sw.) Moore. (*D. rubiginosa* (Kaulf.) Moore)

Rhizome 12 mm. thick or more, in cultivated plants mostly wide-creeping on surface of the soil, under surface in native plants; fronds deltoid, dullish green, to 15 dm. long, tripinnate; larger tertiary pinnae deeply pinnatifid into about 11 lobes, each lobe apically bluntly toothed; upper surface of frond bearing whitish or reddish brown hairs, the hairs particularly abundant on rachis and in the rachis groove, the main rachis frequently zig-zag; sori borne in sinuses of the ultimate segments.

American tropics. Semi-hardy. Semi-evergreen.

The long-creeping, thick rhizomes bearing large, somewhat drooping fronds, is the most conspicuous feature of this species. Recently Tryon (1960) has merged *D. rubiginosa* and *D. cicutaria*, stating that insufficient differences exist between the two

FIGURE 1. DENNSTAEDTIA BIPINNATA, PART OF A PINNA. FIGURE 2. D. CICUTARIA, PART OF A PINNA.

to warrant separation. Traditionally *D. rubiginosa* has been separated from *D. cicutaria* by the abundance of hairs on the under surface of the leaves, whereas such hairs are few on the fronds in *D. cicutaria*. Our cultivated plant is the one formerly called *D. rubiginosa* (Fig. 2).

DENNSTAEDTIA DAVALLIOIDES (R. Br.) Moore. Lacy Ground Fern.

Rhizome about 6 mm. in diameter, wide-creeping under the soil; frond deltoid, medium-light green, to about 1 m. long, tripinnate; leaf blade very thin; larger tertiary pinnae pinnatifid into about 9 lobes, these apically toothed; rachis and major veins with scattered whitish hairs; sori borne in sinuses of ultimate segments.

Australia and Tasmania. Semi-hardy. Semi-evergreen.


3


4

FIGURE 3. DENNSTAEDTIA DAVALLIOIDES, PART OF A PINNA. FIGURE 4. D. PUNCTILOBULA, A PINNA.

This fern is more delicately cut and with a thinner blade than those of *D. cicutaria* and *D. bipinnata.* The broad deltoid frond and lack of glandular hairs separate it from *D. punctilobula* (Fig. 3).

DENNSTAEDTIA PUNCTILOBULA (Michx.) Moore. Hay-scented Fern.

Rhizome about 6 mm. in diameter, creeping under the soil; frond narrowly triangular to lanceolate, to 4-7 dm. long, bipinnate-pinnatifid; larger secondary pinnae pinnatifid into about 13 bluntly toothed segments; rachises with acute, simple hairs intermingled with gland-tipped hairs; sori borne in sinuses of ultimate segments.

Newfoundland, eastern United States. Hardy. Deciduous.

The narrower fronds and presence of gland-tipped hairs readily separates this plant from the other cultivated species. At present I know of no specimen of this species established in southern California, although living plants have been purchased from Oregon and the eastern states from time to time (Fig. 4).

Ferns most likely to be misidentified as *Dennstaedtia* are the closely related *Microlepia,* which has a hood-shaped indusium that is placed submarginally and opens on the side facing the apex of the segment. *Dennstaedtia* has a cup-shaped indusium located marginally, and opens at the top. Other species of *Dennstaedtia* reported to be cultivated in the United States are *D. smithii* Moore from the Philippines, and *D. dissecta* from the American tropics.

I wish to acknowledge the kind help of C. V. Morton, of the United States Museum, and of R. M. Tryon, of the Gray Herbarium, Harvard University during preparation of this paper.

LITERATURE CITED

TRYON, R. M. 1960. A review of the genus *Dennstaedtia* in America. Contr. Gray Herb. 187: 23-52.

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A Pteridophyte Botanical Garden

HELEN ROSS RUSSELL

When we purchased our home we acquired also a trapezoidal piece of land at the end of the backyard about 65 × 20 × 55 × 15 feet. The northeast corner of the plot was a good 2 feet lower than the back yard. The southwest corner—6 inches higher. Midway across the plot was a bank with a 45 degree slope.

The plot was surrounded by trees on four sides with a dead and decaying wild cherry tree in the center. The ground was covered with vegetation: mostly Broad-leaved dock (*Rumex obtusifolius)* interspersed with Gill over the ground *(Nepeta hederacea)* and Burdock *(Arctium lappa)* on the higher southern section, and an almost pure stand of Celandine poppy *(Chelidonium majus)* on the lower northern section. Poison ivy flourished along two sides of the property line.

It seemed like "a good piece of land to own" because it would serve as a buffer between our property and a potential building lot. But it looked like a miserable piece of land to own if you cared about yards and growing plants.

Even after we cut down the old and dying wild cherry trees on our property, pushed over the dead tree in the middle of the plot, pulled the hundreds of celandines, poisoned the poison ivy and dug out the dock, the area looked hopeless.

The trees on our neighbors' properties shaded one part or another all through the day and the terrain was neither suited to gardening nor mowing. So we dubbed it "our woods" and decided to specialize in ferns and fern allies.

Our first ferns were common ones of the area. Sometimes they were snatched from destruction by bulldozer and backhoe. Sometimes they were carefully selected from abundant patches in woodland areas. At all times they were lifted with soil on the roots and planted in holes well supplied with leaf mold.

The second spring we watched Royal fern, *Osmunda regalis,* Interrupted fern, *Osmunda claytoniana,* Cinnamon fern, *Osmunda cinnamomea,* Lady fern, *Athyrium asplenioides,* Christmas fern, *Polystichum acrostichoides,* Ostrich fern, *Pteretis nodulosa,* and Senstive fern, *Onoclea sensibilis,* unfold their various fronds and produce spores along the northern edge and across the center of the area. At the same time Hayscented fern, *Dennstaedtia punctilobula,* Eastern bracken, *Pteridum latiusculum,* New York, fern, *Thelypteris noveboracensis,* started to compete for space on the one consistently sunny slope at the edge of the yard. Clumps of Rock polypody, *Polypodium virginianum,* grew on two granite glacial erratics. On the slope which divided the area, in the shade of the bush honeysuckle, Maidenhair, *Adiantum pedatum* and Fragile fern, *Cystopteris fragilis* grew in neutral soil.

We had established 13 species of ferns in four micro-habitats. The first moist, shady and semi-acid, the second sunny and acid, third rocky and the fourth shady and neutral.

Rattlesnake fern, *Botrychium virginianum* and Northern Beech fern, *Phegopteris connectilis* had been planted but did not reappear. Since all the pinnae of the rattlesnake fern had been eaten by some insect the previous summer it seemed reasonable to conclude that it did not have enough food reserves to survive. We could not account for the death of two clumps of Beech fern. Out of four species of *Lycopodium* only *L. obscurum* remained healthy.

We decided that probably soil conditions were at fault here so we dug trenches 18 to 24 inches deep and filled them with leaf mold before reintroducing *L. complanatum, L. lucidulum, L. clavatum* and *L obscurum.* All four species are now holding their own, and L. *complanatum* and *L. lucidulum* have produced fertile strobili and added new growth.

That summer we added three species of *Dryopteris,* the Toothed Wood fern, *D. spinulosa,* the Marginal Shield fern, *D. marginalis,* and the Narrow Swamp fern, *D. cristata.*

Then we went to Bucks County, Pennsylvania on our vacation and visited the Wherry Fern Trail. We knew we couldn't grow as many species or have as many micro-habitats as the

Pennsylvania State Forest had established under Dr. Wherry's supervision but there were undoubtedly other Massachusetts ferns we could grow. That fall we found *Flora of Worcester County,* written by Joseph Jackson and published by the Worcester Natural History Society in 1909, and learned that at that time, Worcester County, Massachusetts had 38 species and six subspecies of ferns, seven species and two subspecies of *Lycopodium* and six species of *Equisetum.*

We again tried Northern Beech fern, *Phegopteris connectilis* and all three clumps flourished. We planted another *Botrychium virginianum.* It did not grow. The chipmunk who lives in "our woods" dug his tunnel under its roots.

We added the Northeastern Bog fern, *Thelypteris palustris* to the moist, shady semi-acid habitat, as well as the Massachusetts fern, *Thelypteris simulata.*

Equisetum hyemale was added at the fence corner, bringing the count of Pteridophytes to 24. Probably because it is in too dry a habitat *E. hyemale* has increased in size slowly adding six new stems in a three year period and losing two.

The next year we collected a Bulblet fern, *Cystopteris bulbifera,* between limestone strata in a New York state gorge. On the same trip we had collected examples of Pennsylvania limestone. When we returned to Massachusetts we set up a new micro-habitat—the first one that was truly foreign to our particular area of the Commonwealth. We decided to use a part of the sloping area for ferns and other plants requiring or tolerating lime. Under the surface we buried small pieces of limestone. On the surface we placed several pieces of limestone whose irregular shapes testified to the dissolving action of water and mild organic acids. We then added a short flight of steps of limestone flagstones.

In the curve of one of the rocks we planted *C. bulbifera.* Before the summer was over we added Maidenhair Spleenwort, *Asplenium trichomanes,* and Brownstem Spleenwort, *Asplenium platyneuron.* All three grew well. In two years *C. bulbifera* has increased greatly in size. Its 40 cm fronds are laden with bulblets.

About this time we discovered the Garden in the Woods in Sudbury. This delightful spot was founded and is maintained by a retired landscape gardener. Along its five miles of trails flourish hundreds of species of native and exotic plants including a bog area overrun with Climbing fern, *Lygodium palmatum*. We learned that if we returned in spring we could purchase a specimen of this fern.

So we again set about creating a new micro-habitat. We dug a hole 2½ feet deep, five feet long and three feet wide and lined it with several layers of heavy polyethylene. We filled the hole with black peat from a swamp area which was being drained. On this we planted *Sphagnum* in which sundews were growing. Our habitat was ready, providing it could survive the activity of the small mammals who thoroughly enjoyed digging and burying things in the damp earth.

The next spring we fought succession as we pulled out the oaks and cherries that had been planted there. But otherwise our habitat was flourishing not only with sphagnum and sundews but with a very healthy *T. simulata* and the Bog clubmoss, *Lycopodium inundatum*.

We made another trip to the Garden in the Woods and returned to "our woods" with a climbing fern for the bog and a Walking fern, *Camptosorus rhizophyllus*, for the limestone slope.

At present our seven microhabitats boast 31 different species of pteridophytes. They add charm to our yard, they introduce a note of expectancy and exploration to our travels, they provide an excellent teaching area for college classes and other groups who hear of it and ask to come visit. Someday, if the Climbing fern and some of the less common ferns continue to flourish and multiply, they may serve as a source of specimens to reintroduce into areas which have lost them through cutting and mismanagement.

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The Essentialty of Boron for Dryopteris dentata and Selaginella apoda[1, 2]

JOHN E. BOWEN AND HUGH G. GAUCH

The essentiality of boron for angiosperms has been recognized for about 50 years, but, despite a diligent search of the literature, the authors are unaware of any investigation of a possible requirement of boron for Pteridophytes.

In order to determine whether any of the Pteridophytes require boron, a true fern, *Dryopteris dentata* (Forsk.) C. Chr., and a club moss, *Selaginella apoda* (L.) Fern., were selected. For the former, very small sporophytes, with well-developed roots and a degenerating prothallus still present, were obtained in the University greenhouses. For the latter, terminal pieces of growth, approximately 5 cm. in length, were collected, taking care to use pieces whose aerial roots had not made contact with the soil. This precaution avoided the necessity of removing soil particles which might have contained boron.

Both types of plants were raised on quartz sand in plastic containers. The sand had been treated with 10% sulfuric acid, and then thoroughly leached with demineralized water and, later, quartz-distilled water. Quartz-distilled water was also used in the nutrient solutions. The cultures were placed under a plastic-covered frame in the greenhouse to increase the humidity around the young plants and to prevent possible contamination of boron from dust or from the tap water spray applied to nearby plants.

The four stock solutions contained 0.5M concentrations of $Ca(NO_3)_2$, KH_2PO_4, and $MgSO_4 \cdot 7H_2O$, and 500 ppm of boron as H_3BO_3. Each liter of nutrient solution contained 2, 0.5, and 0.5 ml., respectively, of each of the first three stock solutions.

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[1] Scientific Article No. A1130, Contribution No. 3581 of the Maryland Agricultural Experiment Station (Department of Botany).

[2] Based on a portion of a thesis submitted by the senior author to the Faculty of the Graduate School of the University of Maryland in partial fulfillment of the requirements for the degree of Master of Science, 1963.

FIGURE 1: DRYOPTERIS DENTATA 126 DAYS AFTER 2" HIGH SPOROPHYTES WERE TRANSPLANTED TO SAND CULTURE AND GIVEN NUTRIENT SOLUTIONS. TOP ROW: PLUS BORON CULTURES; BOTTOM ROW: MINUS BORON CULTURES.

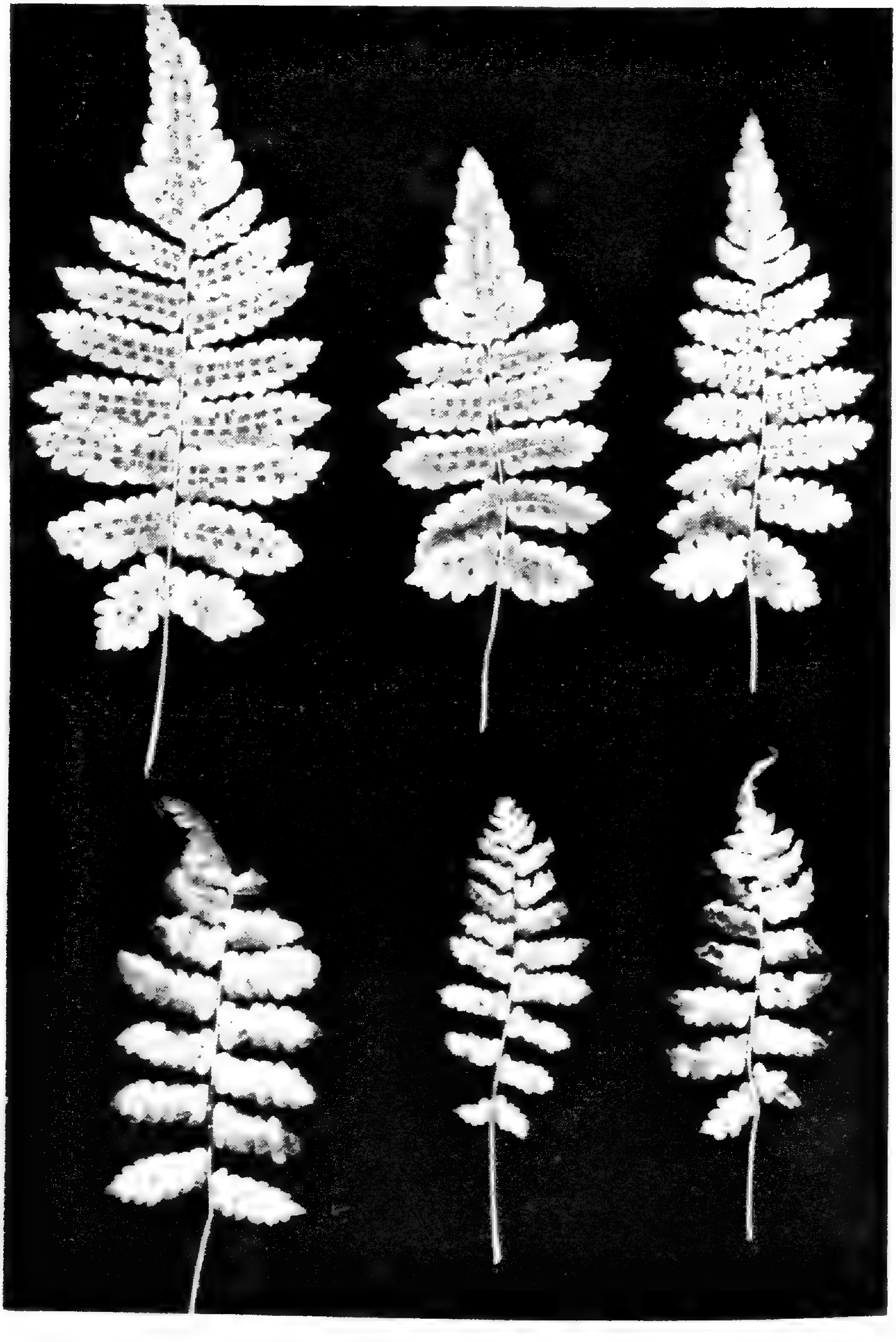
For each liter of nutrient solution which contained boron, 1.0 ml. of the stock solution of H_3BO_3 was added to give 0.5 ppm. of boron. Trace elements, all as salts of ethylene-diaminetetraacetic acid (EDTA), were added to give the following concentrations for iron, manganese, cobalt, copper, and zinc: 5 ppm. for iron and 1.0 ppm. for the other elements. The pH values of both the plus- and minus-boron nutrient solutions were brought to 7.0. Each of the nutrient solutions was stored in a five-gallon polyethylene container and placed in the dark to prevent the growth of algae.

Five sporophytes of *D. dentata*, each approximately 40–45 mm. in height, were placed in sand in each of ten plastic containers, 12 cm. square and 16 cm. deep. The plants in five containers received nutrient solution with no added boron, and, the other five, nutrient solution containing 0.5 ppm. of boron. A polyethylene tray under each container prevented the loss of nutrient solution and any possible contamination of boron from the boards on which the containers rested. Each culture received a total of 100 ml. of nutrient solution per week.

Selaginella apoda was similarly grown except that the plastic containers were 21 $\times$ 9 cm. and 9 cm. deep.

After receiving the two types of nutrient solutions for three weeks, the sporophytes of *D. dentata* receiving no boron were statistically (5% level) smaller than those receiving 0.5 ppm. of boron; from the fourth week on, the difference in heights was highly (1% level) significant (see Table I). During the 15th week after initiation of the treatments, sporophytes receiving no added boron showed necrosis of above-ground meristematic tissues and, during the 18th week, some of the plants receiving no boron were dead or dying (see Fig. 1).

By the 8th week after initiation of the treatments, sori were macroscopically visible on the underside of the fronds of plants receiving 0.5 ppm. of boron in the nutrient solution, but they were not visible on plants receiving no added boron. At the end of 18 weeks, there were numerous sori on the plus-boron plants, but very few on the minus-boron ones (see Fig. 2). In addition,



the sori of the latter plants had either incomplete or no indusia and the sporangia appeared to be partially aborted. No attempt was made to determine whether the few spores in the aborted sporangia would germinate, and hence a report of their viability is not possible.

For *Selaginella apoda*, receiving the two nutrient solutions for 10 weeks, there was a highly significant (1% level) difference between the lengths (heights) of the sporophytes receiving no boron and those receiving 0.5 ppm. of boron. The minus-boron plants were smaller and were a yellowish-green, as compared with the normal green of the plus-boron plants. The most striking differences, however, between the two sets of plants were the number and condition of the strobili. The number of strobili on the plus- and minus-boron sporophytes averaged 2.7 and 0.8, respectively. The strobili on the minus-boron plants were only about one-fourth as long as those on the plus-boron plants and appeared to have aborted (Fig. 3).

Inasmuch as young sporophytes (*Dryopteris*) or pieces of sporophytes (*Selaginella*) were used as starting material, obviously boron was "carried over" at the time of "planting" and placing of half of the plants of the two species on "minus boron." If low-boron plant material could have been used as starting material, it is possible that boron deficiency would have shown up earlier, been more severe, and, possibly, would have shown that plants of these two species could not complete their life cycles in the absence of boron.

The essentiality of boron was not *proven* for either species, since no attempt was made to substitute other elements for boron and both species may have been able to complete their life cycles. That is, the spores of both species may have been viable, but

FIGURE 2: UNDERSURFACES OF LEAVES OF DRYOPTERIS DENTATA SPOROPHYTES SHOWING PROFUSE SORI WITH TYPICAL INDUSIA ON LEAVES FROM PLUS-BORON CULTURES (TOP ROW) AND THE SPARSE SORI WITH INCOMPLETE OR NO INDUSIA ON LEAVES FROM MINUS-BORON CULTURES (BOTTOM ROW).

THESE REPRESENTATIVE LEAVES WERE TAKEN FROM THE PLANTS SHOWN IN THE PREVIOUS FIGURE.

no attempt was made to germinate them. As with higher plants, however, boron appeared to have special significance for *D. dentata* and *S. apoda* with regard to the reproductive phase of growth.

FIGURE 3: CLOSE-UP OF STROBILI OF SELAGINELLA SPOROPHYTES RECEIVING NO BORON (LEFT) OR 0.5 PPM. OF BORON (RIGHT) IN THE NUTRIENT SOLUTION. NUMEROUS APPARENTLY NORMAL STROBILI FORMED ON PLANTS RECEIVING BORON, WHEREAS VERY FEW, ABNORMAL, APPARENTLY ABORTED STROBILI FORMED ON PLANTS RECEIVING NO BORON. (TEN WEEKS ON TREATMENTS).

TABLE I—AVERAGE HEIGHTS AND STATISTICAL SIGNIFICANCE OF DRYOPTERIS DENTATA SPOROPHYTES RECEIVING PLUS-AND MINUS-BORON NUTRIENT SOLUTIONS

	Avg. Ht. of Sporophytes (mm)		
	Treatment		
Date	+B	−B	Statistical significance[1]
5/5/62	50.9	48.9	N.S.
5/12	60.7	58.2	N.S.
5/19	67.5	60.7	*
5/26	72.9	64.9	**
6/2	76.9	67.0	**
6/9	86.3	74.3	**
6/16	92.9	74.7	**
6/23	95.3	81.7	**
6/30	98.8	84.1	**
7/7	101.7	86.4	**
7/14	104.2	87.2	**
7/21	104.5	91.2	**
7/28	105.3	95.2	**
8/4	105.3	98.4	*
8/11	106.3	100.7	*
8/18	106.9	102.5	*
8/25	106.9	101.8[2]	*
9/1	107.6	101.2[2]	*

[1] N.S.—Not significant.
* —Significant at the 5% level.
** —Significant at the 1% level.

[2] Decrease in length was due to necrosis and resultant dieback of the meristematic tips of the fronds.

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Preliminary Field Studies on the Fern Flora of Oaxaca, Mexico

JOHN T. MICKEL

The state of Oaxaca, Mexico, occupies a strategic phytogeographic position. The eastern and western mountains bordering the central plateau of Mexico meet in Puebla and northern Oaxaca, and the Sierra Madre del Sur in turn dwindles to 300 feet elevation on the Isthmus of Tehuantepec and rises again to form the mountains of Central America. Plant species migrating along these mountains are funneled through Oaxaca. The great diversity of habitats here is to be equaled in few, if any, other state in Mexico. Oaxaca has slopes facing both the Gulf of Mexico, and the Pacific Ocean, with quite different floras on each. Rainfall in the state varies from about ten inches in the central dry valley near Mitla to over 250 inches in some of the rainforests on the Gulf slope.

Relatively few botanists have visited the state, and most of these have been general collectors. They include Galeotti, Pringle, Reko, Mexia, and Conzatti. Several fern floras have included the ferns of Oaxaca, such as those by Conzatti (1939), Hemsley (1885-1886), Fee (1857), and Martens and Galeotti (1842), but these are very incomplete. Many fern species, for example, are recorded from the neighboring states of Veracruz and Chiapas, but not from Oaxaca. There are good reasons, however, why the plants of Oaxaca have been incompletely collected. The roads have been few and poor until recent years, and the only means of access to most areas of the state has been by foot. In some parts it is difficult for a stranger to engage porters or guides, and bandits have, at times, made travel dangerous. Several recent developments make this a propitious time to concentrate on the flora of Oaxaca. The state is building many new roads, which will be passable most of the year. Airplanes are visiting more and more villages, and there are reports that helicopter service is available to some areas.

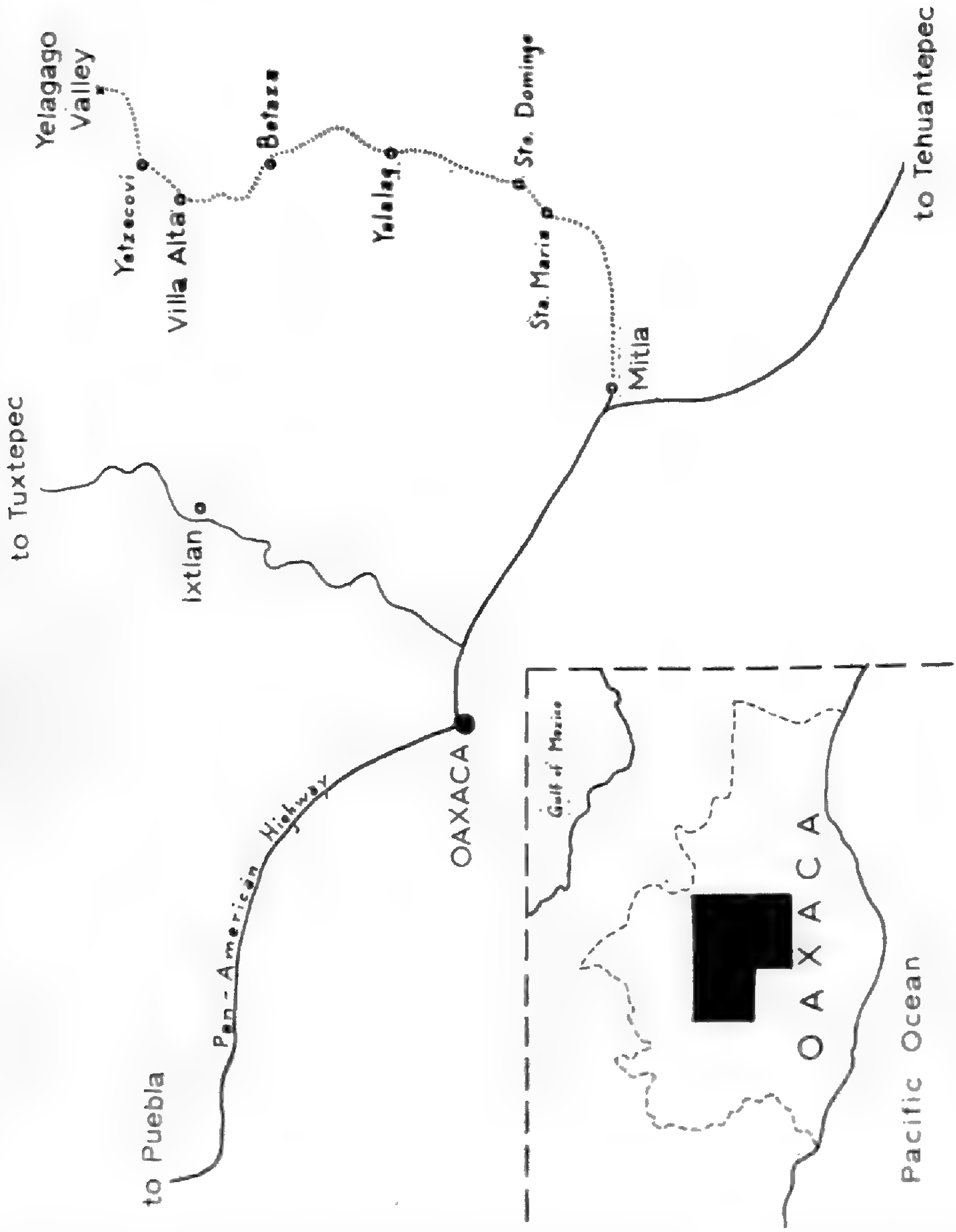
Fortunately, for the present investigation, I have a friend, Mr. Boone Hallberg, living in Oaxaca who has been very cooperative in acting as my guide in several areas of the state, and without whose help much of the progress to date would not have been possible.

I have begun a study of the pteridophyte flora of Oaxaca. The following is a brief report on a reconnaissance trip made in 1962 to sample the pteridophyte flora of the state. My field work extended northeast approximately 70 miles from the dry area of Mitla (see map), across the continental divide, to a coffee ranch owned by Mr. Hallberg in the rainforest of the Gulf slope, an area with nearly 250 inches annual precipitation. The expedition was supported by the Alumni Achievement Fund of Iowa State University and by a grant from the Society of Sigma Xi.

On July 16, 1962, I flew from Des Moines, Iowa, to Mexico City. After spending a day visiting the Instituto de Biología and obtaining the permits necessary for collecting and sending plants from the country, I made the one-hour flight to Oaxaca. The new airport is quite an improvement over the old one, but it is now much farther from the city, much to the consternation of the Indians who fly into Oaxaca from the outlying districts.

The rest of the day was spent in attending to last-minute details for the trip, such as obtaining a raincoat for me (a 6-foot square piece of plastic), bottles for pickling cytological material, and preparing packs and presses for the two boys who were to carry the equipment. The boys, Jacinto and Ernesto, were each to carry a pack of about 50 pounds, for 56 cents per day plus their meals. Late that afternoon we took a bus to Mitla, where we stayed overnight at the Posada La Sorpresa, an inn associated with the Frisell Museum of Zapotec Art.

The area around Mitla is quite dry, the tallest vegetation being *Agave*, *Yucca*, and various cacti. Even so, as we started up the slopes, we found several species of pteridophytes. *Selaginella pallescens*, *S. wrightii*, *Cheilanthes kaulfussii*, and *C. myriophylla* were frequently found, huddled at the bases of exposed rocks. We followed a dusty, dirt road which ran from Mitla east and



then north over the first mountains and into a valley to the village of Santa Maria Albarradas. These mountains were dry also, but apparently received more rainfall than did the valley we had just left. Oaks and pines dominated most of the forests, and the ferns were more abundant, including *Bommeria pedata, Elaphoglossum* sp., *Cheilanthes angustifolia, C. pyramidalis,* and *Woodsia mollis.*

About noon we had reached the summit of the ridge when a truck loaded with people and bags of corn picked us up and carried us the rest of the way (two hours) to Santa Maria. This was the end of the road, and after a quick lunch of beans, tortillas, and a warm soft drink, we were on the trail that led over the continental divide. We had hardly left the village when a light squall freshened the air. This ridge was much wetter than the previous one with several epiphytic polypodiums common in the trees.

The afternoon was well advanced and we had four hours of walking yet before night, so we had no time, unfortunately, to collect in this area. Along the trail we passed some interesting stones, half covered with earth, that displayed carvings in bas relief of serpents and other figures, and we speculated on the possibility of an ancient buried temple being nearby. Just as darkness closed in on us, we came to the village of Santo Domingo Albarradas where we stayed that night in an Indian home. The supper of beans, coffee and tortillas, and the bed of boards and palm mats (petates) were welcome after the long day on the trail and in a bouncing truck, but a mattress was sorely missed.

The next day, July 20, was another bright, sunny day. Although it was the rainy season, nearly every day began this way, but showers could always be expected. The vegetation had a much more luxuriant appearance in this area, reflecting the greater annual rainfall. In spite of heavy grazing by goats, pteridophytes were common all along the trail. Among the rocks were *Pellaea rigida*, *P. ovata*, and *Polypodium thyssanolepis*. Common ferns along the trail were *Anemia adiantifolia*, *A. hirsuta*, *A. tomentosa*, *Cheilanthes microphylla*, *C. pyramidalis*, and *Notholaena sinuata*, while the frequent streams were lined with *Adiantum braunii* and *A. concinnum*.

The trail then steadily dropped to a place called Tres Rios, where three tributaries come together to form the Río Cojonos. It was necessary to wade the river, which was nearly waist-deep. In the vicinity there were three of the "silver-back" and "goldback" ferns, *Notholaena candida* var. *candida* and *N. lemmonii* var. *australis* (both silver-backs), and *Cheilanthes aurea* (a gold-back).

Frequently small streams crossed the trail, and these areas were especially rich in pteridophytes. *Blechnum occidentale, Thelypteris balbisii, T. puberula, Pteris quadriaurita, Adiantum braunii,* and *A. concinnum* were especially numerous. One of the most striking plants in this habitat was the giant horsetail, *Equisetum myriochaetum*, a robust plant over eight feet tall with a stem nearly an inch in diameter, a sharp contrast to its smaller relatives in temperate United States and Europe.

In the late afternoon we arrived at the city of Yalalag, officially named on the maps as Villa Hidalgo. It is the largest city of the district with a population of around eight thousand, but the district capital has always been at Villa Alta, a city of only one thousand. The reason for this is that Yalalag is almost entirely Indian, with very little Spanish influence on its culture, and a high proportion of the population understanding little or no Spanish, while Villa Alta has been more of a Spanish community.

Fortunately, Mr. Hallberg knew the mayor of Yalalag, and we were accommodated for the night on roll-away beds on the third floor of a new concrete warehouse, the largest building in the city. The beds and the concrete building were especially impressive since the only way into the city is by foot or light plane. The nearest road ends about five miles away (although I understand it is now being extended all the way to Yalalag).

We spent the following day in the vicinity of Yalalag. We collected mainly on the trail that leads from Yalalag eastward toward Mount Zempoaltepetl, the highest peak in Oaxaca. It rises to an elevation of over 11,000 feet, an exciting mountain botanically with an intriguing rain forest at 9000 feet.

The forest in the area of Yalalag was largely the same pine-oak type, the elevation being 4000 to 5000 feet. Species of *Cheilanthes, Pteridium, Equisetum, Dryopteris,* and *Adiantum* were common, especially near streams and on the ground in wooded areas, while *Polypodium sanctae-rosae, P. fraternum,* and *Asplenium praemorsum* were common epiphytes on the oaks. *Asplenium* *monanthes* was infrequent at 5300 feet, and quite unusual as it displayed, in some specimens at least, buds and plantlets in the axils of the lower pinnae. This same phenomenon was found later on specimens of this species collected on Cerro San Felipe, although I had not previously noticed it in herbarium specimens.

The next morning we continued toward Villa Alta. The mountains had become much steeper, the valleys narrower, and the walking more tiring. We continued to collect new and different ferns along the way. One especially striking fern was *Trismeria trifoliata*, which grew in a seepage area among low shrubs and attained a height of eight to ten feet. Its trifoliate pinnae were not oriented in one plane as in most ferns, but seemed to be pointing in all directions, so the plant as a whole did not present a very fern-like aspect.

Shortly after noon we passed the village of Betaza while going up the high slope, on the other side of which was Villa Alta. The diversity of ferns along the trail increased. The lacy *Odontosoria schlechtendalii* with its finely dissected, nearly elaminate blades, *Gleichenia bifida*, *Thelypteris oligocarpa*, *T. concinna*, and *Polypodium pulchrum* were all common. At 4800 feet we passed a lush stream with *Osmunda regalis* (a touch of the North) and the large, dimorphic *Blechnum falciforme*, growing along its banks. Further on, we encountered the fascinating flowering plant *Phyllonoma*, a small tree of the Saxifragaceae with clusters of flowers near the leaf apex on the midrib.

After passing the highest point on the ridge, just over 6000 feet, we stopped at another productive spot. Inside a radius of 50 feet around a spring there were 13 species of pteridophytes I had not found up to that time. These included *Osmunda cinnamomea*, *Lophosoria quadripinnata*, *Woodwardia radicans*, and *Adiantum andicola* in the wet area around the spring itself; *Gleichenia palmata*, *G. bancroftii*, *Lycopodium complanatum*, *L. clavatum*, and *L. cernuum* in the drier soil; and *Xiphopteris serrulata* and two species of *Elaphoglossum* covering a shaded, humus bank.

(*To be continued*)

Shorter Notes

RETURN TO PANTHER CREEK, GEORGIA—In an article on the ferns of Stephens County in northeast Georgia (Amer. Fern Jour. **51**: 67-69. 1961), the authors (Franklin D. Snyder and I) mentioned that the gorge of Panther Creek was explored to a point where the stream was confined between vertical cliffs. The common boundary of Stephens and Habersham Counties crossed the creek below the mouth of this chasm, and, as we decided to concentrate on the ferns of Stephens County, we did not attempt to go farther upstream. Also, no lime-bearing rock, the object of our search, was to be expected.

Limestone (a low-grade marble in Brevard schist) was indicated on the geologic map of Georgia as being exposed in the gorge of Davidson Creek, a tributary of Panther Creek which is mostly in Habersham County. This gorge could be entered by a rough road to a pumping station that serves to augment the water supply of Toccoa when the regular source is low. Mr. Snyder and I planned a trip for March, 1961, that included our wives and Professor Wilbur H. Duncan and his family of Athens. On the morning of March 12 we walked downstream enjoying the scenery and the early spring flowers. Much Walking Fern was seen, but it was out of reach on the opposite bank. Soon after lunch, which was eaten on a large boulder overlooking a series of cascades, our exploring was abruptly terminated. Mrs. Snyder accidently dislodged a large rock that broke her leg when it fell against her.

Not discouraged, last spring (1963) she added another fern, *Botrychium alabamense*, to the growing list from Stephens County. After the discovery, she was told that this fern is usually found in old roadbeds. At first she was sure that her find was from natural terrain, but closer examination proved that a road had traversed the locality.

I made three trips to Davidson Creek within a short time later. The only fern seen and not previously collected in Stephens County was *Cystopteris bulbifera*. The Bulb Fern had been reported from only two other counties, which are in northwest Georgia.

In the summer of 1961 I moved to Asheville, North Carolina, and it was not until April 18, 1964, that Mr. Snyder and I entered Panther Creek gorge above the chasm. We could hear the roar of water from the rim of the gorge at a point in Habersham County, and soon after descending we came to a magnificent waterfall, one of state-park caliber. The only intimation of the waterfall was from a friend of the Snyders. His curiosity had been aroused by our interest in the gorge, and he traversed it to look for minerals. We did not see any new ferns, but ledges under the waterfalls and many crevices in the cliffs were inaccessible. The ferns seen included *Asplenium trichomanes*. The most interesting plant display, and a very beautiful one, was provided by the beds of *Polygala paucifolia* Willd. in full bloom.

The next day, April 19, we visited a large exposure of granite gneiss on a mountain about two miles north of Toccoa. Ledges and boulders bordering the smooth sloping expanse of gneiss provided a habitat for *Asplenium pinnatifidum*. This fern had not been reported from Stephens County, and the range in Georgia was extended toward the northeast. Some of the plants possibly were hybrids, but identification will require further study. The only other *Asplenium* seen was *A. platyneuron*.

It may be that Stephens County has more species of ferns and fern allies than any other Georgia county. Should this prove to be so, it would not be surprising, as the topography is so varied, and there are both acidic and basic rocks.—GLADSTONE W. MCDOWELL, *6 Oak Ridge Road, Asheville, North Carolina.*

SCHIZAEA PUSILLA—PERENNIAL GAMETOPHYTE? There is a small fern, *Schizaea pusilla,* growing in New Jersey that is only 1¼–2½ inches high, though it sometimes reaches about twice that height when it is fruiting. Its common name, curly grass fern, describes its appearance and only microscopic examination shows it to be truly a fern. It grows also in Nova Scotia and in Newfoundland but does not seem to be distributed in localities in between. This has aroused considerable interest and speculation over the years, more especially since its nearest relatives now grow in the southern hemisphere. It has been suggested that *Schizaea pusilla* is a relic, preserved in untouched pockets during the last glaciation. If so, it must have survived for a time in a rather cold environment.

Another very interesting thing about this peculiar fern is that its gametophyte is filamentous. The gametophyte known in most ferns is a thallus which is often heart-shaped. When a spore of *Schizaea pusilla* germinates it produces a branching filament and this bears the gametes (sperm and egg) and subsequently the embryo.

In the spring of 1951 I collected spores of this fern in New Jersey; I am indebted to Dr. E. T. Wherry for indicating the locality. The spores were planted on peat in a covered glass dish and left in a north window out of direct sunlight. Growth was good and the surface of the peat was soon covered by a loose mat of branching green filaments. Sex organs appeared and disintegrated, since the water necessary for movement of the antherozoids was kept away from the branches bearing the sex organs. The culture continued to grow. Transplants were made three times: December 3, 1953; on June 12, 1958; on February 11, 1959. Water (sterile to avoid contamination of the culture) was added as needed and also Knop's nutrient solution (to avoid depauperizing the culture in the restricted area of the dish). Temperatures have varied from 66°–70° F. in the heated house during the winter months (November–April) and have reached the eighties during the summer. The plants now have lived for 13 years, newer portions being formed as older ones die off. This may be a record for longevity of a gametophyte under observation, although *Schizaea* is by no means the only fern whose gametophyte will live for some time in culture. A notable example is *Osmunda* with its large thick thallus. A thallus of the royal fern (*O. regalis*) which I once had was heart-shaped at 6 months of age and perhaps ¼ inch long. Two years later it was still alive and might easily have been taken for a liverwort. It had become a green ribbon 2 inches long.

During the winter of 1959–60, my culture of *Schizaea pusilla* was left by mistake in an unheated house. Imagine my astonishment in the spring to find numerous spots of green living filaments of the gametophyte in the dish! These were brought through to the following winter and then deliberately left with a thermometer in the same unheated house during the winter of 1960-61. Mr. Wesley Jansen, of Amherst, very kindly took down the temperature from time to time during the winter. These are given below:

	Time	Temp. in degrees Fahrenheit
December 13, 1960	4:30 P.M.	30
December 20, 1960	4:00 P.M.	28
December 29, 1960	4.30 P.M.	20
January 4, 1961	11:00 P.M.	26
January 23, 1961	4:30 P.M.	20
February 2, 1961	4:15 P.M.	24
February 18, 1961	daytime	34
February 28, 1961	daytime	36
March 6, 1961	daytime	38
March 18, 1961	daytime	30
March 27, 1961	daytime	50

The first six readings indicated above are all below freezing. It is certain, since the temperature readings were taken during the day, that they dropped even lower during the night when it is customarily much colder in our winter climate and these lower temperatures may have held below freezing for days at a time.

The winter climate of coastal New Jersey is more mild than it is in New England and it is tempting to speculate on whether this tiny gametophyte overwinters in New Jersey. It is even more tempting to speculate on whether one of the secrets of the long ancestral line of this fern may not be connected with the longevity of its gametophyte and its ability to withstand cold.—LENETTE R. ATKINSON, *Amherst College, Amherst, Massachusetts.*

OSMUNDA REGALIS var. SPECTABILIS IN INDIA.—Examples of vicariads are to be found in almost any modern taxonomic monograph in which the series of closely related entities inhabiting independent geographical areas are recognized. One example is *Osmunda regalis* L., which has six varieties: Var. *spectabilis* in North America, var. *palustris* in South America, the European variety is var. *plumieri*, and the Asiatic variety is var. *japonica*, the South African is var. *capensis*, and in Northeast Africa is var. *abyssinica*, each with restricted distribution.

In India, var. *japonica* is often met with in the extreme east. In 1952 the author collected a specimen (*Banerji* 622) from a locality in East Nepal at ca. 2,200 m. elevation, the geographical bearings of the locality being 27° 40′ N. and 86° E. This material proved to be *Osmunda regalis* var. *spectabilis* (Willd.) A. Gray. During the course of investigations in the Central National Herbarium, Calcutta (CAL), another similar specimen came to light, from the Khasi Hills (Assam), April 4, 1894, *Gammie* 316, named simply *Osmunda regalis* L. Examination of this specimen reveals that it is also var. *spectabilis*.

These two specimens from different parts of eastern India, collected by different persons, at different times, raise an interesting question as to why the North American var. *spectabilis* occurs in an area where it is logical to expect only var. *japonica*.—M. L. BANERJI, *Indian Embassy P.O., Nepal.*

CYSTOPTERIS BULBIFERA (L.) BERNH. NEW TO TEXAS.—The Guadalupe Mountains that run athwart the Texas-New Mexico state line contains the most mesophytic and florally interesting canyons to be found in West, or Trans-Pecos, Texas. These are the North Fork and the South Fork of McKittrick Canyon. The South Fork has a perennially flowing stream and contains many plants unique for the state, among which are Bittersweet (*Celastrus scandens*), Mountain ninebark (*Physocarpus monogynus*), Bailey's hophornbeam (*Ostryæ Baileyi*), Solomon-seal (*Polygonatum cobrense*) and Arizona Valerian (*Valeriana arizonica*). The latter two species are recent new additions to the flora of Texas.

During June, 1964, Craig A. Hanson and I were botanizing in the South Fork of McKittrick Canyon. High up in the canyon, several miles from its mouth, we came upon several beautiful clumps of *Cystopteris bulbifera.* The plants were growing in pockets of ledges about a small pool which made that part of the narrow canyon impassable except for a rope swing that was provided by ranchers for this purpose. Many of the fronds were heavily weighted with bulbils, the most profuse I have ever seen on any fronds.

The Texas station not only represents a species new to the state, but it is the southernmost locality known for this typically northern species. It has previously been known to occur south to Arkansas, Oklahoma, southeastern New Mexico, and central Arizona.—DONOVAN S. CORRELL, *Texas Research Foundation, Renner, Texas.*

Recent Fern Literature

REPORT ON BOTANICAL EXCURSION TO THE BOREAL FOREST REGION IN NORTHERN QUEBEC AND ONTARIO[1] contains a section on the Pteridophyta, mostly consisting of minor extensions of ranges of ferns into the Clay Belt of Ontario and Quebec discovered by an excursion in connection with the Ninth International Botanical Congress, Montreal, 1959. However, it includes a note on the validity of the generic name *Gymnocarpium* which may be of general interest and which is consequently reproduced below, since the original publication will perhaps not be seen by most members of the Fern Society.

"*Gymnocarpium* Newman

"When the characters of the large genera *Dryopteris* and *Thelypteris* are reviewed and compared, it appears that the Oak Fern, known variously as *Phegopteris Dryopteris* (L). Fée, *Dryopteris Linnaeana* C. Chr., or *Dryopteris disjuncta* (Ledeb.) Morton, can not really be included in either. It

[1] By W. K. W. Baldwin. 1962. National Museum of Canada, Department of Northern Affairs and National Resources.

represents a distinct and ancient line. It should be known as *Gymnocarpium Dryopteris* (L.) Newman.[2]

"The correctness of the generic name *Gymnocarpium* has been questioned by E. T. Wherry[3] on two grounds—that the name is a homonym of the prior *Gymnocarpum* DC. (1828) and that it had been given a name *Currania* Copel. in 1909, prior to the typification of *Gymnocarpium* Newman by Ching in 1933.

"As to the first, according to the *International Code of Nomenclature*, names are homonyms when they are orthographic variants of the same word. The 'carpum' of *Gymnocarpum* is a Latinized form of the Greek noun 'carpos,' whereas the 'carpium' of *Gymnocarpium* is a Latinized form of the Greek 'karpion,' which is a diminutive. The termination ιον in Greek is a diminutive regularly. Therefore, *Gymnocarpum* and *Gymnocarpium* are not orthographic variants but different words, and therefore they are not homonyms, even though they do differ by only the single letter 'i.' They are etymologically as different as *Pteris* and *Pteridium*, the latter being a diminutive of the former, formed by use of the same diminutive termination ιον.

"Dr. Wherry's adoption of the name *Currania* in place of *Gymnocarpium* is based on a misunderstanding of the type method of nomenclature. He would seemingly date *Gymnocarpium* from Ching's typification of it in 1933, and if so, then *Currania* (1909) would be older. However, *Gymnocarpium* was described in 1851, and according to the Code it continues to date from then regardless of the date of its typification. There were only three originally named species in the genus as proposed by Newman—*G. Phegopteris*, *G. Dryopteris*, and *G. Robertiana*, and a type must be chosen among these three. In order to follow the type method, all genera not originally typified must be supplied with a lectotype; *Gymnocarpium* can not just be left in limbo, so to speak, as done by Wherry. If it is typified on *G. Phegopteris*, then *Gymnocarpium* would be the correct generic name for the Beech Fern, because the generic name *Phegopteris* Fée is later, dating from 1852. But Wherry adopts *Phegopteris* Fée, and no one has ever proposed to typify *Gymnocarpium* in this way, although it may be that Newman had the Beech Fern especially in mind when he proposed the genus, because he discusses it more than the other species. However, Ching chose *G. Dryopteris* as the type species of *Gymnocarpium* in 1933. Since *G. Dryopteris* was one of the original species of the genus, since it agrees with the brief original diagnosis of the genus, and since no one had previously typified the genus otherwise, Ching's typification must be adopted. Therefore, *Gymnocarpium* remains the correct name for the Oak Fern.

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[2] For distinctions from *Dryopteris* and *Thelypteris*, see Morton's paper Amer. Fern Jour. **40:** 213-225. 1950.

[3] Nomenclature of the Oak-Ferns. Amer. Fern Jour. **44:** 85, 86. 1954.

"Whether *Currania* Copel. is actually a synonym of *Gymnocarpium* Newm. is doubtful. Wherry assumes that it is, following Ching, but Copeland, who ought to know his own genus and its relationships, keeps it up as a different genus up to his last work on this group.[4]"

Some notes regarding *Dryopteris campyloptera* were published also, and these may be of interest.

"*Dryopteris campyloptera* Clarkson

"The status of this plant has been in some doubt. In my treatment of the ferns of the eastern United States and Canada in Gleason's *New Illustrated Flora,* I used the name *D. austriaca* (Jacq.) Woynar var. *austriaca,* believing that all our eastern spinulose shield-ferns were conspecific with the European *D. austriaca* (*D. dilatata*). Since that time, cytological work by I. Manton, S. Walker, D. Britton, and others has tended to show that several species may be represented—a diploid species *D. intermedia* (Muhl.) A. Gray, distinguished morphologically by glandularity and fine cutting, which occurs primarily in the eastern United States and Canada but which has been found (or at least a very closely allied form) in Madeira; a Eurasian and North American tetraploid species *D. spinulosa* (O. F. Muell.) Watt, eglandular and coarser; and an assemblage which is known collectively as *D. dilatata* (Hoffm.) A. Gray, which includes both diploids and tetraploids, both in Europe and the United States. The common plant of the western United States is diploid, and the usual plant of the east is a tetraploid; morphologically, the plants of the east and the west are extremely close, and I am not sure that they can always be distinguished. The eastern plants have been known as *D. dilatata* var. *americana* (Fisch.) Benedict.

"As a species, the correct name of the eastern plants is *Dryopteris campyloptera* Clarkson. There has been some doubt about this, because the original use of the epithet *campyloptera* was invalid. It dates from G. Kunze's 'Notes on some ferns of the United States' (Am. J. Sci. Arts II, 6: 80, 89. 1848). Since this publication is not available everywhere, I will quote from it:

"'The identity of *A* [*spidium*] *spinulosum,* Sw., *A. dilatatum,* Sw., *A. dumetorum,* W., and *A. intermedium,* W., as different forms of one species, cannot be doubted any longer. A peculiar variety of *A. spinulosum* occurs in the northern latitudes and on the mountains of the Southern States, which must be studied more closely in its native localities, as it may prove to be a distinct species. I have specimens of this form from Newfoundland, (La Pylaie), Greenland, and Labrador, (Breutel and Kurr), New England mountains, sterile (Tuckerman), and from the highest tops of the Black

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[4] Gen. Fil. 140. 1947.

Mountains, North Carolina, (Rugel). Cultivated specimens have been communicated to me from the botanical garden of St. Petersburg. (Dr. Fischer as *A. spinulosum americanum*) and from that of Berlin. The lowest pair of the mostly opposite pinnae is *ascending* and *curved upwards,* and has a *different direction from the other pinnae.* The pinnulae are more deeply pinnatifid, with more and sharper teeth than in the common form; *those of the lowest pinnae, especially near the base, are much elongated downwards,* by which these pinnae assume a very irregularly triangular shape. The sori are nearer the middle nerve. The stipe is thickly covered with brown or reddish paleae. If this form should eventually prove to be a distinct species, the name of *A. campylopterum* would be appropriate.'

"This is the classic form of the *nomen provisorium,* a name proposed in anticipation of the possible future acceptance of the group in a particuar status, in this case that of a species. Such names are by Article 33 of the *International Code of Botanical Nomenclature* (Paris Edition) invalid. This means that the epithet *campylopterum* is not published at all. In 1930 Edward H. Clarkson decided that this plant did actually represent a distinct species, for which he proposed to use the name *Dryopteris campyloptera* (Kunze) Clarkson. Since Kunze's name has never been validly published, as shown above, Clarkson was in effect describing a new species, for which he could have chosen a different name. However, there is nothing in the *Code* to prevent him from using the name *campyloptera,* and he did so. Therefore, the species must now be called *D. campyloptera* Clarkson, and not *D. campyloptera* (Kunze) Clarkson; it dates from 1930. It is based on Kunze's description, quoted above; Kunze's description is, of course, validly published, even though the provisional name attached to it is not. The type of *D. campyloptera* Clarkson will be the various syntypes cited by Kunze; since Kunze's herbarium in Leipzig was destroyed during the last war, some duplicate in another herbarium will have to be selected as lectotype. I do not do so, since I have not seen any of them.

"Mrs. Fern Ward Crane has studied the spores of the American plant. She wrote me (Oct. 16, 1959): 'I do not agree with Walker that *Dryopteris campyloptera* is closely related to the European *D. dilatata.* Our fern does not have glandular indusia, and also the over-all morphology does not coincide with it. The rhizome of the American fern is horizontal while the European one is erect, as in *D. intermedia.* Perhaps *D. campyloptera* and the western tetraploid form (I consider them as one fern) is the fertile tetraploid resulting from *D. intermedia* crossed on the western diploid *D. "dilatata"* reported by Walker. I had examined the spores of the latter and predicted the plant was diploid when he asked for an opinion. Thus the European *D. dilatata* might have arisen from an ancient crossing of their diploid form with the Madeira *D. "dilatata"*.'

"Mrs. Crane's hypothesis may prove to be right, but I doubt it. If *D. intermedia* were a parent, one would expect more *intermedia* characters in the division of the blade and especially in glandularity. If *D. campyloptera* were a cross between western diploid *dilatata* and the glandular *intermedia*, one would expect it to be more glandular than typical *dilatata*, but actually it is less so; in fact, eglandularity is one of the principal distinguishing characters of *campyloptera*. On this account, it seems unlikely to me that it is an allopolyploid derived from *D. dilatata* × *intermedia* by doubling of chromosomes, but rather an autopolyploid, originating from the western diploid *dilatata* by doubling of chromosomes; in the latter case, it does not need to be distinguished as a separate species but should be regarded as a subspecies:

"*Dryopteris dilatata* (Hoffm.) A Gray subsp. *campyloptera* (Clarkson) Morton, comb. nov.

"*Dryopteris campyloptera* Clarkson, Am. Fern J., **20**: 118. 1930."—

—C. V. MORTON, *Smithsonian Institution, Washington, D. C.*

PTERIDOLOGICAL PAPERS FROM THE GRAY HERBARIUM.—SCAMMAN, EDITH. 1960. The Maidenhair ferns (Adiantum) of Costa Rica. Contrib. Gray Herb. **187**: 3–22.—Twenty-seven species of *Adiantum* are treated. A key is provided for their identification and each species is illustrated. The diagnostic characters of the species, and their distribution and ecology in Costa Rica, are discussed. This and the next two papers are based, to a large extent, on the author's extensive field experience and collecting in Costa Rica. They will be useful for the identification of the species of these genera in all of Central America.

SCAMMAN, EDITH. 1961. The genus Pteris of Costa Rica. Rhodora **63**: 194–205.—Thirteen species of Pteris are treated in the same manner as in the previous paper on *Adiantum*.

SCAMMAN, EDITH. 1961.—The genus Oleandra of Costa Rica. Rhodora **63**: 335–340.—The four species of this genus in Costa Rica are treated in the same manner as in the papers listed above.

TRYON, ALICE F. AND DONALD J. BRITTON. 1958. Cytotaxonomic studies on the fern genus Pellaea. Evolution **12**: 137–145. —Reports are given on chromosome counts of 9 taxa of North American *Pellaea* and the mode of reproduction (sexual or apogamous) of each. These data and the geographic distribution are used to interpret the evolution of the species.

TRYON, ALICE F. 1960. Observations on the leaves of Pellaea andromedifolia. Contrib. Gray Herb. **187**: 61–68.—An illustrated study of the morphology of the leaves as they are produced in sequence by the young sporophyte. Other similar investigations are discussed and the possible role of nutrition in the changing characters of the leaves. The use of juvenile leaf form in phyletic studies is commented upon.

TRYON, ALICE F. 1961. Some new aspects of the fern Platyzoma microphyllum. Rhodora **63**: 91–102.—Anatomical and morphological observations are presented that indicate the genus is not a close ally of *Jamesonia* (with which it has been placed). The data bring out a number of relations with the Schizaeaceae that are considered to be of significance.

TRYON, ROLLA M. 1955. Selaginella rupestris and its Allies. Ann. Missouri Bot. Gard. **42**: 1–99.—A monographic study of *Selaginella,* subgenus *Selaginella,* section *Tetragonostachys.* Forty-three species are recognized within four series. Most of the species grow in the western United States and Mexico and are frequent elements of the flora of xeric and semi-xeric regions. There are distribution maps of the taxa and each is illustrated.

TRYON, ROLLA M. 1956. A revision of the American species of Notholaena. Contrib. Gray Herb. **179**: 1–106.—Fifty-eight species of *Notholaena* are recognized in America. They are predominantly species of xeric and semi-xeric habitats. Each species is illustrated by line drawings and distribution maps are provided.

TRYON, ROLLA M. 1960. A glossary of some terms relating to the fern leaf. Taxon **9**: 104–109.—The terms considered are those that apply to the fern leaf and its various parts, their arrangement and their degree of complexity. About 30 of the terms are illustrated. The glossary has been translated into Russian (Bot. Jour. Akad. Nauk, USSR, **46**: 736–739. 1961) for the benefit of our Russian colleagues.

TRYON, ROLLA M. 1960. New species of ferns from Central and South America. Rhodora **62**: 1–10.—Three new species of Tree Ferns, one of *Cheilanthes* and one of *Pteris* are described.

TRYON, ROLLA M. 1960. A review of the genus Dennstaedtia in America. Contrib. Gray Herb. **187**: 23–52.—A taxonomic revision of 11 species of American *Dennstaedtia* with illustrations of each species.

TRYON, ROLLA M. 1961. Taxonomic Fern Notes, I. Rhodora **63**: 70–88. — Taxonomic and nomenclatural notes on tropical American species of *Adiantum, Cheilanthes, Dennstaedtia, Notholaena* and *Pteris*. Three new species of *Notholaena* are described.

TRYON, ROLLA M. 1962. Taxonomic Fern Notes. II. Pityrogramma (including Trismeria) and Anogramma. Contrib. Gray Herb. **189**: 52–76.—A synopsis of the genus *Pityrogramma* is presented with discussion of the validity of *Anogramma* (which is maintained) and *Trismeria* (which is reduced to *Pityrogramma*). The taxonomy of this genus has been greatly confused by the description of many minor variants as species. Less than half of the American species recognized by Domin are considered valid.

WILSON, KENNETH A. 1959. Sporangia of the fern genera allied with Polypodium and Vittaria. Contrib. Gray Herb. **185**: 97–127.—A detailed analysis of the cellular structure of the sporangium is presented and the parts of it that are of comparative value are emphasized. The data derived from a study of the Polypodiaceae (*sens. str.*) and the Vittariaceae are used to assess the taxonomic status of these groups and others that have been proposed in this alliance. The sporangia (and often the paraphyses) of fifty-five species are illustrated by line drawings.

OTHER FERN PAPERS.—GAUDET, JOHN J. 1964. Morphology of Marsilea vestita. II. Morphology of the adult land and submerged leaves. Amer. Jour. Bot. **51(6)**: 591–597. *figs. 1–22.*—Detailed morphological investigations deal with the vascular supply to both types of leaves and indicate a close relationship of type of leaf form with the different activities of the marginal meristem.

A technical paper, but containing interesting information for anyone working with ferns.

KUEHNERT, C. C., AND J. P. MIKSCHE. 1964. Application of the 22.4 MEV Deuteron Microbeam to the study of morphogenetic problems within the shoot apex of Osmunda claytoniana. Amer. Jour. Bot. **51(7)**: 743–747, *figs. 1–5.*—Irradiation of apical region of shoot apex caused destruction of the cells followed by formation of wound tissue. Highly technical report.

WHITTIER, DEAN P. 1964. The influence of cultural conditions on the induction of apogamy in Pteridium gametophytes. Amer. Jour. Bot. **51(7)**: 730–736, *figs. 1–8.*—Direct inhibition of apogamy is caused by high osmotic pressures of the medium, whereas lower osmotic pressure but with different types of basic medium had no effect. A carefully done series of physiological experiments.

BLASDELL, R. F. A monographic study of the fern genus Cystopteris *Mem. Torrey Bot. Club* 21 (4): ii. 102 pp., 23 pls. (10 Jan. 1963).—The author has investigated anatomy, morphology and cytology, has grown dozens of plants and has studied 5000 herbarium sheets. His line-drawings and silhouettes are presented at the same scale, item for item, which makes comparison easy. One starts off with high hopes.

The jackpot question is what to do with the *C. fragilis* complex which, we are told, is what initiated this monograph. The author refers to "taxonomists in the past who have simply lumped together all populations which superficially resembled *C. fragilis,*" but one feels he himself has also "sidestepped" the issue. He has examined few type-specimens, his concepts being based mostly on comparison of original descriptions with herbarium specimens. "Several species for which authentic material has not been obtained have been omitted [*C. tasmanica* Hooker, *C. mairei* Brause] or temporarily referred to other taxa on the basis of the original description." The sources of his chromosome figures are not given in the "Taxonomic Revision" and it is from "Chromosomes and Spore Size" that one has clues to whether they were counted or whether they were inferred, the author using spore size extensively as a measure of degree of ploidy. The main separations of the "Diagnostic Key" are those over which there has been so much divergence of opinion viz. glandulosity and position of vein endings but, having thus segregated, the author links up the most controversial elements with statements of introgression and hybridity (and elsewhere of gene exchange between sympatric species) to allow for intermediates which will not key out cleanly and which are placed at the end of the "Taxonomic Revision."

After much deliberation the author deals with the *fragilis* complex by maintaining "species status for the three extremes" (*fragilis, diaphana, protrusa*); under his "extreme" *fragilis*, however, we find 45 synonyms (including *Cystopteris baenitzii, C. dickieana, C. polymorpha, Polypodium anthriscifolium, P. dentatum*) which "reflects the diversity of *C. fragilis* var. *fragilis*" and wherein "some of the binomials . . . may actually represent plants in which introgression with *C. diaphana* has occurred"; the reason given for their inclusion is because "authentic specimens have not been available"; it would have been better to have followed up typification more diligently before making lists implying opinions of affinity. *C. dickieana* is sunk into *fragilis* as a "spore form" on the grounds that "intermediate conditions have been observed between . . . rugose . . . and echinate"; *baenitzii* is not claimed to have spores anything but rugose, but is sunk into *fragilis* nevertheless; in the description of *fragilis* the spores are given only as echinate; *apiiformis* and *huteri* are accorded varietal status under *fragilis* because of differences in glandulosity and frond-dissection. At the end of the "Taxonomic Revision," under "Hybrids," *alpina* is given hybrid status, partly because of its hexaploidy and partly because the author's imagination has been stimulated by the line-drawing of *fragilis* × *montana* Christ [= *christii* Hahne] but it "needs more study before a decision is made as to its authenticity"; *regia* is designated an introgressant under a "blanket formula" entitled "*diaphana* × *fragilis* complex."

Compared with the *fragilis* complex, the other taxa dealt with are relatively straightforward, but they have suffered much the same treatment.

One feels considerable lack of confidence in an author who has seen only a small proportion of type-material; when he says "the type-specimens show no obvious difference" from another type he has *not* seen and "the specimens at hand agree closely with the original description which I have seen"; when he explains "the deltoid [deltate] outline results from the fact that the basal pinnae are longer than the subsequent pinnae"; and when there are many inaccuracies in the nomenclature. It is a pity vein endings are not clearer in the drawings and that plants and collectors are not indexed. The value of all the work put in by the author is in the evidence made available from his examinations of a large range of material; one should be, however, very sure before publishing taxonomic interpretation and one fears that his venture on this aspect may be a hindrance rather than a help.

The following new names and changes of rank were made; Subgen. Acystopteris (Nakai pro gen) Blasdell, Sect. nov. Emarginatae Blasdell, Cystopteris diaphana (Bory pro spec. Polypodii) Blasdell, *C.* × *laurentiana* (Weatherby pro var. *C. fragilis*) Blasdell, *C. protrusa* (Weatherby pro var. *C. fragilis*) Blasdell, *C. sudetica* var. *moupinensis* (Franchet pro spec.) Blasdell.—J. A. CRABBE, *British Museum (Natural History), London SW 7.*

Notes and News

MRS. CAROL R. CERIMELE (6208 S. 286th St., Kent, Washington 98031) writes that she has many sporelings of greenhouse ferns that she wants to exchange, and wishes to correspond with others who grow greenhouse ferns. She has considerable success in growing ferns from spores with simple equipment. The spores are sown in 3½ inch pots, one-third full of crushed brick and leafmold, set on a cookie sheet, enclosed in a plastic bag, and then placed 12 inches beneath Grow-Lux tubes. She separates the plants in the prothallial or in the one-leaved stage, and transplants them to plastic boxes with lots of air space above them.

At present she is experimenting with growing New Zealand filmy ferns by this technique. She adds further: "I always water my pots containing the sporelings from the bottom only. I just flood the cookie sheet and it is surprising how much water the pots will absorb, even though they are contained in the large plastic bag."

If interested in exchanging young plants, write to Mrs. Cerimele at the address above.

Dr. William Adams, (Department of Biology, Muskingum College, New Concord, Ohio) would like to exchange Ohio ferns for ferns from the eastern coastal states. Please write direct to him for details.

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VOL. 55 JULY-SEPTEMBER, 1965 No. 3

American Fern Journal

A QUARTERLY DEVOTED TO FERNS
Published by the
AMERICAN FERN SOCIETY

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American Fern Journal

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County Distribution of Ferns and Fern Allies in Rhode Island

DOROTHY L. CRANDALL

There has been a reawakening of interest recently in the compilation of floras of vascular plants. Maine (Ogden, 1948) and New Hampshire (Seammon, 1947) have published bulletins on their fern flora. The most recent state list for Massachusetts is that by Churchill, et al. (1928, 1933). The Pteridophyta are included in *The Flora of Vermont* (Dole, 1937) and in *Catalogue of the Flowering Plants and Ferns of Connecticut Growing without Cultivation* (Graves, et al., 1910; Harger, 1930). The most recent publication concerning the ferns of Rhode Island (Wright and Crandall, 1941) is an unannotated list. It excluded the fern allies and gave no information on county distribution. In this paper the list of ferns and fern allies has been brought up-to-date and county records have been compiled from existing herbarium records and from my field collections.

Specimens of the ferns and fern allies noted in this paper are deposited in one of the following herbaria: University of Rhode Island, University of Connecticut, Gray Herbarium, Brown University, Reed Herbarium in Baltimore, and many of the specimens collected by me are in the herbarium at Randolph-Macon Woman's College, Lynchburg, Virginia. Most of the fern specimens in the herbaria checked ~~were~~ collected in the latter part of the 19th century or during the first two decades of the 20th century. Since there are no recent records for some of the ferns and since there have been many changes caused by highway con-

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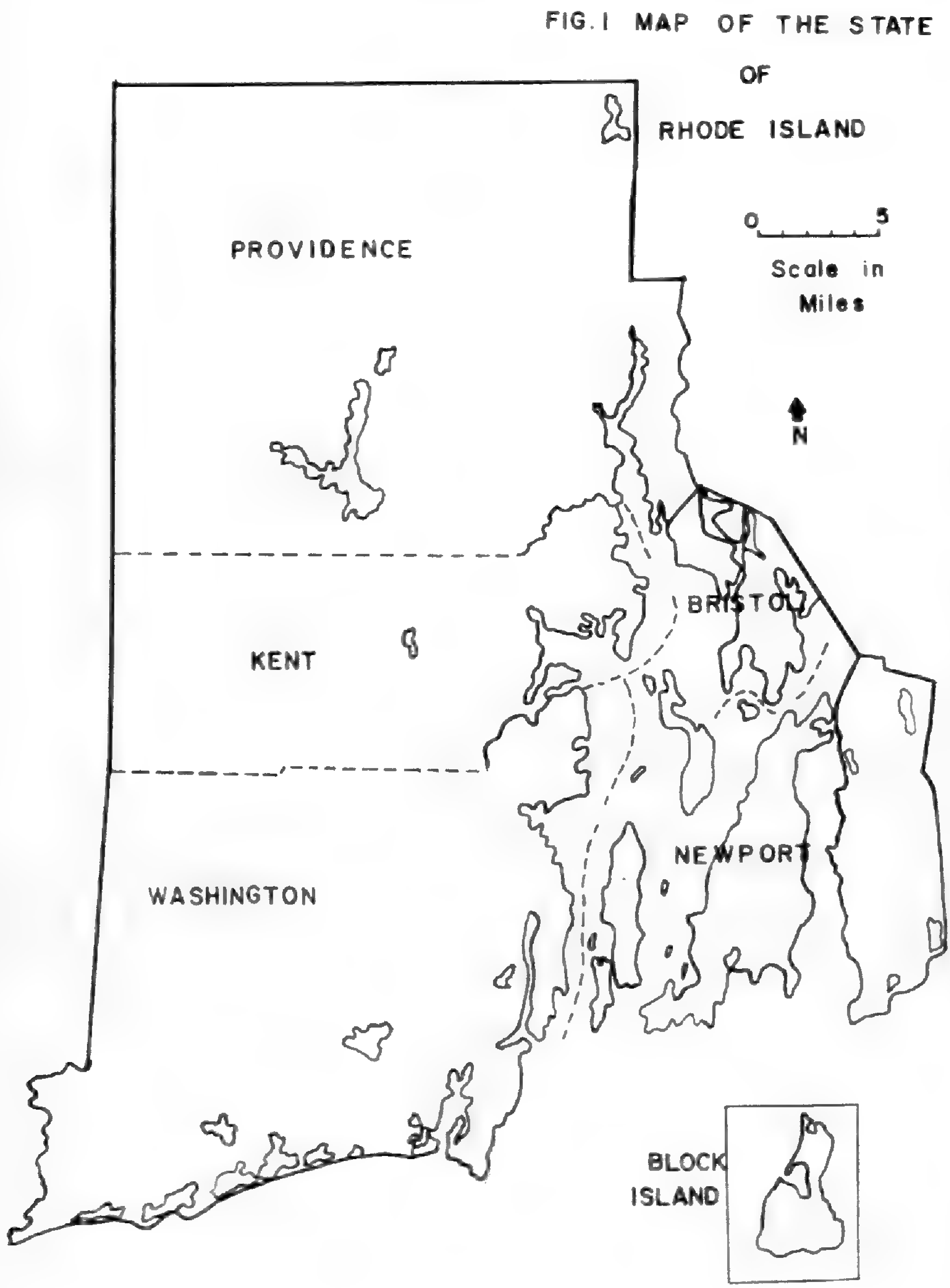
FIG. I MAP OF THE STATE
OF
RHODE ISLAND
0 5
Scale in
Miles
N
PROVIDENCE
KENT
WASHINGTON
BRISTOL
NEWPORT
BLOCK
ISLAND

struction, development of new factories and industries, and urbanization, it is probable that some of these ferns may no longer grow naturally within the State. Verified records of present-day occurrence of these ferns, as well as for those for which only a few examples are known, would be helpful. A new fern record for Rhode Island was published recently (Champlin, 1961).

One of the earliest lists of Rhode Island ferns occurs in *Plants of Rhode Island* (Bennett, 1888), which includes 36 species and varieties of ferns and 18 species of fern allies. *Notes On the Flora of Block Island* (Bailey, 1893) contains only seven species of ferns, all relatively common in the state. Bailey (1895) included the names of 40 ferns. Noble (1920) revised Bennett's list, deleted one species of *Isoetes,* added two new species, *Pellaea atropurpurea,* and *Dryopteris simulata,* and recognized as a *Aspidium boottii* species. This brought the total known species of ferns to 33 and fern allies to 20. Wright and Crandall (1941) listed 39 species of ferns.

Gray's Manual (Fernald, 1950) has been used as the authority for all scientific names in this paper. In addition certain changes in nomenclature discussed in Wherry's *The Fern Guide* (1961) and in Gleason (1952) are considered.

A table listing number of species in the New England states was published in the American Fern Journal by Blake (1950). Apparently the ferns are more adequately represented than the fern allies in Rhode Island. This may be owing to inadequate collecting rather than the actual absence of these species.

Fenneman (1938) gave a detailed description of Rhode Island's physiography in his account of the New England Province.

PLANT COVER OF RHODE ISLAND.—Two general forest types (Braun, 1950) occur within the state. The extreme northern portion is in the "White Pine Region" of New England and the remainder is in the "Sprout Hardwoods Region." Characteristic trees of the former are white pine, hemlock, beech, sugar maple, and yellow birch, while in the latter region occur second growth hardwood, including several species of oaks. Coastal white cedar is dominant in some of the bogs and swamps of the southern portion of the state and associated with it are red maple, sour gum, white elm, poison sumac, mountain-holly and blueberries. Pitch pine occurs on the sand plains adjacent to the ocean and Narragansett Bay.

FERN DISTRIBUTION.—Rhode Island is divided into five counties (Fig. 1). Distribution of ferns and fern allies is tabulated by counties in Table 1. Each record is based on a specimen or specimens deposited in one or more of the herbaria listed.

The existing records for each county partially reflect the size, geology, soils and other natural features. However, some counties have been botanized much more extensively, either because of their proximity to the colleges and universities, or because of peculiar habitat features which have attracted the interest of collectors and botanists during the past 100 years.

DISCUSSION

Equisetaceae—Horsetail Family

Equisetum arvense L.—Field Horsetail
E. fluviatile L.—Water Horsetail
E. hyemale L. var. *affine* (Engelm.) A. A. Eat.—Scouring Rush
E. sylvaticum L. var. *pauciramosum* Milde—Woodland Horsetail
E. sylvaticum f. *multiramosum* Fern.

Of the above four species, *E. arvense* occurs most frequently. It occurs on Block Island and in all the counties. *Equisetum sylvaticum* f. *multiramosum* of Gray's Manual is considered a variety by Wherry (1961), who assigns a definite geographic range to this population. The only two representatives of this form observed were collected in Providence County in 1877 and 1911.

Lycopodiaceae—Clubmoss Family

Lycopodium clavatum L.—Common or Running Clubmoss
L. clavatum var. *megastachyon* Fern. and Bissell
L. complanatum L. var. *flabelliforme* Fern.—Crowfoot
L. inundatum L.—Bog Clubmoss
L. lucidulum Michx.—Shining Clubmoss
L. obscurum L.—Ground-pine
L. obscurum var. *dendroideum* (Michx.) D. C. Eat.—Ground-pine

L. tristachyum Pursh—Ground-pine or Ground-cedar

The first species is known from three counties, Providence, Kent and Washington. Formerly the only herbarium specimen from the latter county was one collected in 1927 from South Kingston. It was found by the author in 1958, growing abundantly in oak and pine woods in Westerly, Washington County. Variety *megastachyon* is represented by one specimen from Providence County.

The Crowfoot Clubmoss or Creeping Jenny is classed as a species, *L. flabelliforme* (Fern.) Blanchard, by Wherry (1961). It is common in some wooded areas but is unknown from Bristol and Newport counties.

All specimens of the Bog Clubmoss in the Gray Herbarium are considered to be var. *bigelovii* and it may be that most or all specimens from this state should be classified as this variety. Because of the confusion within this highly variable taxon Wherry (1961) recognized only the species. There has been no attempt in the present paper to distinguish the variety. Specimens are known from Providence, Washington and Newport counties and from Block Island.

The Shining Clubmoss grows rather abundantly in moist *Rhododendron* thickets and in beds of sphagnum in Washington County. It occurs in all except Bristol County. Numerous collections are known from each of these counties with the exception of Kent, which until the summer of 1963 was represented by one specimen from West Greenwich collected in 1878. Recently several stations were observed on the W. Alton Jones Campus in Kent County.

Both var. *obscurum* and var. *dendroideum* of the Tree Clubmoss, Ground-pine or Princess-pine, as this clubmoss is called in Washington County, are encountered relatively often in moist wooded areas and partial clearings. Variety *obscurum* has been collected in all counties except Bristol and specimens of var. *dendroideum* are recorded from Providence and Washington counties.

Lycopodium tristachyum is known chiefly from Washington County. Only one specimen was seen from Kent and one from Providence County.

Selaginellaceae—Spikemoss Family

Selaginella apoda (L.) Fern.—Meadow Spikemoss

S. rupestris (L.) Spring—Rock Spikemoss

The first of these two species is relatively common in damp areas and has been found in all counties except Bristol and Newport. The second species grows in more exposed situations on rocky ledges and gravelly slopes. The only specimens recorded from Washington County were found by the author in 1958, growing on exposed granite ledges. Only seven other specimens were noted, six of these from Providence County and one from Newport.

Isoetaceae—Quillwort Family

Isoetes engelmannii A. Br.

I. muricata Dur.

I. riparia Engelm.

I. riparia var. *canadensis* Engelm.

I. tuckermanii A. Br.

In this family four species are known from herbarium specimens but the genus is poorly represented in collections. There are only a few specimens of each species. The only specimen of *I. tuckermanii* seen is in the Gray Herbarium. A majority of the few specimens available are in very poor condition and inadequate for accurate identification. These four species were recorded from the Diamond Hill area in Providence County by Ernest Palmer (1947). Perhaps because of their aquatic habitat, their resemblance to tufted grasses, and because they are difficult to identify, these plants have been overlooked or avoided by many fern collectors.

Ophioglossaceae—Adder's Tongue Family

Botrychium dissectum Spreng var. *dissectum*

B. dissectum f. *elongatum* (Gilbert and Haberer) Weath.

B. dissectum f. *obliquum* (Muhl.) Fern.

B. dissectum f. *oneidense* (Gilbert) Clute.

B. lanceolatum (Gmel.) Angstr. var. *angustisegmentum* Pease and Moore.

B. matricariifolium A. Br.
B. multifidum (Gmel.) Rupr. var. *intermedium* (D. C. Eat.) Farw.
B. simplex E. Hitchc.
B. virginianum (L.) Sw.
Ophioglossum vulgatum L.—Adder's Tongue

Fernald (1950) lists many forms of *B. dissectum* that Wherry (1961) calls varieties. One of these forms, *B. dissectum* f. *oneidense* is considered a species by Wherry (1960, 1961). Studies by Wagner (1959) indicate that *B. ternatum*, not included in the above list, occurs in the United States. Since this fern resembles small-lobed forms of *B. multifidum* var. *intermedium* which occurs in Rhode Island, it may be found ultimately that *B. ternatum* also occurs here. Six species and three forms of *Botrychium* have been collected in the state with Providence and Washington counties best represented. I have seen no specimens from Kent County. *B. dissectum* f. *obliquum* is the only grapefern known from Bristol County.

The only observed specimen of *Ophioglossum vulgatum* was collected from Providence County and is in the Gray Herbarium.

Osmundaceae—Flowering Fern Family

Osmunda cinnamomea L.—Cinnamon Fern
O. cinnamomea var. *glandulosa* Waters
O. claytoniana L.—Interrupted Fern.
O. regalis L. var. *spectabilis* (Willd.) Gray.—Royal Fern

The Cinnamon, Interrupted and Royal ferns occur in all five counties. *O. cinnamomea* var. *glandulosa* was collected in 1906 from Barrington, Bristol County, and according to Fernald (1950) occurs "on or near Coastal Plain, R. I." If herbarium specimens indicate accurately its frequency, it is relatively rare in the state. These ferns are among the largest that grow within the state. The Cinnamon Fern occasionally attains a height of six feet in swamps and at margins of bogs in Washington County.

Schizaeaceae—Curly-Grass Family

Lygodium palmatum (Bernh.) Sw.—Climbing Fern

This interesting fern with its twining rachis is known from only two counties. During the past year a sight record was reported in Washington County but it has not been verified. The most recent specimens from Providence County are dated 1906, while specimens from Kent County were collected in 1920.

Polypodiaceae—Fern Family

Adiantum pedatum L.—Northern Maidenhair Fern

This beautiful fern is known in Rhode Island only from Washington and Providence counties. Most specimens were collected in the last decade of the 19th century and probably several of the early stations are no longer in existence. E. J. Palmer (1947) found this species in a few places in rich and moist woods in Providence County.

Asplenium montanum Willd.—Mountain Spleenwort

A. platyneuron (L.) Oakes—Ebony Spleenwort

A. trichomanes L.—Maidenhair Spleenwort

The Mountain Spleenwort was reported from Rhode Island first by Champlin (1961). The specimens were discovered in West Glocester, Providence County. It is surprising that a species (unless introduced) should be discovered so recently in an area in which there has been intensive collecting for many years.

Although the Ebony Spleenwort is not recorded from Kent County, it is found so commonly in the other parts of the state that a search in this county may reveal its presence. It is well represented in the herbaria checked.

The Maidenhair Spleenwort is an inhabitant of rock crevices in Providence, Kent and Washington counties. The only specimen from Kent is dated 1897 and the two from Washington County, 1908.

Athyrium filix-femina (L.) Roth var. *asplenioides* (Michx.) Farw.—Lady Fern

A. filix-femina var. *michauxii* (Spreng.) Farw.—Lady Fern

A. thelypteroides (Michx.) Desv.—Silvery Athyrium

The first named of the above ferns is maintained as *Athyrium asplenioides* (Michx.) A. Eaton, and the second as *A. angustum* (Willd.) Presl., by Wherry (1961). The latter name is found in many of the early fern lists, including that of E. J. Palmer (1947). Fernald (1950) describes this species as "discouragingly variable" and numerous forms of variety *michauxii* are labeled in the herbaria. Among these are f. *elatius, rubellum, elegans* and *laciniatum*. The variety *michauxii* is widely distributed in the state, having been collected from all counties and from Block Island. Only a few specimens of variety *asplenioides* were observed, none from Kent or Bristol. The Silvery Athyrium is known from Providence, Kent and Washington counties.

Camptosorus rhizophyllus (L.) Link—Walking Fern

The Walking Fern is rare within the state, known only from the towns of Lincoln and Smithfield in Providence County. In the five herbaria checked, the most recent specimen was collected in 1910.

Cystopteris bulbifera (L.) Bernh.—Bulblet Fern

C. fragilis (L.) Bernh.—Fragile Fern

C. fragilis var. *mackayi* Lawson

Two specimens of the Bulblet-fern were observed from Providence County. One was collected on September 18, 1899, from "Dr. Field's Grounds," indicating that it may have been cultivated in his garden. The other specimen was collected on July 9, 1873, in East Greenwich, Kent County. Whether or not this fern may still grow native in the state is uncertain. Numerous records of the Fragile Fern are known from Providence and Newport counties but only one from Washington County.

Dennstaedtia punctilobula (Michx.) Moore—Hay-scented Fern

This fern, growing on Block Island and in all five counties, is one of our most common ferns in pastures and open woodlands, frequently spreading rather rapidly along stone walls and edges of woods.

Dryopteris cristata (L.) Gray—Crested Wood-Fern

D. disjuncta (Ledeb.) C. V. Mort.—Oak Fern

D. hexagonoptera (Michx.) Christens.—Broad Beech-Fern

D. marginalis (L.) Gray—Marginal Shield-Fern

D. noveboracensis (L.) Gray—New York Fern

D. phegopteris (L.) Christens.—Long Beech-Fern

D. simulata Davenp.—Massachusetts Fern

D. spinulosa (O. F. Muell.) Watt—Spinulose Wood-Fern

D. spinulosa var. *intermedia* (Muhl.) Underw.

D. thelypteris (L.) Gray var. *pubescens* (Lawson) Nakai—Marsh or Meadow-Fern

Hybrids

Dryopteris clintoniana × *cristata* Wherry
D. cristata × *intermedia* Dowell
D. cristata × *marginalis* Davenp.
D. intermedia × *spinulosa* Wherry

The Crested Wood-Fern has been found in all five counties.

The only three specimens of the Oak-fern observed were from Washington County. Wherry (1961) and Gleason (1952) accept the name *Gymnocarpium dryopteris* (L.) Newman, but Fernald (1950) retains the genus *Dryopteris*. Nomenclature of the Broad-Beech-fern is also questioned and this species is assigned to the genus *Dryopteris* by Fernald (1950), to *Phegopteris* by Wherry (1961) and to *Thelypteris* by Gleason (1952). Herbarium specimens of the Broad Beech-fern are known only from Providence County.

Specimens of the Marginal Shield-fern have been collected in all counties, with f. *elegans* (J. Robins.) F. W. Gray known from Providence County. One specimen is filed from Bristol, three from Newport and twenty-four from Providence County.

Examples of the New York Fern, a relatively common inhabitant of acid woods and boggy or swampy places, have been collected from all five counties. Both Gleason (1952) and Wherry (1961) assign this fern to *Thelypteris*.

The Long Beech-fern, known from Providence, Kent, and Washington counties, is included in *Dryopteris* by Fernald (1950) but has been placed in *Phegopteris* by Wherry (1961). Gleason (1952) includes both of the Beech Ferns in *Thelypteris*.

The Massachusetts or Bog Fern is known from all five counties and Block Island and is well represented in the various herbaria. Both Gleason (1952) and Wherry (1961) assign this fern to *Thelypteris*.

Several varieties and/or hybrids of the Spinulose Wood-fern occur throughout much of the state. *Dryopteris spinulosa* var. *spinulosa* grows in all five counties. The most frequently encountered variety, *intermedia*, is given species status by Wherry (1961). All except Newport County and Block Island are represented by specimens in the herbaria.

The Marsh or Meadow-fern is represented by numerous specimens from each of the counties and from the vicinity of Harbor Pond on Block Island.

Much confusion exists concerning *Dryopteris* hybrids and this paper will not attempt to verify the records and names for them. For uniformity the four hybrids that presumably occur within the state are listed under the names of the two parents although not all of these are included in Fernald (1950).

The hybrid *D. clintoniana* × *cristata* was found in Washington County and identified as *D. clintoniana* var. *australis* Wherry. Fernald did not recognize the species *clintoniana* but considered this a variety of *D. cristata*. Today this fern is thought to be a hybrid between *clintoniana* (hexaploid) and *cristata* (tetraploid) and has been given the epithet *D.* × *australis* (Wherry, 1961). However, the absence of one of the parents of *D. clintoniana*, namely *D. goldiana*, from Rhode Island raises doubt in the mind of the author that this hybrid actually occurs here. Perhaps on the basis of glandular indusia and other similarities, these specimens may prove to belong to the next hybrid.

Boott's Shield Fern (*D. cristata* × *intermedia*), one of the commonest and best known of the *Dryopteris* hybrids, is intermediate between *D. spinulosa* var. *intermedia* and *D. cristata* and probably occurs over much of the state where the two parents are found. It was recognized by Fernald as *D.* × *boottii* (Tuckerm.) Underw. Records are known from all counties except Newport.

The only specimen of *D. cristata* × *marginalis* or *D.* × *slossonae* Wherry was collected in Bristol County in 1894.

Two specimens collected by J. F. Collins from Barrington in Bristol County and labeled *D. spinulosa* var. *fructuosa* (Gilbert) Trudell, appear to be the hybrid, *D. intermedia* × *spinulosa*, or *D.* × *triploidea* Wherry, since upon examination most of the spores appear to be aborted. Wherry (1960) notes that most of the specimens in herbaria labelled "*fructuosa*" are merely luxuriant *intermedia* but this is presumably not the case in this instance.

Onoclea sensibilis L.—Sensitive Fern

Dr. Wherry prefers the common name "Bead Fern" which refers to the bead-like fertile pinnules rather than the more familiar name (at least to the author) of Sensitive Fern which is in reference to the blackening of the fronds at first frost. This fern occurs in all five counties and on Block Island.

Pellaea atropurpurea (L.) Link—Purple Cliff-brake

The Purple Cliff-brake, one of the rare ferns in the state, is known only from limestone cliffs in Limerock, Providence County, where it was collected in 1906 and 1913.

Polypodium virginianum L.—Rock-polypody

The Rock-polypody or Rock-cap fern is known from all counties, where it occurs chiefly in humus on rock outcrops.

Polystichum acrostichoides (Michx.) Schott—Christmas Fern

The Christmas Fern is common in some of our wooded areas and specimens have been collected from all counties and there are representatives in all five herbaria. Newport County is represented by one specimen from the town of Portsmouth and Bristol by one specimen from the town of Barrington.

Pteretis pensylvanica (Willd.) Fern.—Ostrich Fern

Although included in the genus *Pteretis* by Fernald (1950) the accepted name today is *Matteuccia pensylvanica* Raymond (Wherry, 1961; Gleason, 1952). The Ostrich fern is rather rare in Rhode Island, having been collected only from Providence County in 1914 and 1925.

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw.—Brake or Bracken

The Bracken Fern may cover extensive areas in dry woods and pastures especially following fire or other disturbance. Although this is perhaps one of the more common ferns in the state, it was not represented from Newport County in the herbaria studied.

Woodsia ilvensis (L.) R. Br.—Rusty or Fragrant Woodsia

W. obtusa (Spreng.) Torr.—Blunt-lobed or Large Woodsia

The only two specimens of the Rusty Woodsia seen were collected in 1908 from Copper Mine Hill in Providence County and are filed in the Gray Herbarium and Brown University Herbarium. Many collections of the Blunt-lobed Woodsia are known from Providence County but only two sites have been recorded for Washington County and one for Kent County. In 1937 this *Woodsia* was found growing profusely in the rock walls of a well in Washington County. This well has since been covered over and the station no longer exists.

Woodwardia areolata (L.) Moore—Netted Chain-fern
W. virginica (L.) Sm.—Virginia Chain-fern

Both species of *Woodwardia* have been collected from all five counties and from Block Island. They are especially prevalent in the Great Swamp and the cranberry bogs in Washington County. The Netted Chain-fern is placed in the Genus *Lorinseria* by Wherry (1961) but is included in the Genus *Woodwardia* by both Fernald (1950) and Gleason (1952).

TABLE 1. County Distribution of Ferns and Fern Allies in Rhode Island

	COUNTIES					
	P	K	W	B	N	Bl
EQUISETACEAE						
Equisetum arvense var. ***arvense***	x	x	x	x	x	x
E. fluviatile	x				x	
E. hyemale var. ***affine***	x	x			x	
E. sylvaticum var. ***pauciramosum***	x		x	x		
E. sylvaticum f. ***multiramosum***	x					
LYCOPODIACEAE						
Lycopodium clavatum var. ***clavatum***	x	x	x			
L. clavatum var. ***megastachyon***	x					
L. complanatum var. ***flabelliforme***	x	x	x			
L. inundatum (? var.)	x		x		x	x
L. lucidulum	x	x	x		x	
L. obscurum	x	x	x		x	
L. obscurum var. ***dendroideum***	x		x			
L. tristachyum	x	x	x			
SELAGINELLACEAE						
Selaginella apoda	x	x	x			
S. rupestris	x		x		x	

ISOETACEAE						
Isoetes engelmannii	x				x	
I. muricata	x	x				
I. riparia var. *riparia*			x			
I. riparia var. *canadensis*	x					
I. tuckermanii	x					
OPHIOGLOSSACEAE						
Botrychium dissectum var. *dissectum*	x		x		x	
B. dissectum f. *elongatum*			x			
B. dissectum f. *obliquum*	x		x	x	x	x[1]
B. dissectum f. *oneidense*	x		x		x	x[1]
B. lanceolatum var. *angustisegmentum*	x					
B. matricariifolium	x		x			
B. multifidum var. *intermedium*	x		x			
B. simplex	x		x			
B. virginianum	x					
Ophioglossum vulgatum	x					
OSMUNDACEAE						
Osmunda cinnamomea	x	x	x	x	x	x
O. cinnamomea var. *glandulosa*				x		
O. claytoniana	x	x	x	x	x	
O. regalis var. *spectabilis*	x	x	x	x	x	x[1]
SCHIZAEACEAE						
Lygodium palmatum	x	x				
POLYPODIACEAE						
Adiantum pedatum	x		x			
Asplenium montanum	x					
A. platyneuron	x		x	x	x	
A. trichomanes	x	x	x			
Athyrium filix-femina var. *asplenioides*	x		x		x	x
A. filix-femina var. *michauxii*	x	x	x	x	x	x
A. thelypteroides	x	x	x			
Camptosorus rhizophyllus	x					
Cystopteris bulbifera	x	x				
C. fragilis var. *fragilis*	x		x			
C. fragilis var. *mackayi*	x				x	
Dennstaedtia punctilobula	x	x	x	x	x	x
Dryopteris cristata	x	x	x	x	x	
D. disjuncta			x			
D. hexagonoptera	x					
D. marginalis	x	x	x	x	x	
D. noveboracensis	x	x	x	x	x	
D. phegopteris	x	x	x			
D. simulata	x	x	x	x	x	x[1]
D. spinulosa var. *spinulosa*	x	x	x	x	x	
D. spinulosa var. *intermedia*	x	x	x	x		
D. thelypteris var. *pubescens*	x	x	x	x	x	x

Dryopteris clintoniana × *cristata*			x			
D. cristata × *intermedia*	x	x	x	x		
D. cristata × *marginalis*				x		
D. intermedia × *spinulosa*					x	
Onoclea sensibilis	x	x	x	x	x	x
Pellaea atropurpurea	x					
Polypodium virginianum	x	x	x	x	x	
Polystichum acrostichoides	x	x	x	x	x	
Pteretis pensylvanica	x					
Pteridium aquilinum var. *latiusculum*	x	x	x	x		
Woodsia ilvensis	x					
W. obtusa	x	x	x			
Woodwardia areolata	x	x	x	x	x	x
W. virginica	x	x	x	x	x	x[a]

[a]Not listed by Bailey and Collins (1893)

SUMMARY.—Exclusive of varieties, forms, and hybrids, the existing herbarium specimens represent 16 species of fern allies and 40 species of ferns. These records are summarized by counties as follows:

	Fern Allies	*Ferns*
Providence	16	39
Kent	9	24
Washington	11	29
Bristol	2	19
Newport	8	19

There are known collections of all ferns and fern allies from Providence County except *Dryopteris disjuncta* which has been collected only in Washington County. In order to have as complete a list as possible, I would appreciate hearing of additional verified reports of county records of ferns and fern allies within the state.

LITERATURE CITED

BAILEY, W. W. 1893. Notes on the Flora of Block Island. Bull. Torrey Club **20**: 227-231.

———. 1895. Among Rhode Island Wild Flowers. Preston and Rounds, Providence, R. I.

———, and J. F. COLLINS. 1893. A list of Plants Found on Block Island, R. I., in July and August. Bull. Torrey Club **20**: 231-239.

BENNETT, J. L. 1888. Plants of Rhode Island. Providence Press, Providence, R. I. 128 pp.

BLAKE, S. F. 1950. State and Local Fern Floras of the United States. Supplement I. Amer. Fern Jour. **40**: 148-165.

BRAUN, E. LUCY. 1950. Deciduous Forests of Eastern North America. The Blakiston Co., Philadelphia. 596 pp.

CHAMPLIN, RICHARD L. 1961. A Fern New to Rhode Island. Rhodora **63**: 46.

CHURCHILL, J. R. et al. 1928. Reports on the Flora of Massachusetts I. Rhodora **30**: 12-19.

————. 1933. Reports on the Flora of Massachusetts II. Rhodora **35**: 351-359.

DOLE, ELEAZER, J., ed. 1937. The Flora of Vermont. 3rd rev. ed. Vermont Botanical Club XIV +353 pp.

FENNEMAN, N. M. 1938. Physiography of Eastern United States. McGraw-Hill Book Co., Inc., New York. 714 pp.

FERNALD, M. L. 1950. Gray's Manual of Botany. 8th ed. American Book Co., New York. 1632 pp.

GLEASON, H. A. 1952. New Britton and Brown Illustrated Flora, vol. I, pp. 1-57. Botanical Gardens, New York.

GRAVES, C. B. et al. 1910. Catalogue of the Flowering Plants and Ferns of Connecticut Growing without Cultivation. Bull. Conn. Geol. and Nat. Hist. Surv. 14. 569 pp.

HARGER, E. B. et al. 1930 (1931). First Supplement. Additions to the Flora of Connecticut. Bull. Conn. Geol. and Nat. Hist. Surv. 48. 94 pp.

NOBLE, G. 1920. Ferns, Fern Allies and Flowering Plants of Rhode Island. Snow and Farnham Co., Providence, R. I. pp. 2-4.

OGDEN, EDITH B. 1948. The Ferns of Maine. University of Maine Studies. No. 62. Maine Bull. **41** (3): 1-128.

PALMER, ERNEST J. 1947. Ferns and Fern Allies of Cumberland, R. I. Amer. Fern Jour. **37**: 33-38.

SCAMMON, EDITH. 1947. The Ferns and Fern Allies of New Hampshire. New Hampshire Acad. Sci. Bull. No. 2. 96 pp.

WAGNER, W. H., JR. 1959. American Grapeferns Resembling *Botrychium ternatum*: A Preliminary Report. Amer. Fern Jour. **49**: 97-103.

WHERRY, E. T. 1960. Progress in the Study of *Dryopteris* Hybrids. Amer. Fern Jour. **50**: 87-92.

————. 1961. The Fern Guide. Northeastern and Midland United States and Adjacent Canada. Doubleday and Co., Inc., New York. 318 pp.

WRIGHT, K. E. and DOROTHY CRANDALL. 1941. Rhode Island Ferns. Torreya **41**: 73-75.

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Vernation in Some Species of the Genus Cheilanthes[1]

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Circinate vernation, or the coiled condition of the leaves prior to expansion, or within the bud, is a well known characteristic of many species of ferns. Modern work on this phenomenon is summarized by Steeves and Briggs (1958) and by Briggs and Steeves (1959). The coiling is due to more active cell division and cell elongation on the abaxial (lower) side of the blade until the crozier beomes dormant. The unequal growth on the abaxial side may be termed hyponasty. The unrolling of the croziers is due to more rapid and more total growth on the adaxial side of the blade. The unrolling is an epinastic phenomenon. Both coiling and uncoiling are independent of light and gravity. Thus mitosis and elongation seem to be the factors involved directly. However, auxins, diffusing from the young developing pinnae, play an important part in elongation.

The following available species of the genus *Cheilanthes* exhibit circinate vernation: *C. viscida* (Fig. 7), *C. wrightii* (Fig. 8), *C. siliquosa* (Fig. 13), *C. lanosa* (Fig. 14), *C. californica* (Fig. 15), *C. feei* (Fig. 16), *C. intramarginalis* (Fig. 17), *C. pyramidalis* (Fig. 18) and *C. parryi* (Fig. 21). Other species in this category which are not figured are *C. cooperae* and *C. kaulfussii*.

Non-circinate vernation has been known at least since 1854 (Newman, 1854). This was noted at that time in the bracken fern and has been studied more recently in the same species by Webster and Steeves (1958). In the *Ophioglossaceae*, one finds non-circinate fronds in *Ophioglossum* and doubtfully so in *Botrychium*. Some species in the *Hymenophyllaceae*, according

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VERNATION IN CROZIERS OF CHEILANTHES. FIGURES 1-6, 9-12, 19, 20, AND 22, NON-CIRCINATE: FIGURES 7, 8, 13-18, AND 21, CIRCINATE. FIG. 1, C. ALABAMENSIS. FIG. 2, C. AEMULA. FIG. 3, C. EATONII. FIG. 4, C. MICROPHYLLA. FIG. 5, C. CLEVELANDII. FIG. 6, C. GRACILLIMA. FIG. 7, C. VISCIDA. FIG. 8, C. WRIGHTII. FIG. 9, C. HORRIDULA. FIG. 10, C. NOTHOLAENOIDES. FIG. 11, C. TOMENTOSA. FIG. 12, C. LEUCOPODA. FIG. 13, C. SILIQUOSA. FIG. 14, C. LANOSA. FIG. 15, C. CALIFORNICA. FIG. 16, C. FEEI. FIG. 17, C. INTRAMARGINALIS. FIG. 18, C. PYRAMIDALIS. FIG. 19, C. FENDLERI. FIG. 20, C. WOOTONII. FIG. 21, C. PARRYI. FIG. 22, C. VILLOSA. FIG. 23, C. LEUCOPODA.

to the 1930 observations of Goebel as reported by Steeves and Briggs (1958), are non-circinate. Du Buy and Neurnbergk (1938) noted the same characteristic in *Pteris serrulata*(?), *P. umbrosa* and *P. cretica*. Wherry (1926) reported *Cheilanthes tomentosa* as non-circinate and Weatherby (1926) added *C. eatonii*.

Generally, in this type of development, the blade is not coiled but is directed straight downward, and the upper part of the stipe, at varying distances below the blade, exhibits an approximately 180° bend. It would thus appear that the mitotic activity and subsequent elongation are, in respect to bending and unbending, more localized in non-circinate than in circinate vernation. This has yet to be confirmed. Bean seedlings develop a hook similar to the non-circinate "bend" in some ferns. Dr. R. J. Downs (1964) of the Crops Research Division, Agricultural Research Service, U.S.D.A., quoted the findings of W. H. Klein on this subject, "The opening of the excised hypocotyl hook of beans is brought about by the stimulation of cell elongation on the inside (concave) of the hook and not by cell division, since no mitotic stages have been detected in any prepared slides. The elongation is proportional to the incident energy." Dr. Downs added his own observations that "Opening and closing of hooks in dicotyledons is controlled by light. Although IAA, GA, and Kinetin can affect the response, there appears to be no interaction between the radiant energy and the additives."

The following available species of *Cheilanthes* exhibit the non-circinate condition: *C. alabamensis* (Fig. 1), *C. aemula* (Fig. 2), *C. eatonii* (Fig. 3), *C. microphylla* (Fig. 4), *C. clevelandii* (Fig. 5), *C. gracillima* (Fig. 6), *C. horridula* (Fig. 9), *C. notholaenoides* (Fig. 10), *C. tomentosa* (Fig. 11)—(dark color is due to over-fixation), *C. leucopoda* (Fig. 12), *C. fendleri* (Fig. 19), *C. wootonii* (Fig. 20), and *C. villosa* (Fig. 22). Other non-circinate species are *C. covillei*, *C. lendigera*, *C. lindheimeri*, *C. myriophylla* and *C. pringlei*. *Cheilanthes villosa* does not have, however, as well-developed a hook as occurs in some species. *Cheilanthes leucopoda* (compare Figs. 12 and 23) actually is non-circinate but the lateral pinnae develop so rapidly shortly after emergence from the ground that a resemblance to a coil can be noted.

The two types of vernation possessed by these ferns is undoubtedly a fixed genetic response and not changeable by environmental factors. A scrutiny of both the normal habitats of the ferns and of the creeping or non-creeping nature of the rhizomes, reveals no apparent correlation with the type of vernation. One might suggest that the buds on widely-creeping species would emerge more intact from the ground if the stipe-hook preceded the more delicate frond. It may be, however, that the abaxial bend on a normal circinate crozier is equally effective in protecting the bud against abrasion.

LITERATURE CITED

BRIGGS, W. R. and T. A. STEEVES. 1959. Morphogenetic studies on *Osmunda cinnamomea* L.—The mechanism of crozier uncoiling. Phytomorphology **9**: 134-147.

DOWNS, R. J. 1964. (Personal communication).

DU BUY, H. G. and E. L. NUERNBERGK. 1938. Growth, tropisms and other movements, *in* F. Verdoorn, Manual of Pteridology. The Hague, M. Nijhoff.

NEWMAN, EDWARD. 1854. A history of British ferns. London, John van Voorst. ED. 3.

STEEVES, T. A. and W. R. BRIGGS. 1958. Morphogenetic studies on *Osmunda cinnamonea* L.—The origin and early development of vegetative fronds. Phytomorphology **8**: 60-72.

WEATHERBY, C. A. 1926. Imperfectly circinate vernation in ferns. Amer. Fern Jour. **17**: 109-111.

WEBSTER, BARBARA D., and T. A. STEEVES. 1958. Morphogenesis in *Pteridium aquilinum* (L.) Kuhn.—General morphology and growth habit. Phytomorphology **8**: 30-41.

WHERRY, E. T. 1926. Observations on the Wooly fern. Amer. Fern Jour. **17**: 107-109.

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Preliminary Field Studies on the Fern Flora of Oaxaca, Mexico

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(Continued from p. 79)

The city of Villa Alta is located at 4000 feet elevation. The trail from the summit was quite wide and it took little more than an hour to hike down to the village.

The next day, Monday, was market day in Villa Alta. This enabled us to obtain extra boys to carry the additional presses brought in by plane from Oaxaca. Mr. Hallberg secured three boys without difficulty, and late in the afternoon we were off on the trail again. This time it was to get across the valley (down 1500 feet and up 2000 feet) on very steep trails to the next and last village of Yetzecovi for the night. This tiny village of 130 people has official jurisdiction over Mr. Hallberg's coffee ranch. By making this start on the trail to the ranch, we were able the next day to make a more leisurely hike to the ranch, collecting ferns along the way. The trail from Yetzecovi to the ranch rose steadily but not too steeply (compared to the other side) for three hours to the highest point of the ridge at 7200 feet. In abandoned fields near Yetzecovi we passed through a "forest" of Bracken fern, *Pteridium*, the fronds reaching 10 to 12 feet in height. Pine and oak were still the principal trees on this side of the mountain. The average rainfall was conspicuously heavier here than earlier on the trip, as indicated by the many epiphytes. For example, filmy ferns (*Hymenophyllum myriocarpum*) made their first appearance. Also species of *Gleichenia* became common in open areas on the upper parts of the slopes (*G. palmata, G. pectinata, G. bancroftii,* and *G. underwoodiana*).

When we reached the peak, it was like stepping into another world. There was a nearly constant cover of clouds and the vegetation showed their effect. The epiphytic mosses and ferns were so dense as to cover completely all trunks and branches. Here the true rainforest began. (Weather instruments kept by Mr. Hallberg in the next valley beyond recorded about 240 inches of rain per year.)

The woods were dark, cool, and moist. This might truly be called "the fern-hunter's paradise." Epiphytic species outnumbered the terrestrial species by about three to two. The former included several species of *Elaphoglossum*, as well as *Asplenium harpeodes, A. fragrans,* large polypodiums *(P. loriceum, P. lowei)*, and many tiny ferns that are easily overlooked among the bryophytes, such as species of *Hymenophyllum (H. fucoides, H. microcarpum, H. elegantulum, H. polyanthos), Cochlidium rostratum, Xiphopteris delitescens, Polypodium anfractuosum, P. pilosissimum, and P. cultratum.* Conspicuous among the terrestrial species were several large-leaved ferns: *Hypolepis nigrescens* with its lax 16-foot fronds, *Polystichum denticulatum, Culcita coniifolia,* and *Marattia weinmanniifolia.* The *Marattia* is quite common throughout the forest. It is called "maiz del monte" by the Indians, who in times of poor corn crops have ground the fleshy stipules of *Marattia* as a substitute. We searched for the large, ribbon-shaped gametophytes of *Marattia* but collected by mistake only great quantities of the liverwort *Symphyogyna.* (*Symphyogyna* is quite interesting in its own right, however, possessing well-developed tracheary tissue.) Also on the forest floor we frequently saw banks of *Sphagnum* bearing many sporophytes. Another interesting find in this area was the first tree fern of the trip, *Cyathea fulva.* This species was of particular interest since it had not been collected in Oaxaca since the type collection made by Galeotti, who had also found his specimen in the District of Villa Alta.

From the peak of the ridge we continued for about an hour on a gentle downward slope through clouded forest that here included the peculiar angiosperm *Weinmannia* (Cunoniaceae) and the conifer *Podocarpus* until we came to a small spring, El Pozo.

From this point the trail dropped markedly and ranged over steep, wet rock stairs (La Escalera), bare tree roots, and slick, wet clay. It is impossible for any beasts of burden (other than man) to traverse this trail, so all supplies and equipment to come to Mr. Hallberg's ranch must be carried on someone's back. This rich valley is the valley of the Yelagago River.

The trail ran down the west side of the valley, and after two more hours we arrived in Mr. Hallberg's ranch. The ranch consists of a clearing of several acres, a house and a couple of outbuildings. The ranch house is made of hand-sawed boards. The roof is thatched with bunches of *Setaria paniculifera*, a broad-leaved grass common in the clearing. The clearing itself is used primarily for the cultivation of coffee, corn, and beans.

Here I stayed for ten full days of collecting. Ernesto, who is a Mixe Indian, worked for me full-time, and was an excellent assistant. He was quick, eager to learn, and seemed to be interested in the project itself. He remembered just which ferns we did and did not have, and he would go to great lengths to get a new one whether it was high in a tree or hanging from a cliff. When I saw Ernesto again in 1963, he still remembered the scientific generic names that I had taught him.

The Yelagago Valley is the richest area for pteridophytes I have seen in Mexico. During my ten-day stay at the ranch I collected nearly 100 species that I had not seen previously on the trip. The tree ferns were of course the most conspicuous. (See Fig. 1.) Several of these columnar plants were common, including *Alsophila schiediana*, *Cyathea princeps*, *C. mexicana*, and *C. jurgensenii*. The latter species, known only from Veracruz and Oaxaca, has been collected only rarely.

Besides the omnipresent *Marattia*, another member of the Marattiaceae, *Danaea cuspidata*, is common in the woods. The filmy ferns are some of the most interesting and at the same time frustrating ferns found. I found 14 species of Hymenophyllaceae, largely epiphytes, but they are so abundant and interwined among the mosses on the tree trunks that in spite of my efforts several mixed collections resulted. The genus *Elaphoglossum*, the stag-tongue ferns, is represented by approximately 15 species, but due to the great difficulty in identifying them, most of them remain unnamed. The other best-represented genera in numbers of species are *Asplenium*, *Thelypteris*, and *Selaginella*.

Many of the species which were found can now be reported for the first time for Oaxaca, and several are first records for Mexico. The greatest single range extension found was for *Blechnum divergens (Struthiopteris exaltata)*, which previously had not been reported north of Costa Rica. Only two species of *Pteris* were found. *Pteris quadriaurita* is common in southern Mexico, but *P. podophylla* is quite striking with fronds over ten feet long.

FIGURE 1. CYATHEA PRINCEPS IN YELAGAGO VALLEY. FIGURE 2. PTERIS PODOPHYLLA, SAME AREA.

(See Fig. 2.) Around the edge of the clearing and in exposed areas in the forest the bramble fern, *Hypolepis*, forms dense thickets. With prickles on the backs of the rachis and costae, this plant is as great a nuisance as *Rubus* in the northeastern United States. In the clearing itself *Pityrogramma calomelanos* and *Histiopteris incisa* are common weeds.

One of the most interesting groups of ferns both taxonomically and morphologically is that of the radicant aspleniums, which act like our walking fern, *Asplenium (Camptosorus) rhizophyllum*. *Asplenium rutaceum* is common and several taxa ascribed to *A. radicans* are also found. Plants placed in *A. radicans* vary in their dissection from once pinnate to nearly four times pinnate, each form having a separate varietal name. Miss Shirley Nordahl of Iowa State University is currently studying this group to determine whether this is indeed a single species with distinct varieties, or a series of closely related species.

The Lycopsida are also abundant in the Yelagago Valley. Seven species of *Selaginella* have been identified, including the large, plume-like *S. martensii*; one or two others are probably as yet undescribed. *Lycopodium* is represented by six species: the terrestrial *L. reflexum*, *L. complanatum*, and *L. clavatum*; the pendant epiphytes *L. taxifolium* and *L. linifolium*; and the erect epiphyte *L. pithyoides*. I nearly missed finding the latter species. While I was at the ranch, trees were being felled to make new land available for corn. I took advantage of these huge fallen trees (100-150 feet tall) to explore for epiphytes. It was here that I ran across a few plants of *L. pithyoides*. This species has the appearance of a pine seedling; the plant grows erect with a thick, deep red stem and leaves over an inch long that resemble conifer needles.

Collecting in the rainforest presented the obvious problem of how to dry specimens. The blotters from my presses had to be dried over a fire each day. The air was far too humid for effective drying of the blotters in the sun (and it was, in any event, a waste of sunny weather not to be out collecting).

On August 4, after ten days of collecting in the Yelagago Valley, we hiked back to Villa Alta. Ernesto and three other boys carried the dried and living specimens while I hiked ahead of them, collecting additional ferns. After waiting a day in Villa Alta, I took the light plane from there to Oaxaca, and soon departed for the United States.

The pteridophytes in the collection made during this field exploration include over 200 species, most of which were found in the Yelagago Valley. Of this number between 15 and 20 species have apparently not been described heretofore, and include species in *Asplenium, Selaginella, Thelypteris, Grammitis, Polypodium,* and *Diplazium.*

Since the expedition described above, I now have made subsequent collections in four other parts of the state: central Oaxaca, on Cerro San Felipe and other parts of the valley of Oaxaca; north-central, north of Oaxaca on the new road through Ixtlan toward Tuxtepec; southeast, on the Isthmus of Tehuantepec and towards the Chiapas border; and south, from Oaxaca to Pochutla on the Pacific Coast. My own collections from Oaxaca now include over 300 species and represent what I feel is still a relatively sparse sampling of the state. Most of the previous collections have been from only four of the 30 state districts: Central. Pochutla, Tuxtepec, and Cuicatlan. Ten of the districts apparently have never been touched at all. Further collecting in all parts of Oaxaca will undoubtedly increase considerably the number of known species.

LITERATURE CITED

CONZATTI, C. 1939. Flora Taxonomica Mexicana I. Mexico, D. F.

FÉE, A. L. A. 1857. Catalogue méthodique des Fougères et des Lycopodiacées du Mexique. Strasburg.

HEMSLEY, W. B. 1885-1886. Biologia Centrali-Americana 3. London.

MARTENS, M., and H. GALEOTTI. 1842. Mémoire sur les Fougères du Mexique. Brussels.

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Dr. Mickel has found a fern student's paradise! Many isolated valleys and ranges in the American tropics and subtropics are likely to yield treasures such as he reports in this paper. May he return to the Oaxacan localities as often as his teaching duties permit, and supply a more complete listing as soon as he can make the difficult determinations required.—Editor.

An Analysis of a Variable Population of Equisetum arvense and E. × litorale.

RICHARD L. HAUKE

INTRODUCTION—The first species in the genus *Equisetum* suspected to be of hybrid origin was *E. litorale.* Ruprecht described it as a species in 1845 from material supplied by Kuehlewein. He noted that it was intermediate between *E. arvense* and *E. fluviatile.* Lasch independently described the same plant under the name *E. inundatum* a year later. Lasch, according to Milde (1852) suspected it to be a hybrid between *E. arvense* and *E fluviatile*, and Milde, after studying its internal structure and noting the constant spore abortion, decided that it was such a hybrid (1851). He later (1867, p. 368) was impressed with how common *E. litorale* seemed and decided on that basis that rather than a hybrid, it was a species becoming extinct (hence the sterility). The acceptance, otherwise, of *E. litorale* as a hybrid between *E. arvense* and *E. fluviatile* was general. There were but few exceptions, such as DuBuysson (1888, p. 204) who considered it a true species, and A. A. Eaton (1901), who reserved judgment pending further information (p. 84, "At present it is an open question, but those holding the hybrid theory are certainly wrong in saying the burden of proof rests with those who reject it, for hybridity being contrary to the natural mode of propagation, it certainly cannot appertain to those who hold the natural method to prove that it is violated.")

John Schaffner (1923) dismissed *E. litorale* as being semi-sterile shoots of *E. palustre* and also hybrids between *E. palustre* and *E. arvense*, and perhaps between *E. fluviatile* and *E. arvense.* He later (1926) decided it was only semi-sterile shoots of *E. palustre.* Victorin (1927) wrote that "E. littorale est une categorie très artificielle, une sorte de (depotoir) taxonomique" into which are placed specimens combining the characters of the three species *E. arvense*, *E. limosum* (*E. fluviatile*) and *E. palustre.* He later (1935) considered it a hybrid between *E. arvense* and *E. palustre.*

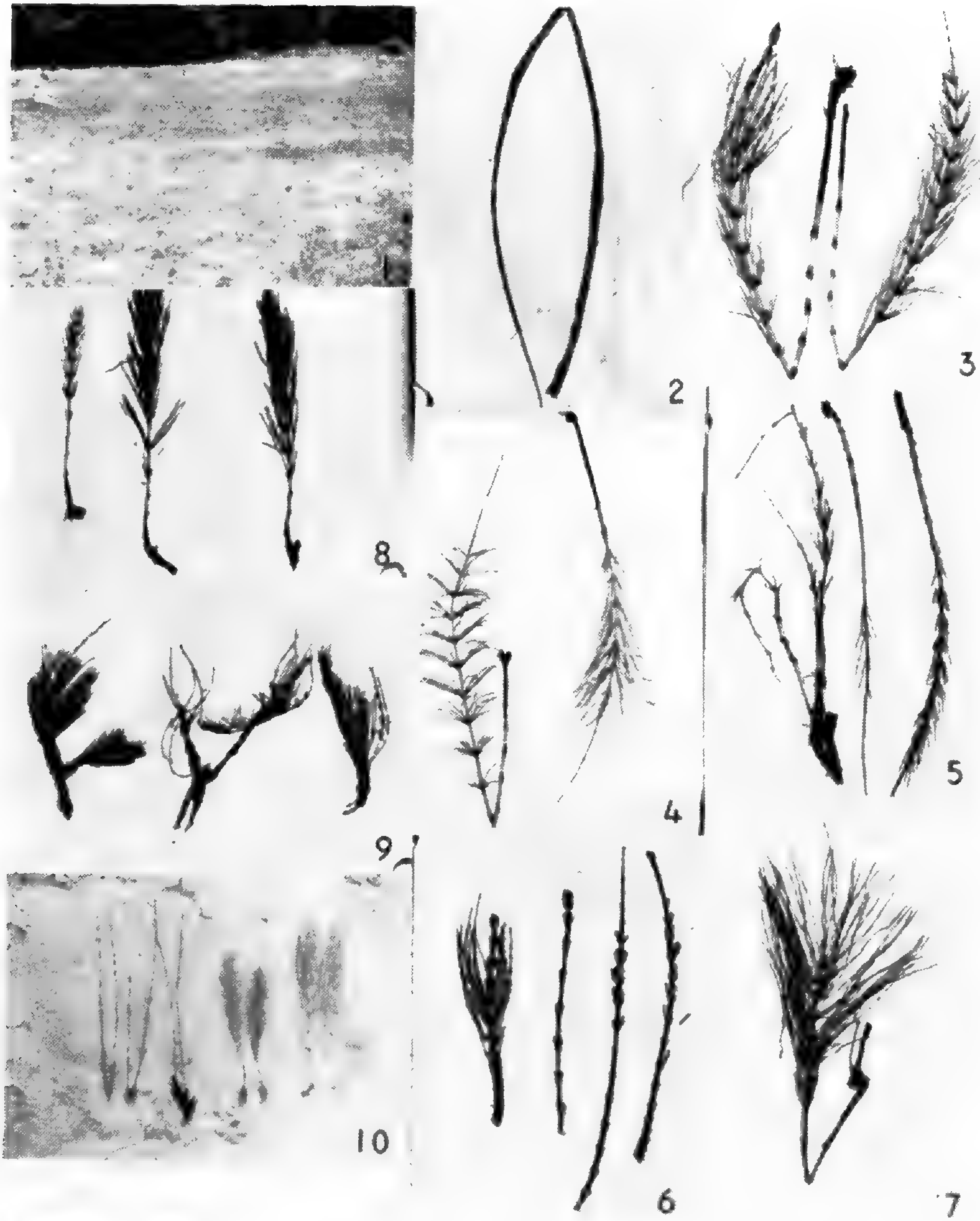


FIGURE 1. AREA IN WHICH EQUISETUM ARVENSE AND E. × LITORALE WERE GROWING. FIGURES 2-3. SPECIMENS COLLECTED IN FLOODED DITCH NEARBY; 2. E. FLUVIATILE, 134; 3. E × LITORALE, 105B. FIGURES 4-9. SPECIMENS COLLECTED IN AREA PICTURED: 4-6. E. × LITORALE; 4. 105B₁, WET WOODS; 5. 105B₂, WET FIELD; 6. 105B₃, DRY FIELD; 7-9. E. ARVENSE; 7. 133B₁, WET WOODS; 8. 133B₂, WET FIELD; 9. 133B₃, DRY FIELD. FIGURE 10. LEFT, E. FLUVIATILE; MIDDLE, E. × LITORALE; RIGHT, E. ARVENSE.

Dr. Irene Manton (1950) showed cytological evidence that *E. litorale* is a hybrid, and accepted Milde's morphological evidence that the parents are *E. arvense* and *E. fluviatile.*

I had the good fortune to be introduced to an extensive mixed population of *E.* × *litorale* and *E. arvense,* in an area where *E. fluviatile* was also present. This population was discovered by Dr. Warren H. Wagner, Jr. Since the hybrid and one parent were present in large numbers over a variety of habitats, it was decided to make mass collections and to study them closely. Consequently, on June 3, 1957 Doctors Wagner, Aban J. Randeria, Robert F. Blasdell and I went there and collected a series of specimens. The analysis of these revealed two noteworthy things: that *E.* × *litorale* is indeed intermediate in nearly every character between *E. arvense,* and *E. fluviatile,* and that the morphological responses of *E. arvense* to environmental stress are paralleled closely by the responses of *E.* × *litorale.* The purpose of this report is to elucidate these two observations.

DESCRIPTION OF AREA AND POPULATION—The population under discussion was growing in Monroe County, Michigan, just west of Hitchingham Road, 0.2 mi. north of Darling Road. This locality is about 3 mi. east of Milan. The area is rather flat terrain, with dry sandy soil, the result of submersion by glacial lakes. Along the road was a flooded ditch inhabited by *E. fluviatile* and *E.* × *litorale.* Across the ditch, there was a dry open field, once planted in beans but later abandoned, according to the owner, because of the persistent growth of horsetails. The field abutted on a wet wooded area (Fig. 1). The two horsetails *E.* × *litorale* and *E. arvense* grew intermingled in the field and into the woods. It was surprising to find *E.* × *litorale* in a dry sandy area but presumably its clonal nature enabled it to invade an area where it would not normally grow. Most surprising was to find that only in the dry part of the area was *E.* × *litorale* cone-bearing.

METHODS OF STUDY—Mass collections were made from four different habitats within this area, as follows: 134. *E. fluviatile* in

Table 1. Mean values for measurements of *E.* × *litorale* and its possible parents.

Number (except where noted)		*E. arvense* 42	× *litorale** 80	*E. fluviatile* 15	*E. palustre* 5
Sheath	Length	2.8	4.9	6.0	9
	Width	2.9	3.9	5.8	4.7
Teeth	Number	9.6	11.3	14.7	8.6
	Length	1.6	2.0	2.4	5
Internode	Number	16.7[a]	23.8[d]	31.6	—
	Branched	8.8	10.1[e]	5.3[h]	11.3[j]
	Above branches	6.5[b]	7.7[f]	13.6[i]	—
	Width	1.7	2.8	4.9	3.1
	Length	17.4	21.8	37.9	61
Plant height		216[c]	400[g]	1005[i]	760[j]
Sheath width ÷ Internode width		1.75	1.34	1.19	1.52
Teeth number ÷ Sheath width		3.45	2.96	2.60	1.86
Sheath length ÷ Sheath width		0.96	1.26	1.04	1.92
Internode length ÷ Sheath length		5.99	5.56	6.42	6.90

*except cone-bearing stems.
a-21 specimens b-22 c-32 d-73 e-71 f-65 g-74 h-10 i-8 j-4.

flooded ditch (Fig. 2); 105. *E.* × *litorale*, 105b (Fig. 3) with 134, 105 b_1 (Fig. 4) in wet woods, 105 b_2 (Fig. 5) along edge of woods in wet part of field, 105 b_3 (Fig. 6) in dry part of field; 133 *E. arvense*, 133 b_1 (Fig. 7) with 105 b_1, 133 b_2 (Fig. 8) with 105 b_2, 133 b_3 (Fig. 9) with 105 b_3. Specimens were pressed for later analysis. Measurements were taken from these specimens and recorded on duplicated forms. To standardize measurements the following procedure was observed. Sheath measurements were made on a sheath from the lower portion of the stem, but not the lowermost. Sheath length was measured from the base of the teeth to the slight constriction marking where the sheath joins the stem. Sheath width was measured just below the teeth. The base of the tooth was marked by the depth of the sinus between teeth. Internode measurements were made on the internode above or below the nodal sheath measured. Width was measured near the middle. Length was taken from the base of one sheath to the base of the sheath next above. Plant height measurements were taken from ground level, this being judged by the darker color of the below-ground portion of the stem.

When all the measurements had been made, means and standard deviations were calculated, and the collections of one species from several habitats were compared. Then an overall average for each species was obtained and these were compared. For comparison, a collection of *E. palustre* from the northern part of the lower peninsula was included in the study.

RESULTS.—As Table 1 shows, *E.* × *litorale* does indeed fall between *E. arvense* and *E. fluviatile* in most of the characters measured, and *E. palustre* is quite divergent from these. An exception is in the number of nodes bearing branches, but this can be explained readily by the fact that *E. fluviatile* is initially unbranched, and becomes more branched as the season progresses. That is, the genus *Equisetum* is characterized by formation of branch buds at the bases of the leaves (between leaves). In the species which are normally unbranched, these buds remain dormant; in the species which are normally branched they develop readily. In *E. fluviatile* they develop more slowly than in *E. arvense,* and many of them remain dormant. Whereas this collection averages 5.3 branch-bearing nodes per plant, and 13.6 nodes above the branched nodes, a collection from another locality made on 11 July averaged 11.8 branched nodes and 13.3 nodes above the branched nodes.

Two of the ratios calculated, sheath length-width and internode length-sheath length reveal that *E.* × *litorale* is not intermediate between its postulated parents in sheath form or relative sheath length. In each case this is the result of an imperfect intermediacy of the hybrid in the two characters used in the ratio; i.e. it is more like one parent in the first character, but closer to the other parent in the second character. This non-intermediacy of ratios is of interest because in an earlier work, (Hauke, 1963, pp. 88, 90) I postulated that a hybrid might inherit a ratio (i.e. a form). Rather than the several dimensions of a given plant part being each controlled by a separate set of genes, it was hypothesized that one dimension and a certain form might be genetically determined. For example, one species may have leaves averaging 10 inches long and 5 inches wide, or a ratio of 2/1. Another may have leaves averaging 2 inches long and 4 inches wide, for a ratio of 1/2. A hybrid between them might inherit an intermediate length 6 inches, and an intermediate form, a 1/1 ratio. It would have leaves 6 inches wide, or wider than either parent. Recent experimental evidence (Haber, 1962; Haber and Foard 1963, 1964) has supported this by showing that the overall form of an organ is under strong morphogenetic control. In the present case, however, *E.* × *litorale* seems to have inherited, not an intermediate form, but rather an intermediate size.

One might question the parentage of the hybrid, but consideration of the other possible parent, *E. palustre*, shows that in sheath length-width ratio *E.* × *litorale* is intermediate between it and *E. fluviatile*, whereas in internodal length-sheath length ratio the hybrid is lower than any of the possible parents.

Table 2. Comparison of mean values for sterile and fertile stems of *E.* × *litorale* from the dry field habitat.

Number (except where noted)		*Sterile* 24	*Fertile* 25
Sheath	Length	4.3	5.2
	Width	3.5	4.3
Teeth	Number	11.3	11.6
	Length	1.9	2.8
Inter-node	Number	20.9	11.5
	Branched	5.5[a]	3.0[b]
	Above branches	8.3[a]	4.0[b]
	Width	2.2	2.6
	Length	18.2	19.0
Plant height		264	165
Sheath width ÷ Internode width		1.62	1.69
Tooth number ÷ Sheath width		3.29	2.74
Sheath length ÷ Sheath width		1.23	1.22
Internode length ÷ Sheath length		4.30	3.69

[a] 15 specimens
[b] 9 specimens

In constructing Table 1, I used only non-strobilate material of *E.* × *litorale*. This was done to make it comparable to the postulated parents. A separate comparison of sterile and fertile *E.* × *litorale* was made (Table 2). Here, for comparative purposes, only specimens from the single habitat containing fertile stems were used. Table 2 demonstrates that the fertile stems have larger sheaths, longer teeth, fewer branched internodes, fewer total internodes, and are thicker than the sterile stems. The sheaths have

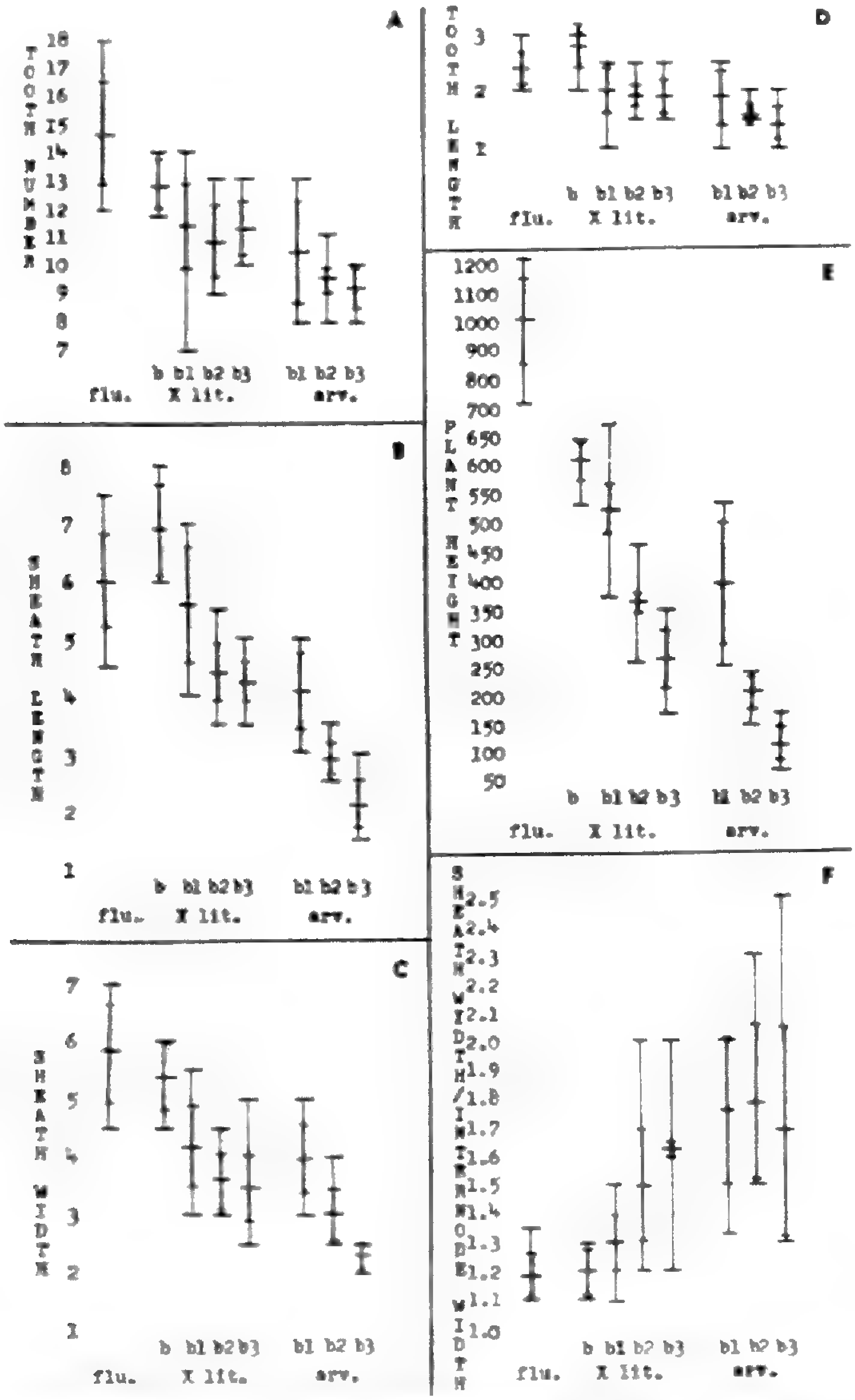


Table 3. Comparison of various characters of *Equisetum* × *litorale* and *E. arvense* from different habitats: A. Tooth number; B. Sheath length; C. Sheath width; D. Tooth length; E. Plant height; F. Sheath width-internode width ratio; *flu.* = *E. fluviatile* from a flooded ditch; × *lit.* = *E.* × *litorale*; *arv.* = *E. arvense*; *b* = same habitat as *E. fluviatile*; b_1 = wet woods; b_2 = wet field, partial shade; b_3 = dry, open field.

fewer teeth per unit sheath, and the sheaths are relatively larger than the internodes. All of these features reveal a tendency toward the dimorphism of fertile and sterile stems which is such a prominent feature of *E. arvense* and which is absent in *E. fluviatile.* So here again, it would appear that *E.* × *litorale* is intermediate between *E. arvense* and *E. fluviatile.*

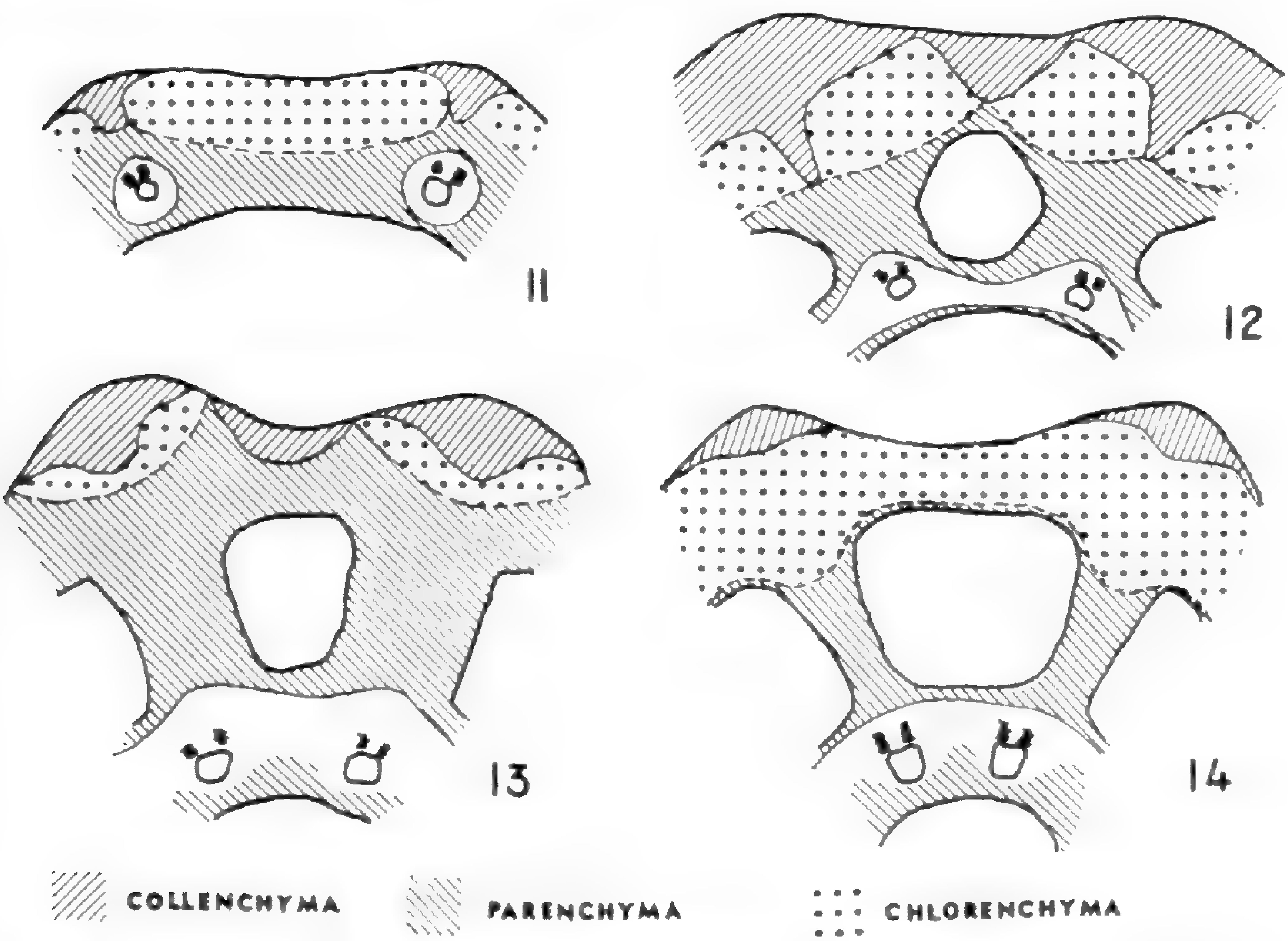
An analysis of *E.* × *litorale* and *E. arvense* from the several habit-forms[1] present in the population under study was made. On Table 3 are given the ranges, means and standard deviations for several characters of *E. arvense, E.* × *litorale,* and *E. fluviatile* from several habitats. In sheath length, sheath width, and plant height there is a progressive reduction in *E. arvense* as the habitat becomes hotter and drier. This is paralleled closely by *E.* × *litorale,* which however, remains always intermediate between *E. arvense* and *E. fluviatile.* In tooth length and number, *E.* × *litorale* remains constant (except for specimens from the flooded ditch) even though *E. arvense* shows a reduction with drier habitat. In the sheath width-internode width ratio *E. arvense* remains relatively constant, and *E. litorale* in wet habitats is closer to *E. fluviatile,* while in drier habitats it becomes progressively more like *E. arvense.*

The intermediate morphology of *E.* × *litorale* shows up in other ways not apparent in the tables. Whereas *E. fluviatile* has relatively short, spreading branches and *E. arvense* has relatively long, ascending branches, *E.* × *litorale* has branches about as long as those of *E. arvense* or shorter, which tend to spread (Fig. 4). As a consequence, the long whip-like vegetative tip characteristic of *E. fluviatile* frequently shows up in *E.* × *litorale,* while the tip of *E. arvense* is inconspicuous (Fig. 10). The first branch internode is longer than the subtending nodal sheath of the stem in *E. arvense,* and shorter in *E. fluviatile.* In *E.* ×

[1]I purposely avoid calling them ecotypes because since *Equisetum* is a strongly clonal group, it is quite possible and is assumed here that all of the *E.* × *litorale* specimens are from one clone, the result of one sexual fusion, and hence represent one genetic individual. The same is true of *E. arvense*

litorale the lower whorls of branches have the internodes shorter, whereas the upper have the internodes longer than the subtending sheath. The stem cross-sections (Figs. 11-14) also show, as Milde pointed out so long ago, that *E.* × *litorale* is intermediate between *E. arvense* and *E. fluviatile.* The hybrid has greater variation in stem structure than either parent, particularly in its endodermal pattern. Usually each vascular bundle has its own endodermis, like *E. fluviatile,* and sometimes there is both an outer and an inner *common* endodermis (Fig. 12), which is a remarkable approach to an intermediate pattern between the individual endodermis of one parent and the outer common endodermis of the other.

DISCUSSION.—The quantitative data given above provide detailed substantiation of Milde's (1851) conclusion that *E.* ×



FIGURES 11 - 14. DIAGRAMS OF CROSS-SECTIONS OF NON-STROBILATE AERIAL STEMS, DRAWN FROM SECTIONS PREPARED BY GEORGE CONANT, RIPON, WISCONSIN; 11. E. FLUVIATILE; 12. E. × LITORALE; 13. E. ARVENSE; 14. E. PALUSTRE.

litorale is intermediate between *E. arvense* and *E. fluviatile.* His original hypothesis, that *E.* × *litorale* is a hybrid between those two species, is further supported by Manton's (1950) cytological demonstration of its hybrid nature, and the repeated observation that the spores of this taxon are abortive.

Schaffner's (1923) statement that *E. litorale* comprises semi-sterile shoots of *E. palustre* and hybrids between *E. arvense* and *E. palustre,* and *E. arvense* and *E. fluviatile* is misleading. The name *E. litorale* designates a specific category of plants set according to a type specimen. The fact that various specimens have been misidentified as *E. litorale* does not make them *E. litorale.* To contend that it represents semi-sterile shoots of *E. palustre,* as Schaffner later did, is also fallacious. I have shown that populations of *Equisetum* do exist which are intermediate between *E. arvense* and *E. fluviatile.* Manton has shown that such plants have the irregular meiosis characteristic of hybrids. I have seen specimens collected by Kuehlewein at the type locality ("in litore marino prope Ora" 21 Jun. and 3 Jul. 1847. Herb. Norm XIII n.99. S-PA) which he labeled "*E. litorale* m" and which bear a close resemblance to the specimens from my hybrid population. Consequently I believe that the name *E.* × *litorale* is correctly applied to the hybrid between *E. arvense* and *E. fluviatile.*

The confusion between this hybrid and *E. palustre* is understandable when one considers that *E. palustre* itself in some ways resembles *E. arvense* and in others *E. fluviatile,* and Linnaeus himself included a specimen in his herbarium under the name *E. arvense.* As the data above show, however, *E. palustre* is distinct from *E.* × *litorale,* and this hybrid is not intermediate to any great degree between it and *E. arvense.*

A second conclusion to be drawn from the data presented above is that the size of *E. arvense* is strongly affected by environment. Thus the range of stem height, sheath length, and sheath width for specimens from within the moist, shaded habitat is completely outside that for specimens from the sunny, dry habitat, and the two collections constitute two distinct statistical populations.

Yet, the population was continuous from the woods into the field, showed intergradation, and presumably represented a single clone. Even though superficially quite different, the plants from different habitats were, upon close inspection, found to be quite similar in many respects, such as sheath shape, tooth number, branch morphology, and anatomical structure. In fact, the only characters strongly affected by environment are size and habit, i.e. upright, reclining, or decumbent stems with simple or compound branches. Abortion of the main-stem apex and elaboration of the branches is also of frequent occurrence. Identical manifestations of morphological plasticity are exhibited by *E.* × *litorale*. It is indeed unfortunate that these and other obvious morphological responses to environmental conditions should have been named taxonomically, as they have by various authors.

The morphological plasticity of *Equisetum* has long been recognized. Alvah A. Eaton wrote (1898, p. 49), "As applied herein, however, the term 'variety' includes all forms and monstrosities of a species, without any claim that they are constant," (1902, p. 43) "all forms being readily accounted for by environment alone, and may be produced from one root-stock." W. N. Clute stated (1928, p. 47), "None of these [named forms of *E. arvense*] seemed fixed, and it is likely that all can be changed to the normal form by a change in the soil and surroundings." Despite this general recognition of the ease with which *Equisetum* is modified by environment, many authors still retain the varietal and form names. This practice should be abandoned since these names are purely descriptive and do not indicate natural taxa. Perhaps we should reconsider Schaffner's (1928) proposal for the use of descriptive polynomials, such as "*E. fluviatile* L. f1 (fluctuation) *multiramulosum proliferum polystachyum,*" which he considered, however, an exercise in organographic ecology, not taxonomy. "For if taxonomy is not naming and establishing larger and smaller groups which reproduce themselves after their kind, then it has no legitimate basis as science."

I thank Dr. Warren H. Wagner, Jr. for his assistance and encouragement. The work was supported in part by N. S. F. Grant GB 1703.

LITERATURE CITED

CLUTE, W. N. 1928. The Fern Allies. Joliet, Illinois.

DUBUYSSON, M. R. 1888. Monographie des cryptogames vasculaires d'Europe. I. Equisetaceae. Revue Scientifique du Bourbonnais et du centre de la France. I: 1-7, 38-45, 112-121, 201-210, 245-254, *3 pl.*

EATON, A. A. 1898. The Genus Equisetum with reference to the North American species. I. Fern Bull. **6**: 45-59.

————. 1901. ibid. IX. Fern Bull. **9**: 81-84.

————. 1902. The Genus Equisetum in North America. X. Fern Bull. **10**: 43-45.

HABER, A. H. 1962. Nonessentiality of concurrent cell divisions for degree of polarization of leaf growth. I. Studies with radiation-induced mitotic inhibition. Amer. Jour. Bot. **49**: 583-589.

HABER, A. H. and D. E. FOARD. 1963. Nonessentiality of concurrent cell divisions for degree of polarization of leaf growth. II. Evidence from untreated plants and from chemically induced changes of the degree of polarization. Amer. Jour. Bot. **50**: 937-944.

————. 1964. Further studies of gamma-irradiated wheat and their relevance to use of mitotic inhibition for developmental studies. Amer. Jour. Bot. **51**: 151-159.

HAUKE, R. L. 1963. A taxonomic monograph of the genus Equisetum subgenus Hippochaete. J. Cramer, Weinheim.

MANTON, I. 1950. Problems of cytology and evolution in Pteridophyta. Cambridge University Press.

MILDE, J. 1851. Uber Equisetum inundatum Lasch. Bot. Zeit. **9**: 705.

————. 1852. Zur Entwickelungsgeschichte der Equiseten und Rhizocarpeen. Nova Acta Leop. **23**: 557-612.

————. 1867. Monographia Equisetorum. Nova Acta Leop. **32**: (2).

SCHAFFNER, J. H. 1923. How to distinguish the North American species of Equisetum. Amer. Fern Jour. **13**: 33-40, 67-72.

————. 1926. On the trail of Equisetum for four thousand miles. Amer. Fern Jour. **16**: 81-92.

————. 1928. Fluctuation in Equisetum. Amer. Fern Jour. **18**: 69-79.

VICTORIN, FRÈRE MARIE. 1927. Les Équisétinées du Québec. Contrib. Lab. Bot. Univ. Montreal No. 9.

————. 1935. Flore Laurentienne. De LaSalle Press, Montreal.

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Recent Fern Literature

NOTES ON TWO RECENT BOOKS.—Two books have recently appeared which might be of interest. Each, though primarily concerned with other things, does make some reference to ferns.

The first is FLOWERING EARTH by Donald Culross Peattie. Originally published in 1939, it has been reissued by Viking Press as a handsome paperback with several attractive woodcuts by Paul Landacre. Price, $1.45.

As we expect from D. C. Peattie, the book is enjoyable to read, yet instructive. After several chapters about plants in general, such as, "What a plant is," and "Protoplasm—the body of life," the author presents a survey of the kinds of green plants. Chapter 9, "The fern forests," could be more aptly titled "The origin and early development of the land flora." It actually says little about present day ferns, but presents a fascinating insight into the science of paleobotany. Since this group of plants has had such a prominent place in the fossil record, fern enthusiasts should have some appreciation for the role ferns played in the history of the world's flora.

CHERRY, ELAINE C. 1965. Fluorescent Light Gardening. D. Van Nostrand Co., Princeton, N. J. Price, $6.95.—This book contains much general information for those interested in indoor gardens. Especially useful to the neophyte may be the rather technical information about fluorescent fixtures and bulbs, and about light. Of particular interest here, however, is the section in which specific recommendations are made for various groups of plants. Ferns are mentioned on pp. 182-183, and apparently F. Gordon Foster is the source for Mrs. Cherry's information, for she merely repeats what he has suggested concerning substrate, temperature, light level, and ferns easy to grow.—RICHARD L. HAUKE, *Dept. of Botany, University of Rhode Island, Kingston, Rhode Island.*

RUSSIAN FERN SPORE STUDIES.—An important series of studies of the spores of Russian ferns, by A. N. Sladkov, which has not been noticed in the Journal is the following:

POLYMORPHISM OF SPORES IN CRETAN *Pteris*.[1]—The majority of the spores of *Pteris cretica* as it occurs in the Caucasus Mountains are typically tetrahedral, with a 3-rayed fissure proximally, the distal side being dome-shaped and covered with tubercles of different sizes. However, there are also many bilateral spores with a single fissure, as well as some 4-rayed. This polymorphism is attributed to differences in the reduction division of the spore mother cells.

MORPHOLOGICAL FEATURES OF THE SPORES OF THE FERNS OF THE SUBFAMILY PTERIDEAE DIELS IN THE FLORA OF USSR.[2]—Descriptions of the exospore, perispore, and epispore of *Anogramma leptophylla, Pteris cretica, Cheilanthes* sp., *Pteridium aquilinum, Coniogramme fraxinea, Adiantum* sp., and *Cryptogramma* sp., with new definitions of true perispore, false perispore (or pseudoperispore), and double perispore.

ON THE MORPHOLOGICAL SIMILARITY OF DIFFERENT SPORES OF SPECIES OF *Cryptogramma* R. BR. and *Botrychium* SW. IN THE FLORA OF THE USSR.[3]—The spores of both *Cryptogramma* and *Botrychium* are round-triangular, with the distal side dome-shaped and nodular, the proximal side concave, flat, or slightly convex. Details for the identification of three species of *Cryptogramma* and six of *Botrychium* are given.

TYPES OF DEFORMATION IN THE FOSSIL SPORES OF FERNS HAVING A RADIAL STRUCTURE.[4]—Comparison of spores of the fossil *Anogrammites imperfectus* Bolch and the living *Anogramma leptophylla* (L.) Link indicates that these represent close or identical species. It is suggested that another subgroup *Heterolateritriletes* be added to the morphographic system of S. N. Naumova (1937) to include spores with radial structure and ob-

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[1] Doklady Acad. Nauk SSSR **117** (5): 900-903, figs. 1957. (In Russian) (AIBS translation pp. 232-235).
[2] Doklady Acad. Nauk SSSR **125** (1): 219-222, figs. 1959. (In Russian) (AIBS translation pp. 81-84).
[3] Doklady Acad. Nauk SSSR **125** (2): 414-416, figs. 1959. (In Russian) (AIBS translation pp. 85-87).
[4] Doklady Acad. Nauk SSSR **129** (5): 1176-1179, figs. 1959. (In Russian) (AIBS translation pp. 290-292).

servable differences in the surfaces of the distal and proximal sides of the spores, as in *Anogrammites.*

SPORES OF THE FERNS OF THE SUBFAMILY PTERIDEAE DIELS IN THE FLORA OF THE USSR. I. SERIES PTERIDEAE—GYMNOGRAMMINAE[5]—Descriptions and illustrations of *Anogramma leptophylla, Coniogramme fraxinea, Notholaena marantae*, and *Cryptogramma crispa.*

SPORES OF THE FERNS OF THE SUBFAMILY PTERIDEAE DIELS OF THE FLORA OF SSSR. II. SERIES PTERIDEAE—CHEILANTHINAE.[6]—Descriptions and illustrations of the spores of *Notholaena marantae, Cheilanthes argentea, C. kuhnii, C. pteridioides, C. persica, Cryptogramma crispa, C. acrostichoides*, and *C. stelleri.*

SPORES OF THE FERNS OF THE SUBFAMILY PTERIDEAE DIELS OF THE FLORA OF SSSR. III. SERIES PTERIDEAE—ADIANTINAE AND PTERIDINAE.[7]—Descriptions and illustrations of the spores of *Adiantum pedatum, A. capillus-veneris, Pteridium aquilinum*, and *Pteris cretica.*

KEY FOR IDENTIFICATION OF SPORES OF THE FERNS OF THE SUBFAMILY PTERIDEAE DIELS IN THE FLORA OF THE USSR.[8]—A key to all the species mentioned in the three papers listed above, plus *Pteridium tauricum* (Presl) V. Krecz.

ON THE SPORE TETRADS OF PTERIDOPHYTES.[9]—Pteridophyta have either tetrahedral or bilateral spores, the type usually being characteristic of a genus or a whole family. The globular spores of *Equisetum* do not have a suture. Heterosporous pteridophytes usually have the spores alike, but in *Selaginella* the megaspores are tetrahedral and the microspores bilateral. Among tetrahedral spores of *Lycopodium* and *Pteris cretica* are occasionally found

[5] Bull. State Univ. Moscow, Ser. VI, **6:** 45-62, figs. 1961. (In Russian).
[6] Bull. State Univ. Moscow, Ser. VI, **4:** 48-59, figs. 1962. (In Russian).
[7] Dept. (Ministry) of Higher and Middle Special Education, SSSR Sci. Reports Grad. Schools, Biol. Sci. **1961** (3): 112-119, figs. 1961. (In Russian).
[8] Dept. (Ministry) of Higher and Middle Special Education, SSSR Sci. Reports Grad. Schools, Biol. Sci. **1962** (1): 129-134, figs. 1962. (In Russian).
[9] Doklady Acad. Nauk SSSR **143** (2): 464-466, figs. 1962. (In Russian) (AIBS translation pp. 436-437).

bilateral spores, and among the bilateral spores of *Marattia* may be found some tetrahedral ones. Transitional types are possible. Paleobotanical research indicates that bilateral spores are relatively more recent than tetrahedral.

THE POLAR AXES OF SPORES AND THE SEPARATION OF THE NUCLEI IN THE MEIOSIS OF TETRADS OF DIFFERENT TYPES OF FERN PLANTS.[10]—Theoretical and geometrical discussion of the formation of tetrads of fern spores. In the tetrahedral tetrad the pairs of polar axes lie in two mutually perpendicular planes, and any axis may form a pair with any second axis; in the cruciform tetrad the pairs of axes lie the same way but the axes of identically oriented tetrads will be paired; in the isobilateral tetrad all the polar axes lie in one plane and the angle between adjacent axes is 90°.

ON SPORE AND POLLEN MORPHOLOGY OF RECENT PLANTS IN THE USSR.[11]—The study of fossil spores and pollen by statistical methods is a special branch of paleobotany that should be distinguished from the morphological study of recent spores and pollen, which can be called "palynomorphology." The morphological study of fossil spores and pollen can be called "paleopalynomorphology." The study of the external envelopes of spores and pollen can be termed "tectomorphology."—CLYDE F. REED, *Baltimore, Md.*

AN AMATEUR'S EVALUATION.—The two best-selling, modern fern books for amateurs in Northeastern U. S. are Cobb[1] and Wherry.[2] The review[3] of Cobb in this journal was extremely critical. Aside from the illustrations, the reviewer found nothing

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[10] Doklady Acad. Nauk SSSR **146** (1): 225-228, figs. 1961. (In Russian) (AIBS translation pp. 1121-1123).

[11] Reports Soviet Palynologists to the First International Palynological Conference. Acad. Nauk SSSR, Geol. Inst. pp. 5-16. 1962. (In Russian, with English summary).

[1] Boughton Cobb. A Field Guide to the Ferns. Houghton Mufflin Company, Boston, Mass. 1956.

[2] Edgar T. Wherry. The Fern Guide. Doubleday and Company, Inc., Garden City, N. Y. 1961.

[3] Amer. Fern Jour. **46:** 161-167. 1956. (See also vol. **47:** 28-29. 1957).

worthy of praise. The book was called "a disgrace to the Peterson series of Field Guides, and a serious setback to fern study by the amateur." The review[4] of Wherry was very favorable.

Both reviews were made by professional botanists. The worth of a book to professionals is judged differently from its worth to amateurs. The present review (written by an amateur with two years experience using both books side by side in the field) is intended to supplement these professional reviews, for the benefit of other amateurs.

The first need of beginners is always to learn to recognize the various species. Cobb will easily lead anyone to the identification of most ferns, even rare ones. The figures are (and were acknowledged[3] to be) probably the best done to date. Points of difference between similar-looking species are emphasized, and the features of each species are listed conveniently. However, Cobb is not complete; although rare species are covered, several ferns from neighboring regions that grow slightly inside the region covered are not given full treatment in the text, and only the most common hybrids are even mentioned.

On the other hand, Wherry is complete in describing rare species and gives extensive listings of hybrids. However, the novice may find Wherry frustrating at first because of the botanical style of writing. Botanical terms are used (and defined in a glossary), and some topics, such as cytology and synonymy, that are given are of little interest to the beginner. A novice who is confronted with Wherry is apt to decide that the study of ferns is too complicated and technical for amateurs, whereas Cobb would never give that impression.

Keys are given in both books. Wherry's key to genera is based largely on the sori. With fruiting material at hand, and with a strong lens, this is probably the most reliable key. Cobb, on the other hand, gives three "keys." One is a series of frond silhouettes, arranged by overall shape and size. Another is based on poor botanical criteria, but excellent ones for the beginner, name-

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[4] Ibid. **52**: 89-90. 1962.

ly the size, shape, and cutting of the fronds. The third is based on the sori, and is recommended when fertile material is available. But even this key is better, for the beginner, than Wherry's because it is illustrated. It was said in the review[3] that Cobb's "key characters are rather poorly selected and crudely stated." On the contrary, I believe one of Cobb's strong points is the keys, which as an amateur I have found more useful (though occasionally less reliable) than Wherry's key.

Wherry lists in one category, "features," the same information about each species that Cobb lists in separate categories. "style," "leaves," "leaflets," "axis," "stalk," "roots," "fruitdots," etc. These features, which are so useful for field identification, are better displayed in Cobb, for easier reference. On the other hand, Wherry gives additional information about each species, on its culture, nomenclature, and cytology. And Wherry's data on range are better presented than Cobb's.

All this evidence leads to my main conclusion: For beginners, Cobb is the easier and simpler book. The serious amateur and the professional, however, may outgrow Cobb and find Wherry more suitable. The two books thus supplement each other, and beginners would be well advised to use Cobb at first and then gradually shift to Wherry (or use both books) if their interest in ferns continues.

Much emphasis was placed in the review[3] on errors in Cobb. Certainly it is regrettable to find such errors, and I hope corrections can be made in the next edition. However, these errors do not, by themselves, justify a wholesale condemnation of the book. PAUL PENFIELD, JR., *Weston, Mass.*

COMMENT BY A REVIEWER OF "FIELD GUIDE TO THE FERNS."—The author generously submitted the manuscript of the above article to me before publication. Having admired the drawings, it was no surprise to me to hear that a beginner was able to identify ferns from the *illustrated* keys. Had this adjective not applied, that would hardly have been so easy, since Cobb uses familiar words in novel senses and invents etymologically unsound complex terms. Naturally I cannot concur with the view that "features which are so useful in field identification are better displayed in Cobb." His statements are replete with errors and misinterpretations; thus, in the text dealing with the common Christmas Fern there are at least 25 of them. One might wish that the authorship of the Field Guide had been attributed to Mrs. Foster, whose contribution to it is above criticism.—E.T.W.

Notes and News

ASPLENIUM RESILIENS IN UTAH.—Several vigorous patches of *Aplenium resiliens* Kunze were found along damp shaded horizontal bedding planes of sandstone rocks in the newly created Canyonlands National Park, San Juan County, in southeastern Utah. This is the first record of this fern in Utah. The closest locality from which it has been previously recorded is near Flagstaff, Coconino County, Arizona, about two hundred and sixteen air miles distant. Elsewhere in Arizona it is known from the Blue River, Greenlee County, Chiricahua and Huachuca Mountains, Cochise County, along the eastern border of the state, and far to the southwest in the Kofa Mountains of Yuma County. In New Mexico it is known from Santa Rita, Grant County, the Florida Mountains, Luna County, and the Organ Mountains, Dona Ana County, all in the southwestern part of the state. Eastward it ranges from Kansas to Pennsylvania and from Texas to Florida.

Other ferns noted in the Canyonlands National Park are *Cystopteris fragilis* (L.) Bernh., *Adiantum capillus-veneris* L., *Pellaea limitanea* (Maxon) Morton, *Cheilanthes feei* Moore, *Equisetum laevigatum* A. Br. and *Selaginella mutica* D. C. Eat. Other species reported from San Juan County which may ultimately be found in the Park are *Woodsia mexicana* Fée, *W. plummerae* Lemmon, *Cheilanthes eatonii* Baker and *Péllaea fendleri* (Kunze) Prantl, all of which are on the extreme northern or western margins of their ranges.—SEVILLE FLOWERS, *Department of Botany, University of Utah, Salt Lake City.*

FERNWOOD INCORPORATED.—Our member, Mrs. Kathryn Boydston, well known to many members through her activities in running the Spore Exchange for several years, has been developing her estate, Fernwood, for a long time. Fernwood is located along the St. Joseph River, a short distance north of Niles, Michigan. It contains a variety of habitats, from low marshes and ponds, to steep, wooded hills. The natural beauty of the area has been recognized by many, and a group has been organized to maintain Fernwood as a permanent nature preserve. It contains 75 kinds of ferns and over 10,000 fern plants.

It is planned to develop nature trails and to conduct educational programs. Individual memberships to support the project are $5.00 or more annually. Membership dues and contributions are tax-deductible, since Fernwood is a non-profit corporation.

Any fern lover who is interested in such a project should write to Mrs. Kathryn Boydston, Route 3, Niles, Michigan 49120.

WANTED.—One of our members, Mrs. R. M. Gunnison, The White Sands, La Jolla, California, is interested in obtaining, through exchanges or by purchase, herbarium specimens of unusual or uncommon ferns. She prefers them unmounted. If you have any such specimens, please write directly to Mrs. Gunnison.

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American Fern Journal

Vol. 55 OCTOBER-DECEMBER, 1965 No. 4

Observations on Some Ferns in Georgia

WILBUR H. DUNCAN AND DONALD BLAKE

"Ferns of Georgia" (McVaugh & Pyron, 1951) summarized many of the data on ferns that were known at that time. Other publications with direct bearing on the ferns of Georgia include those of Quarterman (1953), Duncan (1954, 1955, 1960), Snyder (1955), Hutto (1960), Rossignol (1956), Bookout (1960), and McDowell and Snyder (1961).

New discoveries about ferns of Georgia have continued. We have accumulated many data and specimens ourselves, and several people have sent us additional information. Their contributions are gratefully acknowledged. The more significant data are presented here. New distributional records presented, unless otherwise indicated, are documented by specimens deposited in the University of Georgia Herbarium (GA). Part of the data contributed by the senior author was accumulated during research supported by the University of Georgia through Dr. Robert McRorie, Director of Research.

EQUISETUM ARVENSE L.—Known previously only from one station (Fulton County) in the Piedmont (McVaugh & Pyron, 1951). The range has been extended into the Blue Ridge Province through its discovery by the junior author and Florence Montgomery (Duncan 22060, Blake, and Montgomery) in sandy deposits on a wooded terrace along Yahoola Creek, ESE of Dahlonega, Lumpkin County. The colonies at both stations probably are adventive. The colony in Fulton County is in a moist area adjacent to a railroad fill, and the other is only a few yards from an abandoned gold ore processing plant.

LYCOPODIUM ALOPECUROIDES L.—In Georgia this clubmoss has been known previously from many stations in the Coastal Plain,

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two in the southwestern part of the Piedmont (Meriwether and Pike Counties), and one in a boggy area in the southern edge of the Ridge and Valley Province. Two colonies have been located in the eastern part of the Piedmont about 70 and 90 miles, respectively, from previously known stations. One station is among an extensive growth of *Arundinaria* in a bog 3.2 miles ESE of Winder, Barrow County (Duncan 21915). The other is at the edge of a small pool in a granite quarry at Echol's Mill, Oglethorpe County (Blake, 5 November 1961).

Duncan (1950) mentioned that the colony in the Ridge and Valley was undoubtedly a recent migrant, but that the distance it had migrated could not be determined. The same is true of the colony at Echol's Mill, for the clubmoss is in a habitat created by relatively recent quarrying. The bog in Barrow County, however, is quite old, containing a considerable deposit of peat-like material.

LYCOPODIUM CERNUUM L.—Previously known from five counties (McVaugh & Pyron, 1951; Quarterman, 1953; Duncan, 1955). It has been found since on moist banks of a roadcut in the south-central part of Long County (Duncan 22100B and Blake). This is the most northeastern locality known for this species.

LYCOPODIUM FLABELLIFORME (Fern.) Blanchard (*L. complanatum* var. *flabelliforme* Fern.)—"Ferns of Georgia" gives three localities for this species. Other published records for the state cite stations in Elbert County (Duncan, 1955), DeKalb and Hall Counties (Hutto, 1960), making a total of six stations reported previously, all in the Piedmont Province. Hutto stated that the plant was reported from ten counties, apparently misinterpreting information sent to him by the senior author. We now have specimens from thirteen more counties, more than doubling the known range in Georgia. Three stations are in the Blue Ridge (Rabun, White, and Gilmer Counties). New Piedmont records are from Banks, Oglethorpe, Taliaferro, Green, Morgan, Coweta, Carroll, Haralson, Cherokee, and Stephens Counties.

This clubmoss often occurs in secondary growth of pine and/or hardwoods and may be somewhat of a weedy component in these situations. Old residents, who know this groundpine, maintain that the species once was more abundant, got rather scarce, and is increasing in abundance again. Some say that years of extensive fires destroyed many colonies, and that now, under fire protection, the species is recovering.

SELAGINELLA APUS (L.) Spring. (*S. apoda* (L.) Spring.).—Occurs commonly above the Fall Line in Georgia and is reported from the Coastal Plain south to Burke, Bibb, Lee, and Decatur Counties, with an outlier in Tift County. An extension in range of over 90 miles was made when Mrs. M. B. Mellinger collected it a few miles from the Atlantic Ocean in Chatham County (Mellinger, 27 April 1959). The junior author has since found it in the lower Coastal Plain in Ware (Blake, July 1963) and Charlton (Blake, 24 August 1963) Counties. The latter locality is at the head of a "bay" SE of Folkston, where the spikemoss is associated with *Osmunda cinnamomea* and *Anchistea virginica,* which were under plants of *Persea pubescens, Gordonia lasianthus,* and *Lyonia lucida.* Our field experience indicates that the species is rare southeast of Burke and Decatur Counties.

BOTRYCHIUM ALABAMENSE Maxon.—Collected infrequently in Georgia, but probably it is more abundant than the records indicate. Diligent search in the field should increase its known distribution. Two such searches have revealed four new stations, including the first two localities for it in the Blue Ridge. Mr. and Mrs. Frank Snyder of Toccoa have sent specimens to the University of Georgia Herbarium from Stephens (Snyder, 17 February 1963) and Rabun (Snyder, 18 November 1956) Counties, and Mrs. Elizabeth Sawyer of Demorest has donated specimens from Habersham (Sawyer 333) and White (Sawyer 334) Counties. All collections were from open areas or open, deciduous woods. This fern seems to prefer disturbed areas.

OPHIOGLOSSUM spp.—McVaugh and Pyron (1951) included four species of this genus in "Ferns of Georgia." Two species were known from two stations each, while the other two were known from one station each. Diddell (1953) reported a single station for a fifth species, *O. petiolatum,* in Camden County.

Finding adder's-tongues is usually a difficult job, for most plants are easily overlooked in the field unless a search is conducted on hands and knees. Identification to species also presents some problems since keys or descriptions of all five species are not readily available, e.g., Clausen (1938) and McVaugh and Pyron (1951), which is out of print.

A key based mostly on our observations, is presented below, along with other information.

Underground stem conspicuously globose, with many fine roots about 0.25 mm. in diameter when dried; leaf blades obtuse at the apex .... *O. crotalophoroides* Walt.

Underground stem slightly globose to narrowly cylindrical, with few to many roots about 0.4 mm. in diameter or larger when dried; leaf blades acute to obtuse at the apex:

- Leaf blades conspicuously broadest immediately above the base, acute at the apex .... *O. petiolatum* Hook.
- Leaf blades broadest at or near the middle, or if sometimes broadest near the base the apex then obtuse:
  - Blades of fruiting leaves to about 3 cm. long, acute at the apex, horizontal or nearly so; strobili to 10 mm. long, the stalks 1 mm. or less in diameter when dried ...... *O. nudicaule* L. f.
  - Blades of fruiting leaves to about 9 cm. long, obtuse and apiculate, or obtuse to rounded and not apiculate, ascending to nearly erect; strobili to 32 mm. long, the stalks usually more than 1 mm. in diameter when dried:
    - Blades of fruiting leaves acute to rounded, apiculate, the veins in two series, larger and heavier groups of polygonal ones enclosing smaller and finer sets of polygonal areoles .... *O. engelmannii* Prantl
    - Blades of fruiting leaves obtuse to rounded, not apiculate; veins usually in one series, forming narrow polygonal areoles enclosing solitary veinlets with free ends *O. vulgatum* L.

In addition to the above characteristics we have noted that *O. vulgatum, O. petiolatum,* and *O. nudicaule* form adventitious buds on horizontal roots. The leaf blades of *O. crotalophoroides* are fleshy, usually horizontal, on or near the soil, and have the lowest length-width ratio. The leaf blades of *O. petiolatum* are usually well above the soil, often wavy margined, their surfaces not flat but irregularly undulate, and their bases cupped upward, giving them a half "funnel-like" appearance. The leaf blades of *O. nudicaule* are at or near the soil and their surfaces are essentially flat.

Ophioglossum crotalophoroides has been reported previously from one station in Georgia. We report seven new stations. They extend the range widely in the Piedmont and well into the Coastal Plain. On 19 March 1961, Donald Banks found plants associated with grasses, *Houstonia patens,* and *Draba brachycarpa* on a slope overlooking a beach at a state park in Morgan County. On 24 March 1962 Dr. Gordon DeWolf found plants in closely cut grass in sandy soil on a road embankment in Bullock County. The senior author collected plants on 5 April 1962 in an undisturbed area of shallow soil at the edge of a sloping granite outcrop above the Savannah River in Elbert County. The junior author found plants on 3 April 1963 in shallow soil at a granite outcrop in Oglethorpe County, and later observed the species in shallow soils of sloping granite outcrops overlooking High Shoals of the Apalachee River in Oconee County.

The senior author showed a likely habitat for the species in Jenkins County to a class in taxonomy. Some students found plants within a few minutes, and eventually all nine persons on the field trip found specimens. All plants of this locality were found in very small areas of bare, sandy soil among grass plants in an open area immediately south of Magnolia Springs. This collection was made on 10 April 1964. Finally on 6 March 1965 the junior author and Florence Montgomery found the species in an old pasture in Wilkinson County. This species probably occurs in many counties south of Elbert and Meriwether Counties.

Ophioglossum petiolatum previously was reported from only one station in Georgia. On 16 September 1961 the senior author found a colony in Brantley County, at the base of a road fill leading to a "high water" bridge south of the Satilla River, 2.5 mi. N. of Hoboken.

Ophioglossum nudicaule was reported by McVaugh and Pyron (1951) from Effingham County, and by Rossignol in Chatham County (1956). The junior author collected sterile plants in moist open flats along the Satilla River in Brantley County on 9 September 1961. These plants fruited in the greenhouse on 8 November 1961.

No new stations are to be added for *O. engelmannii* in Georgia, but three can be added for *O. vulgatum*. On 7 July 1963 the junior author and Thomas Pullen, Jr., collected late fruiting plants in a deciduous woods on a flood plain along a tributary of the Ogeeche River in Taliaferro County. On 21 August 1963 Mrs. M. S. Holverstott showed us plants, some of which were in fruiting condition, from a low level area under deciduous trees beside a small stream in Gilmer County. This is the first record (Duncan 22142) for the Blue Ridge of Georgia. On 25 April 1964 the senior author collected a few plants in a poorly drained area in Jasper County. The plants of this species are the most conspicuous of those known to grow in Georgia. We have looked often and carefully for other stations, so we believe the species is rare.

OSMUNDA CLAYTONIANA L.—Known previously in Georgia from the eastern part of the Blue Ridge and on Sawnee Mountain, Forsyth County. An important extension in range was made by the discovery of this fern by Mrs. Holverstott in western Gilmer County, in the western part of the Blue Ridge.

CYSTOPTERIS PROTRUSA (Weath.) Blasdell. (*C. fragilis* (L.) Bernh. in part).—This fern was reported by Blasdell (1963) in Georgia from only Rabun County. It had been reported elsewhere to occur in scattered localities south to Stephens and Newton Counties. Additional stations have been located in White (Duncan 16359) and Floyd (Duncan 15216) Counties.

CYRTOMIUM FORTUNEI J. Smith.—Morton (1957) reports this taxon as one of the three true species of the genus in cultivation in the United States. Although Holly Ferns may be adventive in some localities (Degener and Hawkes, 1951) *C. fortunei* apparently has not been reported as an escape in the southeastern United States. This fern has become naturalized in Athens, Georgia. It grows in borders of yards, in crevices of rock walls in gardens, in crevices of a north-facing rock wall along Tanyard Branch, and on soil and between rocks of a steep bank in shaded areas of a railway freight yard near the business district.

THELYPTERIS TORRESIANA (Gaud.) Alston.—This fern has been reported in the United States from Florida, Alabama, and Texas. Oliver (1955) predicted that it would soon be found in Georgia. This fern was shown to the senior author in 1959 in Randolph County by Martha Dean Webster and Isabel Terry, and a collection made (Duncan 21655). That same year Lee Webb collected it in Colquitt County, and in 1964 Beatrice Griffin collected the fern in Thomas County (Griffin, 28 November). All three localities are in the southwestern part of the state and confined to the Coastal Plain.

Morton (1962) indicated that the species is naturalized. In Georgia this fern occurs in wooded habitats relatively undisturbed by man, and some colonies are extensive. Although we know that some fern colonies are recent emigrants (Duncan, 1950) and have probably migrated considerable distances, there is little convincing evidence concerning the age of most colonies. Those of *T. torresiana* in Georgia could be quite old. The species is growing abundantly locally and at present definitely is a part of our natural flora. The Randolph County colony occurs in a deciduous forest along a small tributary of Nochaway Creek about 0.5 mile above its junction with Ichawaynochaway Creek, 1.7 miles E 15° N of Shellman. The colony in Colquitt County occurs in a dense forest at the margin of a boggy area; and that of Thomas County is under trees along a small stream 10.2 miles N. of Thomasville.

ASPLENIUM HETEROCHROUM × RESILIENS.—Wagner (1963) has said that this is an undescribed pentaploid, apogamous fern, intermediate between *A. resiliens* and *A. heterochroum*, and apparently is a hybrid between them. He reports this intermediate taxon from North Carolina, South Carolina, and Florida. Georgia now can be added to this distribution. The junior author collected it on mortar between rocks of an old wall in the southeastern part of the state (Blake, 8 Sept. 1963).

ASPLENIUM PINNATIFIDUM Nutt.—This uncommon spleenwort has been found in Hall County (Duncan 18389), which is the seventh county in Georgia in which it is known to occur.

CAMPTOSORUS RHIZOPHYLLUS (L.) Link.—The Walking Fern has been known to be common to scattered in Georgia as far south as Stephens, Bartow, and Floyd Counties. The known range is extended southward by a collection by Thomas Pullen, Jr., made in Polk County (T. Pullen, Jr. 8). A sight record is recorded for Habersham County by Pruitt (1952).

PILULARIA AMERICANA A. Br.—This rarely observed species has been known from three counties in Georgia (McVaugh & Pyron, 1951). The last reported stations found in Georgia were discovered in Washington and Walton Counties in 1936. The junior author and Florence Montgomery found it growing abundantly in 1962 (11 Nov.) rooted in mud under two feet of water (and floating) in a broad, shallow quarry in granite rocks at Echol's Mill, 9.7 miles NE of Lexington, Oglethorpe County. Plants apparently continuously covered with water freely produced sporocarps. Pyron & McVaugh stated that plants "seem to fruit freely only when the water begins to disappear." Also, Pilularia apparently had not been known to thrive in water as much as two feet deep.

LITERATURE CITED

BLASDELL, ROBERT F. 1963. A monographic study of the fern genus *Cystopteris*. Mem. Torrey Club **21**: 1-102, 23 plates.

BOOKOUT, HENRY. 1960. A new station for *Trichomanes petersii* in Georgia. Amer. Fern Jour. **50**: 246-247.

CLAUSEN, ROBERT T. 1938. A monograph of the *Ophioglossaceae*. Mem. Torrey Club **19** (2): 1-177.

DEGENER, OTTO, AND ALEX D. HAWKES. 1951. The Holly Fern. Amer. Fern Jour. **41**: 117-120.

DIDDELL, MARY W. 1953. Fern Notes. Ibid. **43**: 114-117.

DUNCAN, W. H. 1950. Preliminary reports on the Flora of Georgia, III. The distribution of seven Lycopsida. Ibid. **40**: 169-173.

——————. 1954. *Polypodium aureum* in Florida and Georgia. Ibid. **44**: 155-158.

——————. 1955. New records for Georgia ferns. Ibid. **45**: 1-10.

——————. 1960. Azolla caroliniana Willd. in Georgia. Ibid. **50**: 266-267.

HUTTO, THOMAS A. 1960. Two new Georgia stations for *Lycopodium complanatum* var. *flabelliforme*. Ibid. **50**: 240.

MCDOWELL, GLADSTONE, AND FRANKLIN SNYDER. 1961. A parcel of ferns from Stephens County, Georgia. Ibid. **51**: 67-69.

MCVAUGH, ROGERS, AND JOSEPH H. PYRON. 1951. Ferns of Georgia. xvii + 195. Univ. of Georgia Press, Athens, Ga.

MORTON, C. V. 1957. Observations on cultivated ferns, II. The proper generic name for the Holly Fern. Amer. Fern Jour. **47**: 52-55.

——————. 1962. Another name change for the Florida fern known as *Dryopteris setigera*. Ibid. **52**: 27-29.

OLIVER, WILLIAM F., JR. 1955. *Dryopteris setigera* to be found in Georgia? Ibid. **45**: 126.

PRUITT, ROBERT G. 1952. The Brevard Zone of Northeasternmost Georgia. M.S. Thesis, Emory University.

QUARTERMAN, ELSIE. 1953. Pteridophytes from Lowndes County, Georgia. Amer. Fern Jour. **43**: 72-74.

ROSSIGNOL, GILBERT R. 1956. *Ophioglossum tenerum* in Georgia. Ibid. **46**: 107.

SNYDER, FRANKLIN D. 1955. Rediscovery of *Lygodium palmatum* in Georgia. Ibid. **45**: 104-105.

WAGNER, W. H., JR. 1963. A biosystematic survey of United States ferns. Preliminary abstract. Ibid. **53**: 1-16.

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Cytological Observations on Ferns from Southern China

S. K. ROY AND R. E. HOLTTUM

The fern plants which are the subject of the present paper were collected by Holttum in the Ting Hu National Park, about 90 km. from Canton, which he was able to visit through the hospitality of Academia Sinica, Peking, in October 1963. He wishes to express his thanks to Mr. Wang Chu-Hau, who arranged the excursion from Canton and assisted in the identification of the species. The nucleus of the National Park is an area of 500 acres of natural forest in the valley of a stream and on the hillsides rising above it, with a larger adjacent area of hill sides planted with pine trees. Very young fern plants were mostly collected beside paths which have been made in the forest. The plants have been cultivated in the tropical fern houses of the Royal Botanic Gardens, Kew, under the care of Mr. H. J. Bruty, and we are indebted to the Director for permission to have frequent access to them. Cytological observations have been made by Roy, both from root tips ($2n$) and from young sporangia as soon as these were produced. Most of the previous cytological records to which reference is made are listed, with bibliographical data, in the papers by Chiarugi (1960) and Fabbri 1963). The most important new record here presented concerns *Brainea insignis*.

LYGODIUM JAPONICUM (Thunb.) Sw.—$2n = 58$. The only reliable previous cytological record of this species is by Manton & Sledge, from a plant in cultivation at Kew, of unknown origin; this plant is a tetraploid ($n = 58$). The plant brought from Ting Hu is diploid; it is not yet fertile.

CYATHEA PODOPHYLLA (Hook.) Copel.—$2n =$ c. 140 (probably 138). This was the only species of *Cyathea* in the forest, abundant in shady gullies. It belongs to subgenus *Cyathea* section *Gymnosphaera* of Holttum's arrangement (1963). The plants are still too small to bear fertile fronds. Root-tip preparations are more difficult in *Cyathea* than in most other ferns, and the count is approximate. All other *Cyathea* species so far examined, including species of both subgenera recognized by Holttum in Asia and Malesia, have $n = 69$.

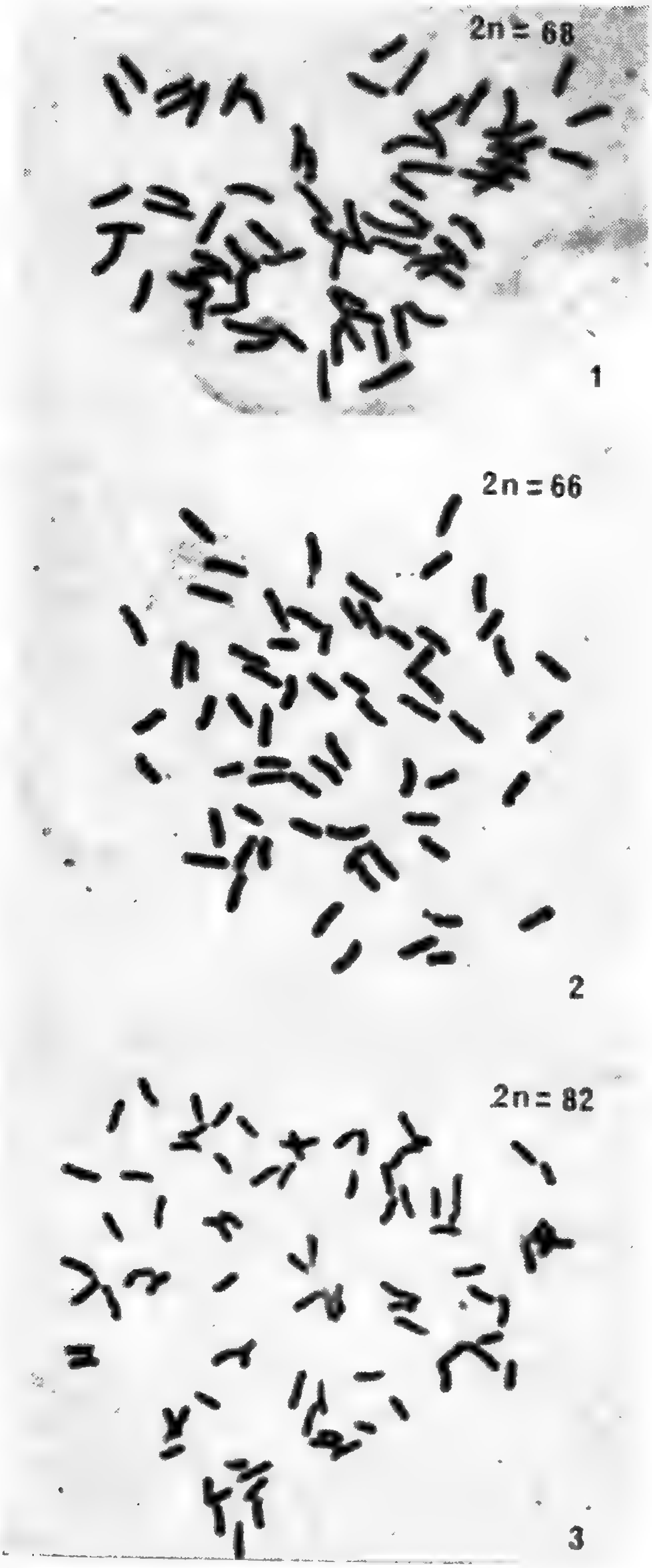
ARACHNIODES CHINENSIS (Rosenst.) Ching.—$2n = 82$ (*Fig. 3*). The closely related and very widely distributed species *A. aristata* (Forst. f.) Tindale (better known as *Polystichum aristatum* or *Rumohra aristata*) has been reported as tetraploid in Ceylon and southern India, and plants obtained in New Guinea now in cultivation at Kew are also tetraploid.

BOLBITIS SUBCORDATA (Copel.) Ching.—$2n = 82$. No previous cytological record of this species has been published; most other species investigated are diploids with $n = 41$. The plant is not yet fertile.

DIPLAZIUM DONIANUM (Mett.) Tardieu.—$2n = 123$. The only observation of meiosis in sporangia shows 41 pairs and 41 single chromosomes; the plant is therefore a triploid hybrid. Ripe sporangia yielded some good large spores and many small shrivelled ones; this indicates apogamy in the gametophyte. The species is distributed from Assam through southern China; southward it appears to overlap with the closely related species *D. bantamense* Bl., which in Malaya has been shown to be tetraploid.

WOODWARDIA JAPONICA (L. fil.) Sm.—$2n = 68$ (*Fig. 1*). This agrees with four previous observations on *W. radicans* (L.) Sm. (The name *W. radicans* has in the past been used in a very broad sense, and Indian records under this name are probably *W. unigemmata* (Mak.) Nakai).

BRAINEA INSIGNIS (Hook.) J. Sm.—$2n = 66$, the first cytological record for this monotypic genus (*Fig. 2*). *Brainea* has a massive trunk as in some species of *Blechnum*, but venation more as in *Doodia* and *Woodwardia* (anastomosing similarly in both sterile and fertile fronds). Unlike both the latter genera, it lacks an indusium, and the sporangia spread along the veins of the contracted fertile pinnae. The numbers 33 and 34 have


2n = 68
1
2n = 66
2
2n = 82
3

been reported for several species of *Blechnum* (see Quinn 1961, and Chiarugi 1960). The spores of *Brainea* are rather similar to those of the *Blechnum* species for which Quinn reported $n = 33$. The present observation supports the generally accepted view that *Brainea* is closely related to *Blechnum*.

PTERIS FAURIEI Hieron.—$2n = 58$. This species of China and Japan belongs to the complex of *P. quadriaurita* Retz. The only previous record for *P. fauriei* is by Walker, whose plant was an apogamous triploid from Japan.

PTERIS MULTIFIDA Poir.—$2n = 116$. This species, widely distributed in China and Japan, and also widely cultivated in other countries, has twice been reported as tetraploid.

ADIANTUM FLABELLULATUM L.—$2n = 116$. There is no previous record for this species, which is widely distributed in tropical Asia. Most of the many *Adiantum* species investigated have a base number $n = 30$; one of the few with $n = 29$ is *A. pedatum* L. to which *A. flabellulatum* is probably related (as judged on grounds of general morphology).

ADIANTUM MALESIANUM Ghatak (1963, p. 74).—$2n = 120$, agreeing with Ghatak's observations. At Ting Hu this is abundant in crevices on limestone hills near the national park; it grows in similar situations in Malaya, and is widely distributed in S. E. Asia. It is a distinct member of the *A. caudatum* complex, for the first time distinguished by Ghatak.

MICROSORIUM FORTUNEI (Moore) Ching.—$2n = 72$. There is no previous record for this species; numerous others included in the genus have been reported as diploid with $n = 36$. A few species have been reported with $n = 37$; this is perhaps an indication that the genus has not yet been clearly defined, like others in the Polypodiaceae (s.str.).

FIGURES 1-3. CHROMOSOMES SHOWN BY ROOT TIP SQUASHES. FIGURE 1. WOODWARDIA JAPONICA (L. FIL.) SM. FIGURE 2. BRAINEA INSIGNIS (HOOK.) J. SM. FIGURE 3. ARACHNIODES CHINENSIS (ROSENST.) CHING. ALL $\times$1000.

LITERATURE CITED

CHIARUGI, A. 1960. Tavole cromosomiche delle Pteridophyta. Caryologia **15**: 27-150.

FABBRI, F. 1963. Primo Supplemento alle Tavole Cromosomiche delle Pteridophyta di Alberto Chiarugi. Caryologia **16**: 237-335.

GHATAK, J. 1963. Two new species of the *Adiantum caudatum* complex. Bull. Bot. Surv. India **5**: 71-77.

HOLTTUM, R. E. 1963. Cyatheaceae, in Flora Malesiana, Series II, **1**: 65-176.

QUINN, C. J. 1961. Chromosome complements of the Tasmanian representatives of the genus *Blechnum*. Pap. & Proc. R. Soc. Tasmania **95**: 1-5.

KEW GARDENS, RICHMOND, SURREY, ENGLAND.

Cytological and Morphological Observations on Metaxya rostrata (H.B.K.) Presl

S. K. ROY AND R. E. HOLTTUM

Living plants of this species were collected in Suriname, in the year 1961, by Dr. K. U. Kramer of Utrecht, and sent to Kew, where they have been cultivated in the tropical fern houses. They have proved somewhat difficult to manage, and their earlier fertile fronds gave neither satisfactory cytological preparations nor good spores. However, after re-potting in a shallow pot, one plant made good new growth in 1964, and from it Roy made preparations showing mitosis in root-tips. Subsequent fixation of sporangia gave approximate confirmation of the count of chromosomes in root-tips. Dr. Kramer has also provided photographs of young and mature plants in the Suriname forest, (*Fig. 2, 3*) and a drawing by Mr. W. H. A. Hekking (*Fig. 1*) showing the leaf-form of young plants, which we believe has never previously been illustrated. We believe that these data, together with a re-examination of other characters of the plants, provide significant new information about the monotypic genus *Metaxya*.

A detailed morphological examination of *Metaxya* was first made by Bower (1913; summarized in 1926), who pointed out distinctions from *Alsophila* (in which genus the species had been

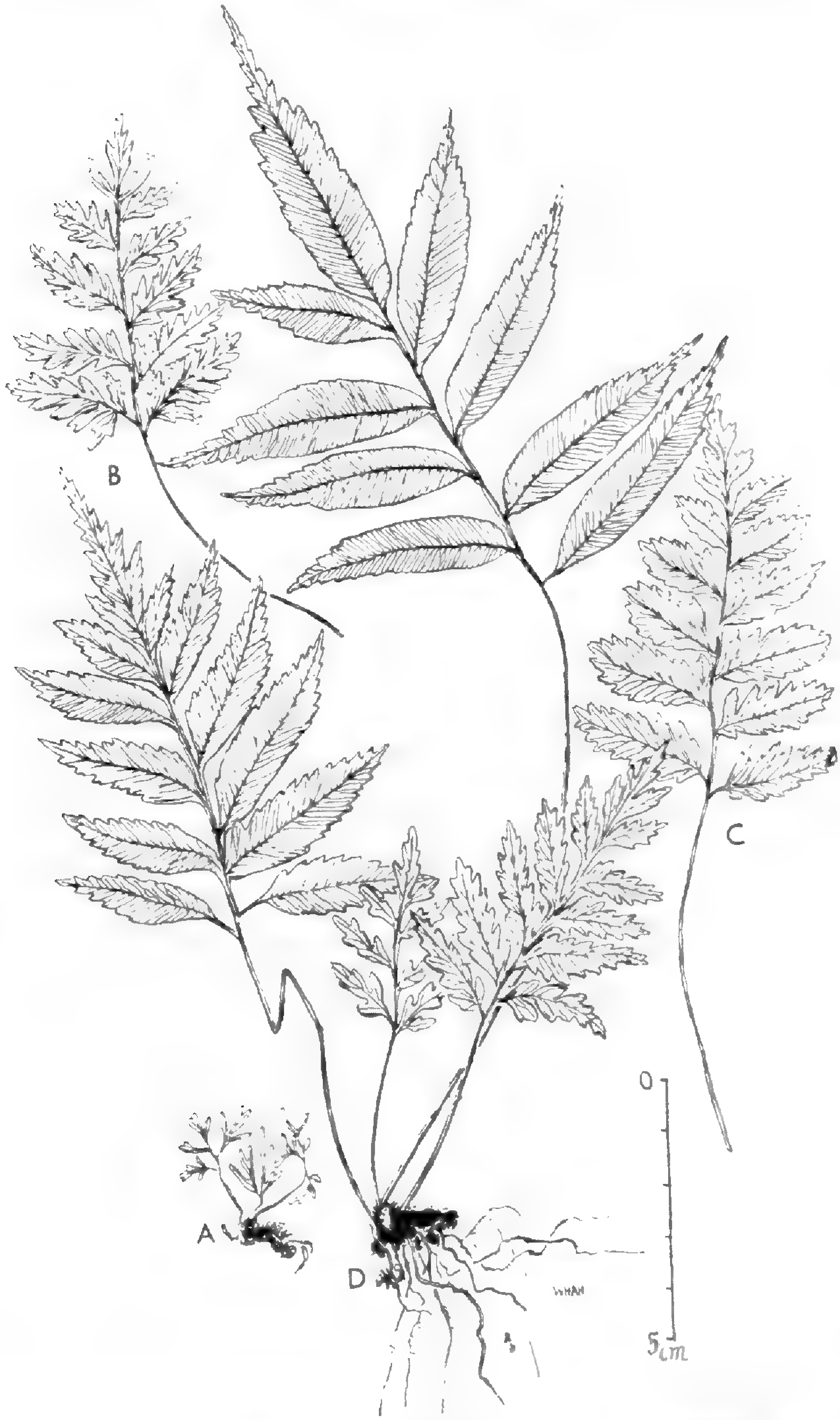


Figure 1. Metaxya rostrata (H.B.K.) Presl. Drawings of juvenile plants, showing very young sporophyte at "A," successively older fronds at "B" and "C." Plant at "D" with one frond approaching mature characteristics. (Drawing by W. H. A. Hekking).

placed by most authors) in its creeping hairy rhizome and form of sorus and sporangia. *Metaxya* presents a peculiar combination of primitive and advanced features. The hairy rhizome, and "simple" character of the sorus (sporangia simultaneous in development) are primitive; but the simply pinnate fronds, the sori spread a little along the veins and often two on one vein, and the form of individual sporangia, are advanced, as compared with *Cyathea* (to which *Alsophila* should be united; see Holttum 1963, p. 76). But Bower failed to mention some other considerations.

Bower called the vascular system of the rhizome a solenostele; but the rhizome, though prostrate, is not dorsiventral, which is the significant feature of the solenosteles of *Dennstaedtia*, *Dipteris* and *Dicranopteris* (see Holttum, 1965). The more important difference from *Cyathea* lies in the absence of sclerotic tissue. The prostrate, not erect, growth of the stem is not an important distinction; there are prostrate and erect stems in both *Cibotium* and *Culcita*.

As pointed out by Bower, the simple pinnae of the fronds indicate by their marginal serrations that they have evolved from more amply branched fronds. This indication is further strengthened by the form of pinnae on young plants, which are quite deeply lobed, so that the fronds are almost bipinnate (*Figs.* 1-3). Furthermore, the pinnae are very asymmetric at their bases and the lowest pinnae are largest. These young fronds agree in shape rather with *Culcita* and *Thyrsopteris* than with *Cyathea* or *Dicksonia*. In *Culcita*, the deltoid shape of the frond and of its leaflets is associated with a grooved upper surface of rachises, the groove of a larger rachis open at its junctions with smaller ones. In *Metaxya* a similar arrangement, simplified owing to the simpler branching of the frond, is found;

FIGURES 2 AND 3. METAXYA ROSTRATA AT FOOT OF THE TAFELBERG, SURINAME. FIG. 2. YOUNG PLANTS WITH JUVENILE FRONDS (LENS COVER 4 CM. IN DIAMETER). FIG. 3. MATURE PLANT WITH SIMPLE-PINNATE LEAVES. (PHOTOGRAPHS BY K. U. KRAMER, FEB. 1961).

the short stalk of each pinna is grooved, and the groove is continued upwards as the midrib of the pinna, while downwards the stalk-groove opens into the groove of the upper surface of the main rachis.

Bower does not mention spores. These are thin-walled, smooth.

FIGURE 4. ROOT TIP MITOSIS OF METAXYA ROSTRATA, SHOWING $2n = 192$. ($\times$ 1538).

almost spherical, with very slight ridges indicating their trilete structure. Possibly they are short-lived.

Roy's observations of root-tips show that the sporophyte complement of chromosomes is not less than 190 nor more than 192 (*Fig.* 4), 192 being the more probable figure. Assuming that the sporophyte is diploid, this gives 96 as the haploid chromosome number. Fixation of sporangia in February 1965 gave a count of 94-96; the preparations were not good enough to give an exact number. Comparing the information now available for the other genera of Cyatheaceae (in the broad sense of Holttum and Sen 1961), we have the following list.

Cyathea (sens. lat.), several species	$n = 69$
Cnemidaria (Jamaica, T .G. Walker, verbal report)	$n = 69$
Dicksonia, species from New Zealand, New Caledonia, New Guinea and St. Helena	$n = 65$
Lophosoria (Jamaica, T. G. Walker, verbal report)	$n = 65$
Culcita (subgenus *Culcita*) *macrocarpa*	$n = 66\text{-}68$
Culcita (subgenus *Calochlaena*) *dubia*	$n = 55\text{-}58$
Cystodium sorbifolium (Roy and Holttum, 1965)	$n = 56$
Metaxya rostrata	$2n = 192$ (or 190) $n = 94\text{-}96$

Thus the cytology of *Metaxya* does not clearly indicate affinity with any of the other genera, but rather adds emphasis to the isolated position of the genus, and supports its status in a separate subfamily accorded by Holttum and Sen (1961). The evidence of the form of young fronds, and of rachis-structure, would point to an affinity with *Culcita* or *Thyrsopteris* rather than with *Cyathea* or *Lophosoria;* but the position of the sori, and especially the existence of two sori on one vein, point to a long history of evolutionary divergence from such a fern as *Culcita*.

LITERATURE CITED

BOWER, F. O. 1913. Studies in the Phylogeny of the Filicales, III. On Metaxya and certain other relatively primitive ferns. Ann. Bot. **27**: 443-450.

———. 1926. The Ferns, Vol. II, chapter 32. Cambridge.

HOLTTUM, R. E. 1963. Flora Malesiana, Ser. II, 1, pt. 2, Cyatheaceae.

———. 1965. The evolution of the vascular system in Ferns, with especial reference to dorsiventral rhizomes. Phytomorphology **14**: 477-480.

HOLTTUM, R. E., AND U. SEN. 1961. Morphology and Classification of the Tree ferns. Phytomorphology **11**: 406-420.

ROY, S. K., AND R. E. HOLTTUM. 1965. New Cytological Records for Cystodium and Dicksonia. Amer. Fern Jour. **55**: 35-37. Two figures.

KEW GARDENS, RICHMOND, SURREY, ENGLAND.

Observations on Cultivated Ferns, VIII. Stenochlaena

C. V. MORTON

The small genus *Stenochlaena* consists of a few species native to the Old World tropics. They are large, coarse ferns with simply pinnate sterile blades, climbing on tree-trunks in forests by means of thick scaly rhizomes.

The modern understanding of the genus dates from L. M. Underwood, who in his paper "The Genus Stenochlaena"[1] delimited four sections—*Eustenochlaena, Cafraria, Teratophyllum,* and *Lomariopsis.* R. E. Holttum[2] presented a much more detailed account, in which Underwood's delimitations were accepted, except that *Teratophyllum* and *Lomariopsis* were recognized as distinct genera rather than sections. Holttum's conclusions seem to be well taken. In *Stenochlaena* there is a vein on each side of the midrib of the pinnae, this forming a row of elongate loops (areoles) along the midrib. The other veins arise from the outer side of this costal vein, and run straight to the margin.

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[1] Bull. Torrey Bot. Club **33**: 35-50. 1906.

[2] Gardens' Bulletin Straits Settlements **5**: 245-316. 1932.

where about half of them end in sharp, spinulose teeth. In *Lomariopsis* and *Teratophyllum* all the veins are free and arise directly from the midrib.

Only two species of *Stenochlaena* are cultivated in the United States. These may be distinguished as follows:

Fertile pinnae bipinnate; sterile pinnae with numerous, close, and conspicuous spinulose teeth (Sect. *Cafraria*) .... S. tenuifolia

Fertile pinnae simply pinnate; sterile pinnae with distant, more inconspicuous teeth (Sect. *Stenochlaena*) .... S. palustris

STENOCHLAENA TENUIFOLIA (Desv.) Moore, Gard. Chron. **1856:** 193. 1856.

Lomaria tenuifolia Desv. Berlin Naturf. Freund. Mag. **5:** 326. 1811. Type from Madagascar.

Lomaria meyeriana Kunze, Linnaea **10:** 509. 1836. Type from South Africa, *Drege.*

Stenochlaena tenuifolia, the only species of sect. *Cafraria* Presl,[3] is a native of South Africa, Madagascar, and the Mascarene Islands, but it is apparently nowhere common. It was in cultivation in the Botanical Garden in Washington, D. C., at least as early as 1884, and was probably present in other botanical gardens, but it was seemingly not in cultivation by gardeners until about 1925. The first to grow it was probably Mr. Mulford B. Foster, of Orlando, Florida, who introduced it to the trade. Mr. Foster sold about 50 plants, and so the species was not uncommon in gardens in Florida by the mid 1930's. Since it grows well outdoors in Florida, it may be expected to be found in the wild eventually, but there are no specimens in the National Herbarium, as yet, other than cultivated ones.

When forwarding a specimen to the National Herbarium, Mr. Foster commented that the species is quite slow and rather difficult to start, as it does not like to be moved. He established new plants by layering the runners. However, once established it grows rapidly, providing there is good shade and heavy soil. Mr. Foster wrote further: "It seems that the most rapid growth of this fern is during the rainy season, and growth continues

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[3] Epim. Bot. 166. 1849 [1851].

until our November cool weather. I have had the fern climb seven feet up a tree-trunk in a single season. I have had many fronds as long as six feet. However, the fronds as they creep out into the sun are much shorter than those suspended from the climbing sections on the pergola. The fertile fronds are generally produced in August, but are not very numerous. In some years I find but two or three. The plants will stand light frost without damage, but temperatures of 24° to 26° will injure many of the fronds seriously."

In recent years *Stenochlaena tenuifolia* has been grown in southern California, where it was perhaps introduced by the late Mrs. Fay A. MacFadden. According to Mrs. MacFadden, it needs lots of water and attention, and does not like cold weather, which if too severe will kill it. Also, it does not fruit abundantly or regularly in California.

A slightly variant form with extremely narrow pinnae has recently been introduced directly from Zululand, South Africa, through Dr. R. Rodin. This has been cultivated and distributed from the University of California Botanical Garden.

STENOCHLAENA PALUSTRIS (Burm.) Beddome, Suppl. Ferns So. India & Brit. India 26. 1876.

Polypodium palustre Burm. Fl. Ind. 234, 1768. Type from Ceylon.

This species, common in tropical Asia and Malaysia, is hardly known in cultivation, although it was formerly somewhat grown in England as a hothouse plant under the name *Acrostichum scandens.* Recently it has again been introduced into cultivation by the University of California Botanical Garden from material originally grown from spores collected in New Guinea by W. H. Wagner and D. Grether. Although spores have been distributed to interested persons, this is such a large and coarse vine that not many growers are likely to have space for it, especially since it is not particularly ornamental.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C.

Dispersal of Marsilea mucronata by Water Birds[1]

CHARLES R. MALONE AND VERNON W. PROCTOR

The aquatic fern *Marsilea mucronata* commonly occurs in playas (temporary lakes) in west Texas and in other isolated bodies of water on the Great Plains from northern Mexico to southern Canada (Correll, 1956). The means by which this and other species of *Marsilea* reach isolated habitats is unknown.

Guppy (1906) suggested that *Marsilea* might be dispersed by adhering to the external surfaces of birds. However, this apparently never has been demonstrated. Brown, Larson, and Bold (1964) found that spores of some terrestrial ferns may be dispersed by wind. Both these methods of dispersal seem unlikely for *Marsilea* because of the size and weight of the sporocarps.

Recent investigations have shown that many fresh-water organisms incapable of active overland transport may be effectively dispersed via the intestinal tracts of migratory water birds (Proctor, 1959, 1962, 1964). In most cases resistant eggs and spores account for the ability of organisms to withstand passage through the intestinal tract.

Although intact sporocarps have been found in the stomachs of various birds (McAtee, 1939), it is not known whether sporocarps will pass unharmed through the entire intestinal tract. Neither is it known whether the spores are sufficiently protected by the sporocarp wall to retain their viability after passage.

To determine the effects of avian digestion upon the viability of *Marsilea* spores, sporocarps of *M. mucronata* were fed to 5 species of water birds. Six killdeer (*Charadrius vociferus*), 2 mandarin ducks (*Aix galericulata*), 2 wood ducks (*Aix sponsa*), 2 Chiloe widgeons (*Anas sibilatrix*), and one mallard (*Anas platyrhynchos*) were used.

Sporocarps fed to ducks were mixed with either chopped aquatic vegetation or small grain. Killdeer were fed sporocarps

[1] Research supported by National Institute of Health Grant GM 11394-01A1.

mixed with ground commercial shrimp. No attempt was made to determine the number of sporocarps ingested per bird. Immediately after ingesting the sporocarps, the birds were caged and their feces collected and examined every hour. Birds were caged at least 24 hours and released if no sporocarps had been passed within that period. If sporocarps were passed the bird was retained for an additional 24 hours following passage of the last sporocarp.

Sporocarps recovered from the feces were either placed directly into sterile soil and water or were first scarified. The cultures were inspected after 2 weeks and the approximate number of young plants recorded.

RESULTS AND DISCUSSION

Table 1 gives the number of trials per species of bird, the number of sporocarps recovered, and the range and mean rate of passage of the sporocarps. Both the greatest number of recovered sporocarps and the greatest time of retention resulted from killdeer. These birds are largely carnivorous and less than 5% of their diet consists of seeds (Bent, 1929). For this reason their stomach usually contains little grit. Thus, the sporocarps probably were subjected to little grinding.

Although food passes rapidly through killdeer, sporocarps were retained longer than expected. A meal normally passes through the intestinal tract of these birds in about 2 hours: sporocarps were never passed under 5 hours. It seems likely that the sporocarps remained in the gizzard much as would grit.

Spores from crushed sporocarps occasionally were found in the feces of killdeer. These were placed in sterile soil and water but none was viable.

Ducks ingested many more sporocarps than did killdeer yet passed fewer. Feces from all the ducks contained large numbers of nonviable spores indicating that most sporocarps were crushed. Fewer sporocarps were recovered from wood ducks than from any other bird. Wood ducks ate large quantities of sporocarps but were very efficient in crushing them. The diet of these birds

TABLE 1: RECOVERY OF *Marsilea mucronata* SPOROCARPS FROM THE INTESTINAL TRACT OF WATER BIRDS

Bird	N	Sporocarps Recovered	Rate of Passage: Hours R	$\overline{X}$
Killdeer	20	55	5-60	19.5
Mallard	8	6	2-24	8.0
Chiloe Widgeon	14	8	1-24	8.5
Mandarin	9	23	1-8	3.0
Wood Duck	9	2	7	7.0

includes nuts and acorns (Mabbott, 1920) and they are known for their muscular gizzard.

In only 2 cases did sporocarps recovered from birds release their spores without being scarified. One each was recovered from a mandarin and a wood duck. In both instances, half the sporocarp wall had been torn off. The spores were released within a few minutes after the sporocarps were placed in water. Seven and 12 visible megaspores were contained in the damaged sporocarps taken from the mandarin duck and from the wood duck, respectively.

Apparently the sporocarp wall provides protection for the spores. Recovered undamaged sporocarps, regardless of their rate of passage, contained as many viable megaspores as did sporocarps not fed to birds. The usual number in either case was 30 to 50. Damaged sporocarps contained significantly fewer viable megaspores. Megaspores from crushed sporocarps were never viable.

Proctor and Malone (1965) studied the effect of the digestive processes of 4 kinds of birds upon eggs and spores of various aquatic organisms. They concluded that because of differences in digestion, some birds are probably more effective agents of dispersal than others. This appears to be likely when considering the dispersal of *M. mucronata.* Killdeer could carry larger numbers of sporocarps for greater periods of time than could any species of duck studied here. However, due to food habits, killdeer and other shore birds probably ingest fewer sporocarps than do waterfowl. Among the ducks, wood ducks are less likely than the other species to carry sporocarps. The efficiency with which wood ducks grind their food assures that most of the ingested sporocarps would be crushed.

These results, together with accounts of sporocarps being found in the stomach of waterfowl, suggest that dispersal via the avian intestinal tract is of importance to *M. mucronata.* Although the spores themselves are not resistant to avian digestive processes, the wall of the sporocarp provides them ample protection. Sporocarps can remain within the intestinal tract sufficient time to allow considerable distance of dispersal by a flying bird. The wide spread occurrence of *M. mucronata* attests to the effectiveness of its means of dispersal.

LITERATURE CITED

BENT, A. C. 1929. Life histories of North American shore birds. Order Limicolae (part 2). U. S. Natl. Mus. Bull. **146,** 412 p.

BROWN, R. M., JR., D. A. LARSON, AND H. C. BOLD. 1964. Airborne algae: their abundance and heterogeneity. Science **143:** 583-585.

CORRELL, D. S. 1956. Ferns and fern allies of Texas. Texas Research Foundation, Renner, Texas, 188 p.

GUPPY, H. B. 1906. Observations of a naturalist in the Pacific. Vol. II, Plant-dispersal. Macmillan and Co., Ltd., New York, 627 p.

MABBOTT, D. C. 1920. Food habits of North American diving ducks. Tech. Bull. 643, U.S.D.A., Washington, D. C.

MCATEE, W. L. 1939. Wildfowl food plants. Collegiate Press, Inc., Ames, Iowa, 141 p.

PROCTOR, V. M. 1959. Dispersal of fresh-water algae by migratory water birds. Science **130:** 623-624.

————. 1962. Viability of *Chara* oospores taken from migratory water birds. Ecology **43:** 528-529.

————. 1964. Viability of crustacean eggs recovered from ducks. Ecology **45:** 656-658.

————, AND C. R. MALONE. 1965. Further evidence of the dispersal of small aquatic organisms via the intestinal tract of birds. Ecology **46:** (in press).

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A New Sexual Form of Pellaea glabella var. glabella from Missouri

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KATHERINE L. CHEN[1]

Between 5% and 10% of fern species are non-sexual. The non-sexual or apogamous type of life cycle is now known in over 80 species among such genera as *Adiantum, Asplenium, Cheilanthes, Dryopteris,* and *Pteris.* This form of reproduction bypasses the regular sexual fertilization of egg by sperm, and the details of the pattern were worked out by W. Döpp and Irene Manton in particular (reviewed by Mehra, 1961). The sporophyte and the gametophyte have the same chromosome number. The typical fusion of egg and sperm that occurs in the archegonium is lacking. The new fern plant simply grows out of the tissue of the prothallus as a bud. If the chromosome number of the sporophyte is, for example, 87, the spore will have the same number, the prothallus the same number, and so on. The only change in chromosome number occurs just before spore formation, when there is usually an automatic doubling of chromosome number in the spore mother cells. Instead of producing the normal 16 spore mother cells with 87 chromosomes, the spore-cases produce 8 mother cells with 174. Normal spore formation follows, producing only 32 spores, not the typical 64. If doubling does not occur and there are the usual 16 spore mother cells, the 64 spores which result in a regularly apogamous fern are abortive and will not germinate normally. Thus doubling is required, and the "good" spores are only those which occur 32 per sporangium. Because of these spore products it is not necessary to make cytological studies to judge in general whether a given fern is apogamous or sexual. By merely looking through the microscope at sporangia from dried herbarium sheets it is

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usually possible to distinguish which type of reproduction occurs.

FIGURE 1. PELLAEA GLABELLA VAR. GLABELLA. SPECIMENS, OTHERWISE INDISTINGUISHABLE, SHOWING BOTH TYPES OF SPORES SHOWN IN FIGURE 2, THE DIPLOID-SEXUAL AND TETRAPLOID-APOGAMOUS. (*E. J. Palmer* 19449, MO).

Typically, if all or most of the spore-cases contain 64 uniform spores, the plant is sexual. If some of the sporangia contain 64 abortive spores and some contain 32 uniform spores, the plant is probably apogamous. This is an excellent example of one of the uses of spores as a tool in systematic studies of ferns (Cf. Wagner and Chen, 1965, on the use of spores in detecting *Dryopteris* hybrids).

Alice Tryon (1957) used the above criteria to assess the type of reproduction in species and varieties of cliffbrakes, *Pellaea*. Confirmation was made by germination tests and cytological studies by Donald M. Britton. In regard to the wide ranging smooth cliffbrake, *P. glabella,* three varieties were distinguished. Samples of two of the varieties showed 116 chromosomes, 32 "good" spores, and apogamy—var. *glabella* (Fig. 1), occurring from Vermont to Minnesota and Texas and having large fronds (4-36 cm. long), the pinnae made up of 3-7 segments; and var. *simplex,* from British Columbia to Washington and Utah to New Mexico, with small fronds (1-20 cm. long), the pinnae usually with 3-5 segments. The remaining variety had 58 chromosomes, 64 spores, and sexuality—var. *occidentalis,* from Alberta to Wyoming and South Dakota, the fronds very small (1-5 cm.) and the pinnae usually sessile and with only one segment. Dr. Tryon's opinion of the varietal relationships was as follows: "*Pellaea glabella* var. *occidentalis* is undoubtedly the source from which the polyploid members of the complex have been derived, either through hybridization or possibly autopolyploidy." She further suggested (p. 147) that "Var. *glabella*" with 116 chromosomes may have arisen as the hybrid of the apogamous *P. atropurpurea* with 87 chromosomes and the sexual *P. glabella* var. *occidentalis* with 29 gametic chromosomes.

The above hypotheses will need to be rather profoundly modified as a result of the facts to be reported below. We now have evidence of a 64-spored, diploid, sexual form of "Var. *glabella*" which occurs in the region to the south and west of St. Louis, Missouri. The bearing of this new form on the interpretation of varietal relationships in *P. glabella* will be discussed below. The discovery of two forms of the same variety, one sexual and one apogamous, has considerable theoretical interest. As will be noted below, the two forms may even exist sympatrically, i.e., in the same habitat.

On October 16, 1964, Donald R. Farrar collected a series of *Pellaea glabella* var. *glabella* on the river bluffs 10 miles west of DeSoto, Jefferson County, Missouri. The smooth cliffbrakes were growing with such other ferns as *Asplenium platyneuron*, *A. resiliens*, *A. ruta-muraria*, *Cheilanthes feei*, and *Pellaea atro-*

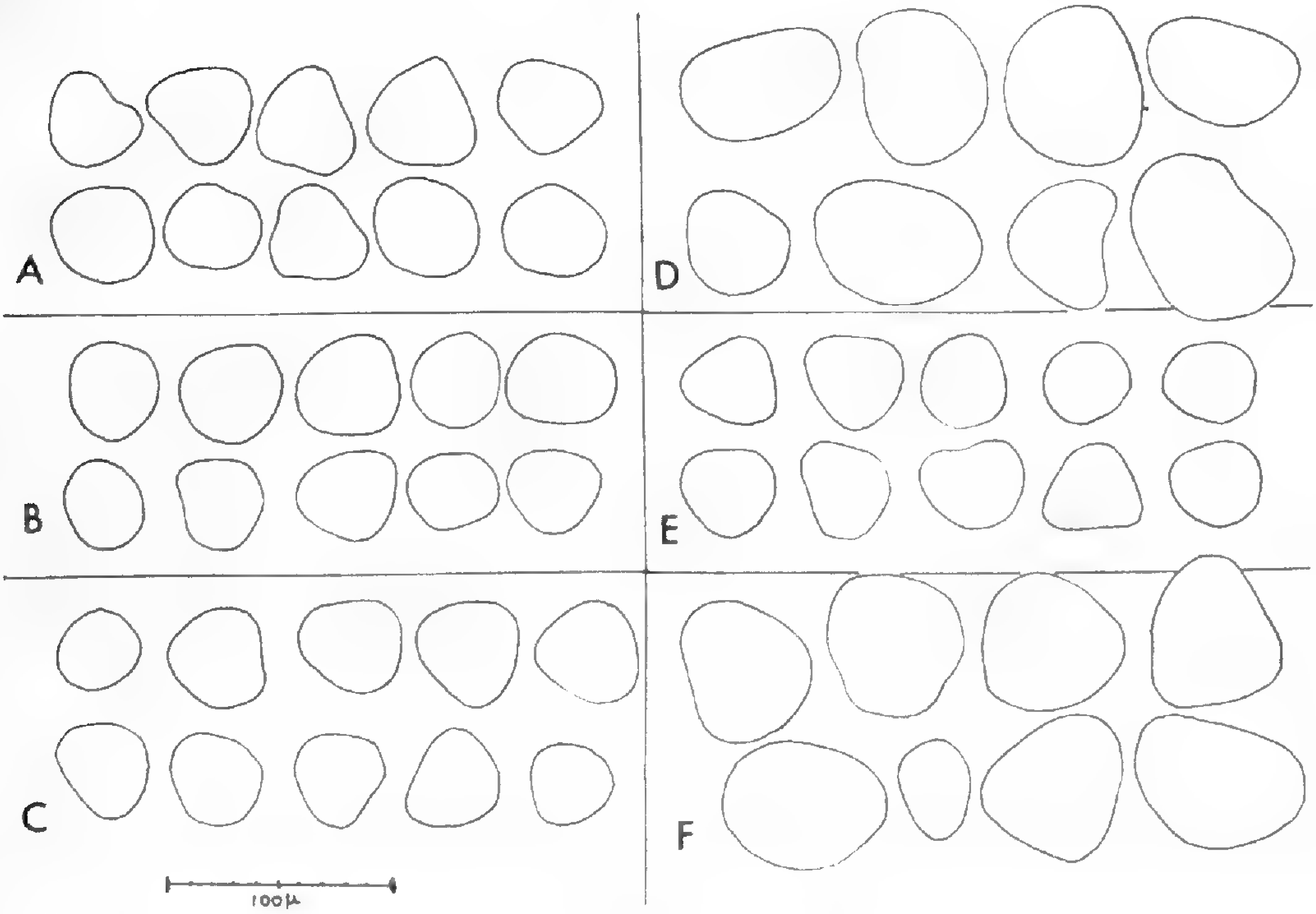

FIGURE 2. OUTLINES OF RANDOM 10-SPORE SAMPLES MOUNTED IN DIAPHANE. SEXUAL SPORE TYPE A, B, C, E; APOGAMOUS SPORE TYPE D, F. ALL FROM STATE OF MISSOURI. A. JEFFERSON COUNTY, *Farrar s.n.* (MICH). B. FRANKLIN COUNTY, *Steyermark* 31404 (MO). C. PULASKI COUNTY, *Palmer* 39199 (MO). D. CHRISTIAN COUNTY, CHADWICK, *Steyermark* 23010 (MO.). E. CARTER COUNTY, *Palmer* 19449 (MO). F. SAME DATA AS E.

purpurea on the limestone rocks. A check of the spores (Fig. 2, A, B, C, E) showed them to be wholly unlike those previously reported in var. *glabella* (Fig. 2, D, F), being uniform in size and shape, much smaller, and numbering 64 or nearly that number in each spore-case. Then, on May 2, 1965, Farrar collected cytological materials to test our prediction that the plant is a sexual diploid. The results (shown in Fig. 3) fully confirmed our prediction.[2]

In order to determine the geographical distribution of the sexual form, we examined a large number of specimens sent on loan by the Missouri Botanical Garden and the U. S. National Museum. We discovered that the morphology of the plants cannot be used to distinguish the diploid sexual form from the apog-

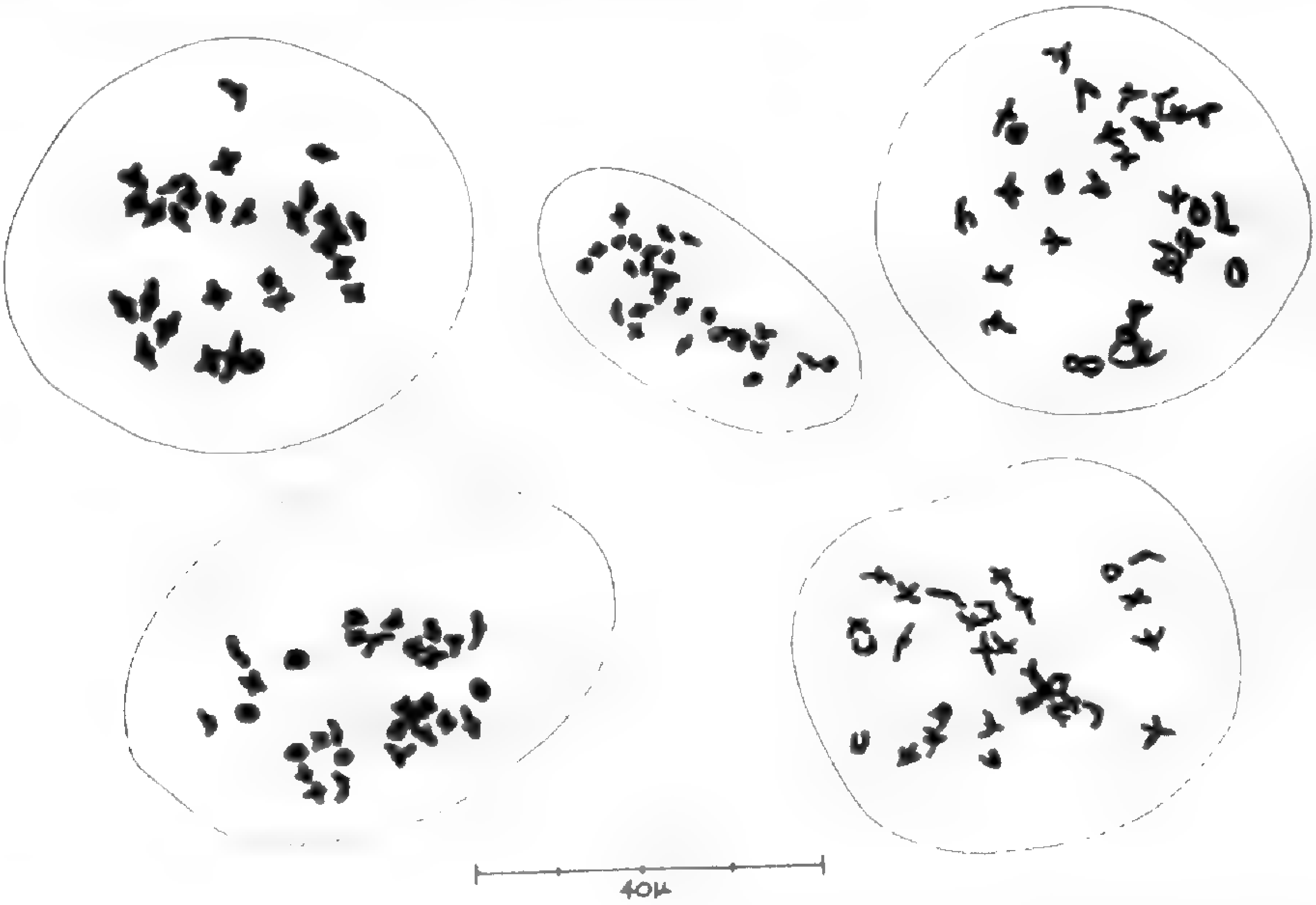

FIGURE 3. CHROMOSOME SQUASHES AT MEIOTIC METAPHASE SHOWING $n = 29$ CHROMOSOME PAIRS. ALL EXCEPT LOWER RIGHT COLLECTED IN EARLY MAY; LOWER RIGHT, IN LATE MAY; FROM NATURALLY GROWING PLANTS IN JEFFERSON COUNTY, MISSOURI. DOTTED BODIES PROBABLY NUCLEOLAR MATERIAL.

[2] It is interesting to note that in all figures seen of the diploid, a small object, staining lightly and varying in size from mother cell to mother cell, was observed. Possibly the object represents nucleolar material.

amous form, so we were forced to make microscope slides of all the specimens to prepare the county distribution map in Missouri shown in Figure 4. (It is not at all unlikely that further studies of the sporangial contents of this fern will show that the sexual form occurs in other states besides Missouri, but such a survey was not made by us.) The small-spored sexual form is confined, so far as our present collections show, to the

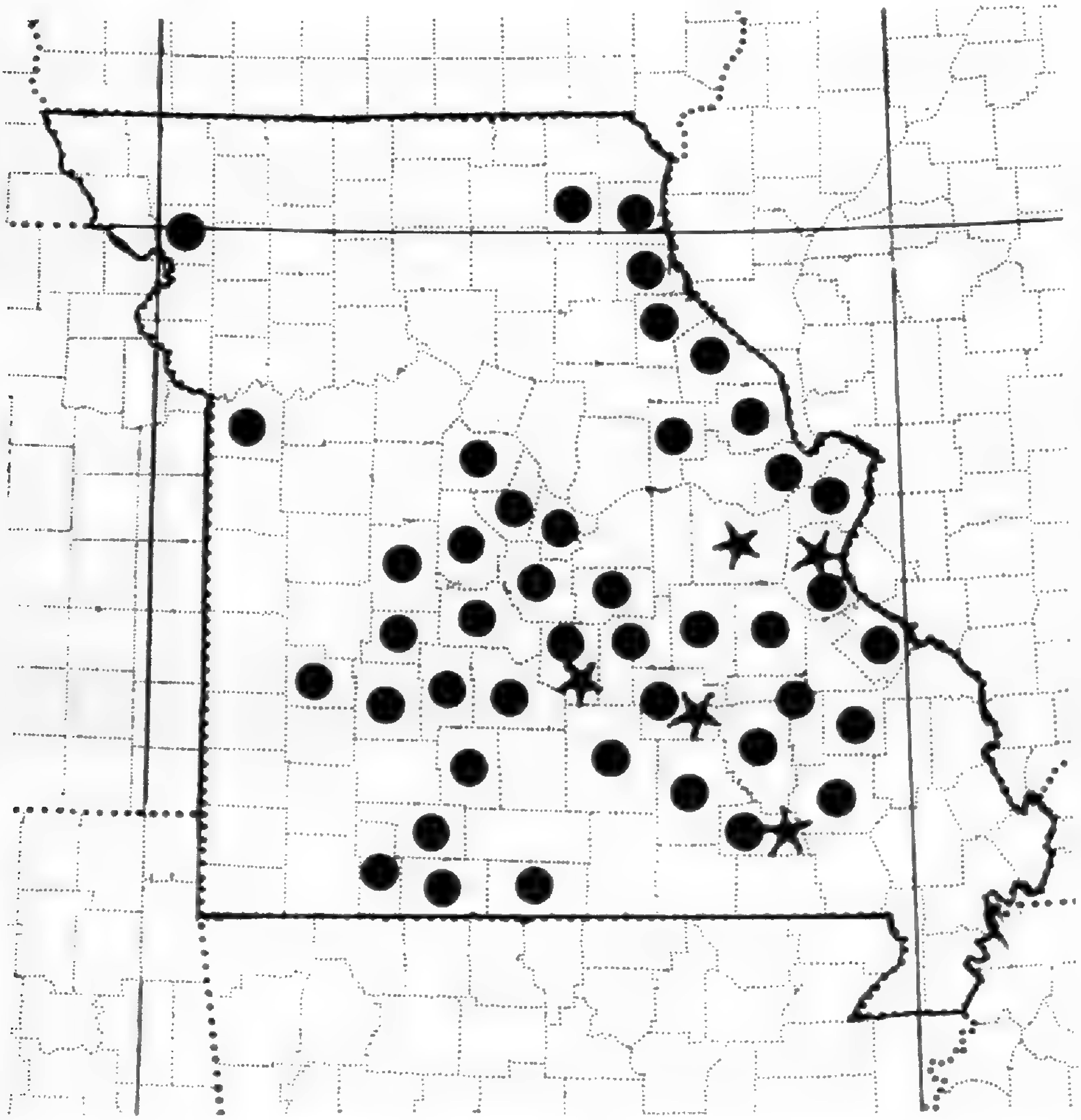

FIGURE 4. COUNTY DISTRIBUTION MAP OF PELLAEA GLABELLA VAR. GLABELLA IN THE STATE OF MISSOURI. DOTS = APOGAMOUS 32-SPORED FORM. STARS = SEXUAL 64-SPORED FORM.

quarter of the state which is south and west of St. Louis. The large-spored apogamous type runs much further west and north. The earliest collection of the diploid we encountered was that of E. J. Palmer in 1920 (Carter County).

All of the collections of sexual var. *glabella* are listed as follows, but it must be noted that only *one* specimen per sheet was examined. Thus it is possible that some collections are mixed. In four out of five of the counties where the diploid form occurs, the apogamous type was also observed. In one case, indicated below, specimens from the same locality (Carter County, Van Buren) included both forms. Where the two occur together interesting hybrids should be sought with $5x$ chromosome number of 145.

COLLECTIONS: *Franklin County:* Semi-shaded dry limestone cliffs near Meramec River, State Park east of Sullivan, *Julian A. Steyermark* 1404 (MO). *Jefferson County:* River bluffs 10 miles west of DeSoto, ¼ mile upstream from junction of "H" road and "Big River," *D. R. Farrar* (cytological vouncher, n = 29, MICH). *Pulaski County:* Face of dolomite bluffs, near Hazelgreen, *E. J. Palmer* 39199 (MO, US). *Dent County:* Bluffs along Meramec River between Howe and Sligo, *Julian A. Steyermark* 15696 (MO). *Carter County:* Dry limestone cliffs of Current River near Van Buren, *E. J. Palmer* 19449 (MO)—Both of the 2 sheets of this collection have specimens with the apogamous type of spore and specimens with the sexual type, cf. Fig. 1, E and F.

In spite of our effort to find some morphological differences other than the spores, we concluded that the sexual form is inseparable from the apogamous form. At first we thought that the diploid, sexual plant was more slender and delicate, but we later discovered that some of the large-spored apogamous specimens were also slender and delicate. Furthermore, two of the small-spored sexual specimens (Pulaski and Dent Counties) are thick and robust plants. Cleared material of several samples of each form showed a tendency toward thickening of the lower epidermal walls in the diploid, but there was much variation in this character.

On the basis of the above facts, the interpretations of the *Pellaea glabella* varietal complex outlined above must be altered. Our present knowledge indicates that the correlation of varietal differentiation in this species with different life cycles is not as definite as was previously supposed. As shown here, one of the varieties, namely the typical var. *glabella*, exists in two different forms—the one an apogamous tetraploid, and the other a sexual diploid which has been heretofore overlooked. It is conceivable that still other cytological forms will be found in var. *glabella*. Similar diversity in life cycles may exist also in the other two varieties of *P. glabella* as well. An hypothesis that var. *glabella* might have arisen as a hybrid between *P. atropurpurea* and *P. glabella* var. *occidentalis* is made very unlikely by the information presented here. More likely the apogamous tetraploid is an autopolyploid derivative of the sexual diploid of the same variety in which chromosome doubling and modification of the life cycle took place at some time in the past. The much wider range and greater abundance of the non-sexual apogamous form of var. *glabella* strongly suggests that the apogamous life cycle is more efficient and successful, at least in the state of Missouri.

LITERATURE CITED

MEHRA, P. N. 1961. Cytological evolution of ferns with particular reference to Himalayan forms. 48th Indian Science Congr. Part II (Presidential Address): 1-24.

TRYON, ALICE F. 1957. A revision of the fern genus *Pellaea* Section *Pellaea*. Ann. Missouri Bot. Gard. **44**: 125-193.

———— AND DONALD M. BRITTON. 1958. Cytotaxonomic studies on the fern genus Pellaea. Evolution **12**: 137-145.

WAGNER, W. H., JR., and KATHERINE LIM CHEN. 1965. Abortion of spores and sporangia as a tool in the detection of Dryopteris hybrids. Amer. Fern Jour. **55**: 9-29.

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SHORTER NOTES

JAPANESE CLIMBING FERN SPREADING IN SOUTH CAROLINA.—On November 16, 1957, we discovered a healthy plant of the Japanese Climbing Fern, *Lygodium japonicum* (Thunb.) Sw., growing in semitidal unmanaged marsh along the Uernezobre Bank dike on the Savannah National Wildlife Refuge. This fern grew to a height of 12 feet and was heavily covered with fruiting fronds.

On January 7, 1965, five more clumps of this fern were found on the marsh side of a dike berm at least a mile from the original station. These had been mowed off partially, but all had fruiting fronds. Much new and bright green growth was evident, even though we have had several severe frosts.

These are the only records of this fern from South Carolina other than a report of a collection near Summerville in 1920 (Amer. Fern Jour. **11**: 90. 1921). Previous records report *Lygodium japonicum* appearing in a wild state in Florida, southwestern Georgia, Alabama, Mississippi, and Texas.—MARIE B. MELLINGER, *Route 1, Hardeeville, South Carolina.*

A SIMPLE METHOD FOR GROWING FERNS FROM SPORES.—Start with a sparkling clean, glass, one-gallon jug; a base made of one-by-four about seven inches long, to which screen molding has been nailed along eash side to keep the jug from rolling off; a strip of thin aluminum two inches wide and 14 inches long; and a number ten tin can (clean, of course). Place a mixture of two parts good loamy soil and three parts of peat moss in the tin can, saturate with water, cover with a piece of aluminum foil, and bake in an oven at 400° or 500° F. for an hour or two to sterilize the mixture.

While the soil is being sterilized and cooled, bend the strip of aluminum upward along both sides to form a narrow, evenly rounded trough which can be inserted through the mouth of the jug. When the soil-peat moss mixture has cooled to room temperature, scoop up a bit and insert the trough holding the mixture into the jug and carefully roll it over to drop the soil-peat moss mixture to the bottom of the jug as it lies on its side on the rimmed piece of one-by-four, with the handle of the jug turned down. This method of inserting the soil keeps the "top" of the jug clean. After enough soil mixture to make a layer an inch or so deep has been placed in the jug, gently pull it back and forth to level the soil. (Don't roll the jug laterally, for you want the glass above the bottom layer to remain crystal clean and clear).

Next, sift spores into the aluminum trough, insert it into the jug and gently shake the spores over the surface of the soil. Add just enough cooled, sterilized water through a piece of tubing or with a syringe, to moisten the soil.

The jug, lying on its side in the base formed by the board (painted if desired), should be set in a cool, shady place. Let time take care of it for a while. Oh yes, the mouth of the jug should be closed with a firmly packed wad of sterile cotton or gauze to keep out objectionable insects and reduce the rate at which water might evaporate. It is surprising how soon some fern spores develope into the prothallia, and these produce second generation sporophytes. Bracken sometimes will do this in two or three months.

This method was developed to serve as a nearly fool-proof method for growing ferns for display in school libraries, classrooms and lobbies, and to show youngsters how ferns grow from spores. Since I am a gardener for the whole North Bend School District, which consists of eight schools, I needed something of interest for the libraries and classrooms, and such displays had to be those that required no attention for prolonged periods.

Although the scheme was intended to interest the children, many adults became fascinated with watching the plants grow. The jug provides an ideal climate for growth, because the warmer the room becomes, the more rapidly the water in the soil of the jug goes into vapor in the confined space.

Growing ferns in this way has brought up a puzzling question:

When the growth first appears, the soil is covered closely with the minute prothallia. Later, after the prothallia have developed and young sporophytes appear, the latter are relatively far apart. Does it take more than one spore to produce a prothallium? If not, what happens to the rest of the tiny plants initiated by the spores?[1]

This type of unit might be ideal for rest homes and residents for elderly people. They might keep memories green for the oldsters, and would need no care after the initial preparation. They last for several years, and the small plants grow beautifully indoors.—Jesse T. Martin, *2622 Liberty St., North Bend, Oregon.*

Recent Fern Literature

The Ferns of Peru. Polypodiaceae (Dennstaedtieae to Oleandreae), by Rolla Tryon. Contributions from the Gray Herbarium of Harvard University. No. CXCIV, 253 pages, 196 figures, 42 maps. Cambridge, Mass. November 19, 1964—Dr. Tryon, who began his study of the fern flora of Peru about 1954, has wisely assembled and published that portion which he has thus far finished. Since this problem is a large one and the time that will be necessary for its completion is long, this partial account serves two purposes. First, it makes available without undue delay a useful contribution, and, second, it assures the author that his work is produced within his life-span in accordance with his ideas. This in no way precludes the hope that Tryon will live for many years to conclude this project.

Tryon summarizes his contribution better than anyone else could do when he states, "The present portion treats the species

[1] It requires only one spore to produce a prothallium, and the initial growth often is remarkably good. It appears that every spore germinated and started a new prothallium. But competition among the rapidly growing young plants is intense, and many more die than survive this process. Under certain conditions of additional nutrients being introduced at intervals of a few weeks, the soil may remain completely covered with prothallia, but such crowding is inimical to the health of the tiny plants and many of them fail to produce sporophytes—and die.—Editor.

of seven tribes of the Polypodiaceae. These tribes are represented by 33 genera and 176 native species. This is probably about a third of the genera of Pteridophyta to be found in Peru and about a quarter of the species. Three introduced species are also treated and eight that are to be expected in Peru, one of these in an additional genus."

With few exceptions, the work is essentially monographic, and Tryon is to be congratulated on the fact that he has made every effort to examine the holotype, isotype or authentic material of each basionym. This effort forms a solid basis for his thorough and conservative treatment of all the species in the seven tribes studied; namely, Dennstaedtieae, Cheilantheae, Pterideae, Vittarieae, Davallieae, Lindsaeeae, and Oleandreae.

The work comprises a short introduction that includes some notes on the geography of Peru with comments on the distribution and some ecology of the ferns of that country based on its four major vegetational areas: the Lomas, or coastal foothills of the Andes; the Sierra Steppe and Scrub, the generally dry mountainous region of Central Peru; the Ceja, or cool moist high eastern slopes and ridges of the Andes; the Montaña, or wet forested eastern part of Peru. The introductory matter is concluded by a synopsis of the family Polypodiaceae with a key to all of its 57 genera that Tryon knows to occur in Peru.

The keys and descriptions are lucid and comprehensive. Critical characteristics of practically all of the species are well-illustrated, and maps are included for some of the species to show their distribution in Peru. A feature that I find attractive is the inclusion of several vignettes that have as their motif interesting habitat views of ferns.

Tryon's work is one of the most thorough on ferns for any country in South America. It will also be very useful for the identification of ferns in these tribes found in countries adjacent to Peru. All who are interested in ferns will want a copy of Tryon's work.—DONOVAN S. CORRELL, *Texas Research Foundation, Renner, Texas.*

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