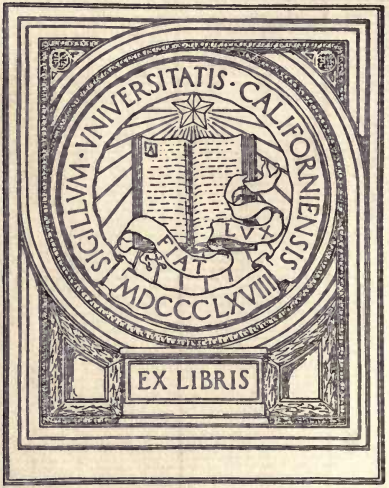
FERNWORT PAPERS 2 1900



FERNWORT PAPERS,

PRESENTED AT A MEETING

OF

FERN STUDENTS,

HELD IN NEW YORK CITY JUNE 27, 1900,

UNDER THE AUSPICES OF THE

LINNÆAN FERN CHAPTER.

Issued December 20, 1900.

Printed for the Linnæan Fern Chapter.

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FERNWORT PAPERS,

PRESENTED AT A SECOND MEETING OF FERN STUDENTS, HELD IN NEW YORK CITY, JUNE 27, 1900, UNDER THE AUSPICES OF THE LINNAEAN FERN CHAPTER.*

Printed for the Chapter. Issued December 20. 1900

THE GENUS ISOETES IN NEW ENGLAND.

BY A. A. EATON.

In the three seasons that have elapsed since the appearance of Dodge's "Ferns and Fern Allies of New England," the study of our local species of the genus *Isoetes* has progressed so far that it seems advisable at this time to present some of the results, and state some of the problems, in order to elicit the co-operation of collectors in clearing up some of the unsettled questions. As the settling of these questions will pave the way to a larger and more comprehensive work, this paper may be considered as preliminary only.

It appears advisable to give a history of the genus, so far as our chosen territory is concerned, and in doing this we can do no better than to adapt and extend Engelmann's chronological history in his comprehensive account of the genus, given in Trans. St. Louis Acad. **4**: 358-390. 1882.

According to this, the first collection was at Upbridge, Mass., by Robbins, in 1831. It was referred to *riparia*.

1840. Robbins collected *lacustris* in the same town.

1843. Tuckerman collected *lacustris* in Echo Lake, N. H.

1845. Robbins found *echinospora Braunii* in Massachusetts.

1848. Tuckerman found near Boston the species which bears his name.

1856. Engelmann found *echinospora Braunii* in Lake Winnipiseogee, New Hampshire.

1857. E. D. Eaton found *Engelmanni* in New England.

* For an account of this Meeting, see Fern Bulletin for July, 1900. The first gathering of those interested in American fern study occurred in Boston, August 24, 1898, and the papers read were published early in 1899, under the title, "Papers Presented at the Boston Meeting."

1860. Boott discovered *echinospora muricata*.

1865. Boott rediscovered *Tuckermani*.

1867. Boott collected *echinospora Booltii*.

1878. Pringle collected *echinospora robusta* in Lake Champlain.

Engelmann also mentions other New England collections, but they are not given in his list. After his time there is a hiatus in publications, but collectors were accumulating undigested material, and wrongly referring it often. The localities for *Braunii* have become so numerous that it appears useless to enumerate them. They occur in all of the New England States.

1887. Kennedy found what is now known as *Tuckermani borealis* in Somes stream, Mt. Desert.

1889. Dr. C. B. Graves found *echinospora muricata* in Connecticut.

1892. Fernald collected *Tuckermani* and *Harveyi* at Mt. Desert, and Rand discovered what is now the type of *heterospora* at the same place.

1893. Pringle and Fernald collected the types of *hieroglyphica* at St. Francis lakes. Dodge discovered *Engelmanni* at Newbury.

1894. Dodge discovered *Tuckermani* and *Braunii* at Newburyport.

1895. Coville discovered *Tuckermani borealis* at Kennebago lakes, and *hieroglyphica* at the Rangeleys. Raynal Dodge and myself found *Tuckermani* at Essex, Mass., and severally discovered it at Amesbury. I also found it at Kingston, N. H., and discovered *muricata* at Kingston and East Kingston, where I found the types of *Eatoni* and one specimen of *Dodgei* in a pond running into Kingston. Graves collected *Gravesii* in Connecticut.

1896. I discovered *Dodgei* at Kingston in abundance, *foveolata*, *Eatoni*, *echinospora robusta*, *muricata* and *Tuckermani* at Epping, N. H., and the last at Nottingham. Dr. Graves collected *Tuckermani* in southern Connecticut.

During the years 1895 and 1896 I found *Engelmanni* to be common in Rockingham county, N. H., and *echinospora Braunii* in many places.

1898. Harvey discovered the type of *Harveyi* at Pushaw pond, Oldtown, Maine. I found *Eatoni* at Amesbury, and Dodge at Newbury, Mass.

1899. Harvey found *Tuckermani borealis* at Oldtown, Maine, *hieroglyphica* and *muricata* at Moosehead lake. I traced *Eatoni*,

foveolata, and *muricata* to Newmarket, N. H. Underwood found some peculiar plants, not clearly referable to any published species, at Goshen, Conn. The spores are either abortive or unripe, and unsatisfactory for study.*

It is hoped collectors will call my attention to the many gaps in this list, that I may fill them.

A critical study, however, shows the remarkable fact that *riparia* and *lacustris*, tho formerly considered common, are very rare and have not been collected in recent years. It is true they have been reported from various localities, but all such specimens which have been accessible to me, have proven to be either *Engelmanni*, *Tuckermani*, *Tuckermani borealis*, or an undescribed species. It is unsafe to draw conclusions until some of the old material has been re-examined, which I hope will be in the near future; but there is a growing probability that the former has rarely been met north of the Delaware, and that the latter in its typical state is not American. I cannot agree with Dodge in his determinations as regards these species, and identify them mostly as *Tuckermani*. Incidentally, his *saccharata* from the Merrimac is immature *Braunii*.

There is one other point in his work to which I take exception, and that is the theory of hybridity of our species. Tho this may well occur, I have never seen a case which I thought called for that explanation. *Eatoni*, as is well known, usually bears only female sporangia, only one plant in two or three hundred bearing male spores, and then the sporanges occupy no regular zone, but are intermixed with the others. It is evident, then, that this would be a very good plant to experiment upon, as the macrospores could be easily obtained without microspores. This has been done by Mr. T. C. Palmer, who, I hope, will soon publish the results. I will anticipate this, however, by stating that while straight cultures yielded plants, attempted crosses between *Eatoni* and *Dodgei* or *Engelmanni* were negative. So we have presumptive proof that hybridity is extremely rare, if not altogether absent. Mr. Dodge based his presumption on spore characters only, a very unsatisfactory character, inasmuch as the sculpture of spores of all species is very variable, in the *echinosporas* often confluent into walls, especially in *muricata;* while in *Tuckermani* spores are often found mixed among normal ones that have the crests, or some of them, broken up into spinules. As these spores have been found in

*Additional specimens from Lynn, Conn., collected by Dr. Graves, prove this to be an undescribed species. It is inserted under the name of *I. Gravesii*.

sporanges with normal ones, I think them explainable better on the theory of accidental variation, than on that of hybridity, especially as they are found where the species do not grew in juxtaposition. My investigations on this point have been extensive, covering thousands of plants, and my conclusion is that hybridity in this genus, though not impossible, nor even improbable so far as externals go, is at least extremely rare among New England species.

I wish here to pay tribute to the general excellence of Mr. Dodge's treatment of the genus, a more practical account never having been written ; and for the beginner, I can conceive of no better directions than are contained in his notes. I wish I could say as much for Britton and Brown's more pretentious "Illustrated Flora," but to anyone with more than the most superficial knowledge of the genus, their treatment is very disappointing.

Considerable labor has been expended by Durieu, Braun, and Engelmann, to devise some system of classification that would hold water, but with ill success, as they themselves testify ; for while it is comparatively easy to classify species of a limited area, the system fails when applied to the genus as a whole. Perhaps the most natural grouping is into the three divisions Aquaticae or Submersae, Amphibiae, and Terrestres, and if applied with sufficient looseness will hold. But Submersae in Europe are bilobed and without stomata, consisting of the species *lacustris* and *echinospora*. When applied to the genus as a whole, however, we find *Gunnii* and *elatior* of Tasmania three lobed, and also find our varieties of *echinospora* with stomata, thus placing them in a different group from the type, as indeed they appear from habit to fall. The system fails, too, when taken in its original sense in the division Amphibiae. All Old World species of this group are three lobed, and this was made use of in the classification ; but not one of our numerous species of eastern America is three lobed, and only four from North America, *Nuttallii*, *Cubana*, *Orcuttii* and *minima*, are so constituted. The only works treating of the genus as a whole, do not tend to clear up the matter. Baker, in "Fern Allies," treats the genus very superficially, while Motelay's more pretentious work is full of inaccuracies, nearly two pages being given to "errata," and these covering a small percentage of those contained in the work. Though a help in many ways, the critical student hesitates to place much weight on statements accompanied by such errors.

The group Terrestres is, it seems to me, unnecessarily limited to the two species with persistent leaf bases. *Nuttallii*, *Butleri*, and

Montezumae of America, placed beside *Duriaei* or *hystrix* of Europe, could not be separated by superficial examination, this one point aside ; and some forms of *Duriaei* and *hystrix*, those growing in damp places, habitually have no scales. On the other hand, the three species mentioned can be separated at a glance from *melanopoda*, *Mexicana*, or *Pringlei*. Leaf sections also are identical in the Terrestres, the leaves being short, setaceous, with very small cavities, and correspondingly wide dissepiments, and with four stout bast-bundles (three in *Nuttallii*), while the others named, as well as most European, African, and Asian species which I have examined, have stout leaves, four primary, and several accessory bast-bundles, narrower dissepiments, and correspondingly larger cavities. I leave a further discussion of these points for a future occasion, especially as they bear only remotely on the immediate subject in hand. I would remark, however, that Engelmann is at variance, and I think rightly so, with European authors in his conception of the subdivisions.

Probably the main reason that our species of *Isoetes* are not better known, both in habit and distribution, is the difficulty novices experience in finding them. Their unattractive appearance and the tedious process of analysis by use of a compound microscope, required to determine them with accuracy, have also conspired to prevent general study. No character given can be expected to be true in all phases. The leaves are long or short, according to the stage of the water ; they are stout or slender, and the trunk large or small, to correspond to the general vigor of the plant. The outer sporanges are usually nearly round, while the inner are two to four times as long as broad. The velum varies greatly in some species, in certain forms of *echinospora* varying from ⅓-⅔ indusiate, and I have seen specimens from Maine and Amesbury, Mass., where a pin head would cover the opening. I should have considered this a good variety, had not fresh specimens from the same place possessed a normal velum. The spores vary greatly in size, and one may always expect to find some larger than the description allows. Location appears to regulate this. *Tuckermani*, for instance, is normal in this respect in most Massachusetts localities, while New Hampshire and Maine plants usually measure 10-20 μ more.

I know of no character more unreliable than the sculpture of the spores. It is always easy to recognize *Engelmanni* in New England, but southward even this breaks up into several varieties.

Eatoni usually has its peculiar convoluted ridges, but one often finds a spore which is cristate. *Dodgei* shows the same tendency to vary, and to a greater extent *Tuckermani, foveolata*, and the *echinosporas*. In the latter one may at times find a spore, or perhaps several in a sporangium, with crests running across the upper faces, while even the spines below are variable. Other spores grown with them, will have very long, slender, forked spines. Indeed, I do not at present feel competent to fix the limits of the varieties, but leave them where Engelmann did; or, where specimens have been referred to one or another of the varieties, the arrangement is tentative only.

I would remark, however, that while most specimens from my neighborhood answer well to the descriptions of *muricata* and *Boottii*, northern and mountain specimens usually have scattered, short, blunt, flat spinules, most nearly corresponding to *Braunii*, which, as originally described, is a mountain form.

The leaves of all species bear a central bast-bundle, but none of ours have more than four peripheral ones, and only four have them at all, *Engelmanni*, *Eatoni*, *Dodgei* and *Gravesii*. In well developed plants of the first, all four are pretty constant, but young or starved plants are liable to have only one or two, perhaps none. *Eatoni* is oftener without than with them.

All our species habitually have bi-lobed trunks, but tri-lobed ones are not infrequently found, and in one species, *Tuckermani*, I find about 25 per cent. tri-lobed, and have found one four- and another seven-lobed. While these plants appear to have been chiefly tri-lobed from the seedling, occasionally one is found which is apparently in process of transformation, One notable case was a plant of *foveolata*, collected at Newmarket, N. H., in 1899, which bore a distinct lesion on one side, in which roots were forming. The cortex between the lobe and lesion had not yet given way, but in the natural course of events would soon have decayed, and probably the root-bearing area would have persisted, the plant thus becoming tri-lobed. Indeed, in the four- and seven-lobed *Tuckermani* specimens, there was evidence that a similar accident had befallen them, and we might conjecture from this that the lower part of the trunk is capable of becoming root-bearing, provided the cortex be ruptured. Nothing conclusive has yet been observed on this point and it needs a series of experiments to demonstrate the truth or falsity of the hypothesis.

In the following arrangement I have based the key on characters which will most easily allow the determination of species without recourse to the compound microscope. Though not perfect, I hope it will be helpful to the general student,

Systematic Arrangement.

Group 1.

Plants habitually under water in the driest seasons, growing in sand or gravel. Bast absent, and stomata few or none. *Submersae.*

Leaves 1.5 to 2mm. in diameter, stiffly erect, stomata none.

10-15 cm. long, spores (averaging under 600 μ) covered with short crests, rarely a little reticulate below. 1. *lacustris.*

5-8 cm. long, spores larger (averaging over 600 μ, at times over 1000 μ), of various shapes, more densely cristate, crests anastamosing but not reticulated. 2. *heterospora.*

Leaves spiral or recurved, stomata few or none.

Leaves very slender, under 1 mm. in diameter, reddish when young, becoming olive-green, 8-15 cm. long, stomata in single series over air cavities, or none, macrospores wavy crested above, more or less reticulate below, 600 μ or less in diameter. 3. *Tuckermani.*

Leaves dull green, stouter, about 1mm., not spiral, slightly recurved, stomata not seen, spores larger, averaging above 650 μ. 3a. *Tuckermani borealis.*

Leaves stouter, over 1 mm. in diameter, shorter, 8-10cm., rigidly recurved, spores less than 600 μ, loosely covered with vermiform wrinkles. 4. *hieroglyphica.*

Leaves very stout, 2.5-3mm., short, 5-6cm., purple bronze in color, rigid, recurved, spores as in No. 3. 5. *Harveyi.*

Group 2.

Plants growing usually in mud on borders of ponds or rivers, inundated most of the year, but fruiting as the water recedes. Stomata abundant but peripheral bast-bundles none. Never far from water, and always in very damp soil. *Amphibiae.*

Spores reticulated below, jagged cristate above, much as in No, 3, but leaves stouter and erect. 6. *riparia.*

Spores smaller, averaging 440 μ, covered with very small pits. 7. *foveolata.*

Spores covered with spinules, stomata absent.
8. *echinospora*, not American.

Stomata present.

Most of the spines short, broad, usually retuse, leaves 25 or less. 8a. *echinospora Braunii.*

Like No. 8a, but leaves 25-70, and more densely stomatose. 8b. *echinospora robusta.*

Spines long and slender, sharp or forked, leaves stiffly erect. 8c. *echinospora Boottii.*

Spines often mixed with short crests, otherwise as in No. 8a, spores larger, leaves long and slender. 8d. *echinospora muricata.*

Group 3.

Plants growing in ditches or near the borders of ponds at higher levels than the preceding, emersed during the greater part of the summer. Stomata many, and bast-bundles (in our species) four. *Palustres.*

Spores smaller (450 μ or less).

Closely set with irregular, thick, rough, anastamosing ridges. 9. *Eatoni.*

Densely covered with short, truncate columns. 10. *Gravesii*

Spores larger (averaging over 550 μ) with irregular, usually scattered, variously anastamosing crests. 11. *Dodgei.*

Spores medium (averaging about 450 μ), regularly honeycomb-reticulated.

Plants larger, with stouter leaves, and four bast-bundles, 12. *Engelmanni.*

Plants weaker, leaves 15 or less, often without bast-bundles. 12a. *Engelmanni gracilis.*

1. I. LACUSTRIS L.

Quite common in clear waters in northern Europe. Variously reported from North America, but most reports have proven erroneous. The nearest approach to it I have yet met, was collected by Coville in Kennebago lake, Maine, in 1895. I have referred his plants doubtfully to *Tuckermani borealis.*

2. **I. heterospora** n. sp.

Trunk bi-lobed, leaves 50-75, 5-8cm. long, very stiffly erect, nearly 2mm. in diameter, tapering to a sharp point, wanting stomata or bast: velum ⅓-⅔ indusiate: sporangium spotted, often thickly so, with dark cells; macrospores normally 540-675 μ, but occasionally 1100 or even 1134 μ, densely covered with thick, jagged, convoluted crests, often honeycomb-reticulated below; microspores 30.8-39.6 μ, averaging 35x27 μ, dark brown, papillose.

This species differs from *lacustris* in its shorter, more numerous, tapering leaves, spotted sporangium, papillose microspores, and larger macrospores.

It is remarkable for the shape and size of the spores. Nearly all the sporanges of my plants are unripe, but good spores are found among the roots. In these the sculpture opens into a network. Normal spores are found, but most of them bear evidence of having grown singly or in pairs in the mother cells, as does *Selaginella rupestris*. These are spherical or hemispherical, without commisures and with no equatorial belt, or with it misplaced, often inclosing a very small space at one end. The microspores also vary, sometimes reaching 44 μ.

Deer brook beach, Jordan Pond, Mt. Desert Island, Maine, *Rand*. Quoted in Redfield and Rand's Flora as *Braunii*. South shore of Jordan Pond, September 10, 1894, *Rand*.

Type in the A. A. Eaton herbarium.

3. I. TUCKERMANI A. Br.

Formerly considered rare, this species appears to be quite common in New England, and any large pond with sandy shores may be expected to yield it, especially if a little silt has been deposited on the sand. It is usually found in "submersed pastures," the belt where littoral vegetation extends beneath the surface of the water for a short distance after the lowest stage of water has been reached. I quite accidentally discovered in 1895 that this species was tri-lobed in many instances, and some localities yield 25 per cent. of tri-lobed plants. Baker (Fern Allies, p. 126) appears to be the first to mention stomata in this species, though the fact was discovered by Mr. Dodge and myself quite independently. Plants taken from inundated situations usually have none, but when growing on the borders of ponds, a few leaves may usually be found which show them.

Distinguishable at sight by its very slender, spiral or recurved, reddish leaves. Spores of northern specimens are much larger than those from central Massachusetts, so far as seen.

At Pautuckaway Pond, Nottingham, N. H., and Kimball's Pond, Amesbury, Mass., I find a few plants which in the field have been taken for this species, but the leaves are larger, the sporangia dark spotted, as much so as most specimens of *Howellii*. It appears to be a new species, but material is inadequate for description.

Mt. Desert, *Rand*, *Fernald:* Oldtown, Maine, *Harvey*. Com-

mon in Rockingham county, N. H., and known from several ponds in Essex county, and near Boston, Mass., ; also from North Stonington, and Ledyard, Conn., *Graves.*

3a. **I. Tuckermani borealis** n. var.

Trunk bi-lobed, leaves 10-20, 3-8cm. long, 1mm. thick, slightly recurved at tip : sporanges sometimes showing a few spots ; macrospores 600-783 μ, sculptured as in the species, but the markings larger.

This might perhaps as well be considered a variety of *lacustris*, but the smaller leaves, wider velum, spotted sporanges and reticulated spores, are characters enough to separate it, even if that species were not so extremely rare.

Somes stream, Mt. Desert, August 13, 1887, *Kennedy;* pond north of Long Pond, Mt. Desert, September 22, 1892 (with *Harveyi* and *Tuckermani*) *Fernald;* Somes stream, September 30, 1893, *Rand;* Kennebago lake (leaves only 2.5-5cm. long), January 12, 1895, *Coville*, no. 78 ; Somes stream, Mt. Desert, September 14, 1895, *Rand;* Pushaw Pond, Oldtown, Maine, August 21, 1899, *Hervey.* I also occasionally find it in Lamprey river, at Epping, New Hampshire.

Type in the herbarium of A. A. Eaton ; co-types in the U. S. National, and University of Minnesota herbaria.

4. **I. hieroglyphica** n. sp.

Aspect of *Tuckermani* : trunk bi-lobed : leaves 10-20, 6-7.5cm. long, recurved, 1-2mm. in diameter, blunt at tip : velum ½ indusiate, sporangium unspotted ; macrospores 486-590 μ, polished, covered with vermiform, subconfluent and somewhat reticulated ridges, becoming naked next the equator ; microspores 31-44 μ, averaging 39 μ, distinctly verrucose.

The spores are unique in appearance ; the ridges are very bold, and the rest of the surface unmarked. I have seen nothing like it from any quarter, but Motelay's illustration of *flaccida* spores gives a fair idea of their appearance, though utterly unlike the species he intends to represent.

St. Francis lakes, Maine, type, *Pringle;* also *Fernald* from the same place ; Moosehead lake, *Harvey;* Rangeley lakes, *Coville.*

Type in the herbarium of A. A. Eaton ; co-types in the U. S. National, and the University of Minnesota herbaria.

5. **I. Harveyi** n. sp.

Trunk deeply 2- or occasionally 3-lobed, 1.6-3 cm. in diameter: leaves 50-140, short (5-6cm.), very stout and fleshy, 2.5-3mm. in diameter, strongly recurved, with an abrupt sharp point, purple-bronze in color, often reddish in drying, without bast or stomata: ligula short, obtuse: velum ¼-⅓ indusiate, sporangium small, unspotted: macrospores 526-648, abnormally 810 μ, with irregular, parallel, thickish crests above, and honeycomb-reticulate below, more broken in large spores; microspores 35.2-39.6 μ long, and 22-30 μ broad, rough.

I have hesitated somewhat whether to make this a variety of *Tuckermani* on its spore characters, or a species on its leaf characters, and finally concluded that it is just as much entitled to specific rank as *Tuckermani* itself, which in spore character is very near *riparia*, but perfectly distinct in leaf character. Although in all three of these species the general average of spores have an individual appearance, some can easily be found, which, if placed with selected spores of the other species, could not by any possibility be separated. The group seems to be connected with *lacustris* by *riparia* in spore characters, and some spores of *Braunii* are much like some spores of *lacustris*. As previously remarked, spore characters are a very unsafe basis for characterization, but one who examines many sets of these species will be struck with the gradation from the slender spined *Boottii* to the beautifully reticulate *Tuckermani*.

The leaves of *Harveyi* are relatively the stoutest of any North American species, and are equalled only by the Peruvian species, *I. Lechleri* Mett., which apparently belongs to the same group.

Pushaw Pond, Oldtown, Maine, *F. L. Harvey;* pond north of Long Pond, Mt. Desert, *Fernald* in part.

Type in the herbarium of A. A. Eaton; co-types in the U. S. National, and the University of Minnesota herbaria.

6. I. RIPARIA Engelm.

Polygamous: a medium sized species, with 15-30 erect, terete leaves, 10-30cm. long: sporangium spotted; velum ¼-¾ indusiate; macrospores 450-650 μ in diameter, with thin, jagged, irregular, mostly short crests, sometimes more confluent and reticulate—almost exactly intermediate in sculpture between *lacustris* and *Tuckermani*.

Reported from Maine, but all specimens so labeled which have

come under my observation, have proven to be *Tuckermani* or the variety *borealis*, notably the Mt. Desert locality of Redfield and Rand's Flora. I cannot agree with Mr. Dodge in his East Kingston, N. H., nor Newburyport, Mass. localities. Also reported from Uxbridge, Mass., and Brattleboro, Vermont. It is extremely rare in New England, to say the least, and the specimens from the old localities should be verified.

7. I. FOVEOLATA A. A. Eaton.

Trunk 2- or rarely 3-lobed: leaves 15-70, very stout, 5-15cm. long, pink, becoming olive-green, stomata few: plants apparently polygamous: sporangium spotted; macrospores 380-560 μ, with lower surface full of little holes, made by the close reticulation of the thick walls, sculpture of upper faces more open; microspores 22-35 μ long, reticulated.

Lamprey (or Pautuckaway) river, Epping, and Newmarket, N. H. Mr. Dodge's East Kingston locality rests upon a single plant.

8. I. ECHINOSPORA Durieu.

Not certainly known from America, our varieties all having stomata, while the species does not. I have specimens from Bradley, Maine, collected by Harvey, which I have examined so far in vain for stomata. They may prove typical in this respect, but differ in other particulars.

8a. I. ECHINOSPORA BRAUNII (Durieu) Engelm.

Leaves 10-30, usually grass-green, spreading, 5-23cm. long; stomata few if immersed, many if emersed: sporangia pale spotted, velum ½ indusiate; macrospores 350-550 μ in diameter, covered with short, broad, forked spinules, usually mixed with longer slender ones.

As commonly understood, this variety is found abundantly in New England in muddy mill ponds and river banks, also in sand at times, the plant then usually having a reddish tinge, and the leaves often spiral, especially if submersed. Dodge says it is often found where the water is very brackish, but I have been unable to verify this. Though subject to three or more feet of tide in the Merrimac at Newburyport, the water is sweet save under exceptional conditions. I am unable to say whether the same conditions prevail in the Maine rivers mentioned by him.

Our species of *Isoetes* appear to be very sensitive to salt water, and I have been unable to find any under its direct influence, save a few plants of *Engelmanni* in a mud hole near a dyke next the salt marsh, where inundated only by the highest tides.

8b. I. ECHINOSPORA ROBUSTA Engelm.

Stouter, with 25-70 leaves, bearing more stomata.

So far as herbarium specimens are concerned, this differs from *Braunii* only in the above characters, but the collector who has a general idea of *Isoetes*, can usually determine when he has this variety, by its appearance. It must manifestly differ in more than size, or a plant might be *Braunii* one year and *robusta* the next. Though it is impossible to separate all small plants with certainty, a goodly percentage can be so separated by the appearance of the plants, but it is difficult to satisfactorily define these differences in a description.

Lake Champlain, *Pringle;* Epping, N. H., *A. A. Eaton.*

8c. I. ECHINOSPORA BOOTTII (A. Br.) Engelm.

Leaves 10-12.5cm long, stiffly erect, of a soft, delicate green: spinules of spores long and slender.

Not certainly known except from Boott's original localities near Boston.

8d. I. ECHINOSPORA MURICATA (Durieu) Engelm.

Leaves 10-15, very slender, the submersed ones 15-40cm. long, ascending, in spirals, stomata few: spores 400-480 μ with slender spinules often mixed with short or elongated crests.

After the fall of the water in summer, the long leaves disappear, and are succeeded by short, bright green ones 5-7cm. long. In this state the plants would not be taken for the same unless the transition had been observed. There is a specimen from Boott's herbarium, collected in this stage, in the National Herbarium.

Maine: Moosehead Lake, *Harvey;* various localities, *Fernald.* New Hampshire: Kingston, East Kingston, Newton, Epping, Newmarket, *A. A. Eaton.* Vermont: Norwich (*fide* Dodge). Massachusetts: Woburn creek and Abajona river, *Boott.* Connecticut: Groton, *Graves.*

9. I. EATONI Dodge.

The largest New England species, exceeded in size by none now known in the world, and equalled only by *Engelmanni valida*

and the European *Maliaverniana*. Leaves 25-200, as much as 60cm. in length in water, about 10-15cm. when growing on banks. Known at once in the field by its size, but especially by the sporangium, which is light brown in color (white in nearly all other New England species), and is sparsely filled with very small spores. Microsporangia are rarely found in this species, but as it is abundant in several localities, it certainly must bear microspores, as it never multiplies by offshoots. It may be possible, but not probable, that some sporanges bear both kinds of spores. I have noted such sporanges in *Tuckermani* and several other species, but the microspores are usually aborted in such cases.

Found thus far only in the waters of three small rivers—Powow at East Kingston and Kingston, N. H., and Amesbury, Mass., in the Lamprey at Epping and Newmarket, *A. A. Eaton;* in Parker river at Georgetown, Mass., *Dodge*.

10. **I. Gravesii** n. sp.

Plant dioecious or polygamous, rather large: rootstock bilobed: leaves 50-75, 12-15cm. long, 1mm. in diameter in the middle, erect, sharp pointed, dark green, with abundant stomata and four bast-bundles: velum quite narrow, inner sporanges oval, light cinnamon in color from the abundance of vermiform, translucent, light-colored sclerenchym cells; macrospores many, small, 351-405 μ in diameter, tetrahedro-globose, the upper facies flat, densely covered with short, truncate, mostly single columns; microspores not seen.

Goshen, Conn., *Underwood*, 1899; gravelley tidal shore, Seldens Cove, Lyme, Conn., August 31, 1900, *Dr. C. B. Graves*. Specimens were sent to Dodge from this locality by Graves in 1895. It was at first referred to *Eatoni*, but was finally separated, and has since lain without name. It has the aspect of *saccharata*, but its affinities are with *Eatoni*, with which it agrees in being polygamous, in appearance of sporangium and shape of spores, which in both have the appearance of being abortive. It is a smaller plant with erect leaves, while the emersed ones of *Eatoni* are not. The spore sculpture, resembling *echinospora* rather than *Eatoni*, safely separates them. Though the majority of the columns are single, each spore usually has a few connected into vermiform or horseshoe-shaped figures, but they are walls rather than wrinkles, and in this respect resemble *Eatoni* but remotely.

The type is in my private herbarium; co-types are deposited

in the U. S. National Herbarium, in the herbaria of the Missouri Botanical Garden and the University of Minnesota.

11. I. Dodgei A. A. Eaton.

Plants medium to large: leaves 10-75, the submersed spirally ascending, 20-45cm. long, the emersed 10-20cm. long, often, especially when the plants are not crowded, tortuous and interlaced, 2-3mm. broad: velum one-fifth to one-fourth indusiate; sporangium spotted; macrospores 500-675 μ, averaging 560 μ, with mostly scattered groups of irregular, spinulose-rosulate crests; microspores ashy, 22-40 μ, wrinkled.

Abundant on the banks of Powow river where overflowed for the purpose of forming a pond during the greater part of the winter, at Kingston, N. H., the only known New England locality.

12. I. Engelmanni A. Br.

Leaves 15-100, bright green, usually erect except when growing out of water in bare places, stomata abundant: sporangium unspotted, velum narrow; macrospores chalk-white, 350-550 μ, honeycomb-reticulated; microspores 24-29 μ, smooth.

Very common in clayey soil in ponds and ditches, rarely in mud or sand. For the greater part of the season it is likely to be obscured by a tangle of swamp grasses and other vegetation.

The spores are peculiar, those of no other American species approaching them in sculpture. Those of *Tuckermani*, *riparia*, *hieroglyphica*, and *Harveyi* are, it is true, more or less honeycombed for a part of the surface, but the pattern is always incomplete. The nearest approach to it is *Japonica*, in which the spores are marked almost identically, but the crests are shorter and less delicate, and the reticulations larger, as well as the spores.

In *Duriaei* of Europe the pattern is also the same, but the walls are ridges rather than laminae, and the spores double the diameter. In *Azorica* the spores are similar in size, but the reticulations are less regular, the walls low, and there is little of the honeycomb. The only other species with spores of this pattern, is *Schweinfurthii* from equatorial Africa. My specimens of this species are immature, but one spore would pass for *Azorica*, while another is covered with short, blunt, crowded tubercles or ridges. The latter was taken from the roots, and may be intrusive.

In specimens from farther south the spores have a tendency to lose their characteristic form, and the species breaks up into vari-

eties. I have seen no typical *Engelmanni* from south of Pennsylvania.

Maine: *Fernald*, according to Dodge, though there are no specimens in Fernald's collection, which he has kindly sent to me for examination. New Hampshire: in nearly every mill pond or ditch with clay bottom in Rockingham county. Massachusetts: common in the eastern part. Rhode Island: Newport, *Farlow, fide* Dodge. Connecticut: Meriden, *Hall;* Waterford and Groton, *Graves.*

12a. I. ENGELMANNI GRACILIS Engelm.

An attenuate form of the type, and often growing with it; apparently caused more by environment than any inherent qualities.

Seabrook, N. H., June 27, 1900.

THE SYSTEM OF FERNS PROPOSED IN DIE NATUERLICHEN PFLANZENFAMILIEN.

BY LUCIEN M. UNDERWOOD.

To those familiar only with the system of Fern Genera that has been followed in *Synopsis Filicum*, and in its main features has been accepted in its application to the ferns of North America by most who have made our ferns a study, the system proposed in Engler & Prantl's *Die Natuerlichen Pflanzenfamilien* will present many strange features; yet, on the whole, it is to be regarded as a very conservative arrangement. Nevertheless, while the true ferns (*Polypodiaceae*) of *Synopsis Filicum* number only 47 genera, the same group in the present arrangement is distributed among 109; and were the system as uniformly consistent as it is in places, the number would quite readily be increased to three times that of *Synopsis Filicum*. Mettenius, Kuhn, and Prantl, the three great German fern taxonomists, have all passed away, and it was left to a novice among ferns—but none the less a trained botanist—to bring the genera together; it is to be judged then in this light, and not as the result of a long continued personal study. While it is a great improvement on the system that has too long been in vogue as the expression of a part of the obsolete English school of fern taxonomists, it is still lacking in many of the characteristics and consistencies that a genuine system must possess.

While some of the excesses of the systems of Fee and Moore are not accepted, many of the really scientific aspects of the systems of Presl and John Smith have not been incorporated, and, as a whole, it lacks most what a master would have put into it—homogeneity and consistency of treatment. For a system that is supposed to proceed from low to high in an evolutionary way, the order of arrangement of the larger groups is surely peculiar, as may be seen by the following:

Family HYMENOPHYLLACEAE
Family CYATHEACEAE
Family POLYPODIACEAE
1. *Woodsieae*
2. *Aspidieae*
3. *Oleandreae*
4. *Davallieae*
5. *Asplenieae*
6. *Pterideae*
7. *Vittarieae*
8. *Polypodieae*
9. *Acrosticheae*
Family PARKERIACEAE
Family MATONIACEAE
Family GLEICHENIACEAE
Family SCHIZAEACEAE
Family OSMUNDACEAE

The family OPHIOGLOSSACEAE is removed to a separate order, as is also the family MARATTIACEAE.

While there is long likely to be two schools of belief regarding the relative position of the eusporangiate and leptosporangiate forms, it is quite evident that were the groups of the *Polypodiaceae* inverted, they would come nearer representing an ascending series, and some of the later families are surely simpler. As to these major groups themselves, there is little fault to be found; possibly *Platycerium* might be held by some to a more distinctive rank than simply a mere member of the tribe *Acrosticheae*, but in the main the separation into families is logical and scientific. With the exception of *Parkeriaceae*, the names are well chosen; this one is unfortunate as based on one of the many synonyms of *Ceratopteris*, while the name *Ceratopteridaceae* which is possibly less euphonious has the double merit of being distinctive, and (in one of its forms at least) more ancient. Some of the commendable features of the work, so far as they pertain to our American ferns, may be noted in brief form:

1. The separation of *Dennstaedtia* from *Dicksonia*, and the breaking up of the latter genus into three. Our own species of *Dennstaedtin*, too long held as a *Dicksonia*, is separated from that genus not only generically but family-wise.

2. The separation of our two species hitherto combined under *Onoclea* into two genera,—certainly as distinct genera as were ever created!

3. The breaking up of the aspidioid forms into several genera. While this has not always been as thorough as might have been wished, it is a good beginning. Of course the selection of generic names was bound to be unfortunate, since the work is presumably based on the absurd and illogical fifty year system. Personally I am loth to see such genera as *Phegopteris*, *Meniscium*, *Goniopteris*, and the like, swallowed up with *Dryopteris*, but I can admit the presence of connecting forms, which is no more than we as evolutionists must expect in genera as well as species.

4. Altho American only in cultivation, the breaking up of *Davallia* into many genera should be commended. The transference of *Nephrolepis* to the *Davallieae* is also logical.

5. The separation of *Asplenium* into several genera. Here again the division could consistently be made still greater.

6. The breaking up of the composite genus *Gymnogramma* as hitherto understood.

7. The removal of *Notholaena* (wrongly written *Nothochlaena*) to a position intermediate between *Pellaea* and *Cheilanthes*.

8. The removal of *Pellaea Stelleri* to *Cryptogramma*, following Prantl's lead.

9. The breaking up of *Pteris* into several genera, of which our *Pteris aquilina* becomes *Pteridium*.

10. The division of *Taenitis* into several genera.

11. The breaking up of *Acrostichum* as comprised under the Hookerian (Kew) system into several genera, of which our species properly remain under *Acrostichum* itself.

These are some of the many favorable points in the Berlin system. Among the questionable points we may note the following:

1. The retention of *Camptosorus* and *Scolopendrium* in one genus—as has always been maintained in the Kew system.

2. The union of *Lomaria* and *Blechnum*. Despite the resemblance, there seems to us a real difference.

3. The joining of certain species of *Notholaena* like *nivea* and *tenera* to *Pellaea*. Possibly a separation of each genus into two

would be more natural, but this deserves a study of a wide array of forms.

4. The unfortunate and illogical treatment of *Polypodium*. A few of the more striking groups like *Dipteris*, *Drynaria*, and *Arthropteris* have been separated, but this is only a beginning. Of our American species, *P. polypodioides*, the least divergent of all, has been placed in the genus *Lepicystis*, while the others are all retained in *Polypodium*. And the same characters that elsewhere have been regarded as of importance, namely, vegetative characters, have been utterly disregarded. Surely our *Polypodium vulgare, aureum, phyllitidis*, and *Swartzii* represent four distinct genera if *Diplazium* is to be separated from *Asplenium*, *Polystichum* from *Dryopteris*, and *Camptosorus* from *Scolopendrium*, or either from *Asplenium*, where Linnaeus placed them.

Venation, belogning to a fundamental portion of the growth of the sporophyte, must for the future be regarded as of first importance in the taxonomy of ferns, and when the system of the future is finally attained, we believe it will be found that the systems of Presl and John Smith will approximate very closely to that ideal. This will involve a greater regard for the fibro-vascular system as represented in venation, and growth characters based on a study of rootstock and caudex, than we have presented in the system under review.

Columbia University, June, 1900.

EXPERIMENTS IN HYBRIDIZING FERNS.

By Margaret Slosson.

Various arguments have been advanced both for and against the probable occurrence of hybridity among ferns in nature, but I shall not here enter into the "pros and cons." There is now no doubt that fern hybridization is possible; it has been brought about artificially. To give the most convincing instance, Mr. E. J. Lowe has succeeded in crossing *Ceterach officinarum* and *Scolopendrium vulgare*, two ferns belonging not only to different species, but to different genera.

The next step is to ascertain whether fern-hybridization occurs in nature; if so, to what extent, and which are the hybrid ferns.

Obviously, the only infallible way to discover this, is to cross the supposed parents of suspected hybrids, and compare with the latter the resultant plants. All other evidence regarding suspected hybrids, such as abortion or eccentricity of the fronds, sterility of the spores, rarity of the plants, presence of the supposed parents, while pointing to the almost irresistible conclusion that the fern is a hybrid, is not positive proof. I have found no record of any attempt of the kind. American pteridologists appear to have left the hybridizing of ferns to pteridologists abroad, who have confined their attention to producing either entirely new forms, or new varieties of the crested and laciniate ferns so dear to our English cousins.

I am indebted to Mr. George E. Davenport's paper on "Hybridity in Ferns," read before the Boston meeting of the Chapter, not only for calling my attention to the subject, but also for suggesting the experiments I have tried. In order to make clear a description of these experiments, it will be necessary for me to repeat part of what he has already said.

There are several methods by which the crossing of the supposed parents of a suspected fern-hybrid may be attempted. Assuming two species to be capable of blending, and their prothalli monoecious, I will state briefly the possibilities of failure in each method.

The direct crossing of ferns by the artificial transference of antherozoids from one prothallus to the archegonium of another is very difficult. I believe no one has succeeded in accomplishing it. I have tried and failed. Owing to the infinitesimal size of the antherozoids, it must be done under a microscope and some instrument must be devised that will lift the antherozoids—not quiescent and adhesive like pollen, but moving rapidly—and deposit them without injury upon the desired archegonium.

Other, less direct, methods have proved more successful. The simplest of these is to sow a mixture of the spores of the two ferns, and trust to the proximity of the resultant prothalli to bring about cross-fertilization. The disadvantages of this method are, that it is impossible to tell whether the germinating spores come from both species (which introduces an element of doubt into the final result), that all or nearly all of one species may fail to germinate, and that, in order not to lose a possible hybrid, it is necessary to raise every one of the young plants, which means a great waste of time and trouble. The objection may also be urged that even should both species germinate, one might germinate later or develop faster than

the other, and thus none of the prothalli of both ripen for fertilization at the same time, but I think this would rarely happen. I have found with every species I have raised from spores, that while many of the prothalli develop plants at the same time, usually on the same day, others remain apparently latent for long periods, sometimes for months.

A third method, successfully used by Professor Bower in crossing *Polypodium aureum* and a variety of *Polypodium vulgare*, is that of sowing the spores of each species separately, afterward planting a prothallus of one species in close contact with a prothallus of the other. This method offers more certainty of success, but allows each species to retain both kinds of organs, which gives excellent opportunity for self-fertilization as well as for cross-fertilization.

A fourth method, pursued by Mr. Lowe, is that of sowing the spores separately, afterward cutting the resultant prothalli into quarters and planting a quarter of a prothallus of one species overlapping a quarter of a prothallus of the other. In order that this method may succeed, it is of course necessary that one of these quarters shall contain archegonia and the other antheridia. Cutting the prothalli in this way would probably as a rule isolate each kind of organ. The danger of this method lies in the fact that the prothallus is so small that by the slightest slip of the knife one might accidentally leave a bit of tissue containing archegonia on an antheridial section, or *vice versa*.

A fifth method, suggested by Mr. Davenport, and, so far as I know, not tried by anyone heretofore, is that of sowing the spores separately, cutting the resultant prothalli in two between archegonia and antheridia, then planting an archegonial section of one species in contact with an antheridial section of the other, so that archegonia and antheridia coalesce. This is the methodI have used, with the slight modification of cutting the prothallus into three sections instead of two; cutting once transversely close to the sinus and through the cushion of tissue on which the archegonia in most species are borne; cutting again transversely near the base, through the root-hairs among which the antheridia are scattered, then discarding the middle section and planting the upper (archegonial) section of one species upright against the lower (antheridial) section of the other, with the lower surfaces of both sections pressed close together. Cutting in this way prevents, I think, all danger of leaving both kinds of organs on the same section. There is some

danger that the prothalli may be cut too late, after fertilization has taken place, in which case plants of pure species would develop. Since some prothalli when fully grown are barely one-eighth the size of others, while many grow at varying rates of speed, it will be found impossible when cutting to distinguish between the small undeveloped prothalli and those which though small are already fertilized, except perhaps by the use of a powerful microscope. However, the newly cut archegonial sections, before being brought in contact with antheridial sections of the other species, could be isolated long enough to allow all fertilized sections to develop plants and be thrown away. There is also danger that plants may develop at any time from asexual growth, such as Dr. Farlow discovered in *Pteris cretica*. But Dr. Farlow has pointed out that in plants arising in this way, the first frond springs directly from the prothallus, so that it is impossible to tell where one begins and the other ends, and the first root develops afterward from the base of this frond; while in plants arising from fertilized archegonia, according to Sachs, both frond and root are separated from the prothallus by a slight connectile known as the "foot," and the first root develops from the base of this foot some time before the appearance of the first frond from its apex. Thus plants arising from asexual growth, as well as from self-fertilization previous to the cutting, could be detected and weeded out.

One would naturally suppose that all other plants arising from these sections must necessarily be the result of cross-fertilization. Unfortunately, there is doubt of that. The prothallial sections usually branch soon after being cut. They nearly always do so sooner or later. The antheridial sections often die down for several weeks, and then send up whole clusters of prothalli. Or new segments may appear from any part of the margin of the old. In archegonial sections a new segment frequently fills up the old sinus. Sometimes the effect is that of an old prothallus with young prothalli starting from the edge; sometimes of a cluster of overlapping prothalli continuous with one another at the base. Each new segment is shaped like a complete prothallus, sinus and all, which naturally suggests the question, may not these new segments replace the organs that have been cut away? I have not yet discovered whether this occurs or not. Mr. Lowe's experience in quartering prothalli would tend to show that it does not. He speaks of the branching of the quarters, and states that while keeping the lower quarters in one dish and the upper in another, no plants, with one ex-

ception, appeared. This exceptional plant may have been the result of asexual growth. Mr. Lowe attributes it to an insect carrying antherozoids from a distance, but there is not time to discuss this possibility. If the sections do replace the missing organs, this fifth method, as well as all the others except the first described, can be used for testing the hybridity of a fern only in cases where the alleged hybrid is so distinct from both of its supposed parents that it could not possibly arise from the self-fertilization of either one.

Of such a nature are *Asplenium ebenoides* and *Aspidium cristatum* x *marginale*. I suppose no one will question for a moment that *Asplenium ebenoides* cannot be considered a variety of either *Asplenium ebeneum* or *Camptosorus rhizophyllus*, but must either be a cross between the two or a distinct species. Now a distinct species certainly could not arise from a prothallus of another species, either from self-fertilization or asexual growth. Therefore if a plant of *ebenoides* should arise from a prothallus of *ebeneum* or *Camptosorus*, *ebenoides* must be a hybrid. Moreover, the characters of *ebeneum* and *Camptosorus* are such that a hybrid between the two, even should it prove unlike *ebenoides*, must be plainly distinguishable from plants of pure species of either fern. And the same is true of *Aspidium cristatum* x *marginale* and its supposed parents, *marginale* and *cristatum*. This fifth method offers, then, a good way of obtaining positive proof of the hybridity or non-hybridity of *Asplenium ebenoides* and *Aspidium cristatum* x *marginale*. It offers, also, more certainty of success than any of the other methods, whether the missing organs are reproduced or not, since before that could occur, cross-fertilization would probably take place.

In December, 1898, with a view to testing the alleged hybridity of *Aspidium cristatum* x *marginale*, I sowed in separate flower pots spores of *marginale* and of *cristatum*, first sterilizing the earth to destroy all alien spores. The following July, the resultant prothalli had grown sufficiently large to be divided. I then cut and planted archegonial sections of *cristatum* in another pot, and a week or so later, about the 5th of August, pressed close against them, antheridial sections of *marginale*. The sections grew and branched. In the conglomeration resulting, it was soon impossible to tell which prothalli belonged to *marginale* and which to *cristatum*. On the 17th of October, a plant developed, followed before December 13th by several others. Three of these survived. One of the three grew from a segment of a prothallus cluster. *Five months afterward*, in May, 1900, seven more plants developed from

what appeared to be other segments of the *same* cluster, each plant from a segment. The second frond of two of these seven plants is plainly dichotomous, a frond of another is slightly eccentric, the other fronds are normal. One of the three earlier plants has from the first shown a striking tendency to produce abortive fronds, and, so far as one can tell from plants barely an inch and a half high, appears truly intermediate between young typical plants of *marginale* and of *cristatum*, as does a second of the plants developed last fall.* This plant has produced one abortive and one markedly eccentric frond. The fronds of the third of last fall's plants are all normal and the character of the plant is like that of pure *cristatum*. In May, about the time that the seven later plants appeared, eight more developed from other prothalli in the same pot. All have normal fronds. These later plants cannot be the result of self-fertilization before the cutting; the time that has elapsed is too great, and the segments from which many or all have sprung were not then in existence. I have not cared to disturb them in order to look for evidence of asexual growth, but it is hardly likely that all fifteen have arisen in that way. What they will prove to be, may throw some light on the question of whether or no the missing organs are reproduced.

In order to obtain a reciprocal cross, I cut, in October, 1899, archegonial sections of *marginale* and antheridial sections of *cristatum*. Because the time was so long since the spores had germinated, I feared that some of the archegonia might have become fertilized, and so isolated both sections for a time in separate pots. Four plants developed within a month and were thrown away. Since no more plants appeared, I planted, in December, the two kinds of sections together. Both kinds had branched freely. In March, two segments of one section developed what appeared to be a broad, much thickened, archegonial cushion of tissue, covered with a mucilaginous liquid. This soon dried, and the cushions swelled outward into points. The point in one cushion developed into a horizontal cylindrical process that is still lengthening, and has flattened at the end into a fan-shaped lobate growth. A

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*These two plants have since shown marked evidence of hybridity. Their rootstocks are caudiciform, like rootstocks of *cristatum* x *marginale* Davenp. The fronds of one are a mean between those of its parents. Of four fronds at present on the other, one has spinulose margins, like young *cristatum*, one large blunt lobes, like young *marginale*, while the remaining two are intermediate in form.

December 6, 1900.

month ago, in May, 1900, four plants appeared from the other prothallial sections in this pot. The fronds are as yet small, all normal, and it is, of course, impossible to say what they will be. Two other attempts at crossing *cristatum* and *marginale* have failed to produce plants.

I have been unfortunate in my attempts to cross *Asplenium ebeneum* and *Camptosorus rhizophyllus*. Prothalli resulting from spores repeatedly sown in sterilized earth have repeatedly died. But I have now several archegonial sections of *Camptosorus*, and antheridial sections of *ebeneum*, which were cut and planted together last winter. One of the archegonial sections has produced a peculiar growth which seems to be a proliferous bud of some kind; the other sections have branched and are doing well.

Whether plants will arise from these and prove a hybrid, and that hybrid *ebenoides*, time alone will show.

Andover, Mass., June 27, 1900.

ATHYRIUM AS A GENUS.

By B. D. Gilbert.

During the last year I have been engaged in a special study of the group of ferns classified throughout the last half century or more as *Asplenium filix-foemina*. In the course of this study it seemed natural that I should take up also the question of the genus of these ferns; and having done so, I propose to lay the results of that study before the Fern Chapter, as briefly as the subject will permit.

Although all writers on ferns are obliged to recognize *Athyrium* by the character of its sori, the tendency has been, since the publication of Hooker's Species Filicum, to make it a section or subgenus of *Asplenium*. Previous to Hooker's time, Roth's genus *Athyrium* had been quite generally accepted by German and even by English botanists; and since Hooker's time, Thomas Moore, the most careful monographer of the English ferns, has retained *Athyrium* for *filix-foemina* and its varieties. In our own country, since the time of Pursh, who followed the Linnæan nomenclature, and placed these ferns under *Polypodium*, and Dr. Jacob Bigelow, who adopted the nomenclature of Swartz and regarded them as

forms of *Aspidium*, American botanists have accepted Hooker's views. Because the sori are long and the indusia are attached by one side to the veins and open on the other side, all of which features are characteristic of *Asplenium*, it has been claimed that *filix-foemina* and other species allied with it belong to that genus. But there is another character which essentially modifies this judgment and compels recognition. That is the curvature of the sorus and indusium, by which the upper end of the sorus is curved across the veinlet and back upon itself, often so strongly as to resemble the sorus and indusium of a typical *Lastrea*, or free-veined form of *Nephrodium*, distinguished by its kidney-shaped indusium. It was this roundish form which induced Linnæus to rank it as a *Polypodium*, and Swartz to place it under *Aspidium*. These three genera therefore have laid claim to it, with each of which it agrees in a modified degree, but with no one of which it agrees entirely. The genus *Athyrium*, however, as constituted by Roth, comprises all these features, and completely satisfies all the generic conditions dependent upon its fructification. What those conditions are will best be discovered by taking Roth's own description of the genus, which I have translated from the Latin :

ATHYRIUM.

"Capsules distributed in ovate sori underneath the disc of the frond, surrounded with an articulate ring. The involucre springs laterally from the venule, lying loosely in the form of a scale, with laciniate-fimbriate margin, at length elevated inwardly, pressed back and semi-lunar.

"Observation.—The essential character of *Polystichum* consists in the involucre being either umbilicate or peltate, or reniform, but on every side nearly free. In the first case, at the time of maturity, the involucre is drawn together centrally to its own fixed point, and very often acquires the shape of a funnel ; but in the latter case it is drawn back sublaterally to a fixed point and changes the sub-peltate shape into a reniform shape.

"But among the Linnæan Polypods there is observed no other of which the involucre has an ovate-oblong shape, and as in *Asplenium*, springing laterally from the venule, draws itself out following the length of the same. It lies more loosely in a heap before the maturity of the capsule, when from the other side opposite and looking backward it rises a little above the costa of the frond or of the lacinia. Toward maturity, it is raised against the costa by the

inward increase of the capsules bursting forth, by which means it assumes a semi-lunar shape. Influenced by these reasons, according to the method of founding the genera of ferns upon the involucre, I have come to the conclusion that plants of this nature should be removed from the rest of the Linnæan Polypods, on account of the situation, shape and condition of the involucre. Nor can they be included in *Asplenium*, on account of the plainly distinct condition of the involucre, although they approach nearer to this genus. Therefore it seems necessary that I should establish a genus of their own, to which I have given the name *Athyrium*."

Now it will be seen from this description that Roth distinctly differentiates *Athyrium* from *Asplenium*. He places only seven species under the genus, of which *A. fontanum* and *A. Halleri*, now recognized as forms of one and the same species, are placed first. In this he follows the universal custom of placing at the head of the list the smallest and simplest forms, not because they are the most typical species of the genus, but because they *are* the smallest. The next five species are all now recognized as varieties of *A. filix-foemina*, and these are the ones which conform most clearly to his description of the genus.

In commenting upon this genus, I would say that more or less of the sori upon each frond are generally straight; some are hamate, like a shepherd's staff; while in other varieties they are bent double and become hippocrepiform or almost round by age. If we ignore the genus *Athyrium*, it is easy to see how one authority can be justified for placing *filix-foemina* in *Asplenium*, while another is equally justifiable in calling it an *Aspidium*. It has seemed to me that the wiser course is to accept *Athyrium* as a valid genus, following the example of Roth and Newman and Moore, the men who have made the closest study of the genus and the most detailed examination of this particular species.

Another character of the genus which is distinctly laid down in Roth's description of it, is the "laciniate-fimbriate margin" of the involucre. There is a difference of opinion among authors as to the exact value of such a character as this, even when it is constant. That it is not constant, can be certffied to by all who have examined any considerable number of specimens of our American *A. filix-foemina*. The free edge of the indusium is generally irregular and somewhat lacerated, but it could not properly be called "laciniate-fimbriate." But the case is different with *Athyrium cyclosorum*. Perhaps no better evidence of the validity of the genus and of

cyclosorum as a species could be found than by taking a young frond of *A. filix-foemina rubellum* just after the laciniae have unfolded in the spring, and a frond of *A. cyclosorum* at the same stage of growth. In *rubellum* the sori are seen as distinctly as when mature, and even at this early period they are beautifully hamate, and the outer edge of the indusium is simply a little ragged. That is all, and there is hardly enough of the raggedness even to be noticeable. On the contrary, the sori on the just opening fronds of *A. cyclosorum strictum* are more often hippocrepiform than hamate, and are sometimes nearly umbilicate, as if they were drawn together with a puckering string on the side attached to the vein; while the outer edge is thickly fringed with long cilia plainly discernible to the naked eye, and which under a magnifier are seen to be *many-jointed*. While these facts show the nature of the genus in both cases, they also show that the fringed indusium can hardly be regarded as a *generic* distinction, but that in the case of *A. cyclosorum* it forms a very beautiful instance of *specific* difference.

If then we allow that *Athyrium* is a valid genus, the question naturally arises, "What species shall be admitted as belonging to the genus?" I should answer: all species which conform to Roth's description of the genus; that is, all species endowed with a greater or less number of hamate or hippocrepiform sori and indusia, that being the character upon which Roth relied in distinguishing the genus from *Polystichum* and *Asplenium*..

Sir William Hooker, in his Species Filicum, threw discredit upon *Athyrium* by including with it as a sub-section, Robert Brown's genus *Allantodia*, which was founded on species having a swollen indusium and a straight, sausage-shaped sorus, as the name indicates. He also stated that "those who maintain the genus (*Athyrium*) are by no means agreed as to the species that should be included in it." That was not a fair statement. If he were going to judge the genus fairly he should have taken it as its author formed it and not as others had made it by introducing characters which the author did not use and evidently did not intend should be used in the genus. Hooker himself was one of the worst of these, for in his characterization of *Athyrium* as a sub-genus of *Asplenium*, he says: "Sori generally short; involucres lax, convex, straight, or often more or less arcuate and even hippocrepiform, sometimes with the lobes unequal." He then includes *Allantodia* as a section of *Athyrium*, giving as *its* character, "Invo-

lucres quite terete, very membranaceous, tender and brittle, often bursting irregularly." So far as I can judge, this is purely gratuitous on Hooker's part, and was entirely foreign to the original idea of Roth. In conformity with that idea, no species possessing habitually straight sori has any place in the genus. Every one of the species and varieties which he names has more or less arcuate sori; and Hooker's unfairness was accentuated when he placed *A. fontanum* under *Eu-Asplenium*, but described the involucres as "very small, *athyrioid*," thus showing that he recognized the *athyrioid* involucre as a valid type.

In conclusion, there are two or three points which I would like to bring out and make prominent. First is the fact that every one of the species which Roth originally put into his genus *Athyrium* was taken from the Linnaean genus *Polypodium*, and was never included by Linnaeus in the genus *Asplenium*, in fact was not considered as having any relation to *Asplenium*.

Secondly, Presl in his remarks on the tribe *Aspidiae* and the manner in which it was broken up by different authors, said: "First came Roth, who in the third volume (1800) of the Flora Germanica divided the indusiate *Polypodia* of Linnæus into more genera, viz. into *Athyrium*, *Polystichum*, and *Cyathea*. The distinguished Bernhardi drove *Athyrium* into *Asplenium* (the word Presl uses is *repulsit*, which is much stronger than *removit* would have been), accepted *Polystichum*, but changed *Cyathea into Cystopteris*, on account of another genus so called by Smith." So we see that until Bernhardi "drove" *Athyrium* into *Asplenium*, the species which composed *Athyrium* had no relation with *Asplenium* whatever.

Thirdly, Roth himself, as I have already shown, distinctly differentiated *Athyrium* from both *Polystichum*, which was his own genus, and the *Asplenium* of Linnaeus, and asserted that the character of its sorus and indusium entitled it to be separated from these genera and to have a genus of its own.

These points seem to me not only to establish *Athyrium* as a valid genus, but to separate it wholly from any of the other genera with which it has hitherto been associated.

ON THE OCCURRENCE OF THE HART'S-TONGUE IN AMERICA.*

By William R. Maxon.

The following account comprises chiefly an historical narrative of the discovery of the American stations for the Hart's-tongue, † *Phyllitis Scolopendrium* (L.) Newm., ‡ with descriptions of habitat, especial mention being made of the natural conditions which appear to determine a suitable environment for the fern. Attention has been given also to the question of the fern's former distribution, and an attempt made to determine the principal causes that have operated to effect the peculiarly limited distribution of the present.

I shall discuss the American stations substantially in the order of their discovery. Considerable care has been exercised in supplying in full and verifying all available references bearing directly upon the subject. The central New York stations are the only ones with which I am personally familiar. These I have frequently visited at various times from 1895 to 1898, while living at Oneida and Syracuse, N. Y. To the several correspondents, mentioned later, who have generously furnished data, largely the result of personal observation, I would extend my sincere thanks. ‖

Central New York Stations.

In central New York the Hart's-tongue has been found growing in four separate localities: (a) Geddes; (b) Chittenango Falls; (c) Jamesville; (d) Perryville. The range of territory covered is comparatively small, and the stations are separated by short distances only. Each station is entirely distinct, however, and scattering plants seem not to occur in the intervening territory.

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* Published by permission of the Secretary of the Smithsonian Institution.

† The term is applied here only to the species *Scolopendrium*.

‡ Principal synonomy:

Asplenium Scolopendrium L. Sp. Pl. 1078. 1753.

Scolopendrium vulgare J. E. Smith, in Mem. Acad. Tur 5: 421. 1793.

Scolopendrium officinarum Sw. in Schrad. Journ. Bot. 2: Part 2, 61. (1800) 1801.

Phyllitis Scolopendrium (L.) Newm. Hist. Brit. Ferns, Ed 2. 271. 1854.

Scolopendrium Scolopendrium (L.) Karst. Deutsch. Fl. Ed. 1. 278. 1880-83.

‖ A large part of the present paper is extracted from aa uupublished thesis by the writer presented to the faculty of Syracuse University, June, 1898, entitled: "A Contribution to the Biology of the Hart's-tongue Fern."

a. *The Geddes Station.* The Hart's-tongne was first discovered in America by Frederick Pursh, on July 20, 1807, near the place now known as Split Rock, a small suburb of Syracuse, about five miles west. Apparently the first mention in literature of this, the earliest American station, is contained in Pursh's Flora,* in which the following statement occurs: "In shady woods, among loose rocks in the western part of New York, near Onondago, on the plantation of J. Geddis, Esq. Perennial. July. *v. v.* This species I have seen in no other place but that here mentioned, neither have I any information of its having been found in any other part of North America." Subsequent search failed to again discover the fern in this locality, though it was found at Chittenango Falls (about 1830) and in the Jamesville vicinity (1857). The latter discovery doubtless led to the renewed attempts to find the plants at Geddes.

At the suggestion of Dr. Asa Gray, Mr. J. A. Paine, in June, 1866, visited the locality for the purpose of verifying Pursh's original station. In his account of the trip † he says, after describing a fruitless search: "Hon. George Geddes, son of the J. Geddes, Esq., referred to by Pursh, was then appealed to for information in general respecting this fern or its earliest station, and he readily cleared up the whole mystery. The place where it was discovered, he said, was nearly five miles west of Syracuse and half a mile south of his father's house; on the single point of its being on his father's farm Pursh must have erred; but it was nearby along a high ledge and about a celebrated sulphur spring." Paine did not succeed in rediscovering the fern at Geddes, and it was generally supposed that it no longer persisted there, until in 1879 (September 30th) it was rediscovered in fair quantity *upon* the Geddes property by members of the Syracuse Botany Club. ‡ The ferns continued to grow thriftily until the summer of 1895, when the Solvay Soda Ash concern blasted out the rocks which had so long served as a shelter. It is extremely unlikely that a single plant has survived.

It seems strange that up to 1879 no one should have rediscovered the fern here. It may be of interest to note that the supposition of Mr. George Geddes and Paine that Pursh was in error in his statement of its occurrence *upon* the farm is not borne out by

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* Pursh, Fl. Am. Sept. **2**: 667. 1814.

† Am. Journ. Sci. & Arts, II. **42**: 282. 1866.

‡ Bull. Torr. Bot. Club, **6**: 345-7. 1879.

the *facts* of its discovery in 1879. Mrs. L. L. Goodrich, of Syracuse, a relative of the Geddes family, and a member of the discovering party, has stated positively to me that the fern was upon that occasion found in considerable abundance well within the limits of the original "Geddes plantations."

Pursh further says of this station: * "Mr Geddes brought me to a deep valley about 1. m. from his house, where we ascended a steep very rocky hill; here large masses of rock seem to be piled up or turned over one & another in such a confused manner, that it has left large chasms between them, which sometimes appear like caves: as it has a north aspect & overshadet with trees, all the rocks are covered with moss and vegetables: * * * & what I thought most of *Asplenium Scolopendrium*—this fern which I dont find mentioned by any one to grow in America I allways had a notion to be here; & indeed I was quit enjoyed to find my prejudice so well founded in truth. It appears to be the same as the european only smaler; query? is the european auriculated at the base like this species?"

Split Rock is a limestone formation, consisting mostly of the Lower Helderberg, which extends to a depth of approximately 125 feet, with the so-called Oriskany sandstone interposing in a very thin sheet, from one to five inches thick, between it and the Corniferous of the Upper Helderberg (12 to 14 feet thick) which caps the plateau. Dr. Underwood has several times † called attention to the fact that in central New York at least, this fern is found only at the outcrop of the Corniferous. It was, before the inroad of the quarryman, a steep ledge about 150 feet high and half a mile long, somewhat semicircular in general outline. At the base of the cliff was a brook, with a sulphur spring upon its bank. It was at some little distance from this spring, I am told, that the plants grew, somewhat sheltered by rocks and trees, but to a large degree exposed to the sweep of the cold northwest winds.

b. *The Chittenango Falls Station.* The second place in America at which this fern is known positively to have been found, is Chittenango Falls, in Madison county, where Mr. William Cooper found it about 1830. From 1830 to 1857 it was the only American

* Frederick Pursh: A Journal of a Botanical Excursion in the Northern Parts of the States of Pennsylvauia and New York during the year 1807. 63-64. Edited by T. P. James, and issued 1869. pp. 87.

† Underwood: Our Native Ferns, Ed 5, p. 6. 1896. Also in Britton & Brown, Illus. Flora North. U. S. and Can. 1: 21. 1896.

station definitely known, * and perhaps on this account Pursh's discovery has often been incorrectly assigned to Chittenango Falls.

The Chittenango creek, flowing northward toward Oneida lake, here takes a double plunge of over one hundred feet, and has worn through the limestone a rough gorge of that depth and more. The sides are extremely steep, but *debris* and soils have so accumulated at the base that the unbroken ledges loom up only along the top of the gorge. It is just out from under these overhanging cliffs and among the broken fallen fragments of limestone (mostly Corniferous) on the left bank, that the Hart's-tongue grows, perhaps thirty-five or forty feet above the level of the stream, and three or four rods distant. The soil is moderately moist, but light, yielding, and very rich in leaf mould. Here, scattered along the steep bank for a distance of nearly a quarter of a mile from the falls, the ferns grow in the fairly dense shade of second-growth maples, beeches, birches and elms. Among its companion plants are *Pellaea Stelleri*, *Asplenium Ruta-muraria*, *Cystopteris bulbifera*, and *Dryopteris Goldieana*.

c. *The Jamesville Locality.* The Hart's-tongue grows abundantly in a number of places in the immediate vicinity of Jamesville, the distance included being ten to thirteen miles west of Chittenango Falls, and four to nine miles southeast of Syracuse. Exceptionally fine plants grow in this locality, and almost the same conditions obtain in each of the stations, which are (1) *Howlett's Gorge;* (2) *Little (or Green) Lake;* (3) *Green Pond;* (4) *Rock Gorge.*

(1) *The Howlett's Gorge Station.* In March, 1866, Mr. Lewis Foote, of Detroit, Mich., found the fern growing plentifully in a deep ravine of Butternut creek, five miles southeast of Syracuse, upon the line of the Syracuse & Binghamton Railway. † This ravine is commonly known as Howlett's Gorge. It is deep and rocky, especially rough on the left or northern side where the Hart's-tongue grows, though more open on the opposite side. The fern, well shaded, once grew here very plentifully, but it has been largely rooted out.

(2) *Little (or Green) Lake.* In September of the same year, Mr. J. A. Paine visited the locality of Jamesville and extended the known range nearly to its present limits. He detected the fern on

* Asa Gray in Am. Journ. Sci. & Arts, II. 41: 417. 1866. I have been unable to find any earlier reference to Cooper's discovery.

† Asa Gray, in Am. Journ. Sci. & Arts, II. 41: 417. 1866.

the shaded talus of cliffs which nearly surround Little Lake. Little Lake is situated approximately a mile south of Howlett's Gorge, and a mile west of Jamesville. Paine aptly describes it as "a deep depression in the surface, walled in on all sides but one with rocks at least 100 feet high, and one-fourth of a mile across from side to side." * The open side is the eastern. † The plant was formerly very abundant on the talus at the south of the lake, but scarcely a half dozen plants may be found now, owing to the greed of picnickers. From thirty to fifty rods to the north of the lake the plant grows thriftily in at least three different places along the sides of two wooded ravines which occur together.

(3) *Green Pond.* Continuing his search, Mr. Paine gave attention to the other pit-hole lakes of the vicinity, and found *Phyllitis* growing at Green Pond. White Lake and Green Pond lie near each other, a mile and a half east of Jamesville, at the base of a ledge of limestone from 100 to 200 feet high. This ledge is a continuation eastward of the steep escarpment which forms the southern cliff of Rock Gorge, lying about a mile northwest of Little Lake. As stated, it extends eastward, and transecting the northerly-trending Butternut valley, runs a half dozen miles farther, incidentally giving rise, at a given point along its base, to Green Pond.

Green Pond (also called Scolopendrium Lake) is similar to Little Lake in lying like a sheltered harbor far within the irregular outline of the surrounding cliffs. It is, however, at least a third of a mile broad. The banks are exceedingly rough and strewn with fragments broken from the towering limestone cliffs. ‡ The cliffs have extensive tali, and it is the continuous steep talus of the great U-shaped cliff which forms the shore of the lake. The fern grows pretty well up on the sides, among the fragments of Corniferous limestone, on both sides at the base of the U. The plants from the cleared (eastern) portion have mostly become of small size and winter-kill badly, owing doubtless to the comparatively recent removal of the forest, which occasions a lack of protection in winter and summer alike. On the western slope, as yet wooded, the plants grow to good size.

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* Amer. Journ. Sci. & Arts, II. **42**: 281. 1866.

† For a complete description of this remarkable lake and vicinity, see the article by Prof. E. C. Quereau, entitled Topog. and Hist. Jamesville Lake, N.Y., in Bull. Geolog. Soc. Am. **9**: 173-182. 1898.

‡ See article by the author, Fern Bull. **7**: 1. 1899.

(4) *Rock Gorge Station.* Rock Gorge, lying about a mile northwest of Little Lake, is one of the more northerly transverse valleys connecting the Onondaga and Butternut valleys. It runs east and west, trending slightly to the southeast, and is utilized by the Syracuse & Binghamton Railway. At a point about "midway its length, and on the south side of the gorge, the wall is cut back in the form of an ampitheatre which is semicircular in outline and about 125 feet deep by 250 feet wide. The walls are nearly perpendicular, with their bases concealed by recent talus accumulation."* In this recess, about 40 feet from the top of the cliff, and among the loose fragments, grow about 125 extremely fine plants of *Phyllitis.* The slope is rather steep, but the plants grow thriftily in the scattering second growth of maple and basswood, shaded by the cliff wall, which serves also as a considerable protection in winter.

A small number of plants have also been observed recently (in May, 1899) to grow in a small depression some 40 rods to the westward and back from the amphitheatre, by Mr. Homer D. House.

Mr. Paine, at the time of his vtsit to Jamesville in 1866, gave a great deal of attention to the general contour of the locality. He remarks† that "these 'highlands' before they were cleared and burned over, formed the very kind of locality where our rare fern delights to dwell, possessing all the conditions of loose limestones, rich mould, moisture and shade; and no doubt their rocky steeps formerly abounded with it. This presumption is confirmed by the fact that on a particular part of the range, where the fire and clearing ceased and the undisturbed forest began, just there was *Scolopendrium* found growing in its greatest luxuriance and scattered along the bank for a fourth of a mile or so, as far as covered by rocks."

d. *The Perryville Station.* An additional central New York station for the Hart's-tongue was discovered in July, 1898, at Perryville Falls, Perryville, by Miss Murray Ledyard, of Cazenovia, N. Y. A small stream, the Canaseraga creek, here falls fully a hundred feet, near the quarries at the railway station, and runs helter-skelter through the narrow wooded ravine below. As at

*See Prof. Quereau's paper previously mentioned. He finds conclusive that this amphitheatre was once a waterfall.

†Amer. Journ. Sci. & Arts, II. **42**: 281. 1866.

Chittenango Falls, the fern grows only upon the western side of the gorge; and the two stations are otherwise very similar. Mrs. James R. Parsons, one of the discovering party, thus writes of its occurrence:* "The plants were * * * *growing in a partial opening among the maples, basswoods and beeches on a steep slope covered with fragments of limestone, some 30 or 40 feet from the base of the cliff. We must have found anywhere from 20 to 30 plants within a radius of as many feet." The fact of its discovery here, in a favorite botanizing field, may indicate a recent origin of this particular station. It may have arisen from the Chittenango station, which is less than three miles distant.

In general, regarding its central New York distribution: It is extremely likely that the fern has by the natural clearing of the country been in some measure exterminated; but it is a fact, nevertheless, that it is only in the more rugged situations of the *uncleared* land that it usually grows. It stands rather as a remaining type of boreal vegetation, persisting only in such places as are well suited to it. It prefers rough, shaded tali in broken country, where extreme drought can never affect it; where it is subjected to a uniformly cool temperature, and protected also by considerable shade. In such a situation the fern now thrives, and doubtless will so continue unless rooted out by reckless collectors. It ought even to become settled in many additional stations in the general locality.

Canadian Stations.

(a) *The Owen Sound Locality.* Owen Sound is a port on the Georgian Bay, the great eastern arm of Lake Huron. The town is nearly on the lake level, the rise being perhaps fifty feet to the mile; while both east and west are cliffs—Clinton on the west side, Medina on the east—which form the sides of the valley. The rock is covered with soil of varying shallowness, and forested with maple, spruce, hemlock, and birch. The country all about is very rocky, and doubtless contains more stations than mentioned here.

The first discovery of the fern at Owen Sound was by Prof. William Hinks, of Toronto, in 1857. He found it growing plentifully around the falls of a stream emptying into the Sound.† This stream is the Sydenham river, and the falls, which are situated over two miles south of the town, are known as "Sydenham" or

*Fern Bull. **4**: 74. 1898.

†J. A. Paine, in Am. Journ. Sci. & Arts, II. **42**: 281. 1866.

"Inglis" Falls. Below the falls occur the plants of *Phyllitis*, in a "fairly heavy wood in the valley and on the sloping sides of the deep chasm through which the Sydenham runs after its fall. The chasm is about a fourth of a mile wide, or less, its sides strewn with boulders and fragments of limestone partially buried in debris. Here the individuals were seldom large, i. e. seldom over 8 inches long.* The fern is reckoned "abundant on limestone debris under cliffs at Sydenham Falls and other localities around Owen Sound (Mrs. Roy)." †

It has also been found close by "growing in a maple wood, where the rock is close to the surface and shows cracks of width varying from two inches to two feet. It grows [here] generally in the cracks, but also on the level ground, doubtless always where the soil is shallow. Companion plants are *Dryopteris marginalis*, *Polystichum lonchitis*, *Camptosorus*, and *Asplenium viride*. ‡

Phyllitis occurs also in a wild situation some twelve miles to the northwest of the village. Here, too, the soil is not deep, and the fern grows rather thriftily in the dark, moist, rocky woods, where the limestone (Clinton) comes close to the surface. In such places it grows on small hummocks slightly raised above, and so drier than the surroundings. *

The finest plants are found at a point about one mile northwest of the town, upon the loose limestone debris fallen from a bluff 40 feet high. The soil is very light, porous, and rather dry, and cannot for any length of time retain moisture. But the situation seems especially favorable, and fronds grow from eighteen to twenty-three inches long. *

Phyllitis grows about Owen Sound very much as in New York, in loose limestone debris, and additionally, in narrow limestone crevices and raised on hummocks in moist, rocky, upland woods—the sort of situations especially claimed for it formerly in central New York by Paine. Mr. Jenkins obtains the best developed specimens from the station a mile northwest of the town, where the soil is the driest and most porous of any of the stations. Fur-

* From correspondence, Prof. W. H. Jenkins, Owen Sound, Ontario, Canada.

† Macoun, Cat. Can. Pl. Part V., 268. 1890.

‡ From correspondence with Mr. W. E. Saunders, London, Ontario.

ther, he states that the summer of 1897 being a "wet one, the fronds were somewhat shorter and narrower than in previous years." The habitat of the fern is, in each case, cool, well shaded, and invariably upon limestone. But Mr. Jenkins remarks further that while each is "moist so far as atmosphere is concerned," it appears that "moisture as a soil constituant is not of prime importance to large growth."

(b) *The Durham Station.* The fern was found in 1883, "on Guelph dolomites, Little Sau river, at Durham, Gray county, Ontario," by Dr. H. M. Ami, of the Canadian Geological Survey,* who has written me as follows: "The specimens obtained were growing in the narrow crevices of the cream-colored dolomites of the Guelph formation (Silurian). They appeared to be somewhat depauperate forms, still sufficiently alive and vigorous to warrant the expectation that they would survive under the existing environment. There was very little earth where they were growing, the rock everywhere being practically bare or destitute of earth or drift." Durham is about 20 miles south of Owen Sound in a very wild country, little explored botanically. Guelph dolomite is a good half magnesium carbonate.

(c) *The Collingwood Station.* In 1898. Prof. Jenkins wrote me of the supposed occurrence of *Phyllitis* at Collingwood, Ontario. Lately I have learned through Mrs. E. G. Britton of its rediscovery by Mr. B. B. Osler, of Toronto, a member of this Chapter. Mr. Osler has kindly communicated most of the following data, which are set down largely verbatim: The location is lot XI. in the 3d concession of the township of Collingwood, Grey county, Ontario. It is seven miles in a westerly direction from the town of Collingwood, which is on the Georgian Bay, and about 50 miles east of Owen Sound. The land is about 1500 feet above sea level and of the Upper Silurian formation, a limestone of sufficient purity to be burned in neighboring kilns. The forest is ordinary Ontario growth of hard maple, mountain maple, basswood, elm, ash, beech and iron-wood, with more or less cedar and butternut. The soil is a rich clay loam, with a great deal of leaf mould. The rock on which the ferns grow is full of seams and crevices, which, together with the absence of quick evaporation (due to the dense shade), generally gives ample moisture. The region is essentially a plat-

* Macoun, Cat. Can. Pl. Part V. 268. 1890.

eau, cut into by several streams which have made valleys and gorges trending mostly to the east. The most northerly of these is the Silver. The Silver rises in a group of springs flowing perhaps 20,000 gallons per hour. The ground is moist, the shade dense, and the ground largely boulder limestone. The ferns are scattered over approximately two acres immediately surrounding the springs. The point of first discovery lies some 120 rods to the northeast of this point, upon the rocky tali and slopes above Kennedy creek. A few plants occur also near the banks of the Silver, about a mile from its source. The valley of the Pretty lies about two miles to the south of the Silver. The fern occurs here in some abundance along the rocky slopes of the valley, though the land is higher and drier, and the shade not so dense. Many granite and schist boulders occur here, but do not carry Hart's-tongue, the fern being always rooted in the limestone crevices.

Mr. Osler is of the opinion that the fern is also to be found in the valley of the Pine and the Mad, the formation and aspect being similar. The Holly fern always occurs with the Hart's-tongue at these stations, and near the springs the Walking-leaf in considerable abundance. Mr. Osler has kindly furnished a series of photographs of the ferns in their native environment. In a later letter, attention is called to the fact of the fern's destruction in quantity by young cattle.

(d) *The Woodstock Station.* The Hart's-tongue was discovered near Woodstock, N. B., in the late fall of 1882 by James Sutton, a gardener in the employ of Mrs. Charles Connell, of Woodstock. During a visit to this village the next September, the attention of the late Peter Jack, of Halifax, N. S., was directed to the plant, a single rather undersized specimen, which had been preserved in Mrs. Connell's greenhouse. Mr. Jack immediately recognized it as "*Scolopendrium vulgare.*" * From Mrs. Dibblee, *nee* Connell, of Woodstock, and Mr. G. U. Hay, of St. John, N. B., I have learned that it was collected some six miles to the westward of Woodstock, upon the "Richmond Road," near the Meduxnakik river where it was open to the northwest. Mrs. Dibblee has stated also that the station "has been all burnt over, ploughed up, and is now a fine farm," and that the fern grew upon what is commonly called

* See *Notice of New and Rare Plants* by George Lawson, in Proc. and Trans. Nov. Scot. Inst. Nat. Sci. 6: 71-72. 1883-6; also a paper by G. U. Hay, entitled *Botany of the Upper St. John*, in Bull. Nat. Hist. Soc. N. Br. No. 2, pp. 31 and 37. 1883.

there the shale land which supports a good growth of elms, butternuts and ash.

Mr. Jack visited the station at the time, but without finding further plants. After his return to Halifax, the gardener upon diligent search secured a number of additional plants, four of which were forwarded to Mr. Jack, who later presented one to the Natural History Society of New Brunswick, and a frond to the Nova Scotia Institute of Natural Sciences. The Eaton Herbarium contains also two fronds of the var. *marginatum*, collected by Sutton in July, 1885. Mrs. Dibblee states that the fern was brought in several times from the same place. Mr. Hay adds that quite a number of them still thrive in the conservatory and upon the rockery at her home, but that plants presented to him at various times have not survived.

Mr. John Macoun has (in correspondence) suggested the possibility of the fern's having become first established as an escape, but a thorough knowledge of the facts attending its discovery has convinced both Mr. Hay and myself that it was undoubtedly native. In fact, Mr. Sutton has stated that he once found the fern in a ravine farther in the woods, about eight miles from town, but that he has not again seen it there. Mr. Hay has long intended a systematic search for the fern about Woodstock. Such a search would probably result in its discovery somewhere in the general vicinity.

The Tennessee Stations.*

The Hart's-tongue has been found in two localities in Tennessee, viz., near Post Oak Springs, and at South Pittsburg, of which the latter only has been known in literature.

a. *The Post Oak Springs Station.* In 1849 Dr. A. Gattinger detected the fern a short distance west of the village of Post Oak Springs, in Roane county. About one mile southwest of the village occurs a pool in an open cave in the front (southeastern) edge of the hill, and from this issues a small stream to the eastward. Over the top of the hill, i. e., on the northern side, and distant about a half mile, occurs another open cave, called the "dry cave," about the mouth of which a few plants were found by Dr. Gattinger. This cave is about one mile directly west of the village.

*In his Tennessee Flora (1887) p. 102, Dr. Gattinger refers the fern to "New Pittsburg," a mistake for South Pittsburg, and adds "not found [there] by myself." The previous station (Post Oak Springs) concerning which he has lately written me, was unfortunately overlooked.

According to the Kingston Folio of the U. S. Geological Survey Atlas, the immediate rock formation is the Knox Dolomite, or Magnesium Limestone of the Lower Silurian. But Dr. Gattinger avers that the Chattanooga Black Shale (Devonian) and the Fort Payne Chert (Lower Carboniferous) both crop out here. The fern probably occurs in the latter. * Immediately above is the Bangor Limestone, which supports the fern at South Pittsburg.

b. *The South Pittsburg Station.* The Hart's-tongue was discovered growing in a deep sink-hole near South Pittsburg, by Major Cheathem, in 1879. † South Pittsburg is a town on the Tennessee river, about three miles north of the Alabama boundary. Some two miles southwest of the town, two spurs of the Cumberland mountains, extending southeast into the level plain of the river, form a narrow valley or "cove," as they say in Tennessee. To reach the sink-hole, *follow the cove* a half mile, or until half way up the mountain. Sixty feet to the left of this narrow valley and about sixty feet above, there is an irregular fissure in the Mountain limestone, sixty feet long by twenty to forty feet wide and ninety-two feet deep. Upon examination, a good-sized spring is found to issue from a cave not more than twenty yards farther up the hill. This spring, tumbling perpendicularly into the hole, strikes a projecting ledge some forty feet below. The water splashing from tth ledge has worn a deep depression in the opposite side, and it is chiefly upon this slope that the fern grows. The area covered by the ferns is not over 200 square feet, and contained (in 1898) about 110 mature plants. A few are variously distributed along the sides and edges of the chasm, with *Asplenium parvulum.* The soil is a sticky, light-colored clay, formed from the disintegrated shales of the upper mountain. The ferns are found mostly about fifty feet below the surface, and are so sheltered that some of them the direct sunlight never reaches, and can possibly reach none of them longer than two hours a day. There is little variation in temperature, naturally, and they are always dampened by the spray of the falling water. After its first drop of forty feet, the water trickles in small streamlets over the rock walls and fragments the remaining fifty-two feet, to disappear in a narrow fissure at the bottom of the

* Dr. Gattinger has kindly furnished me full particulars regarding this station. I am under obligation also to Mr. David White, of the U. S. Geological Survey, Washington, D. C., for information relating to the geology.

† Bull. Torr. Bot. Club, 6: 350. 1879.

pit. It reappears at the surface nearly two miles distant, on the level flat a short distance from the river. Here it is called the Blue Spring.*

As nearly as can be ascertained without a special visit to the place, the formation in which the sink-hole occurs is the Bangor "rotten" or "Mountain" limestone. [See note III in thesis by the writer, previously mentioned.) This limestone includes a few beds of shale, several occurring near the top, so that the presence of the clayey habitat is easily explained. †

Several Supposed Stations.

(a) *Chiapas, Mexico.* In his Ferns of North America, ‡ Prof. Eaton cites the Hart's-tongue as occurring at "Chiapas, Mexico." The specimens (Eaton Herbarium) upon which this determination was apparently based, were collected in "cool regions; crevices of rocks in the bottoms of caves (296-307)" at Chiapas, Mexico, by Ghiesbreght. ‖ They are not to be referred to *Phyllitis Scolopendrium*, but rather to **Phyllitis Lindeni** (Hook.) § a species clearly distinct from the former. The habitats of Ghiesbreght's and Linden's specimens are rather diverse, but not more so than those of many species of *Polypodium* of the same region.

(b) *Sitka, Alaska.* Milde ¶ records the fern from "Insula Sitcha," and adds "(herb. caes. Petrop. horti bot.)," indicating that the specimens are preserved in the St. Petersburg Herbarium. The

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*The greater portion of the foregoing has been kindly contributed by Mr. and Mrs. Joseph H. Lodge, of South Pittsburg, who at the time (1898) of their investigation forwarded several living plants to me. I have described the station in some detail, since an article has recently appeared (James H. Ferriss, Fern Bull. 7: 98. 1899) indicating doubt as to the existence of the fern in that station at present. It is evident that Mr. Ferriss missed the sink-hole in question, which is not remarkable, since there are several in the near vicinity.

†Safford and Killebrew, Elem. Geol. Tenn. p. 153.

‡D. C. Eaton, Ferns N. Am. 1: 247. 1879.

‖See Cat. Coll. Ferns So. Mexico, mainly at Chiapas, by A. Ghiesbreght, 1864-70. This pamphlet (pp. 10), kindly loaned me by Prof. Underwood, is evidently a reprint. The determination of the ferns was accomplished by Hall, probably under Prof. Eaton's supervision. The two sheets have been kindly loaned me by Prof. A. W. Evans, of Yale University.

§*Scolopendrium Lindeni* Hook., well figured and described (Hooker, Ic. Pl. II. 1: *pl.* 488. 1842) from specimens collected "on old oaks, Chamulars, Prov. Chiapas, Mexico," by *Linden*, n. 1543.

¶Milde, Fil. Europ. et Atlant. 90. 1867.

Hart's-tongue is not uncommon in Japan, and may, like some other species (notably *Dryopteris montana*, for a long time supposed not to occur in North America), have an eastern extension across into Alaska, and down the Pacific coast into British Columbia. An examination of the material in the St. Petersburg Herbarium, would of course establish the identity of the specimen, but would not prove the authenticity of this station, since it has frequently happened that plants from Russian territory upon both sides of Behring Sea have been carelessly and indiscriminately labeled.

(c) *Vancouver Island, British Columbia.* In the fall of 1898, Mr. Hamburg, a Swedish botanist, then just returned from a collecting trip in the West, assured me that he had recently collected specimens of this species growing upon Vancouver Island. The statement was, unfortunately, not substantiated by specimens.

(d) *Manitoulin Island, Canada.* Professor W. H. Jenkins has written me of the reported occurrence of the fern upon this island in Lake Huron, rather more than a hundred miles northwest of Owen Sound. I have found no further reference to its occurrence here.

(e) *Louisville, Kentucky.* John Williamson * was inclined to discredit the reported station near Louisville, mentioned by Dr. McMurtrie. † A reference to Dr. McMurtrie's book (Library of Congress) shows the following entry: "Asplenium Scolopendrium Crt. Hart's-tongue," along with a few other ferns reported from the vicinity. It may be taken for granted that the Hart's-tongue was not confused with another species, as the chances for such an error are indeed small. The fact that Williamson was unable to find the fern might indicate either that it has disappeared from the vicinity, that "vicinity" was made to include a considerable territory about Louisville, or that the fern has since been overlooked near the city. The second supposition is the most likely. It seems that Williamson and later botanists would have found the fern if it still occurs in the immediate vicinity of Louisville; and it is not probable that it has been exterminated. At the time (1819)

* Williamson, Ferns of Kentucky, p. iv. 1878.

† H. McMurtrie, M. D., Sketches of Louisville and its Environs, Ed. 1, p. 229 Louisvile, 1819. This book includes a "*Florula Louisvillensis*, or a catalogue of nearly 400 genera and 600 species of Plants, that grow in the vicinity of the town, exhibiting their Generic, Specific, and Vulgar English names."

McMurtrie's book appeared, the Geddes, N. Y. station, was the only one then known in America, having been recorded by Pursh just five years previously.

Conclusions.

I have described with considerable fullness the American localities where *Phyllitis Scolopendrium* is known to have been found. The striking and invariable characteristic of its environment appears to be an affinity for limestone rocks—the Corniferous in central New York; the Guelph Dolomite and Clinton in Ontario; the Bangor (Mountain) limestone in Tennessee,—representing considerable range in choice of formations. The question naturally arises: Why should the number of known localities be so small?

As a matter of fact, the Hart's-tongue is, as I have indicated, far more common than has usually been thought; and it will probably turn up continually in some of the less explored regions of Canada, especially in the northwest. It appears to require for its best growth a cool, well-shaded limestone ravine, talus, or sloping woodland, with rich wood soil, for the most part sufficiently porous to allow free drainage, but firm enough to retain considerable moisture. Such conditions occur in hundreds of glens in the United States and Canada. There is moreover, quite a wide variance, in the wet heavy clay of the South Pittsburg sink-hole, from the rich porous soils and loose leaf moulds of the central New York stations, or the scant soil of the limestone crevices in some of the Owen Sound stations. The South Pittsburg clayey habitat is, to be sure, somewhat anomalous, but it appears that almost any soil upon limestone will support the fern under the right temperature conditions. Perhaps the most important factor now operating for or against the fern's survival and in determining its future distribution, is the presence of a constant low temperature. The Jamesville pit-lakes have a uniformly cool temperature from day to day. The Chittenango gorge is deep and the fern is well shaded. Ferns growing from fifty to seventy-five feet below the surface, as in the irregular South Pittsburg chasm, cooled by a waterfall, can be affected only in slight degree by extremes of temperature. The Canadian stations are mostly near streams. It is true also that extremes of cold do not seem to affect this fern deleteriously. It remains evergreen through ordinarily severe winters, except when unduly exposed by removal of protective forest growth. And so, while the fact of an even low temperature does not adequately

explain the causes resulting in the present peculiar distribution, I think it does throw considerable light upon the relationship between environment and present distribution. Since arriving at this conclusion, I have chanced to note that in several British works, considerable attention is paid to the fact that the Hart's-tongue occurs regularly "in caves, on the seashore and in other cold and damp situations," and again, "more especially about the mouths of caves, deserted mines, at the borders of wells, where there is a *current of cold or moist air*."

It is, of course, a well known fact that plants characteristic of high northern latitudes, are found in more or less abundance upon mountain peaks of the more temperate regions thousands of miles to the south. The accepted explanation is: that during the glacial epoch the plants, gradually forced south by the advancing ice sheet, upon the northward retreat of the ice, moved up the mountains, seeking to maintain accustomed environmental conditions, * or, for the same reason, advanced to the northward. Thus, the Hart's-tongue occurs in America mostly in the north. It has, as I have remarked, been usually regarded as a boreal type. I believe that it was once far more common than at present, and that it will frequently be found in the north, perhaps, as I have suggested, stretching across from Asia to Alaska, and down the Pacific coast. In the United States it has yet to be seen west of the Mississippi, though it may possibly occur along the upper tier of States, assuming that it follow a belt parallel to the lower limit of glaciation. Especial search and exploration in favorable localities would not be without good results in general, and would very likely result in further extensions of range for what has commonly been regarded as one of the rarer American species of ferns.

The distribution of the Hart's-tongue in Great Britain is peculiar as well, and has been commented upon by Mr. Druery (Choice British Ferns, p. 14. 1888) at some length. He remarks that its comparative rarity in Scotland is the more unexpected in view of the "innumerable glens which abound there and seem a very beau ideal of a habitat for it;" and adds, moreover, "this fern is one of the

*An especially interesting exposition of the facts and causes having to do with the distribution of species (especially North American), is contained in the latter portion of Dr. Asa Gray's "Memoir on the Botany of Japan, etc," in Mem. Am. Acad. Arts and Sci. II. 6: 1859.

least dainty in its requirements, seeming to have no antipathy in the matter of soil or position, and in many localities thriving in abundance under the most adverse conditions." Mr. Druery is inclined to the belief that this paucity in certain sections is due to the "greater or less predominance of certain forms of minute insect life. * * Just as we find in our gardens that certain vermin attack and destroy certain plants, so it is only reasonable to assume that either the spores or prothalli of these ferns are the favorite food of some of the minuter insects, in order to explain the absence of adult plants. Climatal conditions are, of course, a potent factor, but do not account for all the phenomena observed." Mr. Druery then cites the cases of certain exotic ferns which attract slugs or snails, and must be grown in isolation. Such a one is *Camptosorus*, in England. "Other plants," he writes, "are especially subject to the attack of wood lice; and so, doubtless, such special appetites characterize also the minuter and microscopic insect world, and as it is manifest, when we consider the myriads of spores which are shed in vain, that these must become mainly the food of such tiny creatures, we need hardly seek further for a solution of the mystery. A harder or softer envelope to the spore, or a more or less attractive flavor in this plant itself, would determine for or against its survival in the struggle for existence."

It seems necessary to suppose that some such cause operates to effect the odd distribution both in England and America. In March, 1898, I noticed the presence of one of the Lace bugs (Tingitidae), upon plants at Jamesville, in considerable numbers. They seemed mostly to attack the spores, but were found apparently destroying the leaves as well. Snails are often found depending from badly eaten fronds. These scant observations tend to substantiate Mr. Druery's proposition. It is indeed perfectly supposable that in certain of its various stages of development, it may peculiarly attract vermin to itself, which so greatly impair its vitality as to lessen its chances for survival and reproduction. A series of careful observations and experiments along this line would be of the greatest interest.

U. S. National Museum, Washington, D. C.