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MOONWORTS (BOTRYCHIUM SUBG. BOTRYCHIUM) OF THE UPPER GREAT LAKES REGION, U.S.A. AND CANADA, WITH DESCRIPTIONS OF TWO NEW SPECIES

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We have encountered unexpected taxonomic diversity in the moonworts, *Botrychium* subg. *Botrychium* (Ophioglossaceae) in western North America (Wagner & Wagner 1981, 1983a, 1986; Wagner et al. 1983). From west of Lake Superior we have lately recognized 13 orthospecies and a number of nothospecies, where previously only 6 orthospecies had been reported. Some of the novelties were found in areas well known to botanists, but they were overlooked because of their rarity (see below). By emphasizing analysis of natural populations using the "genus community method" (Wagner & Wagner 1983b), we have been able to delimit previously unrecognized taxa. We did not suspect that similar overlooked diversity is found also in the upper Great Lakes Region, an area essentially at our own "front door." The only endemic moonwort known in this region prior to 1982 was the "little goblin moonwort," *B. mormo,* a rarity of rich deciduous forests of northern Michigan, Wisconsin, and Minnesota (Wagner & Wagner 1981).

In 1982, J. M. Beitel found populations of a then unrecognized moonwort in the Sleeping Bear Shoreline Dunes. His discovery led us to a whole new exploration project. In this paper we ignore the five hybrids that have turned up so far in this investigation (Wagner 1980; Wagner & Wagner 1988), and discuss only the orthospecies of the region. The recent discoveries of new moonworts in the western Great Lakes area were described by F. S. Wagner (1988); first one new taxon was found, that led to another and so on. Subsequently, herbarium studies revealed a number of new records that we had previously misinterpreted or overlooked.

East of the longitude of Michigan, these plants were well understood for the most part—*B. lanceolatum, B. lunaria, B. matricariifolium, B. minganense,* and *B. simplex,* although *B. lanceolatum* was often confused with *B. matricariifolium,* and *B. minganense* and *B. simplex* were confused with *B. lunaria.*

We discuss in some detail below the problems involved in studying moonworts. It is amazing how few botanists actually find these plants in the field, and even if they do, they usually find only one or a few populations. For the sake of future progress we here enumerate some of the facts about moonworts and some of the vexing questions that we need to consider in improving our knowledge of these plants.

1. Moonwort species are often found growing together with their near relatives, and are often mounted on the same herbarium sheets. Are the different taxa possibly just microhabitat modifications?

2. Moonworts commonly occur in unpromising and often unlikely places, such as weedy roadside banks and ditches, open sandy places, railroad sidings, fallow pastures. Can collectors train themselves to examine carefully such usually unrewarding sites?

3. Many moonworts are very rare and local, and most botanists do not encounter them. Are there ground rules we can use for detecting adequate populations?

4. Some moonworts resemble upright developing shoots of various forbs just arising from the ground, and are thus overlooked. Can field workers develop a search image for distinguishing moonworts from look-alikes?

5. Some moonworts appear above ground for only brief periods; in dry years they may be seen only for several weeks, and in very dry years they may not appear at all. How can we predict whether a particular season will be appropriate for finding botrychiums?

6. In contrast to most ferns and flowering plants there are very few characters that can be used for taxonomy; for example, there are no trichomes at all, and the spores are mostly similar except in size. Can we find new taxonomic characters—chemistry, anatomy, cytology?

7. Such characters as there are are subtle, involving mostly the outlines of the sterile segments (trophophores). Are there ways of making these subtle differences more apparent and readily described?

8. Many occurrences are made up of extremely small plants 2 cm or less tall, in which the diagnostic characters are blunted by extreme reduction. Are there ways that we can extrapolate from tiny plants to full-sized ones?

9. With few exceptions (e.g., *B. lunaria*), the species are highly variable due to genetic differences and effects of habitats (e.g., shaded vs. exposed). How can we judge how to handle these variations taxonomically?

10. It is difficult to make good specimens because of small size, succulence, and three-dimensional orientation. Can methods be adduced to make better and more useful herbarium collections?

11. The plants are difficult, if not impossible, to grow artificially, thus making common garden tests unsuitable. Other than by growing the plants are there experimental ways to assess genetic distinctions?

We have worked with these plants for decades, and yet we continue to make discoveries. Some of the outstanding findings include *B. mormo,* the "little goblin moonwort," *B. paradoxum,* the "paradox moonwort" that lacks a trophophore, and *B. campestre,* the "prairie dunewort," with minute gemmae along the stem that propagate the plant. We have discovered that the "*B. matricariifolium* A. Br. complex" (daisyleaf moonwort) is much more diverse than previously supposed, comprising at least seven taxa (including two new ones to be described here). Also, hybridization is apparently widespread, producing sterile intermediates between co-existing parents, such as *B.* ×*watertonense,* the "Waterton Lakes hybrid moonwort," a spectacular intermediate between *B. paradoxum* and *B. hesperium.* We fully expect that the Upper Great Lakes will yield many more important discoveries in the future (and perhaps northeastern Canada as well—see below). The taxa currently recognized in this area are listed in Table 1, and illustrated in Figure 1.

Botrychium minganense Victorin. Fig. 1h, j.

This North American endemic occurs from eastern Canada and the northeastern United States to Alaska and California. Long confused with the ubiquitous *B. lunaria,* it differs from it in a number of characters and is now generally recognized as a distinct species (cf. Wagner & Lord 1956). In the Lake Superior region it grows side-by-side with *B. lunaria* in many localities, and the differences are very obvious.

As our studies have progressed, we have become convinced that *B. minganense* as currently understood is either an extremely variable species, or comprises two or

FIG. 1. Great Lakes moonworts known in 1989. a. *Botrychium hesperium*. b. *B. mormo*. c. *B. matricariifolium*. d. *B. campestre*. e. *B. lunaria*. f. *B. lanceolatum*. g. *B. acuminatum*. h. Unresolved taxon related to *B. minganense*. i. *B. pseudopinnatum*. j. *B. minganense*. k. *B. simplex*. Scale bar = 5 cm.

more distinct subspecies or species. In particular, we have noticed a plant in the Lake Superior region that conforms to typical *B. minganense* in many ways, but differs sufficiently to bring up the question whether it may be a distinct, closely related species. We hesitate to name it at this time but call it to the attention of collectors. We need new data from a number of localities to establish its true status, and mass collections of leaves are greatly desired, especially from mixed populations.

TABLE 1. Moonwort (*Botrychium*) orthospecies currently recognized in the Lake Superior region. Those with asterisks are discussed in detail.

	Geography	Abundance	Report before 1988	Figures
1. *B. lunaria* (L.) Sw.	Circumboreal and Austral	Frequent	Yes	1e
*2. *B. minganense* Vict.	Nearctic	Frequent	Yes	1h, j
*3. *B. campestre* W. H. Wagner & Farrar	Nearctic	Rare	No	1d, 2, 3
4. *B. lanceolatum* (Gmel.) Angst. subsp. *angustisegmentum* Pease & Moore	Eastern N.A.	Frequent	Yes	1f
5. *B. matricariifolium* A. Br.	Eastern N.A. Western Europe	Common	Yes	1c
*6. *B. hesperium* (Maxon & Clausen) W. H. Wagner & Lellinger	Western N.A. and Great Lakes	Rare	No	1a, 4
*7. *B. acuminatum* W. H. Wagner	Lake Superior	Very rare	No	1g, 5
*8. *B. pseudopinnatum* W. H. Wagner	Lake Superior	Very rare	No	1i, 6
9. *B. simplex* E. Hitchc.	Circumboreal	Common	Yes	1k
10. *B. mormo* W. H. Wagner	Lake Superior	Rare	Yes	1b

The moonwort in question differs from typical *B. minganense* as follows: The habitat is open fields and dunes slopes rather than second-growth low, shrubby fields and woods, the characteristic habitats of *B. minganense*. The plants are more robust, with thicker texture and common stalk, and (when alive) shiny yellow-green rather than dull green. The trophophore is narrowly deltoid rather than linear-oblong, and the lowest pinnae are larger than those distad rather than smaller or equal. The pinnae are widely separated rather than somewhat separated to overlapping, and the number is few (2–7) rather than numerous (3–8). Also, the pinnae are ascending and strongly oblique, not spreading. The lower pinnae are flabellate and the upper are spatulate, not flabellate to semi-orbicular, and they average widest at or just below the apex rather than widest in the middle. They are narrowly adnate (only ⅕–¼ the pinna width) vs. broadly adnate (⅓–½). The outer margin of the pinna is entire to shallowly crenulate and often cleft, the sinuses mostly wide, instead of crenulate to undulate, and when sometimes cleft, the sinuses mostly narrow or closed. The sporophore/trophophore length is 1.2–1.8 vs. 1.5–2.2. The sporangia are 1.2–1.4 mm in diameter rather than 1–1.1 mm, and they mature an estimated two weeks later.

Unfortunately, the above comparison is based upon only a single mixed population where the two entities grow together on a railroad siding west of Marathon, Thunder Bay District, Ontario. Other plants like the ones in question have been seen from Alaska and Northwest Territories eastward to Québec. This form is much rarer than typical *B. minganense,* which ranges southward into central California, northern Michigan, and central New York.

Botrychium campestre W. H. Wagner & Farrar. Figs. 2, 3.

The rare and variable prairie dunewort was discovered simultaneously in 1982 in Iowa by T. Van Bruggen and in Michigan by J. M. Beitel. At first we thought that the dunes-inhabiting plant of the Great Lakes was a different species or subspecies, because the earliest collections showed irregularities of trophophore shape (to be described below). *Botrychium campestre* differs from all other moonworts in its

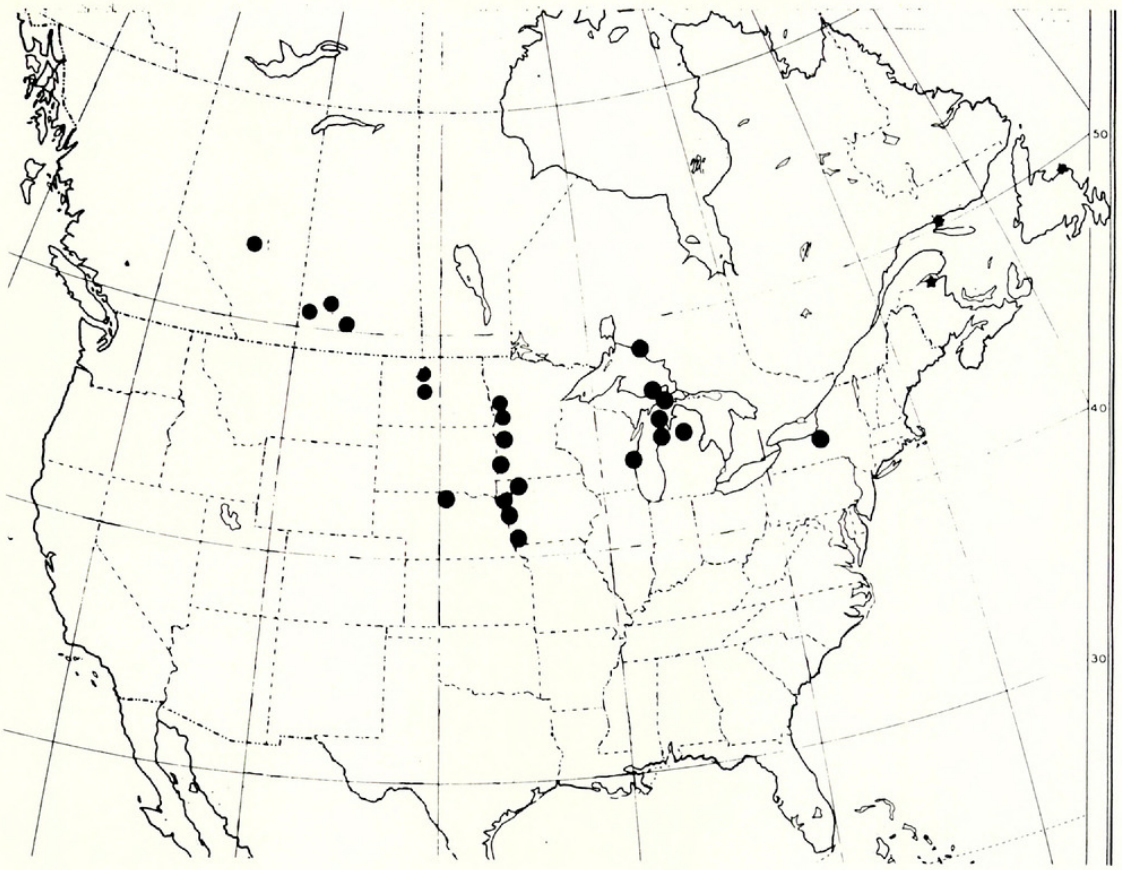

FIG. 2. Distribution of *Botrychium campestre*. Where dots are too close and overlap, only one dot is shown for two or more localities. Possible eastern Canada localities are shown by small stars (see text).

FIG. 3. *Botrychium campestre*. Trophophore forms from dunes in Benzie and Leelanau counties, Michigan, showing irregular arrangement and coalescence of pinnae. Scale bar = 4 cm.

combination of characters: exposed prairie or dunes habitats; very early appearance in spring; masses of minute round gemmae on the stem (currently being studied in detail by D. R. Farrar at Iowa State University); usually sessile or subsessile trophophores with more or less deeply incised, narrowly and asymmetrically flabellate segments; and a chromosome number of n = 45.

After its initial discovery in the sand dunes of Michigan, intensive efforts were made to discover additional localities during the years 1984 to 1988. We found it common but very local in the Sleeping Bear Dunes and Grand Sable Dunes on Lake Michigan and Lake Superior respectively. The most unexpected sites were discovered on the edge of the prairie-like former apple orchard in Crawford Co., central Michigan, and in a grassy Canadian Pacific railroad siding west of Marathon, Thunder Bay District, Ontario.

Eastern Collections Examined: Canada. Ontario, Thunder Bay District, Angler Settlement, along Canadian Pacific Railroad tracks, 17 Jun 1986, *Wagner 86032;* 20 Jun 1988, *Wagner 88030* (MICH).—The following three collections from eastern Canada are still questionable as to identity, but may represent *B. campestre.* Further studies of them should be made, including detailed notes on whether or not they bear gemmae and about their chromosomes, as well as mass collections of carefully pressed leaves: New Brunswick, Belledune Point, 21 miles north of Bathurst, dry sand-gravel spit, 30 Jun 1955, *H. J. Scoggan 12063* (CAN). Newfoundland, Fogo District, Fogo Island near Tilton, rear of beach on short back dune in front of shrub cover, moist sandy slope with short grass, 7 Jul 1985, *D. M. Britton 10671 & A. Anderson* (MICH). Québec, Mingan Archipelago, Duplessus Co., Samuel Island, 50°13′N, 63°45′E, *P. Grondin et al.* on 13 Aug 1977 (QFA).

U.S.A. Michigan. Alger Co., Pictured Rocks National Lakeshore, Grand Sable Dunes, 13 Jun 1985 *Wagner 85043* (MICH), 24–25 Jun 1985, *Wagner 85056* (MICH). Benzie Co., Empire Bluffs, 10 Jun 1985, *Wagner 85024* (MICH). Antrim Co., 7 mi N of Alba, 10 Jun 1987, *R. E. Preston 87015a* (MICH). Chippewa Co., 3 mi E of Trout Lake, 17 Jul 1935, *C. O. Grassl 6834* (MICH). Crawford Co., Maple Forest Township along roadbank, 20 Jun 1987, *Wagner 87226* (MICH). Leelanau Co., Sleeping Bear National Lakeshore, Pyramid Point, 12 Jun 1982, *J. Beitel 82004* (MICH); Sleeping Bear Plateau, 10 Jun 1985, *Wagner 85025* (MICH); near beginning of Scenic Drive, 6 Jun 1986, *Wagner 86012, 86013* (MICH); Glen Arbor Twp., area at end of Dune Road, 6 Jun 1986, *Wagner 86024a, 86024b* (MICH); South Manitou Island, dunes on west side, 11 Jun 1985, *Wagner 85026* (MICH); Garden City area, old field, 12 Jun 1985, *Wagner 85035* (MICH). Wisconsin. Sheboygan Co., Terry Andrew State Park, open sand in dunes along Lake Michigan, full sun, *H. F. Gartman* on 10 Jun 1985 (MICH). New York. Onondaga Co., near Jamesville, dry hillside among limestone rocks, *E. G. Britton* on 4 Jul 1902 (NY); cliffs west of White Lake, three plants together, *S. C. Petry* in 1915 (SYR); Jamesville Road, *Mrs. H. S. Gifford* in 1880 (GH).

Species growing with *B. campestre* in the Lake Superior region are *B. hesperium, B. lunaria, B. matricariifolium, B. minganense, B. acuminatum,* and *B. simplex.* Of all these, *B. campestre* is the first to turn yellow, dry out, and die, usually by the first half of June, and earlier if the season is hot and dry. In late April and early May, leaves of *B. campestre* become fully developed 1–3 weeks before the other species, which are mostly just appearing above ground. A comparison was made between 50 plants each of *B. campestre* and *B. minganense* s.l. at Angler railroad siding west of Marathon on 17 June 1986. All of the blades of *B. campestre* were yellow to brownish green but those of *B. minganense* s.l. were bright green. The sporangia of *B. campestre* were brownish and many had discharged, but only 21% of those of *B. minganense* s.l. were brown, the rest yellow-green (25%) or green (54%), and none were discharged. At all localities where it is found with other species, the latter can mostly still be found in August and early September, while *B. campestre* has long since disappeared.

Non-dune localities for *B. campestre* in the Lake Superior region will probably be found more and more as botanists become familiar with the plant, its habitat and periodicity. The first non-dune site we found was in the Garden City area of South

Manitou Island (*Wagner 85035*); the habitat there was a dry old field, where *B. campestre* grows with a number of other moonworts. Later it was found by Donald and Joyce Drife (*Wagner 87226*) in north-central Michigan, at the edge of a prairie-like field in Crawford Co., some 30 miles inland from the nearest lakeshore line. Another inland collection, that by Carl Grassl in Chippewa County 3 miles east of Trout Lake, includes very large specimens taken under deciduous trees on a limestone outcrop.

Some isolated disjunctive populations have turned up among herbarium specimens from New York and eastern Canada. We explored the Jamesville, N.Y., area where *B. campestre* was found three times from 1880 to 1915. The limestone habitat seems entirely appropriate to this species, and further studies should be made to determine whether it still grows there. In New Brunswick, Québec, and Newfoundland similar explorations should be made not only at the localities where possible representatives of this species have been collected in the past (see above and fig. 2), but in appropriate habitats elsewhere.

A tendency in *B. campestre* for asymmetry in trophophore outline reaches its extreme in Benzie and Leelanau counties, Michigan. It involves an irregular coalescence of segments producing some individuals that appear to be irregularly lobed *B. simplex* (fig. 3). The fusion of segments may be at the base of the blade, producing a more or less stalked appearance, or the middle of the blade, or both. The coalescence may be the same on both sides, or, more usually, unequal on the two sides. In many examples, narrow linear segments do not fuse, but simply cluster close together. This condition appears to be rare among moonworts, but shows to some extent in the eastern *B. mormo* and the western *B. montanum* (Wagner & Wagner 1981, fig. 3).

Other variables are more like forms familiar in the other moonworts, such as abnormal sporangial distribution, including two sporophores but no trophophore (*Wagner 85025a*), a condition that is uniform in the western American *B. paradoxum* but also occasional in such species as *B. minganense* and *B. matricariifolium*. Giant specimens are rare, these reaching 25 cm in over-all height, the sporophore 8 cm tall, the trophophore 6 cm long (*Wagner 85025*). Altogether, *B. campestre,* as we presently define it, is morphologically one of the most variable of moonworts.

Botrychium hesperium (Maxon & Clausen) W. H. Wagner & Lellinger. Fig. 4.

This species is described in detail in Wagner and Wagner (1983a). It was recognized for the first time in the Great Lakes region in June, 1985, and subsequently an intensive search was made for it. From the western representatives of this rather variable species, the eastern ones differ by tending to be narrower with relatively more exaggerated basal pinnae. The individuals reach greater size in the Great Lakes region than in any of its known western occurrences. Especially distinctive are the short, more or less approximate adnate, stubby pinnae above the base, and the tendency toward strongly enlarged basal pinnae, together with a sporophore with three main axes. Young or dwarfed specimens are more or less linear, and the basal pinnae are not exaggerated.

Additional Collections Examined. Canada. Algoma District, just SE of Algoma Central Railroad Bridge over route 17, 22 Jun 1988, *Wagner 88048* (MICH); near Milmac Mine, sand amongst grass, vicinity of Michipicoten Harbour, 12 Jul 1938, *R. C. Hosie et al. 981* (DAO); Thunder Bay District, Mobert Indian Reservation along railroad tracks, 22 Jun 1988, *Wagner 88044* (MICH); Rossport, grass along railroad siding, 21 Jun 1988, *Wagner 88040* (MICH); Angler Settlement, 20 Jun 1988, *Wagner 88031* (MICH), 17 Jun 1986, *Wagner 86031* (MICH); Sibley Peninsula, crest at head of Thunder Cape, 14 Jul 1947, *C. E. Garton 1040* (DAO).—U.S.A. Michigan. Alger Co., Grand Sable Dunes, 27–28 Jun

FIG. 4. *Botrychium hesperium* variations. g. *Wagner 86042*. Extreme shade forms from deep jackpine forests at Grand Sable Dunes. o. *Wagner 88048*. Sun forms, Ontario, Algoma District. Unmarked specimens medium-sized individuals from Grand Sable Dunes. Scale bar = 5 cm.

1987, *Wagner 87228* (MICH), 22 Jun 1986, *Wagner 86042* (MICH). Emmet Co., fields near Stutzmanville Bog, 11 Jun 1988, *Wagner 88019* (MICH); Keweenaw Co., south edge of Eagle River in woods and fields, 20 Jun 1986, *Wagner 86039* (MICH); near Clifton, 25 Aug 1898, *O. A. Farwell 1612a* (BMH); Leelanau Co., S. Manitou Island, Garden City, Jul 1986, *B. Hazlett s.n.* (MICH).

These records represent a major disjunction for the species. It occurs with *B. lunaria, B. matricariifolium, B. minganense, B. multifidum, B. acuminatum, B. pseudopinnatum,* and *B. simplex*. It grows intimately mixed in several localities with *B. matricariifolium,* the species with which it was long confused by Maxon and Clausen, who considered it to be a mere western subspecies. At the time they described taxon *hesperium,* they had no way of knowing that it grows in the same habitats side-by-side with *B. matricariifolium*. Forms of *B. hesperium* in the Lake Superior region range from small, compact sun forms of open dunes and sandy

fields (Fig. 4o) to very lax shade forms of moist shrubby jackpine (*Pinus banksiana*) forest in dune valleys (Fig. 4g). Sometimes *B. hesperium* occurs only as several, or even one, individuals together with much more numerous representatives of other species; at other times it occurs in pure stands, sometimes in large numbers.

Botrychium acuminatum W. H. Wagner, sp. nov. Fig. 5.

B. matricariifolii A. Br. simile; trophophorum brevistipitatum vel fere sessile; pinnae remotae, 3–6 paria, lineari-oblanceolatae, parum lobatae vel subintegrae,

FIG. 5. *Botrychium acuminatum* variations. o. *Wagner 88049*. Ontario, Algoma District, small form of open grassy sites. Remainder from various sites at Grand Sable Dunes, *Wagner 84049*, including medium- and large sized forms. Scale bar = 5 cm.

acuminatae, apiculatae; sporophorum axe principali singulari, trophophoro 1.4–2.0-plo longius, fasciculo sporangiali stipite 1.4–5.0-plo longiore; chromosomatum numerus: n = 90.

Similar to *B. matricariifolium*. Trophophore short-stalked to nearly sessile, ovate-oblong, 1.5–7.0 cm long, 0.8–3.0 cm wide. Pinnae remote except in extreme sun forms but never contiguous or overlapping, 3–6 pairs. Pinna outline linear-oblanceolate, 4–15 mm long, 3–5 mm wide, shallowly lobed or subentire, acuminate, sharply pointed. Sporophore with a single main axis, 1.4–2.0 times as long as trophophore, the stalk itself 0.2–0.7 the length of the sporangial cluster. Chromosome number: n = 90.

HOLOTYPE. U.S.A. Michigan. Alger Co., Grand Sable Dunes, in stabilized sand, growing under jackpine and balsam fir, fairly common, T49N, R14W, Sec. 11, 11 June 1973, *R. H. Read 52* (MICH).

ADDITIONAL COLLECTIONS EXAMINED. CANADA. Algoma District, SW of Algoma Central Railroad bridge over Route 17, ca. 1 mi W of route 108, 22 Jun 1988, *Wagner 88049* (MICH). Thunder Bay District, Rossport, grassy area near Canadian Pacific railroad tracks, 18 Jun 1986, *Wagner 86034* (MICH); railroad right-of-way, Melgund, vicinity of Peninsula, 26 Jul 1939, *T.M.C. Taylor et al. 101* (CAN).—U.S.A. Michigan. Alger County, Grand Sable Dunes, along Lakeshore Trail, 0.5–1.0 mi from beginning at Lake, 24–25 Jun 1985, *Wagner 85047b* (MICH), 1–2 Sep 1985, *Wagner 85973A2, B2, C2* (MICH); 26 Jun 1986, *Wagner 86048* (MICH); 27–28 Jun 1987, *Wagner 87230* (MICH); 18 Jun 1988, *Wagner 88026* (MICH); Grand Sable Lake near Grand Marais, 21 Aug 1956, *F. & R. Case s.n.* (MICH); on back side of Grand Sable Dunes, about ¾ mi SE of Log Slide, 9 Jul 1973, *R. M. Read 252* (MICH).

Botrychium acuminatum resembles a "streamlined" form of *B. matricariifolium*, with which it commonly grows. The pinnae are much more widely separated, however, with narrower and shallow lobes or none at all. They are linear-oblanceolate in outline, with strongly acuminate and pointed tips.

This species inhabits more or less open dunes and grassy areas, commonly in association with *Juniperus communis* and *Picea glauca* and various hardwood shrubs. It also occurs in dune slopes and valleys in shade, as well as grassy railroad sidings and roadside ditches. Extremes in size and form are shown in Figure 5. Its most common associates are *B. matricariifolium* and *B. hesperium*, of which we first thought it was a hybrid. However, the characters are not intermediate, the spores are not abortive, and the chromosome pairing is not appropriate.

Thus far this species appears to be very rare and local. It is most common at Grand Sable Dunes. In the United States, it is known only from Grand Sable Dunes, but it has been found in several localities in Canada.

Botrychium pseudopinnatum W. H. Wagner, sp. nov. Figs. 6, 7.

B. matricariifolii A. Br. simile; trophophorum fere sessile, aliquantum laccatum, lanceo-oblongum, 1.5 cm longum, 0.4–1.5 cm latum; pinnae approximatae vel imbricatae, 5–7 paria, ovatae, profunde et regulariter lobatae, obtusae; sporophorum plerumque breve, trophophoro 1.2–1.0-plo longius, fasciculo sporangiali stipite 1.6–2.5-plo longiore; chromosomatum numerus: n = 135.

Similar to *B. matricariifolium*. Trophophore nearly sessile, somewhat lustrous (when alive), lanceolate-oblong, 1–5 cm long, 0.4–2.5 cm wide. Pinnae approximate to overlapping, 5–7 pairs. Pinna outline deeply and regularly lobed, 0.3–1.3 cm long, 0.2–0.9 cm wide, blunt-tipped. Sporophore mostly short, 1.2–2.0 times as long as trophophore, the stalk 0.4–0.6 times as long as the sporangial cluster. Chromosome number: n = 135.

FIG. 6. *Botrychium pseudopinnatum* variations. *Wagner 86028, 87247.* Ontario, Thunder Bay District, Angler Settlement. Scale bar = 5 cm.

HOLOTYPE. CANADA. Ontario. Thunder Bay District, Angler Settlement, west of Marathon, 17 June 1986, *Wagner 86028* (MICH).

ADDITIONAL COLLECTIONS EXAMINED. CANADA. Ontario, Algoma District, southeast of Algoma Central Railroad bridge over route 17, ca. 1 mi W of Rt. 108, 22 Jun 1988, *Wagner 88049* (MICH). Thunder Bay District. Type locality: locally frequent in sod on sandy soil at Angler, 31 Jul 1961, *E. G. Voss 10430* (MICH), 16 Jun 1966, *D. J. Hagenah 6497* (MICH); Sibley Peninsula, field E of Sibley Creek, Silver Islet, 18 Aug 1956, *C. E. Garten & H. K. Campbell 1278* (2 sheets, DAO); Sibley Twp., Sibley Cove, 25 Jun 1936, *T. M. C. Taylor et al. 101* (CAN).

The first collections of this species that we examined were thought to be peculiar plants of *B. matricariifolium;* however, we realized that it more closely resembles the northwestern North American *B. pinnatum,* especially its forms of exposed

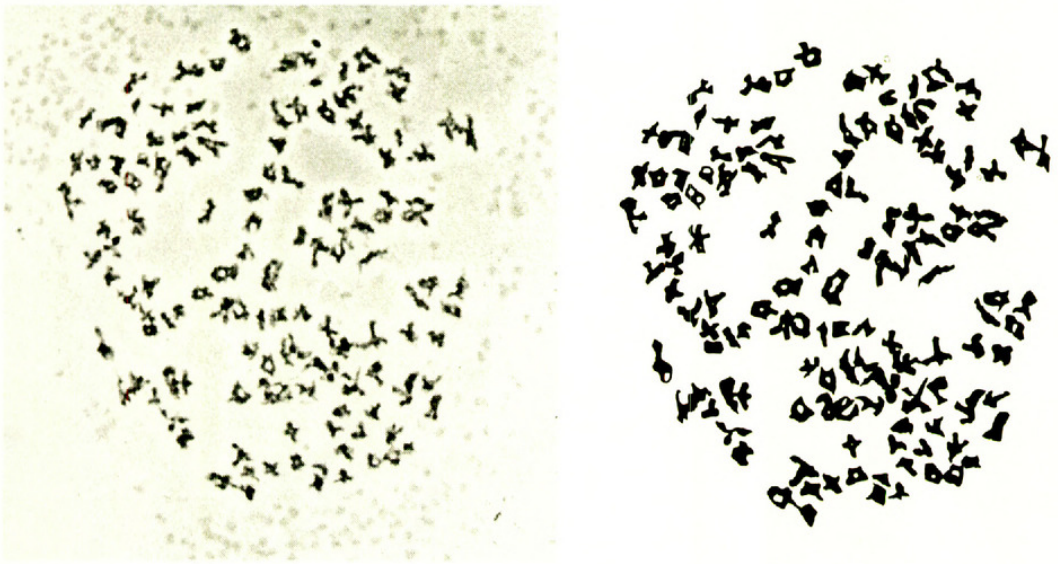

FIG. 7. Chromosomes of *Botrychium pseudopinnatum*, n = 135. Ontario, Thunder Bay District, Angler Settlement.

places. On the contrary, *B. pseudopinnatum* differs from *B. pinnatum* in its thicker texture, duller luster, narrower and more oblong blade, more approximate and ascending pinnae, and smaller and narrower secondary lobes. Also, some individuals of *B. pinnatum* have more or less pointed pinnae. *Botrychium pinnatum* is a tetraploid with n = 90, while *B. pseudopinnatum* is an hexaploid with n = 135, the first hexaploid reported in its subgenus.

Of the familiar eastern North American species, the common *B. matricariifolium* is the most likely to be confused with *B. pseudopinnatum*. However, when the two species grow together or near each other, *B. pseudopinnatum* is stouter and more succulent rather than slender and herbaceous, green rather than yellowish or whitish green, somewhat lustrous rather than dull, the pinnae more ascending and approximate rather than spreading and well separated, the secondary lobes larger and wider rather than smaller and narrower, the pinna tips more broadly obtuse rather than narrowly obtuse to nearly pointed; the sporophore is often shorter and stubbier, usually only about one-third to one-half longer than the trophophore. The chromosome number is 6× rather than 4×. From our observations thus far of *B. pseudopinnatum,* this species appears to be very uniform, unlike *B. matricariifolium,* which is highly variable in cutting. In this respect, *B. pseudopinnatum* resembles *B. lunaria.*

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