

**Native Plant Society of New Mexico Moonwort Workshop
Silver City, August 11-12, 2010**

**OPHIOGLOSSACEAE OF COLORADO, ADJACENT STATES,
AND SOUTHWEST SOUTH DAKOTA**

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OPHIOGLOSSACEAE C. Agardh 1822. MOONWORT FAMILY

The Ophioglossaceae is an ancient family of plants distantly related to modern ferns. Plants produce only a single leaf per year that is divided dichotomously into a sterile, foliaceous part (trophophore) and a fertile, spore-bearing part (sporophore).

World-wide, the Ophioglossaceae is comprised of ten genera. Three occur in Colorado, most adjacent states, and southwest South Dakota: *Botrychium*, the moonworts; *Botrypus*, the rattlesnake-ferns; and *Sceptridium*, the grape-ferns. Traditionally the latter two groups have been included in *Botrychium*, but morphology, and to a greater extent genetics, provide convincing evidence for their separation into distinct genera (Hauk et al., 2003).

The Ophioglossaceae has long held special fascination for those who encounter it. The name “moonwort” reflects medieval beliefs of the plants’ mystical powers to render doors unlocked, horses unshod, and invisibility to anyone dusted with their spores. These tiny plants continue to receive attention disproportionate to their size and diversity.

The first Ophioglossaceae collections in Colorado may be those of Alice Eastwood from 1887 on Pikes Peak and 1891 near Steamboat Springs. These were followed by occasional discoveries over the next century. More intensive search and discovery commenced with the work of Warren (Herb) and Florence Wagner in the 1980’s, and was continued by Colorado’s first “moonwort aficionado,” Peter Root. Further discoveries by Warren Hauk, Toby Spribille, Annette Kolb, Jim Montgomery, Scott (Scotty) Smith, David Steinmann, Erica Smith Sokoloski, Kevin Kovacs, and Ben Legler added many new records, and greatly expanded knowledge of the species and their distributions in our area. Mary Stensvold (2008) has recently revised the *Botrychium lunaria* complex, affecting the taxonomy of several of our species. Undescribed taxa are under study and important additional discoveries undoubtedly lie ahead as field work and genetic analysis promote increased understanding of Ophioglossaceae species and their ecology.

The coverage area for this treatment emphasizes Colorado, but includes all adjacent states (AZ, KS, OK, NE, NM, UT, and WY) and the southwest quadrant of South Dakota. It also accommodates all of the Rocky Mountain Region (Region 2) of the U.S. Forest Service. The treatment excludes species that occur in our coverage area only in the Eastern deciduous woodlands of Nebraska, Kansas, and Oklahoma.

Taxa present in Colorado are in bold-face; other taxa appear in bold italics. Distribution and habitat descriptions are for Colorado unless otherwise noted; county codes follow Weber and Wittmann (2001a, b). In many cases, habitat descriptors apply reliably to adjacent states. The authors thank Karen Pille for couplet illustrations and Chanda Skelton for Plate 1. Couplet drawings illustrate underlined text.

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KEY TO THE GENERA OF OPHIOGLOSSACEAE

- 1a. Trophophore (foliaceous leaf part) simple, entire; veins reticulate; sporophore (spore-bearing leaf part) with sporangia clearly sunken in axis. *Ophioglossum*, ADDER'S TONGUE.
- 1b. Trophophore compound (rarely simple, entire in *Botrychium simplex*); veins forked; sporangia not sunken in axis, exposed as sessile to short-stalked clusters(2)

- 2a. Trophophore ternate or pinnate (rarely simple), generally less than 4.5 cm wide, no more than twice divided. **Botrychium**, MOONWORT
- 2b. Trophophore ternate, generally more than 6 cm wide, three to four times divided (two times divided in some small plants).....(3)

- 3a. Leaf withering away in fall; trophophore and sporophore joined well above ground level; trophophore sessile; pinnae thin and delicate. **Botrypus**, RATTLESNAKE-FERN
- 3b. Leaf persistent and evergreen for 1 year; trophophore and sporophore joined \pm at ground level; trophophore stalked; pinnae thick and leathery. **Sceptribidium**, GRAPE-FERN

BOTRYCHIUM Swartz 1800 [Greek, *botry*, bunch of grapes, from resemblance of the sporangia to clusters of grapes]. MOONWORT

Moonworts are the most diverse and abundant Ophioglossaceae in the Rocky Mountains, and 16 taxa are known to occur in Colorado. The common name is derived from Latin *luna*, moon, in reference to the crescent-moon shape of the pinnae of the type species, *B. lunaria*, and Old English *wyrt*, herb, for alleged curative properties.

Although a few moonwort species in our area have specialized habitat preferences, most occur on well-drained, seasonally mesic soils in sites dominated by perennial herbaceous vegetation. Moonworts have a close association with mycorrhizal fungi on which they depend for their water, mineral, and carbohydrate needs. *Botrychium* distribution is undoubtedly linked to the occurrence of these fungi. Habitats are diverse, ranging from natural meadows and riparian areas to previously disturbed (now stabilized) areas including burns, avalanche chutes, roadsides, mining districts, earthen dams, power lines, timber harvest clearings, old town sites, and ski slopes! Populations tend to appear about 20 years following disturbance, but eventually decline with canopy closure by woody plants.

Moonworts generally occur at elevations above 9000 ft in Colorado, predominately in the subalpine, but also in montane and alpine areas. Although they occur on various soil types, *Botrychium* seem to be especially frequent on soils developed over limestone or other sources of calcium. A good, but not always reliable, indicator of moonwort habitat in Colorado's subalpine is the presence of two or more of the following associates: *Androsace*, *Antennaria*, *Fragaria*, *Senecio*, *Solidago*, *Taraxacum*, and juvenile (often knee- to head-high) conifers. While all moonworts can be stubbornly difficult to find, recent field work has shown them to be much more widespread than previously believed. Some moonworts are markedly more prevalent than others and, 95 percent of the time, those encountered in Colorado are *Botrychium echo*, *B. hesperium*, *B. lanceolatum* (red phenotype), *B. minganense*, and *B. "neolunaria."*

Identification of *Botrychium* species requires careful attention to details of leaf structure used in the key and shown in Plate 1. It is important that specimens be carefully pressed, making sure that the sporophore and trophophore are not overlapping and that pinnae margins are fully and flatly spread. The key is intended to identify typical specimens. Determining what is "typical" requires examination of a number of plants within a population, keeping in mind that species are variable and that very small and very large individuals are often atypical. Also keep in mind that more than one species may occur in productive habitats. The key does not include sterile hybrids, which are sometimes encountered and can be confusing.

The most important characters for identification are the shape and cutting (dissection) of the pinnae as well as the lengths of the stalks of the trophophore and sporophore (see Plate 1). Trophophore stalk length ranges from none (sessile) to longer than the average of the distances between the attachment points of the first (basal) and second, and second and third, lowermost pinnae pairs. Sporophore stalk

length ranges from 1/4 of to longer than the total length of the trophophore. The sporophore stalk is the last part of the leaf to stop growing (it elevates the spores for better dispersal), so its length is most diagnostic after sporangia have matured (yellow and plump, or brown and shriveled following spore release). Throughout the key, “sporophore stalk” refers to the length of the sporophore stalk only, whereas “trophophore length” refers to the total length of the trophophore including its stalk.

Pinna span is very important in once-pinnate species and is measured in degrees of a circle. Pinna span is estimated by imagining a circle with the point of pinna attachment at its center (see Plate 1). Unless stated otherwise, span and other pinna characters refer to the basal pair of pinnae.

The words “usually” or “generally” should be understood to apply to most descriptive characters used in the key, recognizing that there are exceptions. For example, the term “trophophore long-stalked” can be interpreted as “trophophore *usually* long-staked,” because a few short-stalked individuals will often occur in a population of a long-stalked species. These terms have been retained in the leads when particularly applicable.

Underground parts are not helpful in identification. If collection is necessary, carefully cutting (not pinching) the leaf at ground level will provide all the characters needed and will leave a healthy underground stem and roots to produce leaves in subsequent seasons. Refraining from over-collecting is prudent. Photographs that clearly show the features described above are helpful.

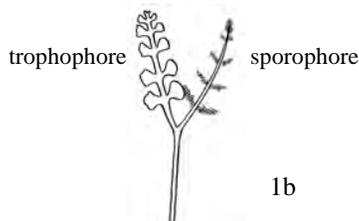
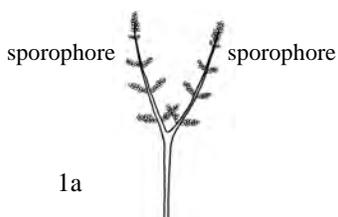
Colorado has received the greatest survey effort, but all states remain incompletely surveyed, and additional taxa likely await discovery. See the table following the key for *Botrychium* presence by state.

Enjoy and don't get discouraged! You will acquire a feel for keying moonworts and will find it becomes easier as you gain familiarity with the species.

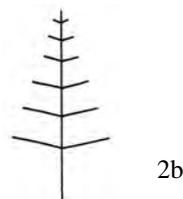
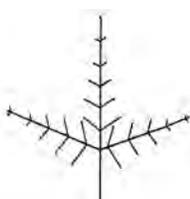
KEY TO THE BOTRYCHIUM

The key to *Botrychium* species also includes *Botrypus* and *Sceptridium* as an alternate separation tool to the genus key.

- 1a. Leaf divided into two sporophores, more or less equal in size and shape; trophophore absent. **B. paradoxum** W. H. Wagner [referring to the peculiar absence of a trophophore], PARADOXICAL MOONWORT, **Plate 2**. One small site, a subalpine grassy slope near Crested Butte, GN. In Colorado, individuals of other species rarely have been observed to produce two sporophores and no trophophore, usually of two different shapes and sizes. If the two sporophores of the *B. paradoxum* mimics are of more or less equal size and shape, such plants can be differentiated from true *B. paradoxum* only by genetic testing. True *B. paradoxum* usually occurs in populations of more than a few individuals.
- 1b. Leaf divided into a sporophore and a trophophore.....(2)



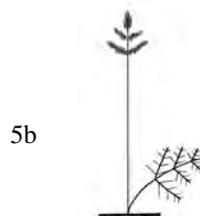
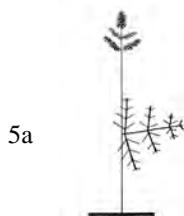
- 2a. Trophophore ternate, appearing to be divided into three more or less equal segments due to great enlargement of the basal pair of pinnae.....(3)
- 2b. Trophophore pinnate, without basal pinnae disproportionately enlarged, or, in small *B. simplex*, trophophore simple and shallowly to not at all divided.....(9)



- 3a. Sporophore absent or tiny (mostly < 2 mm) and undeveloped(4)
 3b. Sporophore present and conspicuous(5)
- 4a. Pinnae apices (terminal tips) cuneate to narrowly acute, forming an angle of $\pm 45-60^\circ$, sharply pointed; pinnae blades thin and delicate. See **Botrypus**
 4b. Pinnae apices broadly acute to obtuse, forming an angle of $\pm 75-100^\circ$, rounded or bluntly pointed; pinnae blades thick and leathery. See **Sceptridium**



- 5a. Trophophore sessile or short-stalked, joined to the sporophore well above the ground at the top of the common stalk(6)
 5b. Trophophore long-stalked, joined to the sporophore near or below ground level; common stalk often not visible(8)



- 6a. Pinnae blades thin and delicate; plants often more than 15 cm tall; trophophore usually more than 10 cm wide, lustrous (glistening) when fresh; sporophore pinnately branched, wholly elevated above a horizontal plane of the trophophore in situ. See **Botrypus**
 6b. Pinnae blades firm; plants usually less than 12 cm tall; trophophore usually less than 5 cm wide, lustrous to dull to glaucous when fresh; sporophore usually ternately branched, not wholly elevated above the trophophore in situ(7)
- 7a. Lobes of basal pinnae elongate and pointed; all but the uppermost pinnae sharply lobed; plants dull to often lustrous when fresh, never glaucous. **B. lanceolatum** (S. G. Gmelin) Ångström subsp. **lanceolatum** [for the narrow, lance-like pinnae and pinnae lobes], TRIANGLE MOONWORT (see also couplet 22). This taxon of the Rocky Mountains exists in two morphologically and genetically distinct types. These are as genetically different from each other as either is from the Eastern subspecies *angustisegmentum*, and recognition of three taxonomic entities may be warranted. The two types can be differentiated as follows:

- 1a. Common stalk maroon (at least at base) or maroon-striped; basal pinnae asymmetric with innermost lower lobes clearly longer than opposing upper lobes, midribs usually upwardly curved **red phenotype. Plate 3.**
 The most common type in Colorado, and widespread in the mountains.
- 1b. Common stalk completely green; basal pinnae symmetrical, midribs usually straight..... **green phenotype. Plate 3.**
 Known in Colorado from only three sites: subalpine meadows and forest openings near St. Elmo, CF, Wolf Creek Pass, RG/SA, and Winter Park, GA.

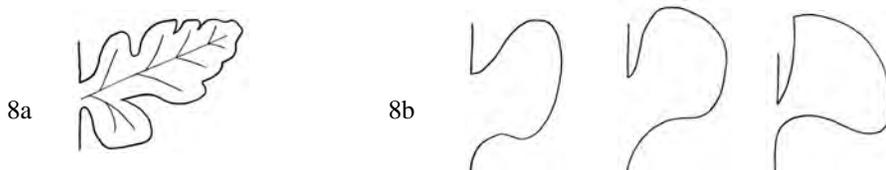


- 7b. Lobes of basal pinnae rounded; pinnae above the basal pair often undissected; plants usually glaucous when fresh.....(24)



- 8a. Pinnae above the basal pair mostly pinnately compound or lobed. See **Sceptridium**
 8b. Pinnae pairs above the basal pair absent or with pinnae mostly simple and fan-shaped, sometimes palmately lobed. **B. simplex** E. Hitchcock [for the reduced expression of characters in small plants]. Two varieties can be recognized in our area as follows:

- 1a. Pinnae above the basal pair broadly attached to the rachis and strongly decurrent (or trophophore simple).....var. **simplex**, LEAST MOONWORT, **Plate 3**. The only variety confirmed in Colorado. Infrequent in forest seeps and streamside meadows, mostly subalpine. Tiny plants may have only a simple, weakly divided or undivided trophophore with a boat-shaped apex. Simple trophophores or trophophores with long, undivided terminal segments above the basal pinnae have strongly decurrent bases. Such trophophores are uncommon in the next variety.
 1b. Pinnae above the basal pair narrowly attached to the rachis and slightly or not at all decurrentvar. **compositum** (Lasch) Milde, YOSEMITE MOONWORT [referring to its abundance in that National Park]. This is the most common variety in the Sierra, Cascade and Northern Rocky Mountains; it is known in our area only from one site in northcentral Wyoming.

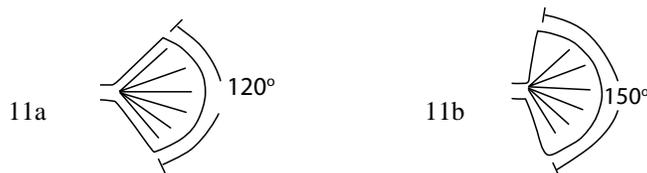


- 9a. [2] Basal pinnae entire or palmately dissected (or trophophore undivided in small *B. simplex*), broadly to narrowly fan-shaped, wedge-shaped, or linear in outline, clearly broadest at the outer margin(10)
 9b. Basal pinnae pinnately dissected to (rarely) entire, ovate to elliptic in outline, broadest at the base or middle(21)



- 10a. Trophophore and sporophore usually joined near ground level; sporophore stalk at maturity (spore release or later) usually much longer than the trophophore length, lax; trophophore compound or rarely simple; plants often in riparian-influenced areas or saturated substrate. **B. simplex** E. Hitchcock (see lead 8b).
 10b. Trophophore and sporophore usually joined well above ground level; sporophore stalk length various at maturity, stalk erect; trophophore compound; plants in various habitats. (Very small or shaded plants of *B. simplex* may sometimes have their trophophore-sporophore junction above ground level)(11)

- 11a. Spans of basal pinnae less than 120°(12)
 11b. Spans of basal pinnae greater than 150°(19)



- 12a. Sporophore stalk approximately $\frac{1}{2}$ or less the length of the trophophore; trophophore sessile or with stalk shorter than the average of the distances between the first (basal) and second, and second and third, lowermost pinnae pairs(13)
 12b. Sporophore stalk $\frac{1}{2}$ or more the length of the trophophore; trophophore stalk \pm equal to or longer than the average of the distances between the first (basal) and second, and second and third, lowermost pinnae pairs.....(17)
- 13a. Spans of unlobed pinnae less than 60°; pinnae or pinnae lobes linear to narrowly wedge-shaped; sporophore stalk $\frac{1}{3}$ or less the length of the trophophore(14)
 13b. Spans of unlobed pinnae greater than 60°; pinnae and pinnae lobes mostly fan-shaped; sporophore stalk approximately $\frac{1}{2}$ the length of the trophophore(15)



- 14a. Pinnae and pinnae segments narrowly wedge-shaped, often shallowly cleft into non-spreading lobes; basal pinnae usually not the longest; native grasslands and low-elevation prairies. **B. campestre** W. H. Wagner & Farrar [Latin, *campestre*, “of fields,” referring to its prairie habitat], PRAIRIE MOONWORT. Colorado’s only low-elevation moonwort is best detected in early spring. Known from one station with few plants, in loess soil of grassland with little bluestem, 3800 ft, at Bonny Prairie Natural Area, YM. Extensive searches for addition populations there and on the Pawnee National Grassland east of Fort Collins have proved unproductive. All plants of high-elevation mountain settings keying to *B. campestre* have been shown genetically to belong to *B. lineare* (see lead 14b).
- 14b. Pinnae and pinnae segments linear with \pm parallel sides, often deeply cleft into spreading lobes; basal pinnae usually the longest; high-elevation settings. **B. lineare** W. H. Wagner [for the linear shape of the pinnae and pinnae lobes], SLENDER MOONWORT, **Plate 2**. Local, in open meadows and on rocky slopes, bare-soil roadsides, and earthen dams, mostly subalpine; straddling the length of the Continental Divide, also at Pikes Peak, EP, and Avery Peak, GN. We include Colorado populations previously informally referred to as *B. furcatum*.” Morphological variability includes some forms that resemble *B. campestre*; *B. campestre* and *B. lineare* are very close genetically and may be better treated as infraspecific taxa.



14a

14b

- 15a. Plants pallid (pale) or whitish blue-green when fresh; divided pinnae asymmetrically divided into longer upper and shorter lower lobes; trophophore distinctly stalked. ***B. gallicomontanum*** Farrar & Johnson-Groh [Latin, *gallico*, of France, + *mont*, mountain, for Frenchman's Bluff, the type locality in Minnesota], FRENCHMAN'S BLUFF MOONWORT. This species of the Midwest has recently been discovered in low-elevation prairie habitats in the Black Hills of South Dakota and in Glacier National Park in northwestern Montana. Its presence in the Wyoming section of the Black Hills is probable. The closest stations to Colorado in South Dakota are in grassy meadows of montane rolling hills, sometimes near *Pinus ponderosa* or under *Symphoricarpos*.
- 15b. Plants green when fresh; divided pinnae, if present, usually symmetrically divided; trophophore sessile to short-stalked.....(16)



15a

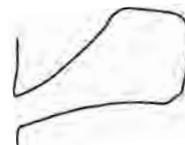


15b

- 16a. Trophophore sessile to short-stalked; outer margins of pinnae and pinnae lobes coarsely toothed; basal pinnae often bearing a few sporangia. ***B. ascendens*** W. H. Wagner [for the upwardly-angled pinnae], UPSWEPT MOONWORT, **Plate 2**. Known from three small sites in the mountains, each with few plants: Guanella Pass, CC, Vail Pass, EA, and Montgomery Reservoir, PA.
- 16b. Trophophore sessile; outer margins of pinnae scalloped to shallowly lobed to entire; basal pinnae seldom bearing sporangia. ***B. spatulatum*** W. H. Wagner [for the spoon-shaped outline of the pinnae], SPATULATE MOONWORT, **Plate 3**. A mere handful of plants from several small sites in the Garfield-Taylor Mountain area near Monarch Pass, CF, in subalpine drainages and open areas.



16a



16b

- 17a. [12] Plants green to yellow-green when fresh; pinnae entire to symmetrically 3 or 5 (odd) lobed, middle lobes often larger; stalks of lower pinnae appearing narrow, stalk widths approximately $\frac{1}{4}$ the pinnae widths; lower sporophore branches stalked, sporangia not obscuring the sporophore rachis. ***B. minganense*** Victorin [for the type locality in the Mingan Islands, E. Québec], MINGAN MOONWORT, **Plate 2**. Widespread in the mountains. We include plants previously referred to provisionally as *B. "colorado."*
- 17b. Plants pallid (pale) or whitish blue-green when fresh; pinnae entire to crenate to asymmetrically 2 to 8 (even) lobed, upper lobes noticeably larger and more developed; stalks of lower pinnae not appearing narrow, stalk widths approximately $\frac{1}{3}$ to $\frac{1}{2}$ the pinnae widths; lower sporophore branches usually not stalked, sporangia partially obscuring the sporophore rachis(18)



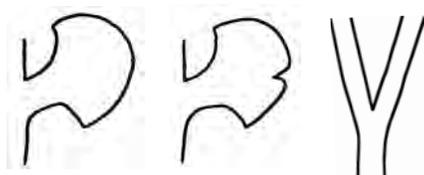
17a



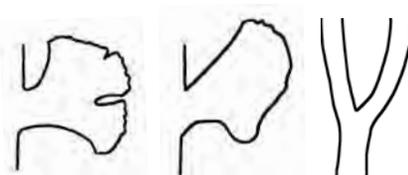
17b



- 18a. Pinnae outline dome- or mushroom-shaped; sporophore and trophophore stalks straight, joining in a straight-sided “V.” ***B. pallidum*** W. H. Wagner [referring to the pale leaf], PALE MOONWORT. This is an Eastern North American diploid species, occurring westward in our area to moist, open deciduous woodlands and mesic meadows in the Black Hills of South Dakota and northeastern Wyoming. It should be sought in Colorado. Care is needed when differentiating this species from the next.
- 18b. Pinnae outline fan-shaped to spatulate, often appearing stubby and irregularly margined; sporophore and/or trophophore stalks \pm outwardly bowed, joining in a \pm wishbone-like, not straight-sided “V.” ***B. “redbank”*** *sp. nov. ined.* [provisional name referring to Redbank Spring in the Black Hills, one area among several where the plant was first recognized as distinct], **Plate 2.** Somewhat frequent, mostly in subalpine meadows and forest openings. This new allotetraploid species, involving *B. pallidum* and an undescribed diploid, occurs in the Black Hills of South Dakota and in the Rocky Mountains from southern Canada to northern New Mexico. Colorado plants previously identified as *B. pallidum* have been shown genetically to belong to this species.

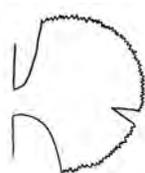


18a

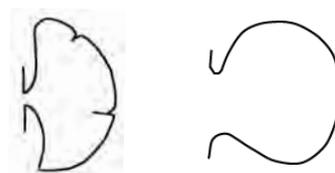


18b

- 19a. [11] Pinnae texture paper-thin and delicate; margins finely toothed or crenulate; plants usually growing in or close to saturated substrate. ***B. lunaria*** (L.) Swartz var. “**crenulatum**” *comb. nov. ined.* [from *Lunaria*, a pre-Linnean name for the species; varietal name referring to the crenulate or minutely toothed pinnae margins], DAINY MOONWORT [referring to the thin texture of the pinnae], **Plate 3.** Three small, subalpine sites influenced by seeps or other moisture: Vail Pass, EA, and Avery Peak and Sheep Mountain, GN. Formerly treated as a distinct species (*B. crenulatum* W. H. Wagner), this taxon is very close genetically to European *B. lunaria* var. *lunaria*.
- 19b. Pinnae texture fingernail-thick and firm; margins entire to undulate, occasionally coarsely toothed or cleft into several segments; plants usually not growing in or close to saturated substrate.....(20)



19a



19b

- 20a. Fresh plants deep green, dull to somewhat lustrous; pinnae symmetrically fan-shaped with abrupt differentiation between outer and side margins; sporophore stalk at maturity (spore release or later) equal to or longer than the length of the trophophore; basal sporophore branches generally ascending and not twisted. ***B. “neolunaria”*** *sp. nov. ined.* [for formal distinction from Old World *B. lunaria*], AMERICAN MOONWORT, **Plate 3.** Widespread in the mountains, and considered handsome by most, with notably uniform morphology. (*B. lunaria* of previous manuals.) Genetic analysis has shown our plants to be distinct from *B. lunaria*, which appears to be restricted in North America to Canada, Alaska, and Greenland. Löve, Löve, & Kapoor (1971) described “yellow plants from Graymont” (Bakerville, CC) as *B. lunaria* subsp. *occidentalis*. Conspicuously yellow plants collected in 2008 from the site proved to have the genotype and morphology of *B. minganense*.

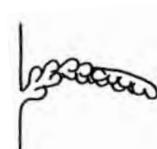
- 20b. Fresh plants green to yellow-green, lustrous; pinnae \pm round without abrupt differentiation between outer and side margins, basal pinnae often asymmetrical with lower half of the outer margin extended outward and downward; sporophore stalk at maturity less than the length of the trophophore; basal sporophore branches \pm spreading and twisted so that sporangia point outward or downward. **B. tunux** Stensvold & Farrar [Yakutat Tlingít, honoring *Tunux*, a legendary Native Alaskan warrior who in 1805 initiated an attack on a Russian fort in Alaska, resulting in permanent European abandonment], MOOSEWORT [referring to the resemblance in some plants of the lower pinnae to palms of moose antlers], **Plate 2**. Scattered open sites, mostly subalpine, along the Continental Divide from Rocky Mountain National Park, GA, to Monarch Pass, CF, and near Gothic, GN. The glistening character of fresh material and rounded pinnae are usually distinctive. In Colorado, *B. tunux* often occurs with *B. lineare*, and hybrids have been found at Avery Peak; these appear to be fertile and may represent a new allotetraploid taxon.



20a



20b



- 21a. [9] Lobes of basal pinnae divergent (like spread fingers); upper pinnae and lobes of lower pinnae narrowly elliptic-elongate with mostly acute apices ($< 90^\circ$).....(22)
- 21b. Lobes of basal pinnae parallel to convergent (not spreading); upper pinnae and lobes of lower pinnae ovate with mostly obtuse apices ($> 90^\circ$)(23)



basal



upper

21a



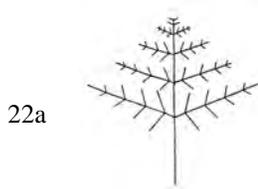
basal



upper

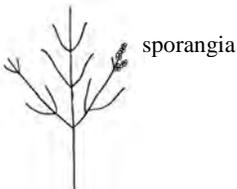
21b

- 22a. Trophophore broadly triangular or pentangular in outline, \pm as long as broad; lustrous dark green when fresh; sporophore ternately branched; sporangia bright yellow before spore release. **B. lanceolatum** (S. G. Gmelin) Ångström subsp. **lanceolatum**, TRIANGLE MOONWORT (see lead 7a).
- 22b. Trophophore ovate to narrowly triangular in outline, longer than broad; somewhat lustrous to dull green when fresh; sporophore usually pinnately branched; sporangia dull yellow before spore release. **B. echo** W. H. Wagner [for the tendency of the species to reflect the characteristics of other similar species], ECHO MOONWORT, **Plate 2**. Widespread in the mountains. Lower pinnae often have a small lower lobe like a mitten thumb. *Botrychium echo* varies greatly from having all pinnae elliptic and unlobed to having all pinnae well-dissected with deep lobing. The former can be differentiated from once-pinnate fan-leaved species by having pinnae that are broadest near the middle rather than at the outer margin. Robust forms with complex lobing can be differentiated from *B. pinnatum* by the narrowness of their lobes, some of which diverge at wider angles than found in *B. pinnatum*.



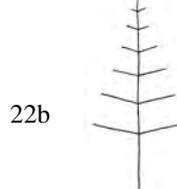
22a

trophophore



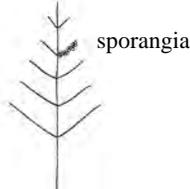
sporophore

sporangia



22b

trophophore



sporophore

sporangia

- 23a. Fresh trophophore lustrous green; all but the uppermost pinnae dissected or lobed on both the upper and lower margins; sporophore pinnately divided; common stalk, if not entirely green, uniformly maroon toward the base. **B. pinnatum** St. John [for the pinnate (non-ternate) branching of the sporophore], NORTHWESTERN MOONWORT, **Plate 2**. Infrequent in forest openings of the mountains, sometimes grassy or seepage influenced. All *Botrychium boreale* reports from North America (except Greenland) are now recognized as *B. pinnatum*.
- 23b. Fresh trophophore weakly to distinctly glaucous blue-green, not lustrous; pinnae above the basal pair often entire or shallowly dissected (often only on the lower margin); sporophore ternately divided; common stalk, if not entirely green, with a maroon stripe extending downward from the base of the trophophore.....(24)



23a



23b

- 24a. [7, 23] Trophophore slightly to distinctly stalked; basal pinnae ovate (not parallel sided) in outline, asymmetrically enlarged on lower side. **B. hesperium** (Maxon & R. T. Clausen) W. H. Wagner & Lellinger [Greek, *Hesperia*, "land of the West," for its former consideration as a Western subspecies of *B. matricariifolium*], WESTERN MOONWORT, **Plate 2**. Widespread in the mountains. We include large plants with strongly overlapping pinnae that previously have been referred to as "*fenestratum*."
- 24b. Trophophore usually sessile; basal pinnae oblong (parallel sided except at tip) in outline, symmetrical. **B. "michiganense"** *sp. nov. ined.* [for the state where its taxonomic status was first demonstrated by Herb and Florence Wagner], MICHIGAN MOONWORT, **Plate 3**. An undescribed, primarily Eastern species known in our area only from mountain meadows and open woodlands in the Black Hills.



24a



24b

Occurrence of *Botrychium* in the Coverage Area

Scientific Name	AZ	CO	NE	NM	SD	UT	WY
<i>B. ascendens</i>		X				M?	M
<i>B. campestre</i>		X	X		X		X
<i>B. echo</i>	M	X		X		M	
<i>B. gallicomontanum</i>					X		
<i>B. hesperium</i>	M	X		X		M	X
<i>B. lanceolatum</i> green phenotype		X		X			X
<i>B. lanceolatum</i> red phenotype	M	X		X		M	M
<i>B. lineare</i>		X		X	X	M	X
<i>B. lunaria</i> var. “ <i>crenulatum</i> ”	M?	X				X	M
<i>B. “michiganense”</i>					X		X
<i>B. minganense</i>	M	X		X	X	M	X
<i>B. “neolunaria”</i>	M	X		X	X	M	X
<i>B. pallidum</i>					X		X
<i>B. paradoxum</i>		X				M?	X
<i>B. pinnatum</i>		X		X		M	M
<i>B. “redbank”</i>		X		X	X		X
<i>B. simplex</i> var. <i>compositum</i>							X
<i>B. simplex</i> var. <i>simplex</i>		X	X	X	X	M	X
<i>B. spathulatum</i>		X					M?
<i>B. tunux</i>	M?	X		X			M?
Total taxa 20	7?	16	2	11	9	11?	18?

X = confirmed genetically at Iowa State University

M = not confirmed genetically, but morphological identification based on reviewed specimens is unequivocal

M? = unconfirmed: morphological identification based on reviewed specimens is less reliable

SD occurrence is for the southwest quadrant. *Botrychium* is not known from KS or OK.

We ignore data based solely on broad distribution descriptions/maps in regional floras and *Flora of North America* (1993).

BOTRYPUS Michaux 1803 [Greek, *botry*, bunch of grapes (derivation as with *Botrychium*), from resemblance of the sporangia to clusters of grapes]. RATTLESNAKE-FERN [from similarity of the terminal segments of the sporophore to a rattlesnake tail]

Botrypus and *Sceptridium* in our area are often readily identified by their generally larger size and are separated from one another by different points of attachment of their sporophores.

One species in North America, **B. virginianus** (L.) Michaux [for colonial Virginia, where the plant was first identified]. Only one or two extant sites (several other sites apparently historic), with very few plants, in cool, moist ravines of the foothills west of Colorado Springs, EP, and Boulder, BL. The most widespread family member on the continent, being present in nearly all states and Canadian provinces. (*Botrychium*.)

OPHIOGLOSSUM L. 1753 [Greek, literally snake-tongue, from resemblance of the sporophore tip].

ADDER'S TONGUE

Two species could occur in Colorado: the Southeastern *O. engelmannii* Prantl [for physician-botanist George Engelmann], LIMESTONE ADDER'S TONGUE, known in adjacent states south and east of Colorado, and a Northern species, *O. pusillum* Rafinesque [Latin, *pusillus*, very small, perhaps alluding to its concealment by surrounding vegetation], NORTHERN ADDER'S TONGUE, known in our coverage area only from northwest Wyoming. The former should be searched for in low-elevation moist areas influenced by limestone, while the latter should be searched for in organic-rich soils along margins of mid-elevation ponds and *Carex* fens; any find would be significant. Chromosome numbers in *Ophioglossum* reach over 1200, the highest known in all vascular plants!

SCEPTRIDIUM Lyon 1905 [Greek, *sceptrum*, from resemblance of the sporophore to a scepter or staff].

GRAPE-FERN [from resemblance of the sporangia to clusters of grapes]. See discussion under *Botrypus* regarding genera differentiation.

One species in our coverage area, **S. multifidum** (S. G. Gmelin) M. Nashida ex Tagawa [for the multi-dissected trophophore], LEATHER GRAPE-FERN [referring to the thick, tough trophophore texture]. Infrequent, fens and streamside meadows, montane to subalpine. The only species in our treatment in which two green leaves may be seen at the same time, early in the growing season before the overwintering leaf from the previous season has decomposed; hence another common name for the genus, EVERGREEN GRAPE-FERN. Some individuals in Colorado populations are relatively small (trophophores 2-6 cm wide) and less dissected. Surveying in fall, when graminoids are senescent and straw-colored, greatly aids detection of the erect, still-green leaf. (*Botrychium*.)

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GLOSSARY

Acute terminating in a sharp or well-defined point.

Apex (plural Apices) the tip, the point farthest from the point of attachment.

Allotetraploid having four complete sets of homologous chromosomes resulting from interspecies hybridization followed by chromosome doubling; a plant with such a condition.

Axis an imaginary line running lengthwise through the center of an organ such as a flower or stem.

Basal pinnae (Basal pinna pair) the lowermost pair of pinnae, closest to the common stalk. See Plate 1.

Blade the flat, expanded portion of a leaf. See Plate 1 for pinna blade.

Cleft technically, deeply cut, usually at least half-way to the middle or base, especially when the sinus is sharp. In this treatment, “cleft” is used for species with fan-shaped pinnae when the cutting simply takes a wedge out of the fan, *i.e.*, a piece of a pie is missing. If cleft segments were fused, they would make a round margin. As used here, clefts can be deep or shallow. Examples of taxa that tend to have cleft pinnae are *B. ascendens* and *B. lineare*. Compare to *lobed*.

Common stalk the stalk below the junction of the sporophore and trophophore. See Plate 1.

Compound divided into a number of similar parts, as the leaflets of compound leaves.

Convergent tending to come together, merging.

Crenate with a scalloped margin of coarse, rounded teeth.

Crenulate with very small rounded teeth along the margin.

Cuneate wedge-shaped, with the narrow part at the point of attachment, usually referring to the base of a leaf.

Cut (Cutting) referring to the presence of dissection or division.

Decurrent referring to the bases of leaves or pinnae continuing down the stem or rachis beyond the point of attachment.

Diploid having two complete sets of homologous chromosomes; a plant with such a condition.

Dissected cut into lobes or lobe-like segments.

Divergent spreading apart.

Divided cut to the base or midrib into lobes or segments. As applied to ferns and fern allies, including Ophioglossaceae, “divided” is a generic term meaning “dissected” and includes pinnate (cut to midrib) and pinnatifid (cut into lobes without divisions reaching the midrib) divisions.

Elliptic ellipse shaped, broadest in the center and narrower at the two equal ends.

Elongate drawn out, lengthened.

Entire undivided; the margin continuous, not incised, lobed or toothed.

Glaucous having a bloom or whitish covering, usually waxy, on the stem or leaf. This may disappear if the plants are heated, dried, or saturated.

Lamina (plural Laminae) see Blade.

Lanceolate long and narrow, but broadest at the base and gradually tapering to the apex.

Lobe a division or segment of an organ. Technically, cut in not over half-way to the middle or base, the sinuses and apex of segments rounded.

Lobed bearing lobes. In this treatment, “lobed” is used for species with fan-shaped or pinnate pinnae in reference to segments with rounded ends. If lobed segments were fused, they would make a scalloped, not rounded, margin. As used here, lobes can be deep or shallow. Examples of lobed species include *B. manganense* and *B. pallidum*, as well as all twice-pinnate species (although one might make an argument for *B. lanceolatum* being cleft). Compare to *cleft*.

Lustrous shiny or glistening, glossy.

Margin the edge, as in the edge of a leaf blade. See Plate 1.

Midrib the central rib or vein of a leaf or other organ.

Oblong two to four times longer than wide and the sides parallel or nearly so.

Obtuse blunt or rounded at the tip.

Ovate egg-shaped in outline and broadest at the base.

Pallid pale.

Palmate having veins, lobes or segments which radiate from a single point, as in maple leaves.

Petiole the stalk to a pinna. See Plate 1.

Pinna (plural Pinnae) a primary division of the trophophore. Pinnae may be further divided into pinnules and again into pinulules. See Plate 1.

Pinna span the width of a fan-shaped pinna at its distal (outer) margin, measured in degrees of a circle, estimated by imagining a circle with the point of pinna attachment at its center. See Plate 1.

Pinnate having veins, lobes, or divisions in the form of a feather, *i.e.*, with one main axis having lateral offshoots.

Pinnule a division of a pinna (*i.e.*, a pinna lobe).

Rachis the main axis of the sporophore or trophophore above the common stalk. See Plate 1.

Reticulate forming a network; net-veined.

Scalloped a series of semi-circles or curves resembling the edge of a scallop; with such a margin.

Segment a division or part of a pinna.

Sessile lacking a stalk.

Simple not compound.

Spatulate oblong, but narrowed at the base, like a spatula.

Sporangium (plural Sporangia) structure containing spores. See Plate 1.

Sporophore the fertile, spore-bearing portion of the leaf. See Plate 1.

Stalk an unexpanded, unbranched supporting structure. See Plate 1 for common, pinna, sporophore, and trophophore stalks.

Ternate compounded into more or less equal divisions or groups of three.

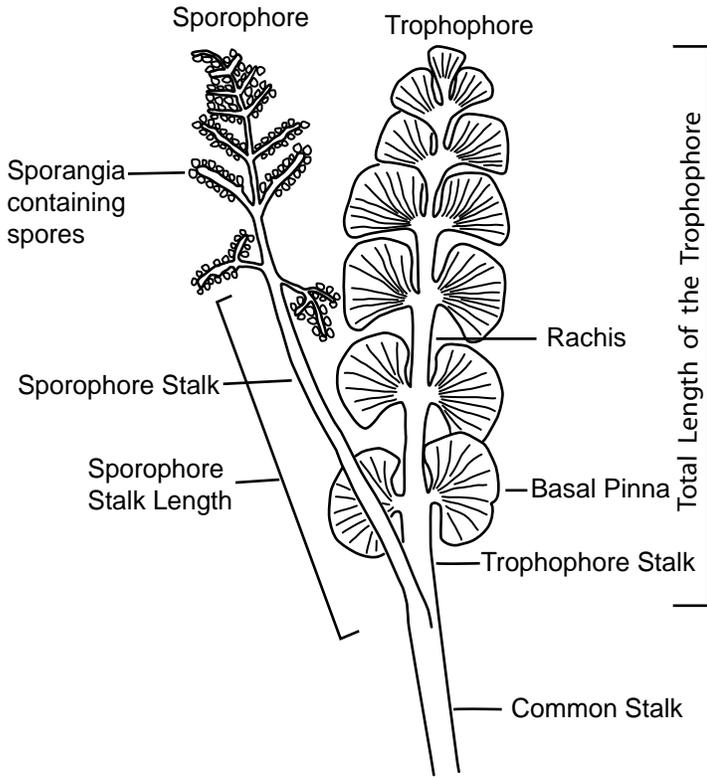
Tetraploid having four complete sets of homologous chromosomes; a plant with such a condition.

Toothed with small lobes or teeth along the margin.

Trophophore the sterile, foliaceous portion of the leaf. See Plate 1.

Undulate gently wavy; with such a margin.

Parts of a Botrychium Leaf



Parts of a Pinna

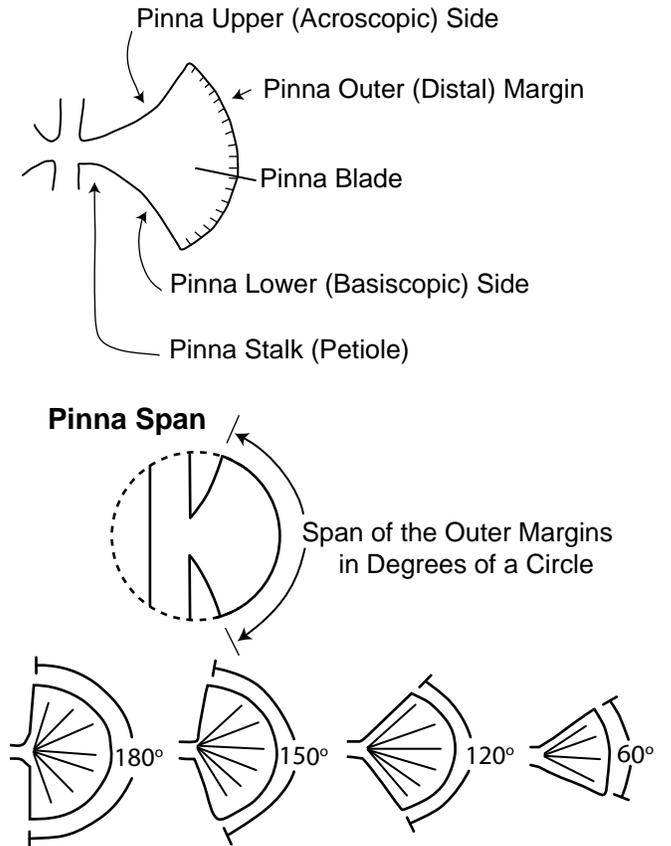


Plate 2

Silver City Workshop

Selected Botrychium Species



B. paradoxum



B. lineare



B. ascendens



B. minganense



B. "redbank"



B. tunux



B. echo



B. hesperium



B. pinnatum

Plate 3

Selected Botrychium Species



B. lanceolatum (red)



B. lanceolatum (green)



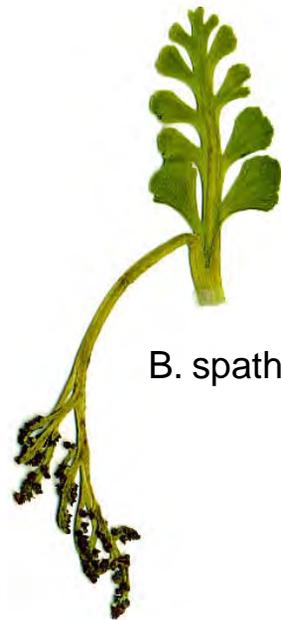
B. "michiganense"



B. "neolunaria"

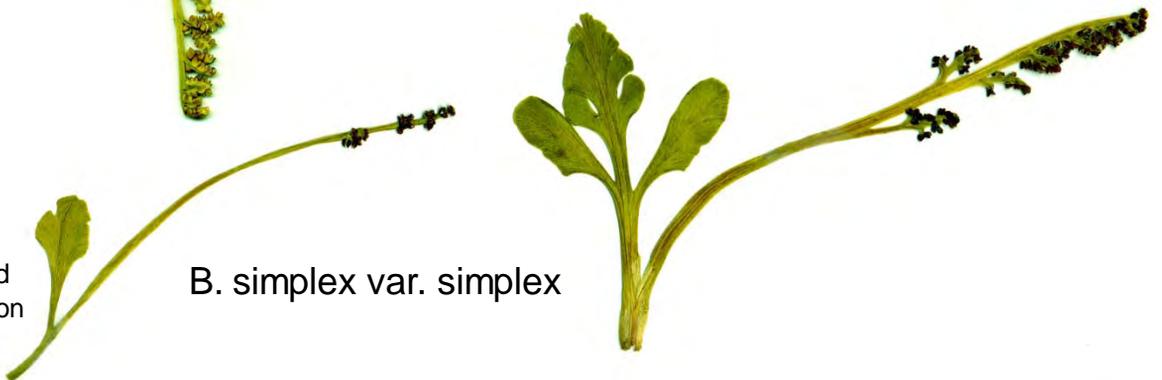


B. lunaria var. "crenulatum"



B. spathulatum

Reduced
Expression



B. simplex var. simplex