

Key revised to incorporate recently published species (*B. furculatum*, *B. rubellum*) and nomenclatural changes (*B. campestre* var. *lineare*), update parentage of several allotetraploid taxa based on recent information, and correct errors in parentage of several allotetraploid taxa from prior revisions. Revised January 13, 2025.

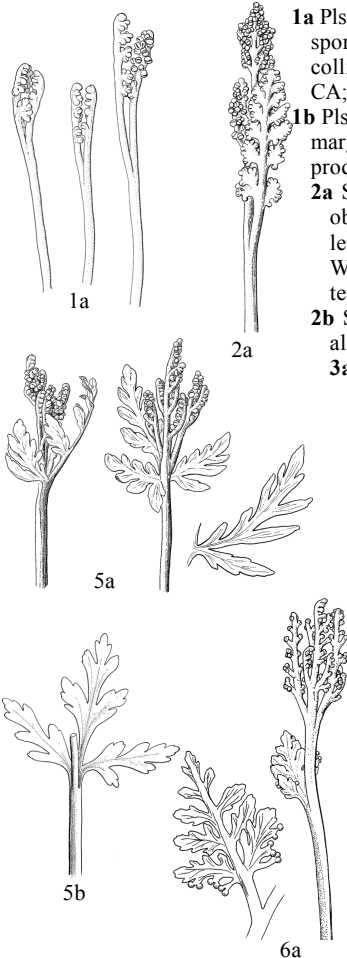
References: Stensvold, M.C. and D.R. Farrar. 2024. A new diploid moonwort, *Botrychium rubellum* (Ophioglossaceae), in the lanceolatum complex of the genus *Botrychium*. American Fern Journal 114(1):49–56.

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Botrychium Sw. Moonwort

Pls glab; lf solitary; trophophore gen pinnately or ternate-pinnately compound to dissected, seldom simple or absent; veins free, forked, terminating near lf margin; sporophore pinnate to decompose; sporangia ∞ , gen short-stalked and free; gemmae sometimes present at st base. (Gr *botrys*, bunch of grapes).

A difficult group of cryptic taxa consisting of diploids and allotetraploids (ploidy and putative parentage is noted below for tetraploids); not all individuals can be reliably identified by morphology. Many of our spp. occur in mesic, mont to subalpine meadows or meadowlike settings among per, herbaceous vegetation, esp with spp. of Asteraceae (e.g., *Antennaria*, *Taraxacum*, *Achillea*) and Rosaceae (e.g., *Fragaria*, *Potentilla*), or in moist, shaded duff beneath mature *Thuja plicata* or *Calocedrus decurrens*. All are obligately mycorrhizal. Multiple spp. often co-occur in a population. Sporophore stalks gradually increase in length prior to spore release; the stalk length is most diagnostic at or after spore release.



1a Pls with two sporophores \pm equal in size and shape (trophophore and lamina absent); sporophore brs rarely > 5 mm; pls gen glaucous; mont to subalpine meadows; seldom coll; RM from s Can to UT, WY and possibly CO, w to c WA, ne OR, and disjunct in CA; paradoxical m.; tetraploid, *B. farrarii* \times ? **1 B. paradoxum** W.H. Wagner

1b Pls with a separate trophophore and sporophore; the trophophore sometimes bearing marginal sporangia but then gen with at least some lamina present (some spp. rarely produce isolated individuals with two sporophores)

2a Sporangia present and abundant on margins of all pinnae; trophophore narrowly oblong, stalked, with oblong, unlobed to slightly lobed pinnae; sporophore stalk $<$ length of trophophore; pls glaucous; grassy, mont meadows; known only from Waterton Lakes NP, to be expected in nw MT and ne WA; Waterton m.; sterile tetraploid hybrid of 1×7 **2 B. \times watertonense** W.H. Wagner

2b Sporangia absent from pinnae margins or confined to lower-most pinnae, if occ also on upper pinnae then pls otherwise not as above

3a Middle and basal pinnae ovate or lanceolate (widest at or below midlength and narrowing to the tip), pinnately lobed (rarely entire in very small pls) with pinnate venation

4a Trophophore broadly triangular or pentagonal in outline, ca as wide as long; pinnae lobes gen acute and not overlapping; sporophore usually ternately br, stalk $1/2$ or less length of trophophore at spore release

5a Basal pinnae curved upwards and asymmetrically lobed with the basal lobe closest to the common stalk disproportionately enlarged; common stalk maroon-tinged or -striped; pls dull green or yellow-green in life; mesic subalpine meadows; AK and Yukon to Cas of WA, and through RMS to NM, disjunct in Greenl; red triangle m. **3 B. rubellum** Farrar & Stensvold

5b Basal pinnae \pm straight and symmetrically lobed, with basal lobes not disproportionately enlarged; common stalk entirely green; pls glossy, deep green in life; mesic mont or subalpine meadows to open for or thickets; throughout w mts from AK to OR and NM, occ e to Norway; green triangle m. (*B. l.* subsp. *l.*) **4 B. lanceolatum** (S.G. Gmel.) Ångstr.

4b Trophophore ovate to narrowly triangular in outline, clearly longer than wide; pinnae lobes rounded to acute, sporophore stalk usually $> 1/2$ length of trophophore at spore release

6a Trophophore stalk = to much $>$ distance between 1st and 2nd pairs of pinnae; pinnae \pm rhomboidal, the tips and lobes gen angular; pls gray-green in life, strongly glaucous; common stalk with a reddish stripe below trophophore; sporangia often present on lower pinnae; sporophore gen ternately br; mesic, mont meadows to dense for; uncommon; AK s to n WA, ne OR, n ID, and nw MT, rarely to CA and e Can; stalked m.; tetraploid, ancestral no $4 \times B.$ **5 B. pedunculatum** W.H. Wagner

6b Trophophore sessile or the stalk < distance between 1st and 2nd pairs of pinnae (rarely = to slightly >, but then other characters not as above)

7a Pls lustrous grass-green, not glaucous; pinnae symmetrically lobed, gradually reduced in size upwards; sporophore gen pinnately br; trophophore gen sessile; common stalk green or with faint uniform maroon tinge; moist subalp meadows to closed for, often near seeps; AK s in RM to NM, w to OM and Cas of WA, ne OR, and CA; nw m. (*B. boreale* misapplied, *B. b. var. obtusilobum*); tetraploid, 4×13

6 B. pinnatum H. St. John

7b Pls pale green to gray-green, often glaucous; middle and upper pinnae gen asymmetrically lobed (lobes larger on lower side) or occ nearly entire; basal pinnae occ much enlarged; sporophore gen ternately br

8a Basal pinnae asymmetrically lobed (lobes larger on lower side), often not much larger than the gradually reduced middle and upper pinnae; trophophore short- to long-stalked; common stalk often with a reddish stripe below trophophore; pls gray-green in life, gen glaucous; mesic, often gravelly, mont to subalp meadows; seldom coll; AK s in RM to AZ and NM, w to ne OR and Cas of WA; w m.; tetraploid, $3 \times B. pallidum$

7 B. hesperium (Maxon & Clausen) Wagner & Lellinger

8b Basal pinnae \pm symmetrically lobed, often much larger than the gen abruptly reduced middle and upper pinnae; trophophore sessile to short-stalked; common stalk green (rarely with faint reddish stripe); pls pale green in life, faintly glaucous; mesic mont meadows; seldom coll; c Alta and s BC to ne WA, nw MT, WY, and SD, e to GL and Que; MI m.; tetraploid, ancestral $4 \times B. pallidum$

8 B. michiganense W.H. Wagner ex A.V. Gilman, Farrar, & Zika

3b Middle (and gen also the basal) pinnae fan-shaped, wedge-shaped, or linear (widest near the tip or with sides parallel); margins entire or palmately lobed with palmate or parallel venation (or rarely the trophophore simple); basal pinnae occ elongate and pinnately lobed in robust pls

9a Trophophore and sporophore joined at or below ground level (occ 1–2 cm above ground in *B. pumicola* or very small pls of *B. simplex*); basal pinnae on large pls gen elongate and pinnately lobed, replicating central axis

10a Sporophore stalk at spore release < trophophore, gen stout with numerous brs; trophophore sessile or with stalk to 1 cm; common stalk well developed but gen hidden below ground; pls strongly glaucous in life, \pm leathery; sparsely vegetated, rocky soils derived from pumice, with subsurface moisture; seldom coll; high Cas, Deschutes Co, OR, s to Mt Shasta, CA; pumice m.

9 B. pumicola Underw.

10b Sporophore stalk at spore release much > trophophore, slender and lax, with brs often in small cluster at tip; trophophore stalk to 3 cm; common stalk gen very short, scarcely extending past the lf sheath; pls grass-green to glaucous, herbaceous; mont to subalp in moist meadows; circumboreal, s to s CA, NM, and NC; least m.; 2 weak vars.

10 B. simplex E. Hitchc.

a1 Pinnae gen with an angular junction between side and outer margins, narrowly attached to rachis; upper pinnae (and terminal lobes of basal pinnae) \pm distinct; moist meadows, stream banks, and lakeshores; BC s in mts to CA, ID, and CO

var. **compositum** (Lasch) Milde

a2 Pinnae gen with a rounded junction between side and outer margins; upper pinnae (and terminal lobes of basal pinnae) gen broadly attached and strongly decurrent, often confluent; margins of seeps and fens; e WA s in e OR to CA, e to RMS, ne US, e Can; Eurasia

var. **simplex**

9b Trophophore and sporophore joined well above ground level on an exposed common stalk; basal pinnae rarely elongate or pinnately lobed

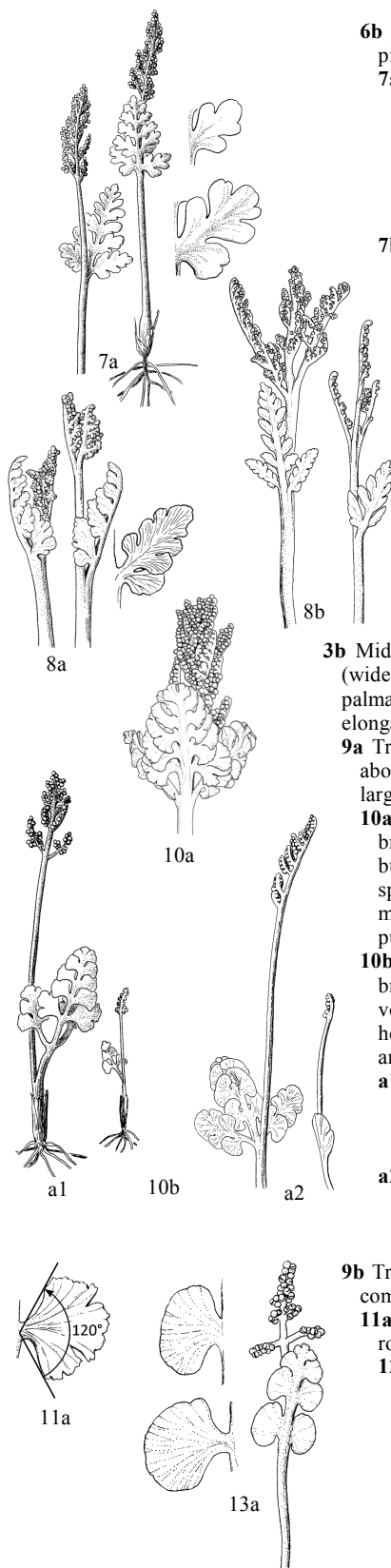
11a Basal pinnae (and often also the middle pinnae) broadly fan-shaped or rounded, the sides spanning an angle of 120° – 180° or more

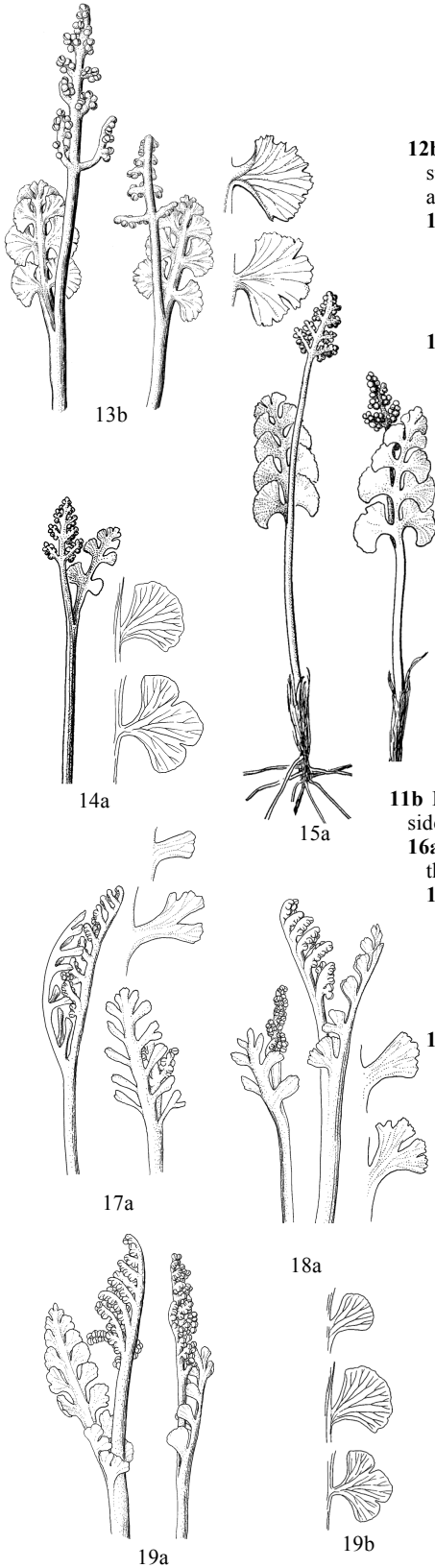
12a Pinnae in (2)3–4(5) pairs, gen all spreading at ca right angle to rachis; sporophore stalk at spore release gen \leq trophophore; sporophore brs widely spreading; pls glossy green to yellow-green

13a Pinnae margins entire to smoothly cleft; basal pinnae (and gen also the upper) strongly rounded, often with lower half enlarged; trophophore sessile to short-stalked; subalp meadows and scree; se AK and nw Can, s sporadically in w mts to CA, NV and NM; moosewort

11 B. tunux Stensvold & Farrar

13b Pinnae margins finely crenulate or lacerate (often also cleft); pinnae all





fan-shaped, with an abrupt angle between outer and side margins, gen symmetric; trophophore gen stalked; edges of mont fens, wet meadows, or seeps, often in dense vegetation or shade; seldom coll; chiefly e Cas, n BC to CA, e to MT, WY, CO, and rarely to MN and ON; dainty or crenulate m. 12 **B. crenulatum** W.H. Wagner

12b Pinnae in 3–7 pairs, the middle and upper ones ascending; sporophore stalk at spore release gen \geq trophophore (occ $<$); sporophore brs gen ascending; pls grass-green to deep green, or pale green

14a Trophophore often stalked; middle and upper pinnae well-spaced or occ overlapping, \pm narrowly fan-shaped (sides usually forming an angle of $< 90^\circ$), proximal margins spreading to ascending, distal margins gen ascending; tetraploid derived in part from no 13, with intergrading characters (see lead 23b) 21 **B. minganense** Vict.

14b Trophophore gen sessile; middle and upper pinnae gen overlapping, all \pm evenly and broadly fan-shaped (sides gen forming an angle of 90° – 120°), proximal margins gen widely spreading to descending, distal margins erect and \pm parallel to rachis

15a Spores 33–39 μm (pls diploid); pls grass-green; middle and upper pinnae fan-shaped, often ascending with the proximal margin widely spreading-descending and distal margin erect (\pm parallel to rachis); sporophore with brs often in small flaglike cluster at tip; mesic, mont to subalp meadows and vegetated scree; widespread in n N Am, south to CA and NM; common m. (*B. lunaria* misapplied, *B. l.* var. *l.* of 1st ed.) 13 **B. neolunaria** Stensvold & Farrar

15b Spores 43–48 μm ; our pls otherwise scarcely separable from no 13, but tending to be darker green with more broadly fan-shaped, spreading middle and upper pinnae with margins more equally angled relative to rachis, and sporophore with the br portion larger and less flaglike; mesic, subalp to alp meadows and vegetated scree slopes in our area; seldom coll in our area; coastal AK and boreal N Am s, in mts, to ne OR, CA, MT, and WY; giant or Yakutat m.; tetraploid, $13 \times$ *B. onondagense*

14a Basal pinnae parallel-sided, wedge-shaped, or narrowly fan-shaped, the sides spanning an angle of $< 90^\circ$ – 120° , or the trophophore simple

16a Trophophore sessile, the basal pinnae attached immediately adjacent to the junction of trophophore and sporophore

17a Sporophore stalk at spore release $\leq 1/3$ length of trophophore; pinnae lobes linear to very narrowly wedge-shaped, the span of unlobed pinnae $< 45^\circ$ – 60° ; outer pinnae margins \pm truncate; subalp meadows and scree, or rarely under *Thuja plicata*; widespread but seldom coll; AK s in mts to CA and NM, e to MN and Que; slender m.; ours var. **lineare** (W.H. Wagner) Farrar 15 **B. campestre** W.H. Wagner & Farrar

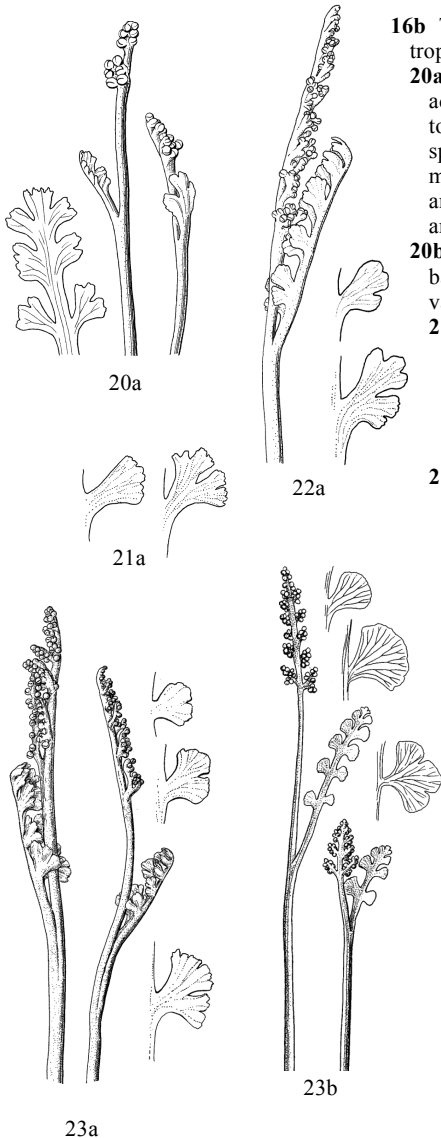
17b Sporophore stalk at spore release $> 1/3$ as long as trophophore; pinnae and pinnae lobes narrowly wedge-shaped to fan-shaped, the span of unlobed pinnae often $> 45^\circ$; outer pinnae margins various

18a Pinnae gen strongly ascending, wedge- or narrowly fan-shaped, gen with \pm truncate outer margins, often \pm sharply toothed, the lower pinnae often also sharply cleft with 2 or 4 \pm lobes; basal pinnae often with marginal sporangia; pls pale green to green; mont to subalp meadows; seldom coll; AK s in mts to CA and CO, occ e to ne N Am; upswept m.; tetraploid, 12×15 16 **B. ascendens** W.H. Wagner

18b Pinnae fan-shaped to spatulate or occ wedge-shaped, gen either with a rounded junction between outer and side margins, or the outer margin entire or with rounded lobes, the lobes gen 3 or 5 or irregular in no; basal pinnae gen lacking sporangia; pls gen green

19a Pinnae broadly spatulate with a gently rounded junction between outer and side margins, outer margin often with rounded scalloping or shallow lobes, occ entire; sporophore stalk at spore release gen $\leq 1/2 \times$ as long as trophophore; mont to subalp meadows; seldom coll; AK s in RM to MT (GNP), e to e Can and VT; spatulate m.; tetraploid, $15 \times$ *B. lunaria* 17 **B. spathulatum** W.H. Wagner

19b Pinnae wedge-shaped to fan-shaped, gen with an abrupt angle between outer and side margins, gen entire or the lower ones with 3 or 5 large lobes; sporophore stalk at spore release gen $1/2$ – $2 \times$ as long as trophophore (see lead 23b) 21 **B. minganense** Vict.



16b Trophophore stalked, the basal pinnae attached above junction of trophophore and sporophore

20a Middle and upper pinnae gen rhombic with \pm parallel sides, broadly adnate to rachis, often strongly confluent, outer margin \pm truncate, often toothed; trophophore stalk gen $1/4-1/2+$ total trophophore length; sporophore stalk at spore release $(1/2-)$ $1-2 \times$ as long as trophophore; moist duff under *Thuja plicata* or *Calocedrus decurrens*, occ also fens and moist subalp meadows; se AK to CA, mostly in and e Cas, e to n ID and nw MT; w goblin m., mt m. **18 B. montanum** W.H. Wagner

20b Pinnae gen wedge-shaped or fan-shaped, the sides rarely parallel, the base not so broadly attached, rarely strongly confluent, outer margin various; trophophore and sporophore stalk lengths various

21a Pinnae gen strongly ascending, wedge- or narrowly fan-shaped, gen with \pm truncate outer margins, often \pm sharply toothed, the lower pinnae often also sharply cleft with 2 or 4 \pm lobes; basal pinnae often with marginal sporangia; sporophore stalk at spore release gen \leq (occ $>$) trophophore; pls pale green to green (see lead 18a)

16 B. ascendens W.H. Wagner

21b Pinnae ascending to spreading, variously shaped but rarely as above, often with outer margin or lobes entire or rounded; basal pinnae gen lacking sporangia; sporophore stalk length various

22a Sporophore stalk at spore release ca $1/2 \times$ as long as trophophore; Pinnae \pm mitten-shaped, asymmetrically divided into longer upper lobes and shorter lower lobes; basal pinnae no larger than middle pinnae; grassy meadows and prairies; scattered and seldom coll; GNP, w SD, and MN; Frenchman's Bluff m.; tetraploid, $15 \times$ *B. pallidum*

19 B. gallicomontanum Farrar & Johnson-Groh

22b Sporophore stalk at spore release gen $(1/2-)$ $1-2 \times$ as long as trophophore, if occ shorter then pinnae not mitten-shaped with longer upper lobe; basal pinnae often largest

23a Pls gen pale green to whitish-green; pinnae wedge-shaped to irreg mushroom-shaped, entire or 2-8 (even) lobed, upper lobe occ largest; sporophore and trophophore stalks often \pm sigmoidal; dry to mesic, mont to subalp meadows and scree; seldom coll; s Alta to nw MT, s in RM to NM; forked m.; tetraploid, *B. farrarii* \times *B. pallidum*

20 B. furculatum Popovich & Farrar

23b Pls gen gen grass-green; pinnae wedge-shaped to fan-shaped, entire or 3 or 5 (odd) lobed, the middle lobe gen largest; sporophore and trophophore stalks \pm straight, forming a narrow V; mesic, mont to subalp meadows, seeps, and duff under *Thuja plicata*; widespread in boreal N Am, s in mts to CA and NM, e to ne N Am, Iceland; Mingan m. (*B. lunaria* var. *onondagense* misapplied); tetraploid, *B. farrarii* \times 13; highly variable

21 B. minganense Vict.

Treatment Metadata:

Family: Ophioglossaceae

Authors: Ben Legler

Comments:

Key revised to incorporate recently published species (*B. furculatum*, *B. rubellum*) and nomenclatural changes (*B. campestre* var. *lineare*), update parentage of several allotetraploid taxa based on recent information, and correct errors in parentage of several allotetraploid taxa from prior revisions. Revised January 13, 2025.

Illustrations:

None needed.

References: Stensvold, M.C. and D.R. Farrar. 2024. A new diploid moonwort, *Botrychium rubellum* (Ophioglossaceae), in the lanceolatum complex of the genus *Botrychium*. *American Fern Journal* 114(1):49–56.