

apex broadly obtuse to sharply acute or occasionally acuminate; costa sometimes short-excurrent as a mucro or rarely ending a few cells below apex, adaxial outgrowths absent, adaxial cells elongate, occasionally short-rectangular to quadrate near apex, in 2–3 rows, abaxial cells elongate; transverse section oval to reniform, adaxial epidermis absent to weakly developed, adaxial stereid band absent, guide cells 2–4 in 1 layer, hydroid strand absent, abaxial stereid band strong, semicircular to ovate in section, abaxial epidermis usually distinct; basal cells differentiated in a small group at base of costa, short-rectangular, little wider than distal cells, 2–4:1, usually thick-walled; distal medial cells subquadrate, occasionally elongate transversely or longitudinally, (5–)7–9(–15)  $\mu\text{m}$  wide, 1(–2):1(–2), papillae either massive, multifurcating and centered over lumens or simple to 2-fid, cell walls thin to greatly thickened, superficially flat to bulging. **Specialized asexual reproduction** rare, by gemmae in axils of leaves. **Sexual condition** dioicous; perigonia and perichaetia terminal on short lateral branches, interior perichaetial leaves convolute-sheathing, ovate-acuminate, 1–1.5 mm, laminal cells shortly rhomboidal to near apex. **Seta** yellow-brown, 0.3–0.8 cm, twisted clockwise proximally, occasionally counterclockwise distally. **Capsule** yellow-brown to brown, ovoid to elliptic, 0.5–1(–1.5) mm, exothecial cells rectangular, walls thin, annulus of two rows of weakly vesiculose cells; operculum long-rostrate, 0.4–0.6(–1.8) mm, cells in straight rows; peristome teeth absent. **Calyptra** cucullate, 1.2–1.5 (–2) mm, smooth. **Spores** 9–12(–19)  $\mu\text{m}$ , weakly to strongly papillose, light brown. **KOH laminal color reaction** yellow to yellow-orange.

Species 47 (3 in the flora): worldwide except Antarctica, especially tropical, arctic and montane regions.

*Anoetangium* is distinguishable from *Molendoa*, a morphologically similar genus also having very short perichaetia-bearing branches arranged laterally on the axis, by its often triangular stem section, constant lack of a ventral costal stereid band, the leaves keeled by a deep adaxial groove along the costa, and the nonglaucous color in nature. *Hymenostylium* has similarly though not as deeply keeled leaves with elongate cells on the adaxial surface, but has terminal perichaetia, lacks a stem central strand, and medial laminal cells are commonly longitudinally elongated. *Amphidium* species are similar in appearance but the sexual condition is autoicous (*A. lapponicum*) or papillae are simple and elliptical (*A. mougeotii*). Species of *Zygodon* may be distinguished by the simple, isolated papillae, not obscuring the lumens. Although the lack of an adaxial stereid band helps separate *Anoetangium* from robust specimens of *Gymnostomum* and *Molendoa*, variation in expression of this trait requires other traits for distinguishing small forms.

1. Gemmae abundant in leaf axils; leaves ligulate to short-elliptic or ovate, very short, 0.4–0.5(–0.6) mm . . . . . 3. *Anoetangium handelii*
1. Gemmae absent; leaves lanceolate to linear or nearly ligulate, longer, usually 1–2 mm.
  2. Leaves distant on the stem, exposing it, short-lanceolate to nearly ligulate, not wasp-waisted; leaf apex narrowly to broadly acute, apiculus short-triangular; costa percurrent in distal leaves into a clear, sharp cell . . . . . 1. *Anoetangium aestivum*
  2. Leaves dense and hiding the stem, long-lanceolate to linear-elliptic, constricted above the leaf base; leaf apex narrowly acute to acuminate, apiculus narrowly triangular; costa regularly excurrent into a short or long, stout mucro of several cells . . . . . 2. *Anoetangium stracheyanum*

1. *Anoetangium aestivum* (Hedwig) Mitten, J. Linn. Soc., Bot. 12. 175. 1869



*Gymnostomum aestivum* Hedwig, Sp. Musc. Frond., 32, plate 2, figs. 4–7. 1801; *Anoetangium compactum* Schwägrichen; *A. euchloron* (Schwägrichen) Mitten

Leaves commonly distant and exposing the stem; short-lanceolate to ligulate, (0.4–)1–1.5(–1.8) mm; apex narrowly to

broadly acute, apiculus short-triangular; margins 1-stratose; costa percurrent in distal leaves, ending in a clear, sharp cell. **Specialized asexual reproduction** absent. **Sexual condition** dioicous. **Capsule** 0.5–1 mm, exceeding the theca in length, ovoid, inclined.

Forming deep green cushions on calcareous and noncalcareous rock, sandstone walls, rock ledges, exposed moist crevices, wet areas; 10–3300 m; Greenland; B.C.; Alaska, Ariz., Colo., Wash.; Mexico; West Indies; Central America; South America; Eurasia; Africa; Atlantic Islands; Pacific Islands (Hawaii, New Zealand); Australia.

Plants of *Anoetangium aestivum* often exhibit a comal tuft, and have leaves with multifid or occasionally 2-fid papillae, these dense and obscuring the cell lumens. Specimens from Massachusetts identified as this species are *Hymenostylium recurvirostrum*. Sporophytes are rare in the flora area. Arizona specimens with blunt leaves have been named *A. euchloron*, representing a morphologically somewhat intergrading, wide-ranging tropical variant.

2. *Anoetangium stracheyanum* Mitten, J. Linn. Soc., Bot., suppl. 1: 31. 1859 [F]



*Anoetangium peckii* Sullivant

Leaves dense, hiding the stem, long-lanceolate to linear-elliptical and commonly weakly constricted beyond the short-sheathing base, (1–)1.5–1.8(–2) mm; apex narrowly acute to acuminate, occasionally blunt, apiculus narrowly triangular; margins 1-

stratose; costa regularly excurrent into a short or long, stout mucro of several cells. **Specialized asexual reproduction** absent. **Sporophytes** absent in range of flora.

Calcareous and noncalcareous rock, wet areas, spray of falls; moderate elevations (300–900 m); N.Y., N.C., Ohio, Tenn.; e, c Asia.

*Anoetangium stracheyanum* was previously treated as a synonym of *A. aestivum* (R. H. Zander 1977), but further study indicates that it is a good match for the Asian *A. stracheyanum*, in the weakly wasp-waisted, narrow leaves with a rather strong, commonly multicellular apiculus, and papillose-crenulate or weakly denticulate basal laminal margins. The “wasp-waist” referred to by Asian authors is usually just a hint of constriction just beyond the short-sheathing leaf base, and many leaves are merely straight-sided. Collections from Maine identified as *A. peckii* are *Amphidium mougeotii*.

3. *Anoetangium handelii* Schiffner, Ann. K. K.

Naturhist. Hofmus. 27: 490, figs. 51–59. 1913 [F]



Leaves dense, hiding the stem, ligulate to short-elliptic or ovate, 0.4–0.5(–0.6) mm; apex broadly acute to rarely rounded, apiculus absent or of one cell; margins often 2-stratose in patches; costa usually ending (1–)3–4 cells before apex.

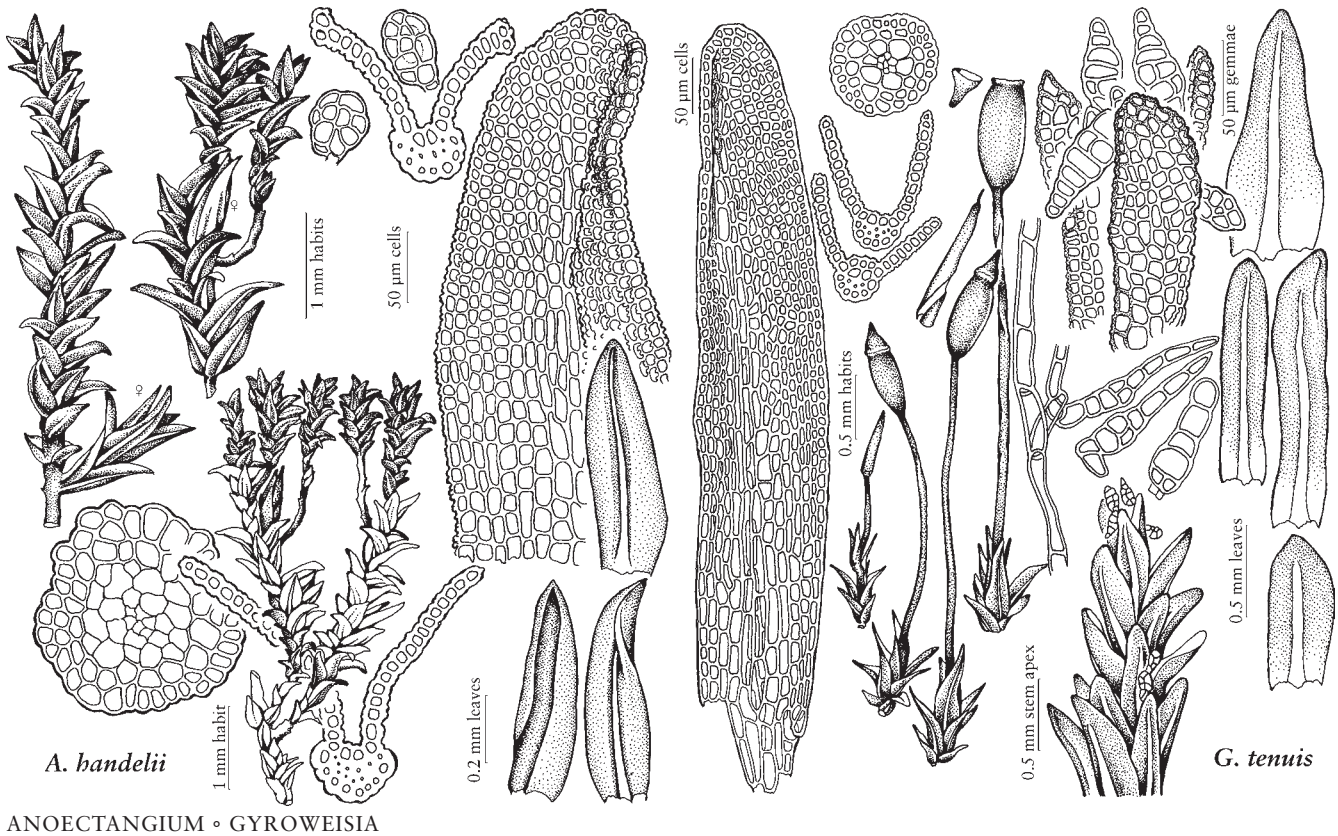
**Specialized asexual reproduction** by ovate gemmae, sometimes

uncommon, occasionally apiculate by a projection, of ca. 8 cells, born on rhizoids in leaf axils. **Sporophytes** unknown.

Fissures in rock, calcareous and noncalcareous sandstone; moderate to high elevations (900–1700 m); Calif., Colo., Nev.; s Europe; sw, c Asia.

*Anoetangium handelii* is quite similar to *Gymnostomum viridulum* in habitat, size, general appearance, and production of axillary gemmae (a morphological phenocopy), but is immediately distinguished by its narrow adaxial costal groove. Though apparently rare (California in Inyo County, Colorado in Boulder and Larimer counties, Nevada in Clark County), its small size and similarity to sterile *Gymnostomum* make *A. handelii* easy for collectors to pass over. C. C. Heyn and I. Hernnstadt (2004b) provided additional discussion of this curious species.

SELECTED REFERENCE Zander, R. H. and W. A. Weber. 2005. *Anoetangium handelii* (Bryopsida, Pottiaceae) in the New World. Bryologist 108: 47–49.



ANOECTANGIUM • GYROWEISIA

11. GYROWEISIA Schimper, Syn. Musc. Eur. ed. 2, 38. 1876, name conserved • [Greek *gyrus*, circle, and genus *Weissia*, alluding to resemblance and well-developed, persistent annulus]

Richard H. Zander

**Plants** gregarious or forming a thin turf, green distally, tan proximally. **Stems** to 0.4[–3] cm, branching occasionally; rounded-pentagonal in transverse section, hyalodermis absent, sclerodermis present as substereids, central strand present or absent; rhizoids few; axillary hairs of ca. 5(–10) cells, the basal 1–2 brownish. **Leaves** appressed-incurved when dry, weakly spreading reflexed when moist; narrowly ligulate or rectangular to long-ovate, adaxial surface nearly flat, 0.25–1.4 mm; base scarcely differentiated to ovate [sheathing]; distal margins plane to weakly recurved, entire, 1-stratose [2-stratose]; apex rounded to rounded acute or obtuse, sometimes apiculate by a sharp cell; costa ending ca. 4[–8] cells below apex [percurrent], adaxial outgrowths absent, adaxial cells elongate in 2–8 rows, abaxial cells elongate; transverse section of costa semicircular to ovate, adaxial epidermis usually present, adaxial stereid band absent or weak, exposed, guide cells 2 in 1 layer, hydroid strand absent, abaxial stereid band present, crescentiform or round in sectional shape, abaxial epidermis present or commonly absent; basal cells differentiated across leaf base in proximal  $\frac{1}{4}$ – $\frac{1}{2}$  of leaf, little wider than distal cells or somewhat bulging [inflated], 3–5:1, walls of basal cells thin to evenly thickened; distal medial cells quadrate or shortly rectangular, ca. 8–11  $\mu$ m wide, 1(–2):1, papillae absent or hollow, simple to indistinctly 2-fid, cell walls thin to evenly thickened, superficially flat to convex. **Specialized**

**asexual reproduction** when present by oval to spindle-shaped gemmae, of several cells, borne on basal rhizoids, green or brown. **Sexual condition** dioicous [autoicous, occasionally heteroicous]; perigonia appear as buds at plant base or terminal, gemmate; perichaetia terminal, inner leaves often strongly sheathing seta, lanceolate, to 1.5 mm, laminal cells often rectangular to rhomboid. **Seta** yellow-brown, ca. 1.5–3[–6] mm, twisted clockwise. **Capsule** yellow-brown, ovate to short-cylindric, [neck differentiated,] 0.8–1 mm, exothecial cells shortly rectangular to rhomboid, thin-walled, annulus of 2–3 rows of highly vesiculose cells, revoluble and deciduous in pieces; operculum short-conic [narrowly rostrate], ca. 0.2–0.3[–0.6] mm, cells in straight rows; peristome teeth absent [16, rudimentary, short, spreading, ligulate or oblong and highly perforate, straight, articulations ca. 3–4, ca. 30–80  $\mu$ m, lightly papillose to closely spiculose, basal membrane low]. **Calyptra** cucullate, ca. 0.7–1[–1.4] mm, smooth. **Spores** ca. 9–11  $\mu$ m, smooth to papillose, light brown. **KOH laminal color reaction** yellow, rarely orange.

Species 6 (1 in the flora): North America, Europe, Asia (China, Middle East), Africa.

*Gyroweisia* species have ligulate leaves with subpercurrent costae and enlarged, hyaline basal cells, a vesiculose annulus, and peristome absent or rudimentary peristome. *Gyroweisia* differs from the similar *Gymnostomum* by the occasional presence of a rudimentary peristome (outside the flora area), the large annulus, sterile plants distinctly smaller than the sporophyte-bearing gametophytes, basal leaf cells differentiated more strongly (often in the basal  $1/4$  to  $1/2$ ), and the more common presence of gemmae.

SELECTED REFERENCES Andrews, A. L. 1922b. The status of *Gyroweisia* in North America. *Bryologist* 25: 97–100. Conard, H. S. 1945. *Gyroweisia reflexa* in North America. *Bryologist* 48: 28–29. Manierre, W. R. 1998. *Gyroweisia reflexa*, a moss new for the United States. *Evansia* 15: 30–31. Mogensen, G. S. and R. H. Zander. 1999. Four moss species new to Greenland: *Barbula amplexifolia*, *Didymodon brachyphyllus*, *D. michiganensis*, and *Gyroweisia tenuis* (Pottiaceae, Musci). *Lindbergia* 24: 77–83. Steere, W. C. 1939. *Gyroweisia tenuis* in North America. *Bryologist* 42: 16–23.

1. *Gyroweisia tenuis* (Schrader ex Hedwig) Schimper,  
Syn. Musc. Eur. ed. 2, 38. 1876 [F]



*Gymnostomum tenue* Schrader ex Hedwig, Sp. Musc. Frond., 37, plate 4, figs. 1–4. 1801

**Plants** scattered or very loosely cespitose. **Stem** to 0.4 cm, central strand absent. **Leaves** 0.25–1 (–1.4) mm, erect to incurved when dry, spreading when moist, base broadened in lower  $1/3$ – $1/2$ , long-rectangular; margins entire; costa ending 2–4 cells below the apex, cells of adaxial surface elongate and flat (not bulging), costa in section with 1 or 2 stereid bands or costa homogeneous; distal laminal cells quadrate, with 3–4 irregular to 2-fid papillae, walls thin and evenly thickened, lumens angular; basal cells differentiated across leaf, filling the leaf base; medial cells hyaline to yellowish, smooth or weakly papillose above, 10–12  $\mu$ m wide, 2–4:1, walls thin. **Specialized asexual reproduction** commonly present in sterile material as gemmae in the axils of leaves, elongate, irregularly clavate, short-branching, or spindle-shaped, of mostly 4–10 cells. **Sexual condition** dioicous; perichaetial leaves strongly differentiated and sheathing the seta. **Capsule** lacking peristome, annulus revoluble, operculum short-conic.

Thin soil and in rock crevices, sandstone, calcareous rock; low to moderate elevations (70–1000 m); Greenland; N.W.T., N.S., Ont.; Alaska, Iowa, Mich., Nebr.; Europe; Asia (China, Middle East); n Africa.

*Gyroweisia tenuis* is similar to and often confused with *Gymnostomum aeruginosum* but the latter has elongate leaves that are commonly acute (occasionally apiculate by a single cell), with quadrate to rectangular (but bulging) cells on the adaxial surface of the costa, gemmae are absent, the perichaetial leaves are little differentiated from the cauline or sheathing the seta only in lower  $1/3$  of leaf, the annulus is vesiculose but persistent, and the operculum is long-conic. Specimens from the upper Great Lakes region are generally fruiting and have very short stems. A comparatively long-stemmed specimen lacking sporophytes from Nebraska (Brown County, Churchill 12286, BC, DUKE, MO) has the characteristic narrowly rectangular cauline leaves and immature but strongly differentiated perichaetial leaves of *Gyroweisia tenuis*, and several-celled ovoid or spindle-shaped gemmae arising from axils of terminal leaves of sterile axes. It is distinguished from *Gymnostomum calcareum* by the present of gemmae, and from *Gymnostomum viridulum* by the narrowly rectangular leaves.



**Excluded Species:**

*Gyroweisia pusilla* (Kindberg) Brotherus

This entity was treated as a synonym of *Gymnostomum calcareum* by A. L. Andrews (1922b).

*Gyroweisia reflexa* (Bridel) Schimper

This is a peristomate species known for the flora area previously only from a single collection in Grey County, Owen Sound, Ontario (*Moxley s.n.*, May 1924, CANM). The specimen is indeed that, but H. A. Crum and L. E. Anderson (1981) questioned the report, suggesting a confusion of specimens by Moxley (as reviewed by

W. R. Manierre 1998). The region of the original station, now built over, has been examined by others, but no additional sites discovered. The Michigan collection (MO) reported by Manierre is *Tortula obtusifolia* (Schwägri) Mathieu, which, though similar in the ligulate leaves and rudimentary peristome, differs significantly in the crowded, short-ovate leaves, and the single stereid band and enlarged adaxial superficial cells of the costa in section. Although it would be difficult to demonstrate the absence of this species, given the circumstances it is now appropriate to consider it absent from the New World.

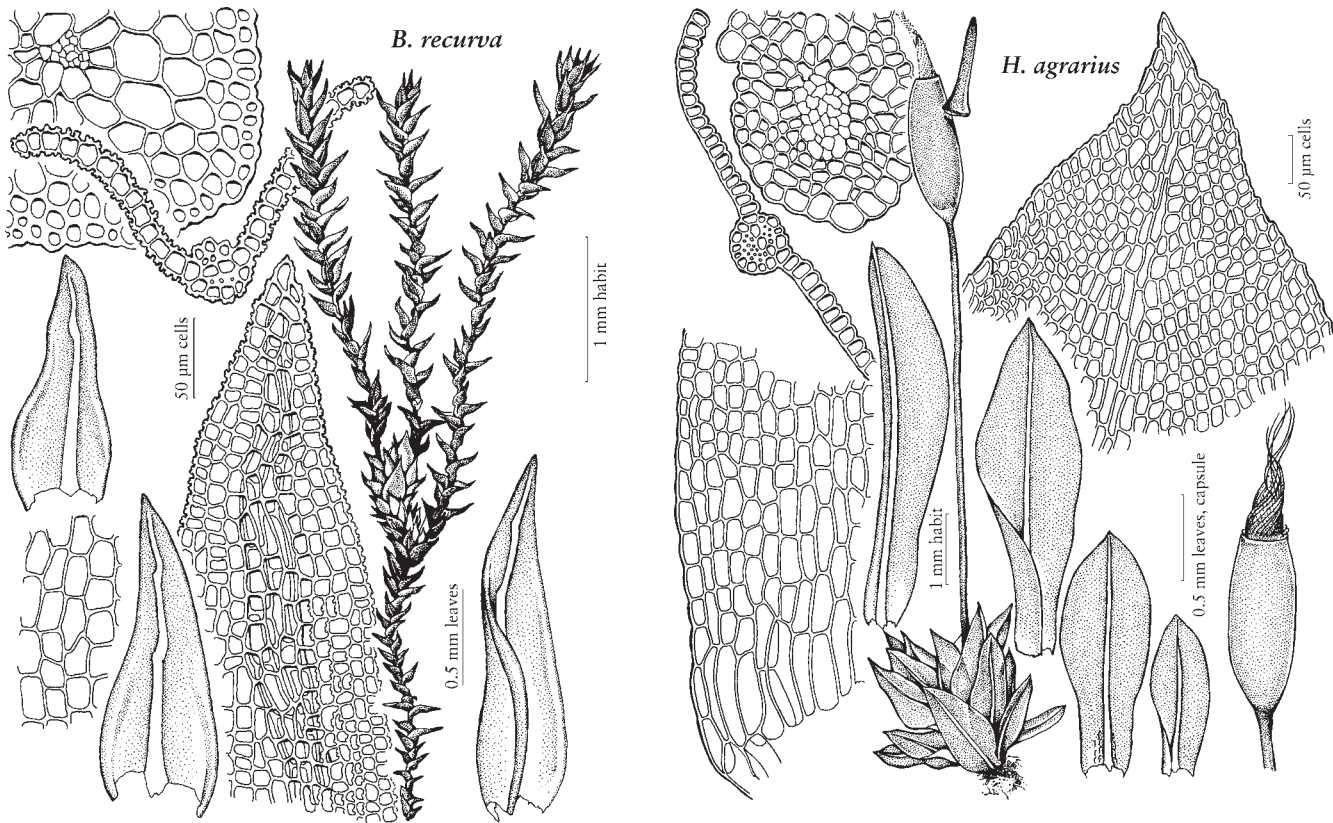
12. BELLIBARBULA P. C. Chen, Hedwigia 80: 222, plate 38. 1941 • [Latin *bellus*, beautiful, and genus *Barbula*]

Patricia M. Eckel

**Plants** in dense turfs, dull yellow-green to red-brown distally, brown or red-brown proximally. **Stems** small, erect, 0.6–3 cm; hyalodermis absent, sclerodermis thick, central strand present; axillary hairs short, 3–4 cells long, the basal 1(–2) cells yellow. **Leaves** incurved and weakly contorted when dry, weakly spreading when moist, short ovate-lanceolate to triangular; base little differentiated or ovate; margins strongly recurved in basal  $\frac{3}{4}$  or nearly throughout, entire, lamina 1-stratose; apex narrow and bluntly acute, sometimes acuminate, occasionally with an apiculus; costa ending before the apex to percurrent, adaxial outgrowths absent, sinuose beyond leaf middle, rather thick, adaxial cells quadrate in 3–4 rows, papillose; transverse section circular or somewhat flattened, adaxial epidermis differentiated, adaxial stereid band moderately developed, guide cells 4–5 in 1 layer, hydroid strand lacking, abaxial stereid band present, abaxial epidermal cells present, semicircular or semi-elliptic; basal cells weakly differentiated medially near the insertion, quadrate to subrectangular, 1(–3):1, walls somewhat thin to evenly thickened; distal laminal cells irregularly hexagonal-quadrate to oval or elliptical, 1:1, 1-stratose, with small, sharp, simple to 2-fid papillae, 4–6 per lumen, thin- to somewhat thick-walled, in section superficially flat to subconvex on both surfaces. **Specialized asexual reproduction** absent. **Sexual condition** dioicous; perigonia at stem apex or as subterminal buds; [perichaetia terminal, distinctive, leaves convolute-sheathing, long-rectangular with an apiculus, to 2 mm. **Seta** 4–6 mm. **Capsule** stegocarpous, theca cylindrical, annulus of highly vesiculate cells, revolvable; operculum short-conic; peristome lacking. **Calyptra** cucullate. **Spores** 15–18  $\mu\text{m}$ .] **Laminal KOH color reaction** red.

Species 2 (1 in the flora): e North America, Mexico, South America (Bolivia), Asia (China, the Himalayas, India).

*Bellibarbula recurva* has recently been removed from *Bryoerythrophyllum*. As originally described by Chen, *Bellibarbula* was separated from other genera in the Barbuleae by the ovate-lanceolate leaves, undifferentiated or scarcely differentiated leaf bases, papillose distal laminal cells, eperistomate capsule and convolute-sheathing perichaetial leaves. It is separable from *Barbula* by the color reaction to KOH of the distal laminal cells: yellow or orange in *Barbula*, red to brick-red in *Bellibarbula*. The sinuose costa in the distal part of the leaf differentiates *Bellibarbula* from *Bryoerythrophyllum*.



BELLIBARBULA • HYOPHILADELPHUS

1. *Bellibarbula recurva* (Griffith) R. H. Zander, Bull. Buffalo Soc. Nat. Sci. 32: 142. 1993 [F]



*Gymnostomum recurvum* Griffith, Calcutta J. Nat. Hist. 2: 482. 1842;  
*Bryoerythrophyllum recurvum* (Griffith) K. Saito

**Stems** occasionally branched in robust specimens, often exposed between subdistant leaf bases; rhizoids few at stem base. **Leaves** somewhat remote on stem, 0.8–

1.5(–2) mm; margin variously broadly channeled to strongly or weakly recurved in proximal  $\frac{3}{4}$ ; apex flat or some leaves somewhat keeled, often ending in a single pellucid cell, some apices occasionally flexed sideways with the sinuose costa; costa sinuose beyond leaf middle, rather thick, papillose on both surfaces; laminal cells 10–13  $\mu\text{m}$  wide, sharply papillose. **Perigonia** gemmate, at the tips of stems or terminating innovations in series along a developing stem, leaves larger than stem leaves, broadly ovate-lanceolate and clasping the antheridia. **Perichaetiate plants and sporophytes** not known in area of the flora.

Thin soil over moist rock in protected mountain stations, forested gorges, coves, cliffs, along streams and by waterfalls; moderate elevations (600–900 m); N.C., S.C.; Mexico; South America (Bolivia); Asia (the Himalayas, s India).

In the flora area *Bellibarbula recurva* is known only from four counties in western North Carolina, and one station in western South Carolina. One specimen examined was perigoniate; all remaining material seen was sterile. The characters that distinguish this species are the sinuous distal costa, the nearly quadrate basal cells, and the red laminal coloration. *Bryoerythrophyllum ferruginascens*, another species rare in the flora area and known from the Appalachians, is very similar but differs by its more elongate basal cells, propagula on the rhizoids and costa straight throughout. *Didymodon vinealis*, a species or species group with an almost entirely western distribution, is separated by its straight costa and a deep apical groove to the apex within which lies an epapillose costal surface with elongate cells; *Bellibarbula recurva* has a flattened apex with quadrate, papillose cells on the costal ventral surface.

13. HYOPHILADELPHUS (Müller Hal.) R. H. Zander, *Bryologist* 98: 372. 1995  
 • [Genus *Hyophila* and Greek *adelphus*, brother]

Richard H. Zander

*Barbula* sect. *Hyophiladelphus* Müller Hal., *Syn. Musc. Frond.* 1: 604. 1849; *Barbula* subg. *Hyophiladelphus* (Müller Hal.) R. H. Zander

**Plants** loosely cespitose to gregarious, blackish green distally, brown proximally. **Stems** very short, to 0.2 cm, central strand present, sclerodermis absent, hyalodermis absent; axillary hairs 2–3 cells long, all hyaline. **Stem leaves** appressed when dry, weakly spreading when moist to rosulate, oblong, 1.2–2 mm, elliptic or spatulate, distal lamina broadly channeled to deeply concave, margins plane, entire; apex broadly acute; base oblong or not differentiated, alar region often enlarged and bulging; costa percurrent to shortly and stoutly excurrent, adaxial superficial cells elongate, (2–)4 rows of cells across costa adaxially at mid leaf, costal transverse section oval to circular, two stereid bands present, adaxially small, epidermis differentiated adaxially, present or occasionally absent abaxially, guide cells 2 in 1 layer, hydroid strand absent, distal laminal cells subquadrate to subrectangular, occasionally rhomboid, walls thin, occasionally evenly thickened, superficially adaxially bulging, abaxially flat, (8–)11–13(–15) mm wide, 1–2:1; papillae absent; proximal cells differentiated across leaf in a small area or up to  $\frac{1}{3}$  leaf length, alar cells often sharply bulging, proximal cells rectangular and curved. **Specialized asexual reproduction** absent. **Sexual condition** dioicous. **Perichaetia** terminal, interior leaves ovate, weakly sheathing in proximal  $\frac{1}{2}$ – $\frac{2}{3}$ , proximal cells rhomboid. **Seta** 0.4–1 cm. **Theca** (0.3–)1–1.7 mm, cylindric to elliptic, annulus deciduous, revoluble, 1–2 rows of strongly vesiculose cells; peristome teeth of 32 narrow rami, filamentous, 500–1200  $\mu\text{m}$ , twisted counterclockwise, operculum long-conic. **Calyptra** cucullate. **Spores** small, 9–11  $\mu\text{m}$ . **Distal laminal KOH color reaction** strongly yellow orange, occasionally medium orange.

Species 1: se United States, Caribbean region and bordering areas.

*Hyophiladelphus* has been segregated from *Barbula* and placed first in the Pottioideae (R. H. Zander 1995), then back into Barbuloideae (Zander 2006). *Barbula* sect. *Agrariae* Steere in Grout is an illegitimate name that has been used for this taxon. The gametophytes of this genus have a distinctive combination of broad leaves and two stereid bands in the costa.

SELECTED REFERENCE Zander, R. H. 1995. Phylogenetic relationships of *Hyophiladelphus* gen. nov. (Pottiaceae, Musci) and a perspective on the cladistic method. *Bryologist* 98: 363–374.

1. *Hyophiladelphus agrarius* (Hedwig) R. H. Zander, *Bryologist* 98: 372. 1995 [F]



*Barbula agraria* Hedwig, *Sp. Musc. Frond.*, 116. 1801

**Stems** densely rhizoidiferous. **Leaf** margins occasionally weakly serrulate near apex, occasionally 2-stratose on margins or medial portion of the lamina, marginal cells rhomboid and thick-walled near apex, proximal laminal cells

20–25  $\mu\text{m}$  wide, 2–4:1, walls thin. **Interior perichaetial leaves** ca. 1.5 mm. **Seta** red-brown, twisted clockwise

proximally, often also counterclockwise distally. **Theca** red-brown, commonly sulcate, peristome teeth with many articulations, twisted 1.5–2 times, proximal membrane 45–100  $\mu\text{m}$  in height, granulate to spiculose, operculum 0.8–1.5 mm, cells twisted counterclockwise. **Calyptra** smooth, 1.4–2.1 mm. **Spores** light brown, weakly papillose.

Sporophytes mature through much of the year, but mainly winter (Jan–Feb). Low areas, limestone and masonry walls, shady, moist areas; Ala., Fla., Ga., S.C., Tex.; Mexico; West Indies; Central America (Guatemala); South America (Brazil).

*Hyophiladelphus agrarius* grows as a low crust, often with cyanobacteria. Characters affording immediate recognition are the ovate leaves with distal laminal cells bulging adaxially, two stereid bands in the costa, and the

peristome twisted. Curiously, though common in Florida, it is not found in the Atlantic counties of that state according to R. S. Breen (1963).

14. BARBULA Hedwig, Sp. Musc. Frond., 115. 1801, name conserved • [Latin *barba*, beard, and *-ula*, diminutive, alluding to peristome]

Richard H. Zander

**Plants** loosely cespitose or forming cushions, yellowish brown, brown or blackish distally, yellowish brown to reddish brown proximally. **Stems** short to elongate, to 2(–3.5) cm; hyalodermis rarely present, sclerodermis present, central strand present; axillary hairs short to elongate, all cells almost always hyaline. **Leaves** appressed incurved to weakly spreading, often contorted or twisted about stem, occasionally catenulate when dry, spreading when moist; ligulate or broadly lanceolate to long-triangular, adaxial surface usually deeply grooved along costa, occasionally broadly concave; base weakly differentiated to broadened and somewhat sheathing, proximal margins sometimes narrowly decurrent; margins usually recurved in proximal  $\frac{1}{2}$ – $\frac{2}{3}$ , occasionally plane throughout, entire or occasionally weakly denticulate near apex; lamina 1-stratose; apex rounded to obtusely acute, usually mucronate, occasionally entire or apiculate; costa percurrent to shortly excurrent as a sharp mucro, occasionally ending a few cells before the apex, adaxial outgrowths absent, adaxial cells elongate, occasionally quadrate to short-rectangular, in 2–3(–5) rows; transverse section ovate to semicircular, adaxial epidermis differentiated, adaxial stereid band usually present, usually small, guide cells 2–4 in 1 layer, hydroid strand occasionally present, abaxial stereid band present, usually strong, semi-lunar in sectional shape, abaxial epidermis usually present but weakly differentiated; basal cells differentiated across leaf or reaching higher medially or occasionally marginally, rectangular, usually little wider than the distal cells, 3–5:1, walls of proximal cells thin to evenly thickened; distal medial cells quadrate, usually 1:1, 1-stratose; papillae hollow or solid, multiplex to 2-fid, 2–3 per lumen, occasionally simple or absent, cell walls thin to evenly thickened, superficially bulging on both free sides. **Specialized asexual reproduction** by tubers borne on proximal rhizoids or gemmae borne on axillary stalks. **Sexual condition** dioicous or possibly sometimes rhizautoicous. **Perichaetia** terminal, interior leaves sometimes strongly sheathing, little differentiated or ovate to long-lanceolate, laminal cells usually rhomboid in proximal  $\frac{1}{2}$ – $\frac{3}{4}$ . **Seta** 0.5–2.5 cm. **Capsule** stegocarpous, theca ovate to long-cylindric, annulus weakly differentiated to strong, of 1–3 rows of vesiculose cells, sometimes revoluble or deciduous in pieces; operculum usually long-conic; peristome teeth of 32 narrow rami, filamentous to narrowly triangular, usually strongly twisted counterclockwise. **Calyptra** cucullate. **Spores** mostly 8–12  $\mu$ m. **KOH laminal color reaction** yellow, occasionally yellowish orange.

Species ca. 200 (6 in the flora): worldwide in temperate zones.

*Barbula* has been much reduced in size. K. Saito (1975) presented cogent reasons for recognizing *Didymodon* as distinct. Characters of importance in distinguishing *Barbula* are: axillary hairs almost always entirely of hyaline cells; leaf adaxially usually deeply grooved along the costa; distal laminal cell papillae rough, knobby, obscuring the lumens, and protuberant



along the distal laminal margins; costa usually excurrent as a sharp mucro or an apiculus of one or more clear cells; peristome is long and twisted, and as Saito (1975) pointed out, *Barbula* has gemmae generally larger than those of *Didymodon*. The three sections are represented in the flora area: sect. *Barbula*, including *B. unguiculata* and *B. orizabensis*; sect. *Convolutae* Bruch & Schimper (*Streblotrichum* P. Beauvois), including *B. amplexifolia*, *B. convoluta*, and *B. indica*; and sect. *Hydrogonium* (Müller Hal.) K. Saito [*Hydrogonium* (Müller Hal.) A. Jaeger], including *B. bolleana*. For many taxa previously long-held in *Barbula*, see 16. *Didymodon*.

SELECTED REFERENCES Steere, W. C. 1939b. *Barbula* in North America north of Mexico. Bull. Torrey Bot. Club 66: 93–119. Zander, R. H. 1994i. *Barbula*. In: A. J. Sharp et al., eds. The moss flora of Mexico. Mem. New York Bot. Gard. 69: 286–296.

- 1. Leaves rather flaccid when wet, distal laminal cells 11–15 µm, often lax, quadrate to rectangular, not or weakly papillose ..... 6. *Barbula bolleana*
- 1. Leaves usually firm when wet, distal laminal cells 7–12 µm, firm, quadrate, usually distinctly and strongly papillose.
  - 2. Abaxial costa surface cells doubly prorate (i.e., with both ends of rectangular superficial cells protruding) near apex, often with coarse mammillae in rows across the costa; leaf base widened but not sheathing ..... 4. *Barbula indica*
  - 2. Abaxial costa surface cells with crowded, simple or occasionally 2-fid, hollow or solid papillae or smooth, seldom distinctly prorate near apex (and if so then papillae scattered); leaf base weakly sheathing (leaf base strongly sheathing only in *B. amplexifolia*).
    - 3. Costa percurrent or ending before the apex; leaf apex entire or apiculate by a smooth or weakly papillose conical cell; specialized asexual reproduction when present by tubers on proximal rhizoids, or if by axillary gemmae then gemmae large and single in the axils; perigoniophores very short-stemmed ..... 3. *Barbula convoluta*
    - 3. Costa short-excurrent as a mucro or if percurrent, then leaf acuminate; specialized asexual reproduction when present by multiple axillary gemmae; antheridiate plants long-stemmed.
      - 4. Leaves triangular-lanceolate, margins plane or rarely recurved at mid leaf, leaf base long-oblong and sheathing; abaxial surface of costa smooth or rarely with prorulae; costal hydroids absent; gemmae usually present, on stalks in leaf axils ..... 5. *Barbula amplexifolia*
      - 4. Leaves long-ligulate or ovate-lanceolate, margins strongly but narrowly recurved or revolute in proximal half of leaf or to near apex, leaf base short-oblong, widened but not sheathing; abaxial surface of costa with simple papillae; costal hydroids present; gemmae absent or present.
        - 5. Leaf apex obtuse to broadly acute, margins recurved in proximal 1/2–2/3, rarely to near apex; gemmae always absent ..... 1. *Barbula unguiculata*
        - 5. Leaf apex abruptly rounded to emarginate, margins recurved to near apex; gemmae spheric, on stalks in leaf axils ..... 2. *Barbula orizabensis*

**1. *Barbula unguiculata*** Hedwig, Sp. Musc. Frond., 118. 1801



*Barbula unguiculata* var. *apiculata* (Hedwig) Bruch, Schimper & W. Gümbel

**Stems** 1–2 cm. **Leaves** firm when wet, long-ligulate to broadly lanceolate from an oblong base, 1–2.5 mm, base often oblong and widened, not strongly sheathing, margins recurved in the proximal

1/2–2/3, rarely to near apex or plane, apex broadly acute to rounded; costa excurrent as a short or long mucro, seldom muticous, abaxial costal surface with scattered

solid papillae, hydroids present; distal laminal cells firm-walled, quadrate, 8–12 µm wide, 1:1, papillose. **Specialized asexual reproduction** absent. **Perichaetial leaves** weakly differentiated. **Seta** 1–2.5 cm. **Theca** 1–2.5 mm. **Spores** 8–11 µm.

Capsules mature in winter and early spring, occasionally summer or fall. Soil, sand, gravel, sandstone, granite, limestone, walls, roadcuts, paths, lawns, ditches; low to high elevations (50–2700 m); Alta., B.C., N.B., Nfld. and Labr. (Nfld.), N.W.T., N.S., Ont., P.E.I., Que., Sask., Yukon; Ala., Alaska, Ariz., Ark., Calif., Colo., Conn., Del., D.C., Fla., Ga., Idaho, Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Mass., Mich., Minn., Miss., Mo., Mont., Nebr., N.J., N.Mex., N.Y., N.C., N.Dak., Ohio,

Okla., Pa., R.I., S.Dak., Tenn., Tex., Utah, Vt., Va., Wash., W.Va., Wis., Wyo.; Mexico; Central America; South America; Europe; Asia; n Africa; Australia.

*Barbula unguiculata* is common in eastern North America and Europe, and elsewhere in the North and South Temperate zones, but rare in the tropics and the Arctic, with, for instance, only two known sites in Mexico and a single one north of the Arctic tree line. The leaves are often blackened. Forms with strongly mucronate leaf apices have been referred to var. *apiculata* though modern authorities generally treat this as a form. *Barbula indica* is often confused with this species, but differs immediately in the leaves conduplicate but not contorted when dry, with plane or weakly recurved margins, and prorate abaxial surface of the costa. *Barbula convoluta* is similar but has plane margins, costa not excurrent as a mucro and seta yellow rather than reddish brown.

2. *Barbula orizabensis* Müller Hal., *Linnaea* 40: 638. 1876



**Stems** 1.5–2.5 cm. **Leaves** firm when wet, long-ligulate to broadly lanceolate from an oblong base, 1.5–2 mm, base oblong but not strongly sheathing, margins recurved or revolute to apex or nearly so, apex broadly acute to rounded; costa excurrent as a stout mucro, abaxial costal surface with

scattered solid papillae, hydroids present; distal laminal cells firm-walled, quadrate, 7–9  $\mu\text{m}$  wide, 1:1, papillose. **Specialized asexual reproduction** by spheric or occasionally elliptic gemmae on stalks in leaf axils, 30–35  $\mu\text{m}$  long. [Perichaetial leaves weakly differentiated, antheridiate plants long-stemmed. **Seta** 0.9–1.5 cm. **Theca** 1–2.5 mm. **Spores** 8–11  $\mu\text{m}$ .]

Disintegrating rock; moderate to high elevations (1000–2000 m); Ariz.; Mexico; West Indies.

In the flora area, *Barbula orizabensis* is known only from Santa Cruz County, Penna Dam, I. Haring 11984, 15 Feb. 1957 (CANM). This species replaces *B. unguiculata* at approximately the Mexican border. The presence of gemmae is apparently constant and will best distinguish it from the latter species.

3. *Barbula convoluta* Hedwig, *Sp. Musc. Frond.*, 120. 1801 [F]

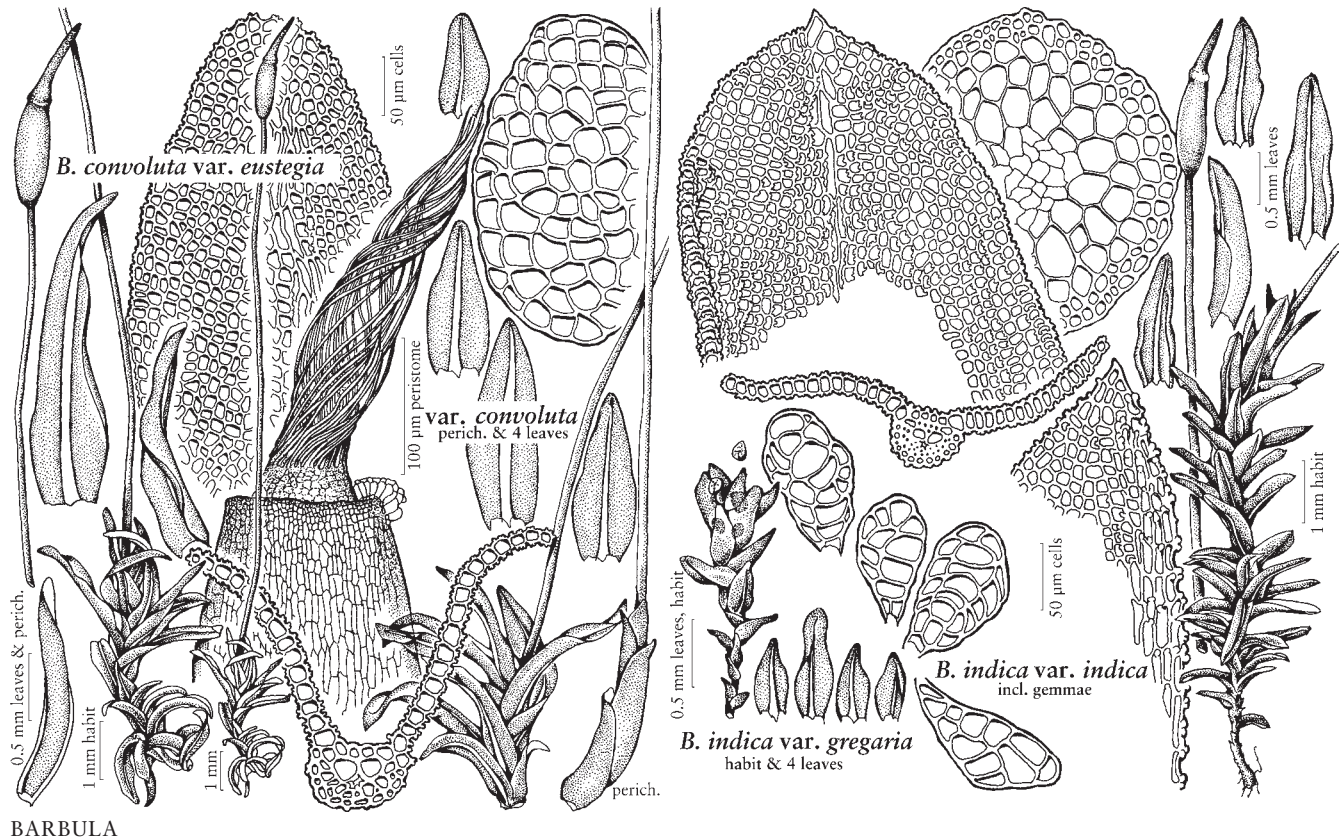


**Stems** to 1–1.5 cm. **Leaves** firm when wet, long-ligulate to broadly lanceolate from an oblong base, seldom ovate, 1–1.7 mm, base often elliptic, widened not strongly sheathing, margins plane or weakly recurved in proximal  $\frac{1}{3}$ , apex broadly acute to rounded, entire or apiculate; costa ending 1–

6 cells before the apex, rarely excurrent, abaxial costal surface with scattered solid papillae, hydroids absent; distal laminal cells firm-walled, quadrate, 8–10  $\mu\text{m}$  wide, 1:1, papillose. **Specialized asexual reproduction** by large, spheric to elliptic, red-brown tubers born on an often dense mass of rhizoids buried in soil, 100 to 250  $\mu\text{m}$  long, or in var. *gallinula* by large gemmae, 120–250  $\mu\text{m}$ , occurring usually singly in leaf axils. **Perichaetial leaves** obtuse to broadly acute strongly sheathing and convolute; antheridiate plants short-stemmed (to 2 mm), appearing as buds on soil at base of archegoniate plants. **Seta** 1–1.8 cm. **Theca** 0.8–1.2 mm. **Spores** 10–12  $\mu\text{m}$ .

Varieties 6 (3 in the flora): North America, Central America, Eurasia, Africa, Pacific Islands (New Zealand).

The yellow seta, mostly plane margins, and large tubers, when present, buried in the soil, and the operculum commonly as long as the theca readily distinguish *Barbula convoluta* from the similar *B. unguiculata*. *Bryoerythrophyllum ferruginascens* also has tubers, but the lamina is red in KOH solution. The small antheridiate plants that appear as buds on the soil indicate the possibility of rhizautoicy, as noted by A. Casares-Gil and A. Caballero (1919–1932, vol. 2), but, because they are usually grouped, they may have been generated on protonema of a separate spore. This is one of the few species of the family to fruit in the Arctic. When sterile, *Barbula convoluta* may be quickly distinguished from the hygrophile *Gymnostomum aeruginosum* by its leaves very deeply keeled distal to mid leaf, and leaf tips more commonly reflexed and more broadly acute or rounded. *Barbula convoluta* differs from *B. indica* by its simple papillae on the abaxial surface of the costa and the commonly papillose clear cell of the apiculus, when present. *Syntrichia amplexa* is occasionally mistaken for *B. convoluta* but is immediately identified by its recurved leaf margins and red color in KOH. Although var. *eustegia* is clearly a western taxon, attempting to ascribe North American sterile collections to either var. *eustegia* or the typical variety (or fertile collections to any European variety with consistency in character combination) is presently futile (R. H. Zander 1997).



BARBULA

1. Leaves ovate; specialized asexual reproduction as very large, oval gemmae in axils of distal leaves ..... 3c. *Barbula convoluta* var. *gallinula*
1. Leaves long-ligulate to broadly lanceolate, seldom ovate; specialized asexual reproduction as spheric tubers on proximal rhizoids buried in soil.
2. Perichaetial leaves highly differentiated, strongly sheathing the seta, apex obtuse to rounded and laminal cells mostly rhomboid and smooth throughout .....  
..... 3a. *Barbula convoluta* var. *convoluta*
2. Perichaetial leaves weakly differentiated, more loosely sheathing the seta, apex abruptly acute to subulate and laminal cells often quadrate and papillose in distal 1/4 .....  
..... 3b. *Barbula convoluta* var. *eustegia*

3a. *Barbula convoluta* Hedwig var. *convoluta* [F]



*Barbula closteri* Austin; *B. convoluta* var. *obtusata* Müller Hal. & Kindberg

**Specialized asexual reproduction**, when present, as spheric tubers on proximal rhizoids buried in soil. **Perichaetial leaves** highly differentiated, closely sheathing, apex obtuse to rounded and

laminal cells mostly rhomboid and smooth throughout.

Capsules mature spring–summer (Mar–Aug, Jun). Rock, soil, sand, thin soil on rock, gravel, lava, cement, often associated with limestone or dolomite, bricks and mortar, walls, stumps, woods, fields; low to high elevations (10–3300 m); Greenland; Alta., B.C., Man., N.B., Nfld. and Labr. (Nfld.), N.S., Ont., Que., Sask., Yukon; Ala., Alaska, Ariz., Ark., Calif., Colo., Fla., Ga., Idaho, Ill., Ind., Kans., Ky., La., Maine, Md., Mass., Mich., Minn., Miss., Mo., Mont., N.H., N.J., N.Mex., N.Y., N.C., N.Dak., Ohio, Okla., Oreg., Pa., S.C., S.Dak., Tenn., Vt., Va., Wash., W.Va., Wis.; Central America; Eurasia; Pacific Islands (New Zealand).

Fruiting specimens of var. *convoluta* with characteristic perichaetial leaves are not uncommon in the far West,



and are often robust in stature. The Illinois record is from J. A. McCleary and P. L. Redfearn Jr. (1979). Many collections cited from Florida are actually *Barbula indica*.

**3b. *Barbula convoluta* var. *eustegia*** (Cardot & Thériot) R. H. Zander, *Bryologist* 100: 520. 1998

[E] [F]



*Barbula eustegia* Cardot & Thériot, *Bot. Gaz.* 30: 17, plate 4, fig. 1. 1900; *B. chrysopoda* Müller Hal. & Kindberg; *B. whitehouseae* H. A. Crum

**Specialized asexual reproduction**, when present, as spheric tubers on proximal rhizoids buried in soil.

**Perichaetial leaves** weakly differentiated, loosely sheathing, apex abruptly acute to subulate and laminal cells often quadrate and papillose in distal 1/4.

Capsules mature late spring, summer–fall (May, Jun, Jul, Oct). Sandy banks, soil, logs, in pine woods, shores; low to high elevations (50–3100 m); B.C.; Calif., Idaho, Ill., Mont., Oreg., Tex., Utah, Wash.

Variety *eustegia* has the same gametophytic characteristics as the typical variety, including perigoniote buds on the soil at the base of the archegoniophores and the large rhizoid-borne tubers in the soil. *Barbula* sect. *Convolutae* in Europe has apparently differentiated into a number of distinct species and varieties, as discussed by K. G. Limpricht ([1884–]1890–1903, vol. 2) and A. Casares-Gil and A. Caballero (1919–1932, vol. 2), most of which, however, are not found in the flora area (R. H. Zander 1979). Plants in the type collection of var. *eustegia* are smaller than average for the species, but other collections (e.g., types of *B. whitehouseae* and *B. chrysopoda*) may have the large size of, e.g., the European var. *commutata* (J. Juratzka) P. T. Husnot. Large plants of any variety growing in mesic environments are more likely to have recurved leaf margins. Although W. C. Steere (1938) and H. A. Crum (1965c) have commented on the similarity of this taxon to the European *B. enderesii* Garovaglio (as *B. flavipes* Bruch & Schimper), specimens of the latter I have seen commonly have narrowly acuminate leaves (but the same small antheridiate plants). Three specimens: Utah, Salt Lake County, *Flowers* 3151, 7291, COLO; and British Columbia, Vancouver Island, *Schofield* 28431, DUKE) are clearly intermediates in the important characters distinguishing between var. *convoluta* and var. *eustegia*.

**3c. *Barbula convoluta* var. *gallinula*** R. H. Zander, *Phytologia* 44: 195, figs. 15–19. 1979 [E]

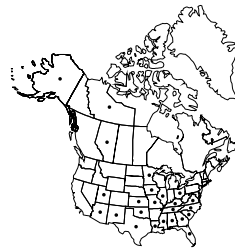


**Specialized asexual reproduction** as very large, oval gemmae in axils of distal leaves. **Sporophytes** absent in range of flora.

Rock, usually limestone, or soil or humus; low to moderate elevations (50–400 m); B.C., N.W.T.; Alaska.

The massive, dark gemmae of var. *gallinula*, occurring usually one per leaf axil, are easily visible under the dissecting microscope and rival the leaves in size. Although the leaf apices of var. *gallinula* are ovate and somewhat cucullate, lacking an apiculus, certain undoubted var. *convoluta* specimens match them; thus the axillary gemmae are needed for sure identification. This taxon is apparently fairly abundant at Virginia Falls on the South Nahanni River, Northwest Territories.

**4. *Barbula indica*** (Hooker) Sprengel in E. G. Steudel, *Nomencl. Bot.* 2: 72. 1824 [E]



*Tortula indica* Hooker, *Musci Exot.* 2: 135. 1819

**Stems** to 1.2 cm. **Leaves** firm when wet, long-ovate to ligulate, 0.5–1.8(–2) mm, base often elliptic, widened not strongly sheathing, margins plane or weakly recurved to mid leaf, apex broadly acute to rounded, apiculate or occasionally mucous; costa percurrent or ending 1–4 cells before the apex, abaxial costal surface doubly prorate (rough by projections at each end of superficial cells), often also with simple or 2-fid papillae, hydroids absent; distal laminal cells firm-walled, quadrate, 7–10 μm wide, 1:1, papillose. **Specialized asexual reproduction** by gemmae borne on stalks in leaf axils. **Perichaetial leaves** obtuse to broadly acute, strongly sheathing and convolute. **Seta** 1–1.8 cm. **Theca** 0.8–1.2 mm. **Spores** 10–12 μm.

Varieties 2 (2 in the flora): North America, Mexico, West Indies, Central America, South America, Asia, Africa, Australia.

Sporophytes of *Barbula indica* are rare in the flora area (collection date of the single fruiting collection seen not given). The distal laminal margins are usually plane and the abaxial surface of the costa is prorate, i.e., papillose by projecting ends of cell walls, often forming doubled projections, but sometimes additionally papillose by simple or 2-fid papillae.



1. Leaves narrowly oval to elliptic, margins plane or weakly recurved at mid leaf; specialized asexual reproduction by small, green, obovoid gemmae occurring in masses in distal leaf axils, of several cells, 70–90  $\mu\text{m}$  . . . . . 4a. *Barbula indica* var. *indica*
1. Leaves broadly ovate, margins plane; specialized asexual reproduction by massive, brown, elliptic to spheric, many-celled gemmae occurring singly or very few together in distal leaf axils, of up to 50 cells, 95–300  $\mu\text{m}$  . . . . . 4b. *Barbula indica* var. *gregaria*

4a. *Barbula indica* (Hooker) Sprengel var. *indica* [F]



*Barbula cancellata* Müller Hal.;  
*B. cruegeri* Müller Hal.

Leaves narrowly oval to elliptic, margins plane or weakly recurved at mid leaf. **Specialized asexual reproduction** by small, green, obovoid gemmae occurring in masses in distal leaf axils, of several cells, 70–90  $\mu\text{m}$ .

Soil, clay, limestone, cement, walls; low to moderate elevations (50–1000 m); N.W.T.; Ala., Alaska, Ariz., Fla., Ga., Ill., Iowa, Kans., Ky., La., Minn., Miss., Mo., N.Mex., N.C., Ohio, Okla., S.C., Tenn., Tex., Utah, Va.; Mexico; West Indies; Central America; South America; Europe (Hungary); Asia; Africa; Pacific Islands (Hawaii); Australia.

Capsules of var. *indica* are rare in the flora area but mature in summer in Mexico. The gemmae are usually small and obovoid, but in some specimens are somewhat enlarged and branching. The typical variety is commonly fruiting; the seta is reddish, unlike that of *Barbula convoluta*, which is yellow. This species is often misidentified as *B. unguiculata* in the southeastern states, but viewed from the side, the abaxial costal papillae form rows across the costa, lined up as they are at both ends of epidermal cells. A hygrophyllic variant may be confused with *B. bolleana* when incrustated with lime but its leaf cells are much smaller. The Alaskan station is clearly of this variety, though the prorulae are poorly developed, being replaced with dense simple to 2-fid papillae; the Northwest Territories specimen is more clearly of the standard morphotype.

4b. *Barbula indica* var. *gregaria* (Mitten) R. H. Zander, Cryptog. Bryol. Lichénol. 2: 6. 1981 [F]



*Tortula gregaria* Mitten, J. Proc. Linn. Soc., Bot., suppl. 1: 29. 1859

Leaves broadly ovate, margins plane. **Specialized asexual reproduction** by massive, brown, elliptic to spheric, many-celled gemmae occurring singly or very few together in distal leaf axils, of up to 50 cells, 95–300  $\mu\text{m}$ .

Soil; moderate elevations (1600 m); Alta.; Mexico; West Indies (Dominican Republic); Central America (Panama); South America (Colombia).

Variety *gregaria* is known in the flora area from only two, nonfruiting collections (see R. H. Zander 1979). The costa in the Alberta collection ends before the rounded apex; Mexican specimens generally have, however, apiculate leaves like those of the typical variety.

5. *Barbula amplexifolia* (Mitten) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1871–1872: 424. 1873



*Tortula amplexifolia* Mitten, J. Proc. Linn. Soc., Bot., suppl. 1: 29. 1859;  
*Barbula corensis* (Cardot) K. Saito;  
*B. haringae* H. A. Crum

Stems to 1 cm. Leaves firm when wet, short-lanceolate to lanceolate, 1.1–1.5 mm, base long-oblong to elliptic and sheathing, margins plane or rarely recurved at mid

leaf, apex acute, strongly mucronate; costa short-excurrent, abaxial costal surface smooth or occasionally doubly prorate, rarely simply papillose near apex, hydroids absent; distal laminal cells firm-walled, quadrate, 7–10  $\mu\text{m}$  wide, 1:1, papillose. **Specialized asexual reproduction** by clusters of red-brown ovoid gemmae borne on stalks in leaf axils, 40–100(–150)  $\mu\text{m}$  long. **Sporophytes** absent in range of the flora.

Rock, often limestone, occasionally sandstone, usually in moist areas, mountain slopes, cliffs, tundra, mist zone of waterfalls; moderate to high elevations (700–1800 m); Greenland; Alta., B.C., N.W.T.; Alaska, Ariz., Calif.; Asia (India, Japan, Korea).

*Barbula amplexifolia* belongs in sect. *Convolutae* by the convolute-sheathing perichaetial leaves, lack of hydroid cells in costa, and occasional prorulae on abaxial surface of costa. It is distinguished from *B. convoluta* most immediately by the stiff and sharply pointed leaves with a smooth, short mucro. On further study, the distinctions between *B. corensis* (Cardot) K. Saito and this species made by M. S. Ignatov and R. H. Zander (1993) do not hold; e.g., the type of *B. haringae* has short, 65–75  $\mu\text{m}$ , propagula and rough costal abaxial surface;

a specimen from the Northwest Territories (*Steere* 76-605, NY) has rough costae and propagula variably 90–150  $\mu\text{m}$ ; the type of *B. amplexifolia* has a smooth costa and intermediate-sized propagula, ca. 90  $\mu\text{m}$ . *Barbula convoluta* var. *eustegia* (as in the type of *B. whitehouseae*) may have a similarly stout costa, but the percurrent costa is apiculate only by a single, usually papillose cell and has narrower, nonsheathing leaves.

6. *Barbula bolleana* (Müller Hal.) Brotherus in H. G. A. Engler et al., Nat. Pflanzenfam. ed. 2, 10: 280. 1924



*Meesia bolleana* Müller Hal., Bot. Zeitung (Berlin) 20: 338. 1862;  
*Barbula ehrenbergii* (Lorentz) M. Fleischer

Stems to 3.5 cm. Leaves lax when wet, short-ligulate to long-elliptic, 2–2.7 mm, base scarcely differentiated to ovate, not sheathing, margins plane or weakly recurved

in proximal  $\frac{1}{2}$  to  $\frac{3}{4}$ , apex narrowly to broadly obtuse, occasionally broadly acute, entire or weakly apiculate; costa percurrent to ending 2–3 cells before the apex,

abaxial costal surface smooth, hydroids absent; distal laminal cells lax-walled, short-rectangular, 11–15  $\mu\text{m}$  wide, 1–2:1, smooth or with low, simple papillae. **Specialized asexual reproduction** by fusiform or armed gemmae borne on stalks in leaf axils, to 185  $\mu\text{m}$ . **Sporophytes** absent in the flora area.

Wet limestone, moist areas, wet rocks; moderate elevations; Ariz., Ark., Mo., N.Mex, Okla., Tex., Utah; Mexico; West Indies; Eurasia; n Africa; Australia.

The name *Barbula bolleana* replaces the long familiar *B. ehrenbergii* (J.-P. Frahm et al. 1996). The lax, largely smooth distal leaf cells, easily seen with the dissecting microscope, distinguish this hygrophilic species. Specimens with largely quadrate distal laminal cells may appear to have a weak intramarginal border along the leaf base of somewhat elongate cells. This species may be confused with *Didymodon tophaceus*, which generally has smaller leaf cells (9–12  $\mu\text{m}$  wide) in fewer longitudinal rows (10–15 for *D. tophaceus*, 20–30 for *B. bolleana*), and often has long-decurrent leaf margins. *Barbula indica* is rarely also tuft forming. A specimen (*Patterson* 2185, NY) previously reported for Virginia (Frederick County) is *Didymodon tophaceus*.

15. GYMNOSTOMUM Nees & Hornschuch in C. G. D. Nees et al., Bryol. Germ. 1: 112. 1823, name conserved • [Greek *gymnos*, nude, and *stoma*, mouth, alluding to lack of peristome]

Richard H. Zander

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**Plants** growing in turf or cushions, light to dark or olive green distally, light to dark brown basally. **Stems** to 2.7 cm, branching often; pentagonal to rounded-triangular in transverse section, hyalodermis usually absent, sclerodermis absent or occasionally present, central strand usually present, weak; sparsely radiculose; axillary hairs 3–10 cells in length, the basal 1–2 usually brownish. **Leaves** appressed to appressed-incurved when dry, weakly spreading to spreading recurved when moist; usually long-ligulate, occasionally ovate to circular, adaxial surface flat to broadly convex, 0.3–1.1(–2) mm; base scarcely differentiated to ovate, margins of leaf base often denticulate; distal margins plane or occasionally recurved below mid leaf, entire or minutely crenulate by projecting papillae, in patches sometimes 2-stratose marginally beyond mid leaf; apex rounded-obtuse to broadly acute, sometimes apiculate; costa percurrent or ending 2–5 cells before apex, costal adaxial cells quadrate or shortly rectangular (longer in much reduced plants) in 2–4 rows, abaxial cells elongate, occasionally shortly rectangular to quadrate distally, transverse section of costa ovate to semicircular, adaxial epidermis present, adaxial stereid band weak or lacking, guide cells 2(–4) in 1 layer, hydroid strand absent, abaxial stereid band present, often weak, crescent-shaped to round in section, abaxial epidermis occasionally little differentiated; basal cells differentiated across leaf or rising higher medially, rectangular, little wider than medial leaf cells, 2–4:1, walls of basal cells thin; distal laminal cells subquadrate,

7–11  $\mu\text{m}$ ; 1:1; papillae simple to 2-fid, low, small but crowded, scattered, 3–5 per lumen, cell walls thin to weakly and evenly thickened, flat to convex on both sides. **Specialized asexual reproduction** when present by spherical to obovoid or spindle-shaped gemmae, usually of 5–10 multiseriate cells, borne on branching stalks in leaf axils. **Sexual condition** dioicous; perigonia gemmate, terminal or lateral; perichaetia terminal or lateral on short branches or both, inner leaves little different from the cauline though commonly broadened below mid leaf, to sheathing and ovate-lanceolate or triangular, sometimes marginally serrulate, to 2 mm, laminal cells little different from those of cauline leaves though rectangular and occasionally bulging below mid leaf to mostly rectangular or rhomboidal and smooth or weakly papillose throughout. **Seta** yellowish to reddish brown in color, generally 0.3–0.6 cm, twisted clockwise. **Capsule** yellowish to reddish brown, ovoid to elliptical, often with a weak circumstomal collar, (0.4–)1.4–1.8 mm, exothecial cells quadrate to rectangular or bulging, walls thin to somewhat thickened, annulus of 1–3 rows of smaller, transversely elongate cells; peristome teeth absent; operculum rostrate to conic-rostrate, ca. 0.4–0.5 mm, cells straight. **Calyptra** cucullate, 0.5–1.2 mm, smooth. **Spores** 11–16  $\mu\text{m}$ , smooth to papillose, brownish. **KOH laminal color reaction** yellow to yellow-orange.

Species ca. 22 (3 in the flora): worldwide except Antarctica.

*Gymnostomum* is a calcicole of moist environments. It differs from the similar *Gyroweisia* largely by the small annulus (though commonly differentiated as a circumstomal ring), basal leaf cells differentiated less strongly) and the perichaetial leaves only slightly larger or smaller than the cauline (not distinctly much larger). *Barbula convoluta* is similar, but occurs in dry soil, fields, and rarely rock fissures, the adaxial surface of the leaf is keeled, and the costa has elongate adaxial cells. The genus *Gymnostomum* needs revision as many species worldwide are of doubtful distinction or belong in other genera. Those of the flora area are, however, well placed though closely related. *Hymenostylium* differs in lacking a stem central strand in the area of the flora, leaves always lanceolate to ligulate, never short-elliptical or ovate, the leaf margins commonly recurved on only one side (often strongly so), the adaxial costal cells smooth, and the laminal papillae usually simple and scattered, less obscuring of the cell lumen than those of *Gymnostomum*.

SELECTED REFERENCE Zander, R. H. 1994j. *Gymnostomum*. In: A. J. Sharp et al., eds. The moss flora of Mexico. Mem. New York Bot. Gard. 69: 246–247.

1. Exothecial cells flat or weakly convex, usually 20–25(–30)  $\mu\text{m}$  wide; perichaetia single on an axis, terminating the axis, perichaetial leaves ligulate to ovate-lanceolate, with laminal cells beyond the base quadrate and strongly papillose; cauline leaves long-rectangular or long-elliptical to broadly lanceolate, 0.5–1(–2) mm, distal adaxial costal epidermal cells quadrate to very short-rectangular; plants usually loosely cespitose, occasionally crowded, rarely forming a dense turf . . . . . 1. *Gymnostomum aeruginosum*
1. Exothecial cells usually bulging, commonly 30–40  $\mu\text{m}$  wide; perichaetia often multiple on an axis, terminating short or rather elongate lateral branches, perichaetial leaves narrowly lanceolate to triangular, with all or most cells elongate, rectangular to rhomboidal, smooth or weakly papillose; cauline leaves long-rectangular to short-elliptic, usually 0.3–0.6 mm, distal adaxial costal epidermal cells elongate, occasionally short-rectangular or quadrate in robust plants; plants often forming a dense turf.
  2. Gemmae absent; leaves 0.4–0.6 mm; plants light green above, capsules elliptic, narrow-mouthed, with a distinct circumstomal collar; cauline leaves rectangular to elliptic, occasionally ovate . . . . . 2. *Gymnostomum calcareum*
  2. Gemmae present in leaf axils; leaves 0.3–0.4(–0.6) mm; plants dark green above; capsules short-cylindric, wide-mouthed, lacking a circumstomal collar; leaves short-elliptic or ovate . . . . . 3. *Gymnostomum viridulum*