

# Meddelelser om Grønland

**Illustrated Moss Flora of Arctic North America  
and Greenland.**

**3. Andreaeobryaceae – Tetrarhizaceae**

*Gert S. Mogensen (Ed.)*



**Bioscience**  
**23 · 1987**

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Illustrated  
Moss Flora  
of Arctic North America  
and Greenland.  
3. Andreaobryaceae –  
Tetraphidaceae

Editor

Gert S. Mogensen

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## Key to illustrations

Each moss illustrated is shown at life size in the upper left-hand corner.

In composing the individual plate we have striven to use as few symbols and explanations as possible.

ge gemmae

p perichaetial or perigonal leaf

Accepted 1985, additions and corrections 1987.

ISSN 0106-1054

ISBN 87-17-05560-1

Printed in Denmark 4 November 1987 by AiO Print Ltd., Odense

**Andreaebryaceae**

by Barbara M. Murray

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Illustrations by Victoria G. Friis and Gert S. Mogensen<sup>1</sup>.With features of *Andreaebryum macrosporum*.

A family with one genus and one species that is related to the Andreaeaceae primarily by dehiscence of the capsule by means of longitudinal valves and the massive sporeling that germinates within the spore wall and produces thallose protonematal appendages. In addition, stomata are absent in both families. The Andreaebryaceae differ from the Andreaeaceae in the following characters: Capsules elevated prior to maturity on short, stout setae, pseudopodia absent; capsules little changed in shape wet or dry, turbinate, obtuse-conic above, bases abruptly contracted to setae. Sutures consisting of thin-walled cells absent, valves apparently formed by breaks in thick-walled exothecial cells at areas of weakness. Exothecial cells of valves quadrate to short-rectangular; in transverse section triangular, inner walls at base of triangle very thin, other walls very thick. Calyptrae large, covering entire capsule, often persisting to maturity. Axillary hairs with hyaline to partly brownish, rounded-rectangular basal cells, with beaked terminal cells; mucilage apparently extruded apically. Occurrence on calcareous rock.

**1. Andreaebryum***Andreaebryum* Steere & B. Murr., *Phytologia* 33: 407. 1976. – Type: *A. macrosporum* Steere & B. Murr.With features of *A. macrosporum*.**1. *A. macrosporum* Steere & B. Murr.***Figs 1–2. Map 1.**Phytologia* 33: 407. 1976. – Type: Alaska. Brooks Range, Lake Peters, 69°20' N, 145°00' W; 1974 Murray 6713; holotype in NY, isotypes in ALA, ALTA, COLO, MO, LE, seen.

Plants medium-sized to very large and robust, caespitose, perennial, black to dark brown, green only when young or shaded, often with whitish calcareous incrustation below. Massive, globose, multicellular protonemata formed within stretched spore wall, from which branched thallose protonemata, rhizoids and persistent, cylindrical, multiseriate protonematal appendages up to 2 mm long are produced. Stems 2–4 (6 or more) cm long, irregularly branched, often by innovations, in transverse section of  $\pm$ uniform thick-walled cells, cortical cells sometimes smaller and thicker walled than inner cells, central strands absent. Rhizoids basal on stems and sometimes branches, filamentous, uniseriate, red-brown. Minute, imbricate scale-like leaves occur frequently along lower portions of stems, on flagelliform shoots or in areas on middle portions of stems. Irregularly shaped primary leaves resembling pseudoparaphyllia can occur at bases of stems and branches. Leaves spirally arranged, larger and denser at stem apices, sometimes eroded along lower portions of stems; leaves falcate-secund, narrowly lanceolate, tapering

from broad bases to thick, narrowly obtuse subulae, 1.0–1.7 mm long, 0.2–0.25 mm wide near the base. Costae present, single, strong, indistinctly delineated, broad, up to 0.3 or 0.4 the width of leaf bases, decurrent, filling upper subulae, in transverse section of  $\pm$ uniform, thick-walled cells. Laminae decurrent, unistratose at extreme bases, becoming bistratose above. Laminal cells rounded-quadrate to short-rectangular, thick-walled, not pitted, not collenchymatous; 12–14  $\mu$ m wide, bulging, without or with very low papillae; alar cells not differentiated. Margins plane, entire or crenate due to convexity of laminal cells. Axillary hairs consist of 1(2 or more) hyaline to partly brownish, mostly short-rectangular basal cells and elongate terminal cells that are abruptly and broadly rounded above and possess a terminal beak, similar to those of the genus *Takakia*; similar 'hairs' produced on rhizoids and protonemata of mature plants and sporelings. Dioicous. Gynoecial paraphyses not seen. Perichaetial leaves little differentiated from stem leaves, not sheathing or convolute, margins crenate; innermost leaves minute. Archegonia terminal or lateral, usually 1–4. Androecia terminal or lateral, bulbiform, leaves concave, innermost ecostate, margins crenate, paraphyses numerous; antheridia usually 4–6, elliptic, on biseriate stalks. Pseudopodia absent.

Sporophytes terminal. Setae present, short and

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Illustrations of Andreaebryaceae – Tetrarhizaceae were supported financially by Carlsbergfondet and the Danish Natural Science Research Council (both to G. S. Mogensen) and by the National Science Foundation (to New York Botanical Garden: W. C. Steere).

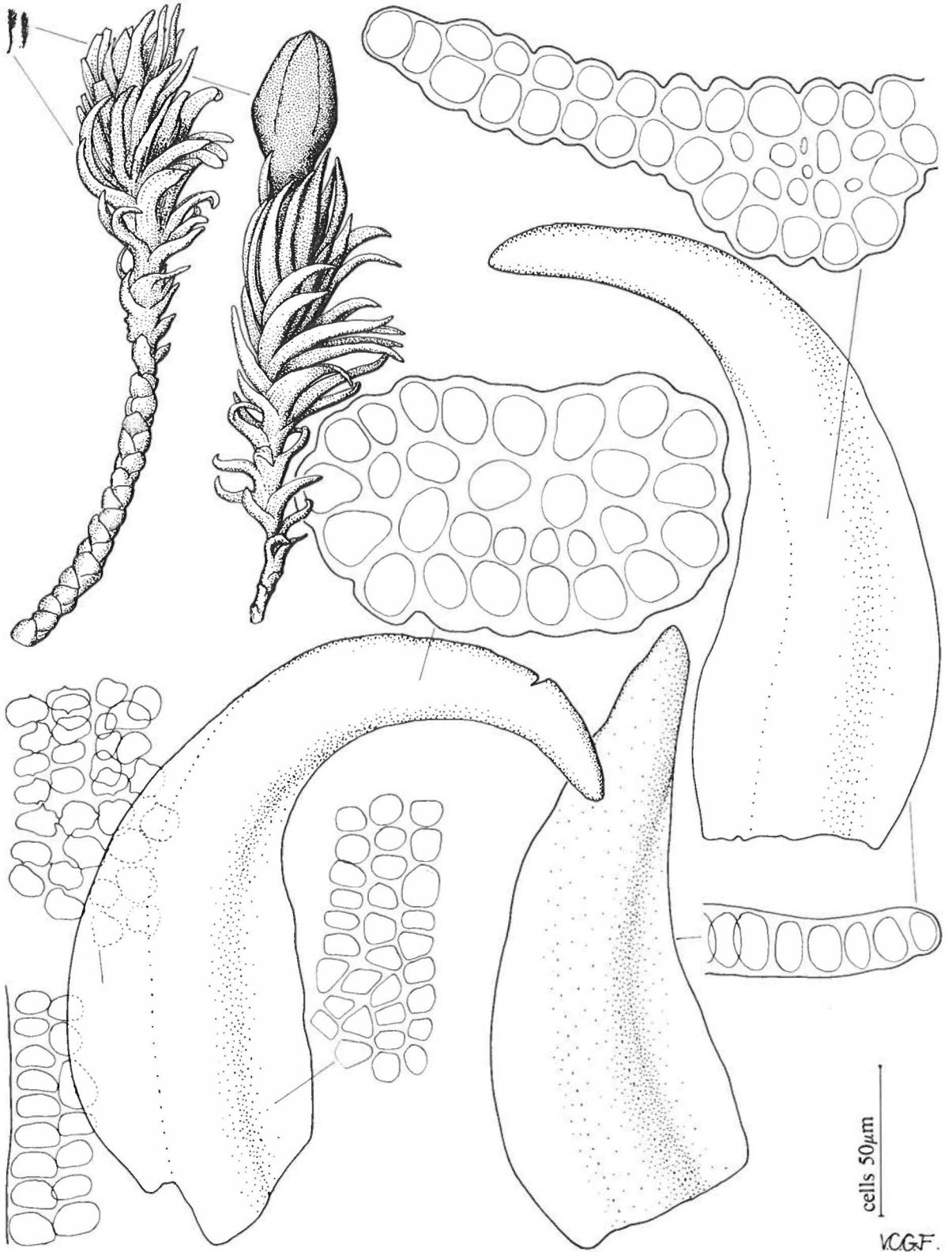


Fig. 1. *Andreaebryum macrosorum*. Atigun Canyon, A Alaska; leg. 1976 Murray 76-256, (ALA. C. NY).

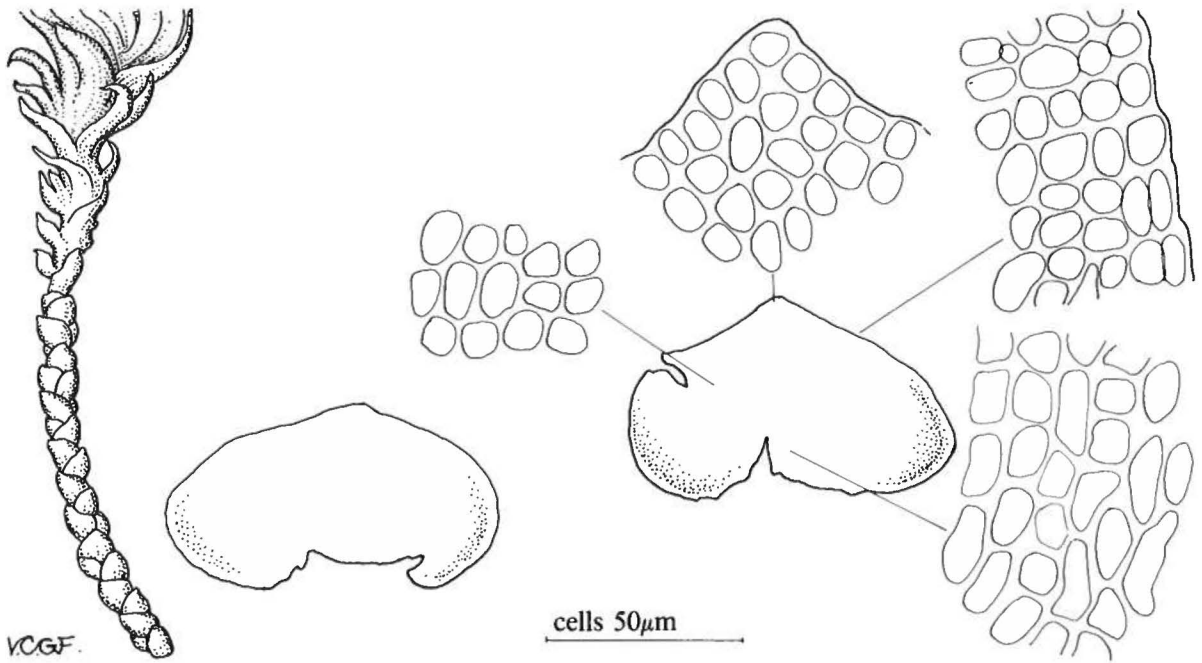
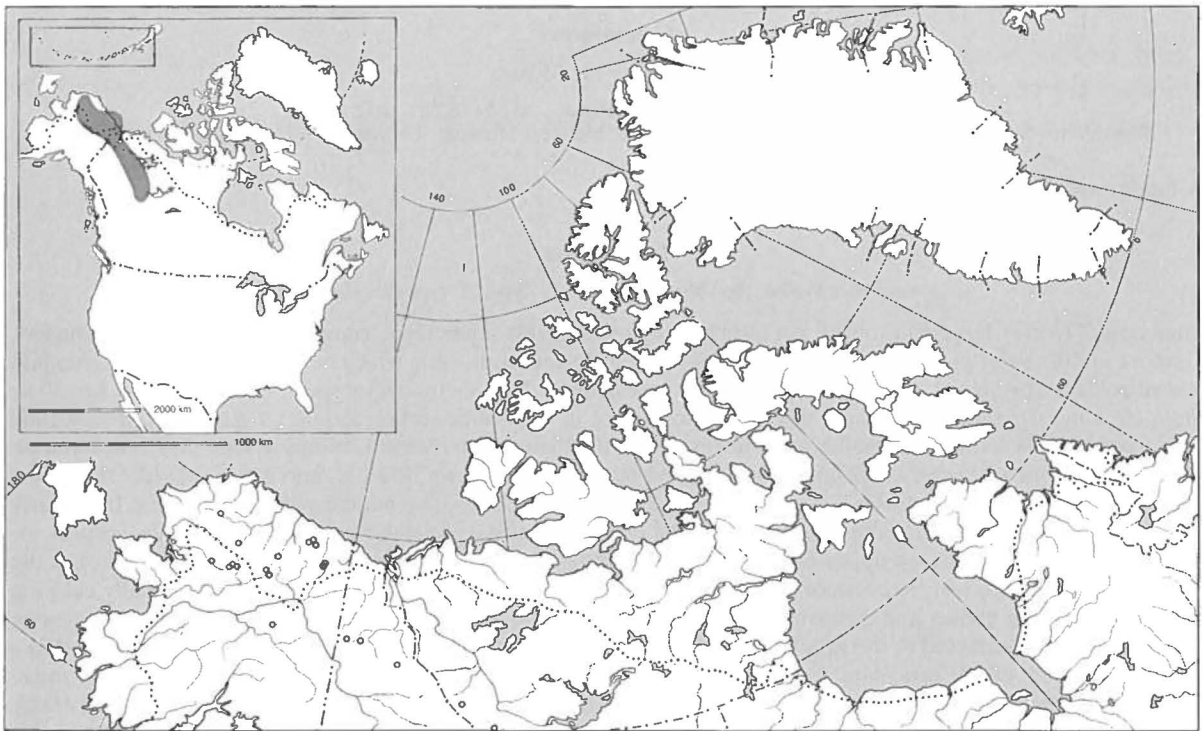


Fig. 2. Same as Fig. 1.



Map 1. *Andreaeobryum macrosporum*. Sporophytes not indicated.

broad, 1.2–1.5(2.0) mm long, 0.2–0.4 mm wide, flattened and ridged, in transverse section outermost 3–5 rows of cells round,  $\pm$ evenly thick-walled, innermost 7–11 rows oval-hexagonal, thin-walled and collenchymatous, central strands absent; foot longly tapering. Capsules elongate-oval when young, at maturity broader and tapering gradually at the apices and abruptly basally, dehiscing by 4–8 irregular longitudinal valves in conic upper part of capsules, valves not reaching apices, margins inrolled when dry,  $\pm$ plane when wet; capsule shape little changed by changes in moisture; chestnut-brown to shining black in upper valved part, paler below. Exothecial cells quadrate to short-rectangular; sutures of thin-walled cells absent; valve exothecial cells with thick longitudinal and thin transverse walls, triangular in transverse section, the inner bases of the triangular cells very thin-walled, sides very thick-walled. Stomata absent. Annuli, opercula and peristomes absent. Sporogenous tissue and columellae derived from endothecium; spore sacs dome-shaped, overarching massive, rod-like persistent columellae; spore sacs not separated by air spaces from capsule walls. Spore abortion frequent; spores very large, spherical to oval; shriveled brown spores about 52–65  $\mu$ m, turgid green spores about (50)88–100(122)  $\mu$ m, papillose to reticulate-papillose. Mature in summer. Calyptrae large, 0.9–1.5 mm long, covering entire capsules, often persisting to maturity, yellowish brown, mitrate, but becoming cucullate as they split when capsules widen.

On irrigated limestone, dolomite and calcareous sandstone; cushions often coalescing and forming extensive mats covering many square meters on vertical cliffs. The large black mats are visible for miles on the white limestone cliffs that predominate in the Brooks Range of Alaska. Sporophytes are common in the northern part of its range but are rare in southernmost collections

Endemic to northwestern North America. Occasional in mountains in arctic Alaska, often locally abundant. Also known from several localities in subarctic Alaska and the Yukon, British Columbia and Northwest Territories.

Selected specimens seen:

Alaska. Kurupa Lake, 68°22'N, 154°39'W; 1974 Iwatsuki 3342 (ALA, NY). – “Mount Hulten”, Mile 271 Dalton Highway, 68°27'N, 149°18'W; 1976 Murray 76–254 (ALA). – Mountain W of Galbraith Lake, Mile 275.5 Dalton Highway, 68°27'N, 149°30'W; 1981 Murray 11,114 (ALA). – Upper Sheenjok Valley: Ambresvajun Lake (Last Lake) vicinity, 68°35'N, 143°43'W; 1975 Batten 75–48 (ALA, NY). – 8 km N of Ambresvajun Lake; 1975 Batten 75–47 (ALA, NY). – 32 km N of Ambresvajun Lake, 68°51'N, 143°28'W; 1975 Batten 75–4 (ALA, NY). – Lookout Ridge, 69°07'N, 158°10'W; 1979 Murray 9222 (ALA). – Lake Peters, 69°22'N, 145°03'W; 1961 Steere 610706–6 (ALA, NY). – Cache Creek, Ikiakpaurak Valley, 69°25'N, 146°00'W; 1974 Murray 6556 (ALA). – Sadlerochit Mts, 69°40'N, 145°50'W; 1983 Lipkin 20 Jul. (ALA).

*Andreaeobryum macrosporum* is easily distinguished from *Andreaea* species by its occurrence on calcareous rock, the broadly conic capsule that tapers abruptly to a stout seta and does not contract in length or bulge when wet, and the very large spores.

### Andreaeaceae

by Barbara M. Murray

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Illustrations by Victoria G. Friis and Gert S. Mogensen, Botanical Museum, University of Copenhagen, Denmark.

A family with one genus.

#### 1. *Andreaea*

*Andreaea* Hedw., Sp. Musc. 47. 1801. – Type: *A. rupestris* Hedw.

Plants small to very large and robust, caespitose, perennial, darkly pigmented, green only when young or shaded. Globose multicellular protonemata formed within stretched spore wall, from which branched thallose protonemata and rhizoids are produced. Leaf-like protonematal appendages observed in several species. Stems from 0.5 to 10 or more cm long, irregularly branched, often by innovations, in transverse section usually of  $\pm$ uniform thick-walled cells, cortical cells sometimes smaller and thicker walled than inner cells, central strands absent. Rhizoids basal on stems and sometimes branches, filamentous, uni- and biseriate, red-brown. Minute, imbricate scale-like leaves occur frequently along lower portions of stems, on flagelliform shoots or along middle portions of stems. Irregularly shaped primary leaves resembling pseudoparaphyllia can occur at bases of stems and branches. Leaves spirally arranged, larger and denser on upper portions of stems, sometimes eroded along lower portions of stems, usually more spreading when wet, in ecostate species often squarrose, variable in orientation and shape: usually clasping below,  $\pm$ spreading above, and  $\pm$ constricted, like a waist, near mid-leaf and apices incurved or secund in ecostate taxa;  $\pm$ abruptly contracted to the subulae and often secund above in costate taxa; usually somewhat narrowed to a straight insertion, rarely auriculate. Costae, when present, variable in form: single or branched, distinctly or indistinctly delineated, short to excurrent, broad or narrow, strong throughout or lacking apically or basally; in transverse section of  $\pm$ uniform, thick-walled cells. Laminal cells variable: in ecostate species usually short above, becoming rectangular to elongate below, mid-leaf and basal marginal cells  $\pm$ differentiated; in costate species often



short throughout, some subcostal cells rectangular; laminal cells usually unistratose in ecostate species, usually bi- to multistratose, at least in spots, in costate species; transverse walls very thin, longitudinal walls often thick and pitted, rarely thin, smooth or sinuose. Margins usually plane to somewhat incurved, rarely reflexed. Axillary hairs with 1–3(4) quadrate, brown basal cells and 1(2-more in inflorescences) elongate, hyaline or brown cells, the terminal cell cylindrical, often clavate, hyaline or becoming brown with age. Usually cladautoicous, often difficult to demonstrate due to brittle stems; rarely dioicous or gonioautoicous. Paraphyses rare or lacking in gynoecia, few or numerous in androecia. Archegonia terminal, rarely lateral, usually 3–6. Perichaetial leaves large, often differentiated, convolute and sheathing. Androecia terminal or lateral, bulbiform, antheridia usually 4–10, elliptic, on biserial stalks. Pseudopodia slender, pale brown to black, slightly twisted to the left in surface view.

Sporophytes terminal. Setae absent, sporophytes consist of capsules and bulbous to shortly tapering feet. Capsules when dry contracting in length and valves bulging, when wet elliptic and valves closed; dehiscence by 4 or rarely 8–10 longitudinal valves that reach neither bases nor apices of capsules, margins of valves  $\pm$  reflexed when dry, plane to inrolled when wet; bases (0.1)0.3–0.5(over 0.8) the length of the capsules; necks very short, apices usually shortly conic-apiculate. Exothelial cells rectangular to long-rectangular, sutures consisting of thin-walled cells present; valve exothelial cells with thick longitudinal and thin transverse walls, usually oval and with all walls thick in transverse section. Stomata absent. Annuli, opercula and peristomes absent. Sporogenous tissue and columellae derived from endothecium; spore sacs dome-shaped, overarching rod-like persistent columellae; spore sacs not separated by air spaces from capsule walls. Spore abortion rare to frequent; spores small to very large, usually spherical, sometimes angled, (10)13–60(110)  $\mu\text{m}$ , usually papillose to reticulate-papillose, rarely almost smooth. Mature from spring to fall. Calyptrae apical, very small, consisting chiefly of unmodified archegonial necks, campanulate-mitrate, usually falling early.

*Andreaea* comprises probably 50–75 species, with the greatest diversity in the Southern Hemisphere. Often called granite mosses, *Andreaea* species are easily distinguished from *Andreaeobryum* by their occurrence on acidic substrates and by the capsule that bulges and contracts in length to release spores, the presence of a pseudopodium, and, except for one non-arctic species, by the smaller spores.

Arctic costate species and the denticulate ecostate *A. alpina* present no great difficulties in identification, but the *A. rupestris* group (here treated as *A. rupestris* var. *rupestris*, *A. rupestris* var. *papillosa*, *A. alpestris* and *A. obovata*) is a problem. *Andreaea alpestris* and *A. obovata* have northern distributions and are structurally quite uniform, but *A. rupestris*, which is more widespread, is extremely polymorphic and has many properties shared by *A. alpestris* and *A. obovata*. Because of this no one character, such as color, leaf shape and orientation, size, papillosoity, cell size, wall thickness or pittedness, should be considered diagnostic. In the North, members of the *A. rupestris* group, with the notable exception of *A. rupestris* var. *rupestris*, frequently occur on coarse mineral soil where they are very well developed and robust. In such situations they are easily identified, but small rock populations may cause difficulty.

Invaluable references describing the variation in the *A. rupestris* group are Schimper (in Bruch, Schimper and Gumbel, Bryol. Eur. 6: 131–156, Pl. 1–14(623–636), 1855), Mårtensson (Kungl. Svenska Vetenskapsakad. Avhandl. Naturskyddsärenden 14: 20–28, 1956) and Nyholm (Ill. Moss Fl. Fennoscandia 2: 688–699, Stockholm, 1969).

The following key includes the most constant group of features by which these taxa can be recognized. In such a variable group, however, it is not unusual for intermediate specimens to occur, and I have taken a broad view of *A. rupestris* and included most such forms within that taxon.

Approximately 1125 specimens of the *A. rupestris* group were examined from 59°N northward from Greenland, Canada and Alaska, of which about one half are from Greenland. About one half of the entire material studied is *A. rupestris* var. *papillosa*, one quarter is *A. rupestris* var. *rupestris*, about 18 per cent is *A. alpestris*, and about 7 per cent is *A. obovata*. *Andreaea alpestris* is quite common in Greenland representing over one quarter of the *A. rupestris* group there, but it is rare in Canada and Alaska where it accounts for about 8 per cent of the group. The ranges of *A. rupestris* var. *rupestris* and var. *papillosa* overlap to a great extent, but the frequency of each differs greatly. Between latitudes 59–63°N the ratio is about 1:1 *papillosa:rupestris*, between 64–67° about 2:1, between 68–72° about 4:1 and between 73–76° over 5:1.

*Andreaea crassinervia* Bruch and *A. rothii* Web. & Mohr have been reported for Greenland, and *A. crassinervia* has been reported from Baffin Island, but all material I have seen is equivocal. It is possible, however, that *A. crassinervia* and *A. rothii* occur in the Arctic, so they are included in the key in brackets.

A specimen in S labeled only *A. crassinervia*, Greenland, Schimper is a mixture of *A. crassinervia* and *A. frigida* Hüb. Both occur in Europe, and other than this incompletely labeled specimen *A. frigida* is not known elsewhere, so I suspect that the specimen is mislabeled. Material in NMW (and duplicates in BM) cited by Wade as *A. crassinervia* (Bryologist 57: 225–229, 1954) from West Greenland is *A. blyttii*. I have not found in BM the specimens collected at Clyde on Baffin Island by Polunin that were determined to be *A. crassinervia* by W. R. Sherrin and cited as being housed in BM, but not seen, by Steere (in Polunin, Nat. Mus. Canada Bull. 97: 1–573, 1947). It is possible that this material was lost when Sherrin's laboratory was destroyed during World War II (loc. cit., p. 375).

*Andreaea rothii* has been reported from Greenland without substantiation in most general 20th century Floras. I do not know the basis for these citations, perhaps the report by R. Brown (in Rink [ed. R. Brown]: Danish Greenland, p. 420, London, 1877) who based this catalog of cryptogams of Greenland on mosses collected by Berggren in 1870 and his own list. His report of *A. rothii* may well refer to Berggren's *A. crassinervia* var. *obtusifolia* (= *A. heinemannii*) as suggested by Lange and Jensen (Meddr Grønland 3: 309–446, 1887).

Microscopic diagnostic features are most easily seen when a mounting medium such as Hoyer's, lactophenol or a dilute solution of potassium hydroxide is used.

1. Leaves subulate and costate.
  2. Leaf margins crenate to serrate, with sharp laminal and costal papillae. Perichaetial leaves larger than stem leaves but not differentiated, neither sheathing nor convolute. . . . . 1. *A. nivalis*
  2. Leaf margins entire or rarely slightly crenate, laminal papillae absent, costal papillae low or absent. Perichaetial leaves differentiated, sheathing and convolute.
  3. Spores 11–19(23)  $\mu\text{m}$ . Basal laminal cells mostly rectangular, walls little pitted, not sinuose. Dioicous. . . . . 2. *A. blyttii*
  3. Spores over 25  $\mu\text{m}$ . Basal laminal cells mostly quadrate, round, rounded-oblate or short-rectangular, walls often pitted and sinuose. Autoicous.
    4. Costae usually weak and flattened above (at most 4-layered), often lacking basally. Usually some basal marginal cells rectangular. . . . . 3. *A. heinemannii*
    4. Costae strong throughout, usually terete above (5–6-layered). Basal marginal cells mostly isodiametric, rarely one or two short-rectangular.
      5. Spores 24–35(40)  $\mu\text{m}$ . Transition between laminae and costae indistinct (dorsal costal surface not bulging). Laminae indistinct in subulae, costae often filling subulae. . . . . [*A. crassinervia*]
      5. Spores (30)35–50(70)  $\mu\text{m}$ . Transition between laminae and costae distinct (dorsal costal surface bulging). Laminae distinct throughout or at least in lower parts of subulae, costae sometimes filling upper parts of subulae. . . . . [*A. rothii sensu lato*]
1. Leaves  $\pm$  lanceolate or panduriform, ecostate.
  6. Margins denticulate at leaf bases. . . . . 4. *A. alpina*
  6. Margins entire or weakly crenate at leaf bases.
    7. Leaves usually curved to secund, with oblique apices. Papillae usually prominent and whitish, at least dorsally on upper leaves. Upper cell lumina often stellate, rounded or oval, walls usually incrassate, pitted, and collenchymatous. Plants greenish bronze, black or reddish.
    8. Leaves lanceolate or occasionally panduriform, gradually narrowed to short or long, obtuse or acute apices. . . . . 5. *A. rupestris* var. *rupestris*
    8. Leaves abruptly narrowed from ovate or panduriform bases to long, acute apices. . . . . 5. *A. rupestris* var. *papillosa*
  7. Leaves usually straight, apices occasionally oblique. Papillae usually low or absent, very rarely prominent or whitish. Upper cell lumina rounded or stellate, walls incrassate, pitted and collenchymatous or not. Plants characteristically brown, black or reddish black.
    9. Leaves usually asymmetric,  $\pm$  lanceolate, broadest below mid-leaf, not apiculate. Papillae inconspicuous. Basal cells short-rectangular with broad, bulging lumina, walls little pitted. Upper laminae unistratose or some leaves with central bistratose patches, cell lumina rounded, walls not very collenchymatous or incrassate. Plants black or brown, occasionally reddish black. . . . . 6. *A. alpestris*
    9. Leaves symmetric, panduriform, broadest above mid-leaf,  $\pm$  apiculate. Papillae rarely conspicuous. Basal cells rectangular to long-rectangular, lumina rarely bulging, walls pitted. Upper laminae unistratose, cell lumina stellate, walls collenchymatous and incrassate. Plants usually reddish or purple-black, occasionally black (when submerged in running water greenish and with distant, often secund leaves). . . . . 7. *A. obovata*

1. *A. nivalis* Hook.

Fig. 3. Map. 2.

Trans. Linn. Soc. London 10: 395. 1811. – Type: Scotland; in BM, seen.

Plants medium-sized to very large and robust, brownish green to red-brown. Stems up to 10 cm long. Leaves when dry erect, curved, secund or falcate-secund, lower stem leaves distant, at stem apices secund or falcate-secund, gradually narrowed from an oblong base to a sharp tip; 1–2 mm long, 0.3–0.5 mm wide. Costae present, single, percurrent or filling leaf apices, strong, about 0.2 the width of leaf bases, tapering gradually or of equal width upwards, distinctly delineated and strong (frequently only costae remaining on lower portions of

stems), reddish, dorsally strongly papillose. Laminae unistratose, areolation distinct, many cells papillose dorsally and ventrally. Laminal cells  $\pm$  uniform, quadrate to rounded, 9–11  $\mu\text{m}$ , occasionally short-rectangular and narrower in leaf bases, thin-walled, not pitted, not collenchymatous. Margins plane to partially reflexed, irregularly denticulate or crenate from papillose cells; auriculate-decurrent. Dioicous. Upper stem and perichaetial leaves similar to stem leaves but abruptly larger, not sheathing or convolute.

Capsules (not seen in Greenland material) usually with 4 large and 2 small valves that extend to near bases and apices. Spore abortion occasional, spores (18)20–30 (40)  $\mu\text{m}$ . Chromosome number reported:  $n=10$  (Japan, the report from South Georgia [Fritsch, Regnum Vege-

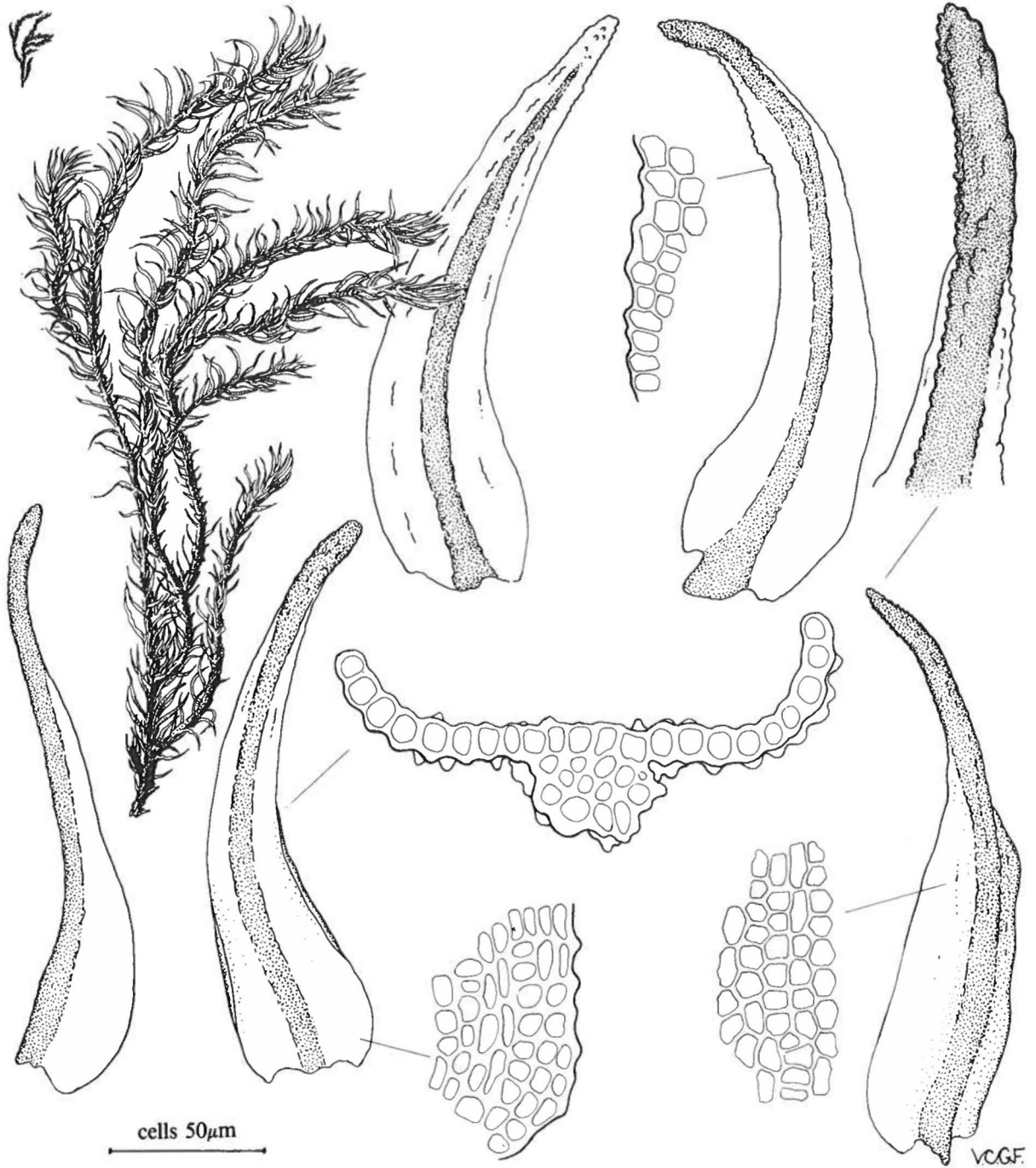


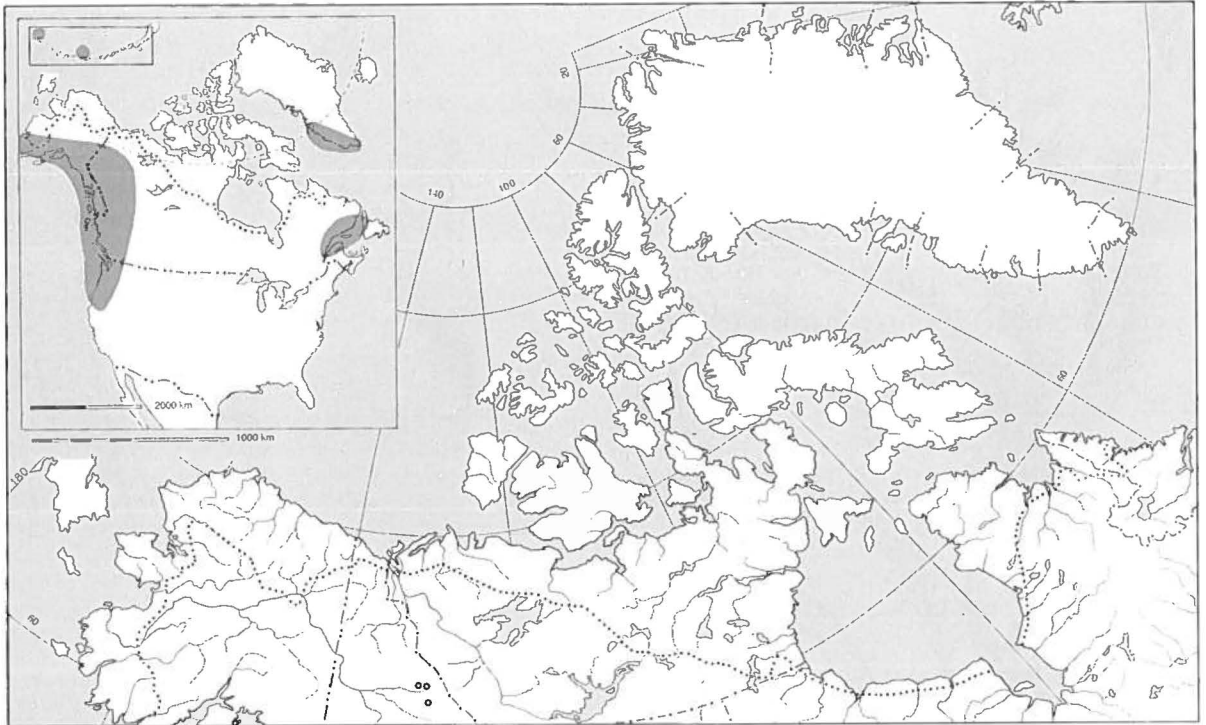
Fig. 3. *Andreaea nivalis*, Tasiussaq, S Greenland; leg. 1966 Holmen 66-576, (C).

tabile 108: 72, 1982] is a transcription error for *A. australis* F. Müll. ex Mitt.).

On wet rocks in streams, snow flushes and on seeping outcrops, often forming large mats.

Very rare in the Arctic, known only from southern and south-

western Greenland in our region and reported from Novaya Zemlya. Generally found in alpine regions in oceanic parts of the Northern Hemisphere: recently reported for eastern North America from western Newfoundland (Belland, *Canad. J. Bot.* 61: 218-223, 1983); in northwestern North America from central Yukon and southern Alaska south to British Columbia, Washington, Oregon and California. Otherwise known from Europe, the Caucasus, Asiatic U.S.S.R. and Japan.



Map. 2 *Andreaea nivalis*. Sporophytes not indicated.



Map 3. *Andreaea blyttii*. Sporophytes not indicated.

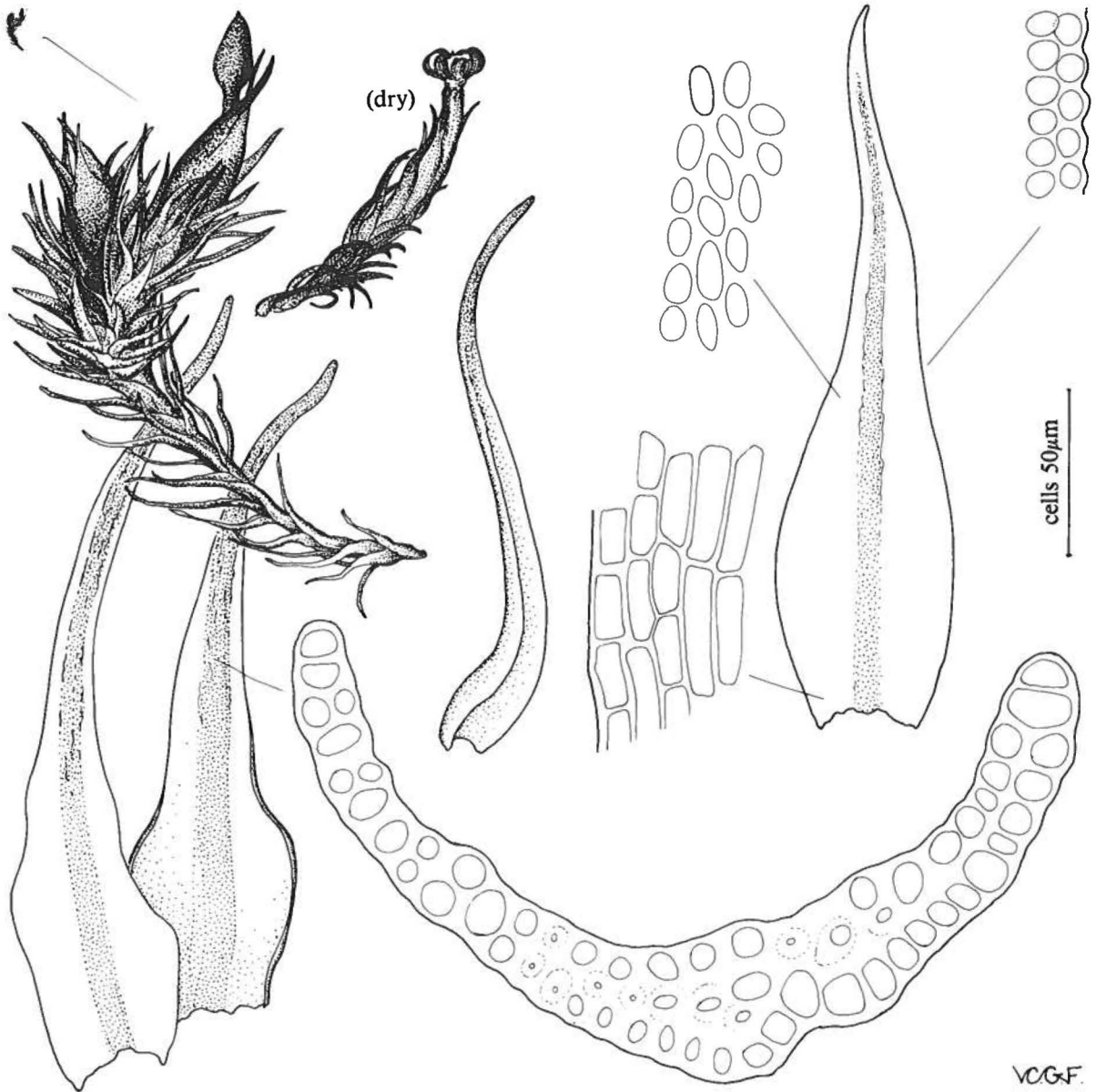


Fig. 4. *Andreaea blyttii*, Langenæs, SE Greenland; leg. 1970 Lewinsky 70-461, (C).

**Specimens seen:**

Greenland. Without locality; 1899 comm. J. Macoun (S). – S1: Christian IV Ø., Tasiussaqa, 60°06'N, 43°47'W; 1966 Gravesen & Hansen 66-576 (C). – W3: 'Sukkertoppen Koloni', 65°35'N, 52°46'W; 1955 Clausen 265 (C, CANM, S).

Easily distinguished by its sharply denticulate and papillose leaf margins and, when fruiting by the non-sheathing perichaetial leaves. In habit it can resemble the hepatic genus *Herbertus* and the non-costate falcate form of *A. rupestris* var. *papillosa*.

**2. *A. blyttii* Schimp.**

*Fig. 4. Map 3.*  
In Bruch, Schimper & Gumbel, *Bryol. Eur.* 6: 155, Pl. 13 (635). 1855. – Type: Norway; holotype in BM, isotype in CANM, seen.

Plants small to medium-sized, brown to black, bases often brown and apices black. Stems up to 2.5 cm long. Leaves when dry erect, curved or secund, especially at stem apices, brittle, gradually subulate from a narrow oblong or ovate base, 1–2 mm long, up to 0.3 mm wide, the subulae 3–4 times longer than the bases, narrow,

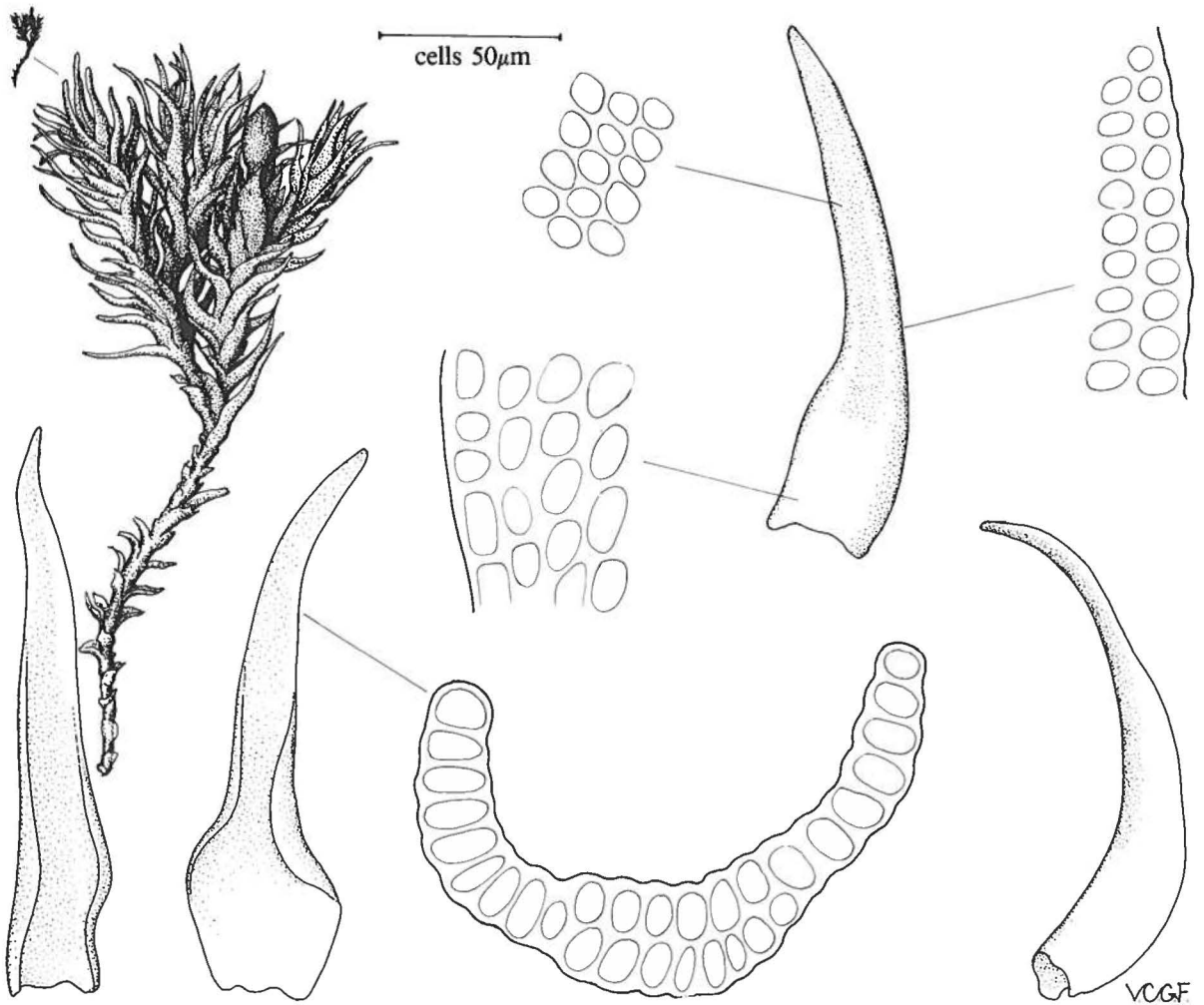


Fig. 5. *Andreaea heinemannii*, Angmagssalik, E Greenland; leg. 1970 Lewinsky 70-849, (C).

often only 2 cells wide apically. Costae present, single,  $\pm$ terete,  $\pm$ filling subulae, of up to four layers, weaker and bistratose or occasionally absent basally. Laminae unistratose, or bistratose especially near costae. Upper laminal cells round or quadrate, (9)10–12  $\mu$ m, not thick-walled or collenchymatous,  $\pm$ smooth to bulging, papillae rare and low. Basal laminal cells rectangular to short-rectangular, very rarely quadrate, in longitudinal rows, lumina angular, walls slightly incrassate, little pitted. Marginal cells in leaf bases mostly short-rectangular, occasionally a few quadrate or long-rectangular. Dioicous. Perichaetial leaves differentiated, sheathing and convolute.

Spore abortion not seen. Spores small, (11)12–19(23)  $\mu$ m, almost smooth.

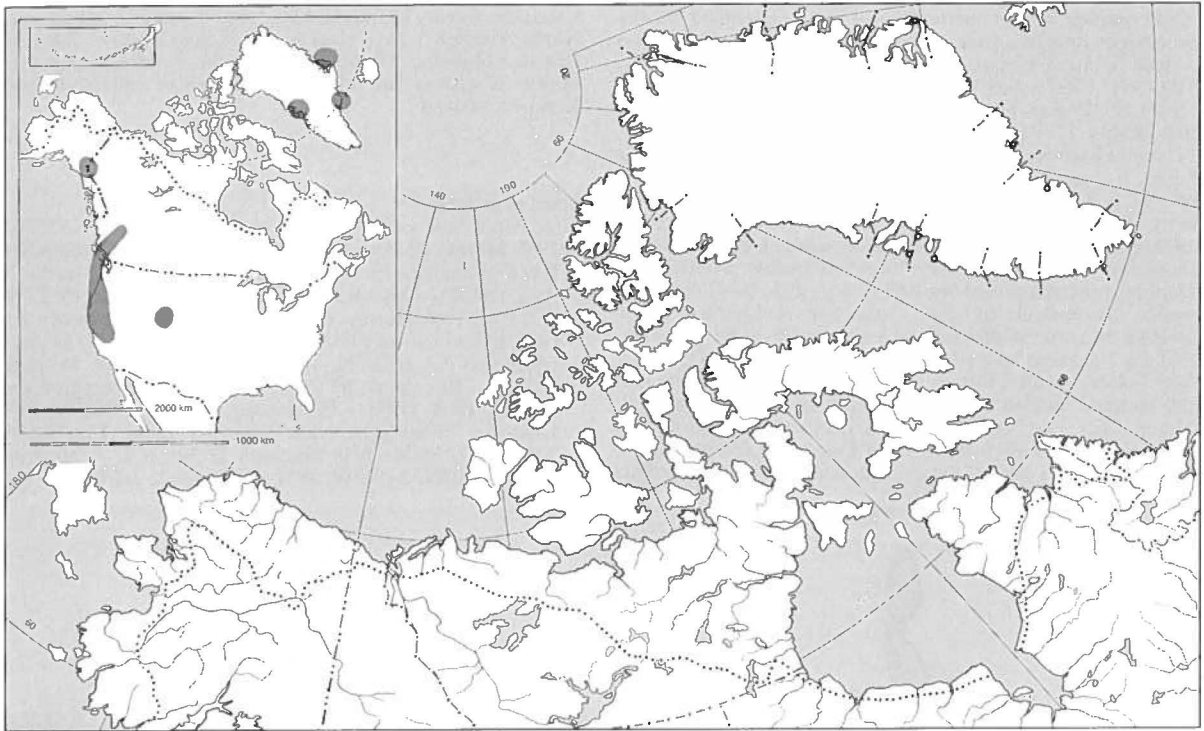
Forming mats on wet rocks or alluvium, usually at the edges of snow flushes; substrate often snow covered and in meltwater early in summer and dry later. Sporophytes occasional.

Sporadically distributed in the Low Arctic. Otherwise known from Quebec and Newfoundland in eastern North America and in the West from alpine localities in central and southern Alaska, southern Yukon, British Columbia, Washington, Oregon and California. Known also from arctic Europe and arctic Asia as well as from alpine localities in Scotland, Fennoscandia and Poland. Reported from Iceland.

Selected specimens seen:

Greenland. S1: Ilua Torsukátak, 60°08'N, 44°20'W; 1959 Ellitsgaard 13 Aug. (C). – W5: Ritenbenk, 69°46'N, 51°20'W; 1870 Berggren *s.n.* (ALTA, B, DUKE, H, NFLD, NY, S, TRH). – W7: Savigsivik (Meteorit Ø), 76°00'N, 65°00'W; 1950 Jakobsen 10317 (C). – E3: Angmagssalik district, Iká-saulaq, near Qártulájik, 65°51'N, 37°10'W; 1969 Daniëls & de Molenaar M 69606a (ALTA, C, CANM, H, MO, NFLD). – E5: Scoresbysund district, Havnen, 70°29'N, 21°58'W; 1924 Hagerup 28 Aug. (NFLD, NY).

Canada. Labrador: Crater Lake vicinity, ca 52 mi WSW of Hebron, 58°02'N, 64°02'W; 1954 Gillett 8909 (CANM). – Northwest Territories: Keewatin district, Southampton I., Hudson Bay; 1864 Macoun 9 Aug. (S). – Franklin district, Baffin I., Pangnirtung and vicinity, 66°09'N, 65°44'W; 1980 Belland, Brassard, & Bridgland 14595 (NFLD).



Map 4. *Andreaea heinemannii*. Sporophytes not indicated.

Alaska. Seward Peninsula, N slope of Bendeleben Mts, ca 65°15'N, 163°30'W; 1948 Sigafos 1495 (MICH). – Brooks Range, Atigun Pass, Mile 247.5 Dalton Highway, 68°08'N, 149°27'W; 1982 Murray 11,343 (ALA).

*Andreaea blyttii* differs from other arctic, costate members of the Andreaeaceae in its very long, narrow subula. In addition, the basal cells are mostly rectangular and the spores are small. Small forms can look superficially like *A. crassinervia* which has short basal cells and larger spores.

### 3. *A. heinemannii* Hampe & C. Müll.

Bot. Zeit. 4: 324, Pl. 2. 1846. – *A. crassinervia* Bruch var. *heinemannii* (Hampe & C. Müll.) C. Müll., Synops. 1: 10. 1848. – Type: Switzerland; holotype and isotype in BM, seen.

*A. angustata* Lindb. ex Limpr., Laubm. Deutschl. 1: 144, Fig. 51. 1885. – *A. blyttii* Schimp. ssp. *angustata* (Lindb. ex Limpr.) Schultze-Motel, Nova Hedwigia 16: 460. 1969. – Type: Austria; isotypes in B, BM, NY, seen.

*A. crassinervia* Bruch var. *obtusifolia* Berggr., Kongl. Svenska Vetenskaps-Akademiens Handl. 13(8): 40. 1875. – *A. obtusifolia* (Berggr.) Kindb., Eur. N. Amer. Bryin. 2: 394. 1897. *Hom. illeg.*, non *A. obtusifolia* T. Jens. 1858. – *A. obtusifolia* Berggr. ex G. Roth, Aussereur. Laubm. 72. 1911. *Hom. illeg.* – *A. blyttii* Schimp. var. *obtusifolia* (Berggr.) Sharp, in Grout, Moss Fl. N. Amer. 1: 3. 1936. – Types: Greenland: Godhavn [Lyngmarken, 69°15'N, 53°33' W]; 1870 Berggren *s.n.*; isotypes in H, NY, S, TRH, UPS, seen. \*Kikertak-ø\*; 1870 Berggren *s.n.*; not seen.

*A. planinervis* Lindb. ex G. Roth, Aussereur. Laubm. 73, Pl. 8, Fig. 2. 1911. – *A. planinervis* Lindb., in Broth., Enum. Musc. Caucasi. 94. 1892. *Nom. nud.* – Type: Caucasus; holotype and isotype in S, seen.

*A. crassifolia* Luis., Broteria ser. Bot. 14: 22, Fig. 1–7. 1916. – Types: Portugal, not seen; and Spain, isosyntype in BM, seen.

Plants small to medium-sized, black to brown. Stems 0.5–1.5 cm long. Leaves when dry erect to divergent, occasionally somewhat flexuose or secund, brittle; oblong-subulate, 1.2–1.5 mm long, up to 0.6 mm wide, subulae gradually formed, about 2 times longer than bases, usually 4–6 cells wide and obtuse apically. Costae present, single ± flattened, ± indistinct, occasionally strong, ± filling the subulae, often lacking basally, of 2–4 layers apically. Laminae unistratose or with bistratose patches, especially near the costae. Upper laminal cells rounded, isodiametric, 11–13 µm, not porose or thick-walled, bulging. Cells at leaf shoulders oblate, basal laminal cells round, oval, oblate to rounded-rectangular. Marginal basal cells rounded or short-rectangular. All basal cells often sinuose. Reportedly autoicous. Perichaetial leaves differentiated, sheathing and convolute.

Spore abortion not seen. Spores angled, 22–32(40) µm.

Occurs most commonly on dry, exposed acidic rock, often with *A. rupestris* var. *rupestris* and var. *papillosa*. Sporophytes frequent.

Rare, in the Arctic previously known only from type material of *A. crassinervia* var. *obtusifolia* in West Greenland. In the protologue Berggren cited material from 'Kikertak-ø', which is a small island in a bay south of Nûgssuaq peninsula (70°00'N, 51°19'W). I have seen no material from there, and Berggren (1875: 11–12) does not mention it in his citation of plants from that locality. He does, however, list it for nearby Ritenbenk (p. 11), and I have seen several collections with that locality on the labels. It is possible that the citation from 'Kikertak' was an error, or that the plants were incorrectly labeled from Ritenbenk. I have seen many specimens of *Andreaea* collected in 1870 by Berggren and none of them are labeled 'Kikertak' even though he cited several species from that locality. Schuster and Damsholt (Meddr Grønland 199(1): 167, 272, 1974) discussed similar discrepancies in hepatic collections and wrote that the labeling mistake "could easily have been made as Berggren visited the Nugssuaq area only one day and stayed at Ritenbenk both before and after this visit." At any rate, it seems clear that the material labeled Ritenbenk is part of the type material. Material in C and NY collected in Greenland (without locality information) by Raben and cited by Lange and Jensen (Meddr Grønland 3: 309–446, 1887) as *A. crassinervia* var. *obtusifolia* was misidentified and is *A. blyttii*.

*Andreaea heinemannii* occurs also in southern Europe, the Caucasus, Canary Islands and Madeira. Previously unknown in North America I have seen material from Yukon, Alberta, British Columbia, Washington, Oregon, Colorado and California as well as one Southern Hemisphere collection from Kerguelen Island.

Specimens seen:

Greenland. W4: vicinity of Egedesminde, 68°42'N, 52°55'W; 1985 Murray 22 Aug. (ALA). – W5: Godhavn, mountain NW of Arctic Station, ca. 69°22'N, 53°34'W; 1985 Murray 20 Aug. (ALA). – Mountain NE of Arctic Station, ca 69°25'N, 53°24'W; 1985 Murray 17 Aug. (ALA). – Arveprinsen Ejland, Laksebugt, ca 69°43'N, 51°19'W; 1985 Murray 14 Aug. (ALA). – Ca 69°46'N, 51°12'W; 1985 Murray 15 Aug. (ALA). – Ritenbenk, 69°46'N, 51°20'W; 1870 Berggren s.n. (NY, S, TRH, UPS). – E3: Tasilaq, 66°04'N, 37°02'W; 1970 Lewinsky 70–849 (C). – E5: Liverpool Land, Kap Tobin, 70°25'N, 21°58'W; 1955 Sørensen 12 Jul. (C). – 'Hvalrosbugt', 70°30'N, 21°58'W; 1951 Anderson 22 Jul. (C).

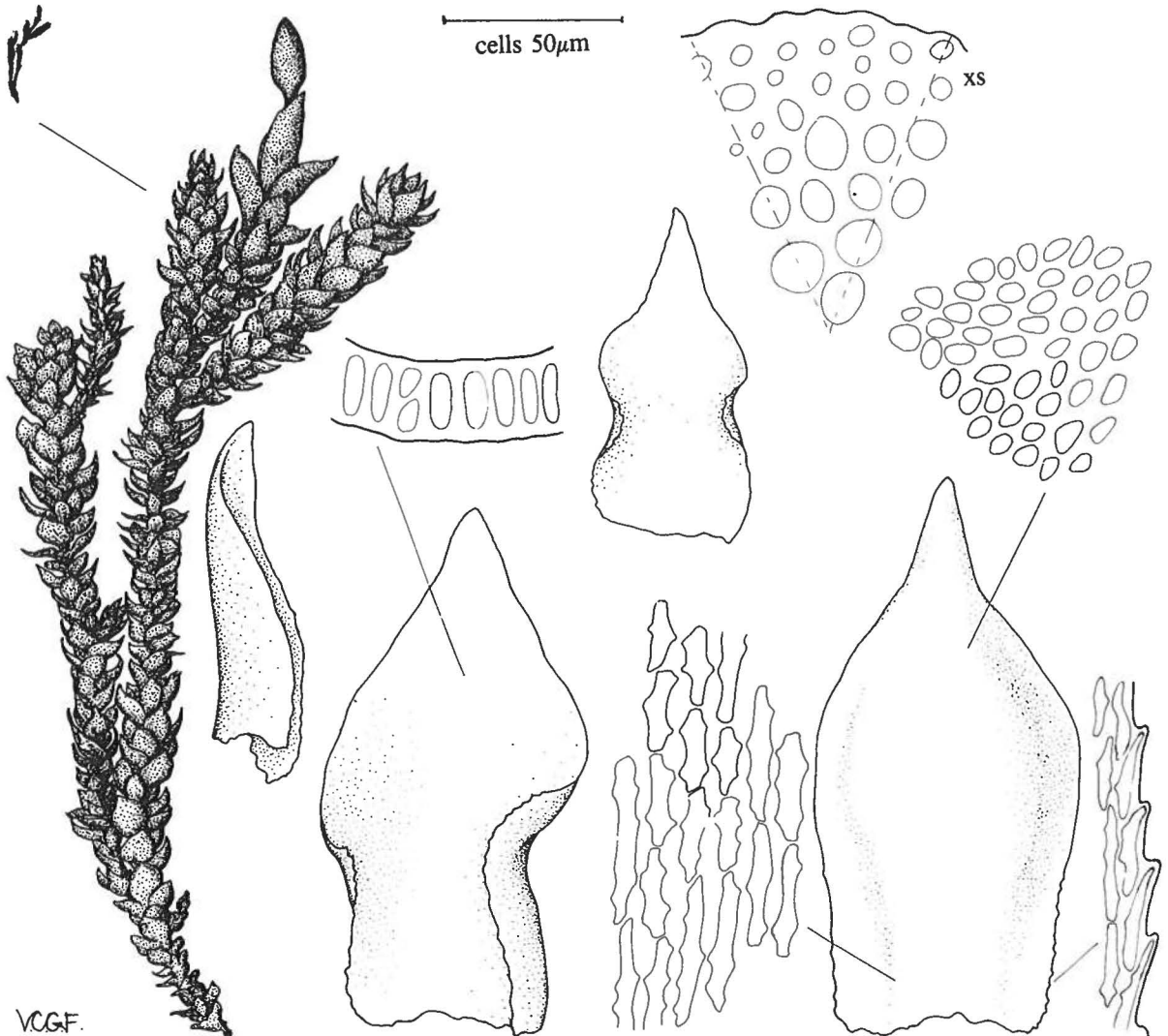


Fig. 6. *Andreaea alpina*. Igdlorsuit, S Greenland; leg. 1970 Jacobsen 5039, (C).



Map 5. *Andreaea alpina*.

*Andreaea heinemannii* is easily identified by its small size, untidy look due to divergent and obtuse leaf tips, the  $\pm$ flattened subula and the costa often very weak or lacking basally. Its spores are twice the size of those of *A. blyttii*, the subula is shorter and broader, and the basal cells are often rounded, oval or oblate with sinuose walls, not rectangular with mostly evenly thickened walls. *Andreaea crassinervia* and *A. rothii*, whose presence in the Arctic has not been established, have much stronger costae and isodiametric basal cells, and *A. rothii* has larger spores. *A. heinemannii* has sometimes been mistaken for *A. rupestris* due to its weak costa.

#### 4. *A. alpina* Hedw.

Fig. 6. Map 5. Sp. Musc. 49, Pl. 7, Fig. 2p. 1801. – Types: Europe; not seen.

Plants large, reddish brown to purplish black. Stems up to 4 cm long. Leaves when dry erect, straight, stiff, apices incurved; panduriform, broadest above constriction, about 1 mm long, 0.4 mm wide, symmetrical, abruptly narrowed to triangular apices about 0.2–0.4 the length of leaves. Costae absent. Laminae mostly unistratose, with occasional bistratose patches especially apically, upper cells round to oval, lumina oval, about 5  $\mu$ m wide, walls thick, about 5–6  $\mu$ m, somewhat collenchy-

matous, papillae lacking. Transition from upper to lower cells  $\pm$ abrupt. Basal cells rectangular to long-rectangular, lumina and walls about the same width, walls pitted and nodose. Margins denticulate from near bases into mid-leaf constriction due to projecting cell ends, appearing bordered by several rows of oblique, thinner walled cells. Perichaetial leaves differentiated, sheathing and convolute.

Spore abortion occasional; shriveled brown spores 17–28  $\mu$ m, turgid green spores 26–38  $\mu$ m, rarely larger.

The Greenland specimen had sporophytes; no ecological information was given. Elsewhere usually on wet acidic to basic rocks.

Very rare; new to Greenland, from the southernmost district. Lagerkranz (Nova Acta Regiae Soc. Sci Upsal. ser. 4 14(6): Appendix, Musci, p. 129–134, 1950) reported *A. alpina* for Upernavik and Qeqertarsuaq (Godhavn) in West Greenland. His list is purportedly based on specimens identified by H. Persson. I have seen Lagerkranz collections identified by Persson in S and UPS. None were identified as *A. alpina*; rather the material from Upernavik was correctly identified by Persson as *A. alpestris* and that from Qeqertarsuaq (Godhavn) or Disko as *A. rupestris*. Apparently someone else named some material *A. alpina* or a nomenclatural error was made in assembling the list. For many years *A. alpina* was nomenclaturally confused and many 19th century reports or identifications cannot be relied upon. All early Greenland collections that I have seen identified as *A. alpina* are really *A. alpestris*.

The southernmost Greenland region where *A. alpina* was

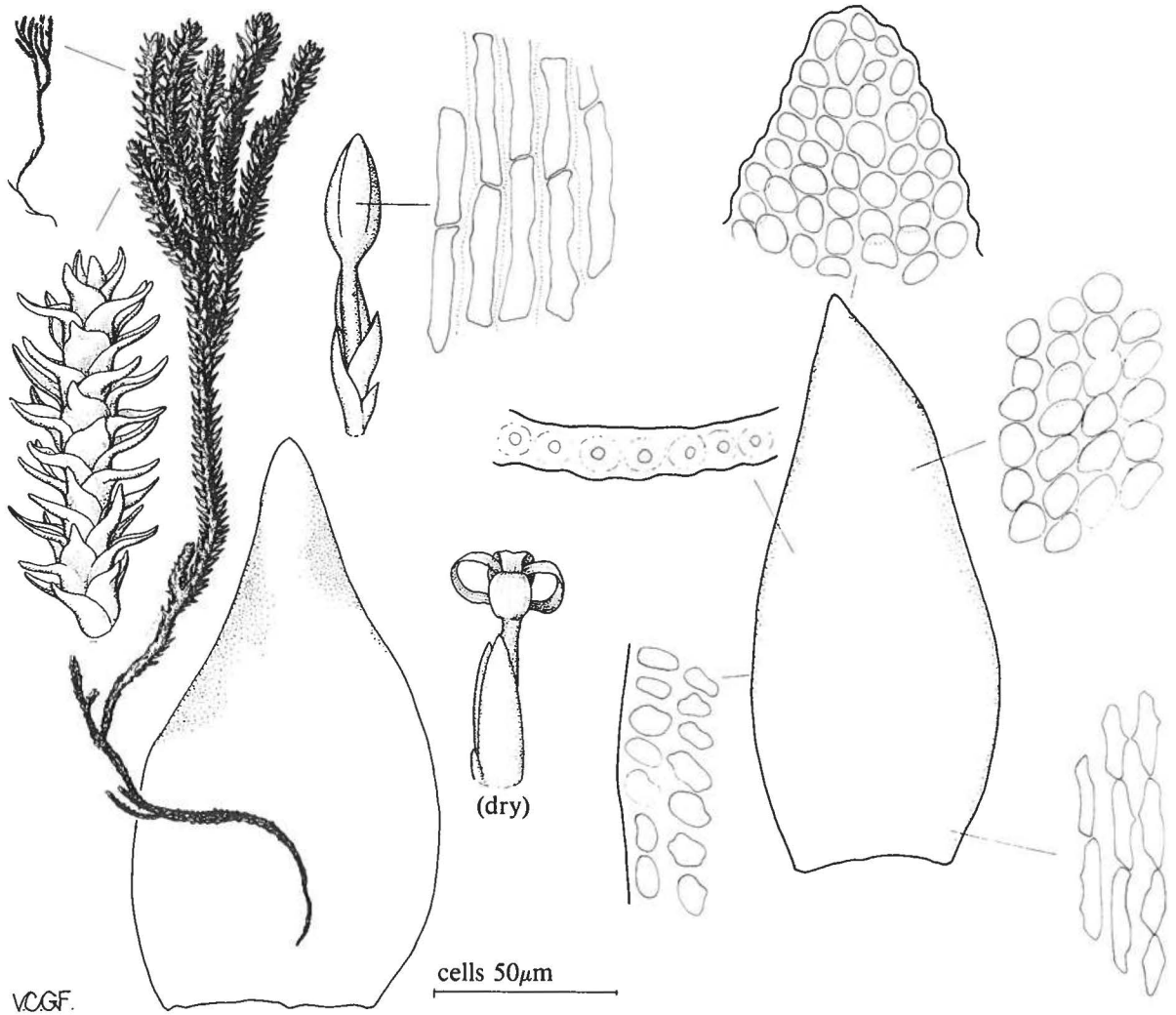


Fig. 7. *Andreaea rupestris* var. *rupestris*.

collected has high summer temperatures and high precipitation, and a cold-temperate or suboceanic floristic element or vegetation is present. For these reasons, the area is considered subarctic and suboceanic rather than arctic by some biogeographers. *Andreaea alpina* occurs in similar climates elsewhere in the North Atlantic region from the British Isles, the Faroes and Norway. In the Southern Hemisphere it is widely distributed on subantarctic and cold temperate islands as well as along the west coast of South America as far north as Colombia. In the Southern Hemisphere it is part of a group of closely related taxa. In the Northern Hemisphere, however, it is taxonomically uniform and has no close relatives.

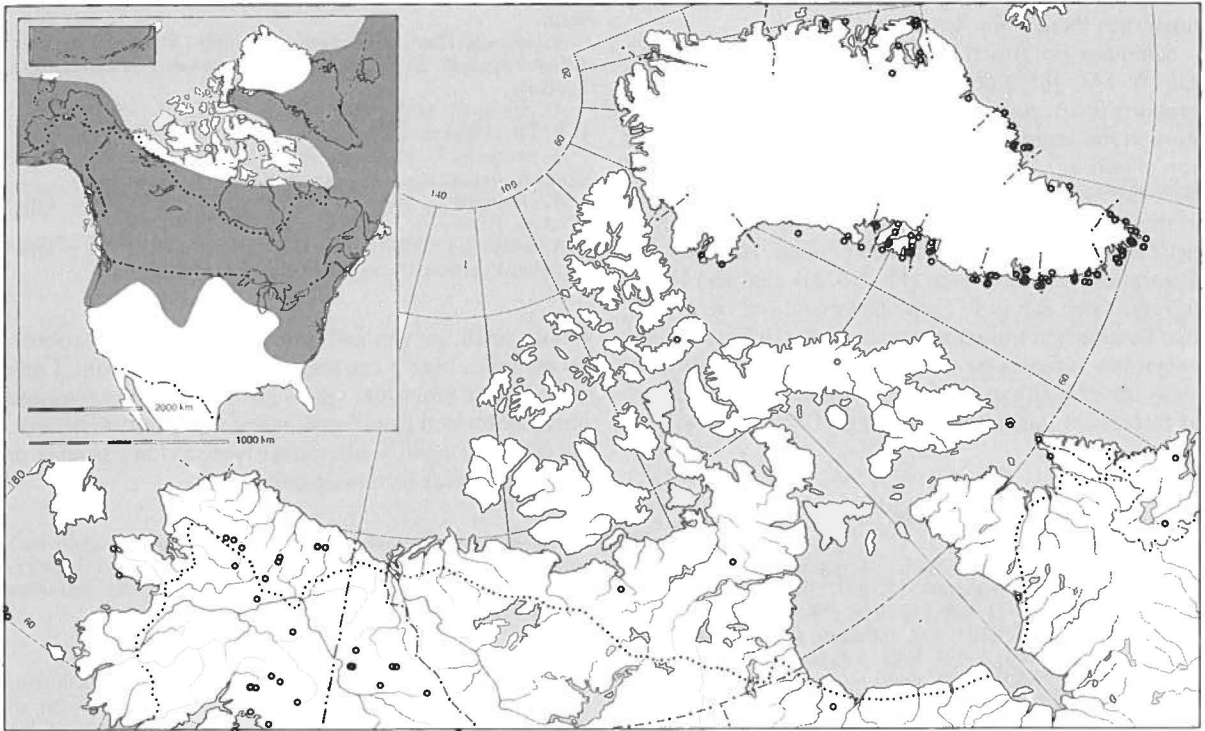
Specimen seen:  
Greenland. S1: Julianehåb district, Kangarsuneq qingordleq, Igdlorsuit, 60°21'N, 44°03'W; 1970 Jacobsen 5039 (C).

Easily identified by its large size, rather coarse appearance, and its symmetric, panduriform leaves that are denticulate along the lower margins and have abruptly formed triangular apices.

**5. *A. rupestris* Hedw.**  
**Var. *rupestris***

Sp. Musc. 47., Pl. 7, Fig. 2g-o. 1801. - Types: Europe; not seen.  
*A. petrophila* Ehrh. ex Fürnr., Flora 10, Beibl. 2: 30. 1827.  
*A. petrophila* Ehrh. var. *homomalla* Thed., Bot. Not. 5: 79, Fig. 48-54. 1849. - Types: Scandinavia, Germany and Britain; not seen.

Plants medium-sized to large, greenish bronze, reddish brown or black. Stems rarely over 3 cm long. Leaves variable: straight to secund, when dry appressed, spreading, squarrose, or sometimes imbricate, when wet widely spreading to squarrose; ovate- to oblong-lanceolate, little constricted above bases or panduriform, usually broadest below constriction, usually less than 1 mm long and 0.5 mm wide; apices usually oblique, often secund, often incurved, obtuse or acute, short to long, gradually formed. Costae absent. Lami-



Map 6. *Andreaea rupestris* var. *rupestris*. Sporophytes not indicated.

nae unistratose, upper cells quadrate to short-rectangular, lumina variable: rounded, oval to irregular, stellate or short-rectangular, about 8–10  $\mu\text{m}$  wide, walls usually thick, 2–6  $\mu\text{m}$ , usually strongly pitted, collenchymatous, characteristically with prominent, whitish cuticular dorsal papillae that are longer than wide. Transition from upper to lower cells  $\pm$  abrupt. Basal leaf cells variable: short- to long-rectangular, lumina wider or much narrower than walls, bulging or not, walls pitted, sometimes strongly so and nodose. Basal marginal cells quadrate, oblate or short-rectangular. Autoicous. Perichaetial leaves differentiated, sheathing and convolute, usually strongly papillose.

Spore abortion frequent; shriveled brown spores usually 20–24  $\mu\text{m}$ , turgid green spores 26–32 (48, rarely more)  $\mu\text{m}$ .

Usually forming greenish or black cushions on  $\pm$  acidic rock that is dry or seasonally wet. Often in drier sites than other *Andreaea* taxa, except the xerophilous *A. heinemannii*, and very rare on soil. Sporophytes frequent.

Occasional to rare, becoming less frequent to the north where it is largely replaced by var. *papillosa*. Widespread in North America, from the Arctic south to North Carolina in the East and to northern California and New Mexico in the West, also in the northern tier of midwestern states: Ohio, Minnesota, Michigan, and Wisconsin. Known from Europe, the Caucasus, Asia, Japan and Pacific Islands. Reported from Central and South America, Antarctica, southern Africa, Tasmania and New Zealand.

Selected specimens seen:

Greenland. S1: Narssaq, 60°56'N, 46°03'W; 1962 Steere 62–881 (C, CANM, NY, S). – W5: Ritenbenk, 69°46'N, 51°20'W; 1870 Berggren *s.n.* (ALTA, H). – E3: Ikásaulaq, 65°59'N, 37°26'W; 1970 Lewinsky 70–1397 (C). – E6: Wollaston Foreland, Daneborg, 74°18'N, 20°12'W; 1947 Holmen 4462 (C).

Canada. Quebec: Hudson Bay, Richmond Gulf, Cairn I.; 1939 Marr M454 (NY). – Northwest Territories: Devon I., True-love Lowland, 75°40'N, 84°40'W; 1973 Peterson 2544 (ALTA). – Ellesmere I., Alexandra Fiord, 78°51'N, 75°40'W; Gillett 18335c (NFLD).

Alaska. St. Lawrence I., Sevuokok, near Gambell, 63°21'N, 169°24'W; 1949 Steere 13690 (ALA, NY). – Etivluk River, vicinity of Etivluk Test Well, 68°22'N, 156°45'W; 1978 Murray 8289 (ALA). – Arctic National Wildlife Refuge, Lake Peters, 69°19'N, 145°03'W; 1974 Murray 6909 (ALA).

The important features that often distinguish this very polymorphic taxon are the bronze-green leaves with prominent whitish papillae, the pitted laminal cells, and the gradually formed, usually short and often oblique tip. Var. *papillosa* usually shares the greenish color and papillae but has a long, abruptly formed leaf tip. Small black forms of var. *rupestris* with incurved, short, obtuse leaf apices, low papillae and less pitted leaf cells are intermediate to *A. alpestris* but usually have oblique, unistratose leaf apices some of which are acute. *Andreaea rupestris* leaves are often panduriform and almost symmetrical, but they are usually strongly papil-

lose and the tip is usually blunt and oblique, which distinguishes them from *A. obovata*.

Schimper (in Bruch, Schimper and Gumbel, Bryol. Eur. 6: 143, 1855) described eight new varieties of *A. rupestris* (as *A. petrophila*). Several have been reported from arctic regions: vars. *acuminata* (as a synonym of var. *papillosa*), *squarrosula*, *silvicola* and *pygmaea*. I have not been able to locate unequivocal type material of these varieties, but all material I have seen in Schimper's herbarium at BM is referable to var. *rupestris*. His illustrations of these taxa (Pl. 2(624)) can also be referred to var. *rupestris*. Schimper wrote (op cit. p. 145) that he attached little importance to the distinctions between the varieties he described but that he wished to show the diversity of forms shown by the species as well as to prevent unnecessary naming of new species.

Var. *papillosa* (Lindb.) Podp.

Fig. 8. Map 7.

Conspectus Musc. Eur. 45. 1954. – *A. papillosa* Lindb., Öfversigt K. Vet.-Akad. Forhandl. 23: 557. 1867. – *A. rupestris* Hedw. ssp. *papillosa* (Lindb.) C. Jens., Skand. Bladmossfl. 4. 1939. – *A. obovata* Thed. var. *papillosa* (Lindb.) Nyh., III. Moss Fl. Fennoscand. 2: 691. 1969. – Types: Spitzbergen; syntypes in H, BM, TRH, UPS, seen.

*A. papillosa* Lindb. var. *gracilis* Lindb., Öfversigt K. Vet.-Akad. Forhandl. 23: 558. 1867. – Type: Spitzbergen; holotype in H, seen.

*A. sparsifolia* Zett., Monogr. Andreaearum Scand. 32. 1855. *A. obovata* Thed. var. *sparsifolia* (Zett.) Nyh., III. Moss Fl.

Fennoscand. 2: 691. 1969. – Type: Norway; in UPS, BM, S, seen.

*A. obovata* Thed. var. *acuminata* Lindb., Öfversigt K. Vet.-Akad. Forhandl. 23: 557. 1867. – Type: Spitzbergen; in H, BM, S, seen.

*A. patens* C. Müll., Bot. Centralbl. 16: 61. 1883. – Type: U.S.S.R., Chukchi Peninsula; isotypes in BREM, H, S, seen.

*A. compacta* C. Müll., Bot. Centralbl. 16: 62. 1883. – Type: Chukchi Peninsula; isotypes in BREM, H, S, seen.

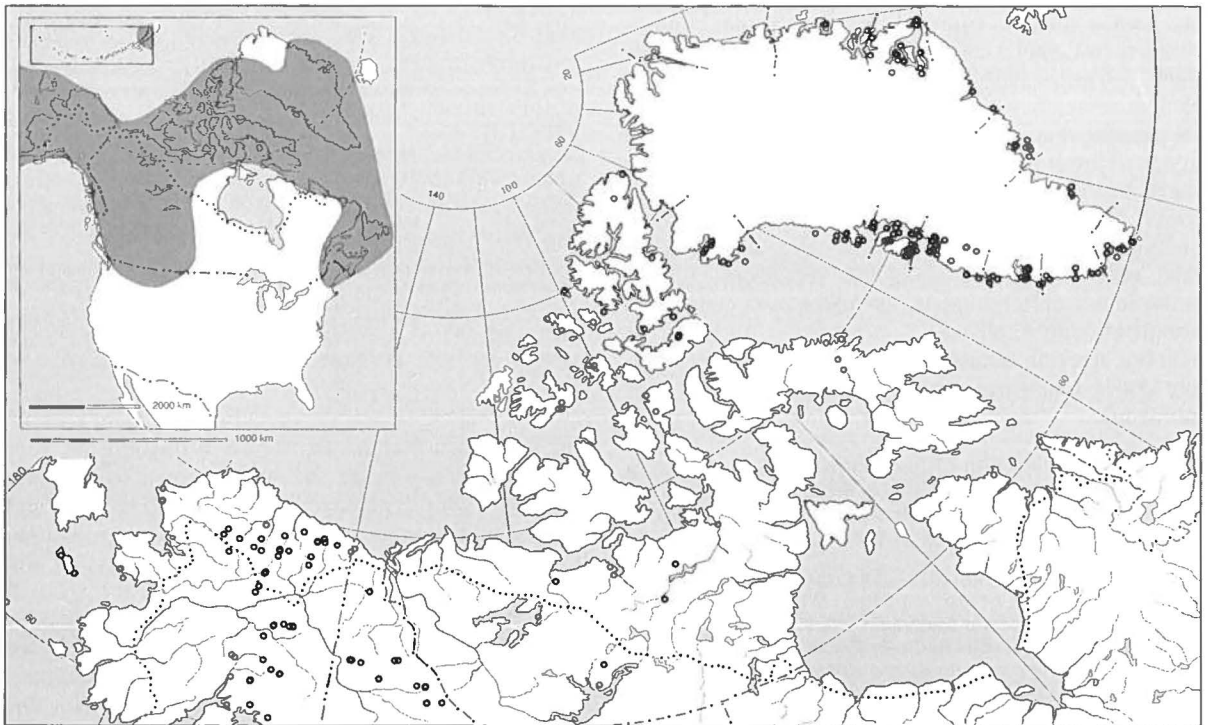
*A. cuspidata* C. Müll., Bot. Centralbl. 16: 62. 1883. – Type: Chukchi Peninsula; isotypes in BREM, H, S, seen.

*A. assimilis* C. Müll., Bot. Centralbl. 16: 63. 1883. – Type: Chukchi Peninsula; isotypes in BREM, H, S, seen.

Plants small, or (on soil) commonly large and robust. Stems often over 3 cm long. Leaves up to about 2 mm long and 0.6 mm wide, apices acute, often very long and abruptly formed from ovate bases; with prominent whitish cuticular papillae often over twice as long as wide or with low, inconspicuous papillae.

Forming dark greenish or black cushions or mats on acidic rock or on coarse mineral soil in snow flushes and streams. When in streams often strongly falcate, with few sporophytes and often mixed with the green second form of *A. obovata*.

Common in the Arctic and the only *Andreaea* taxon occurring in the North American High Arctic. Primarily an arctic or mountainous taxon at high latitudes; only a little material has been seen from south of our region, from mountains of southern Canada and northern U.S.A. Known also from mostly northern and arctic localities in Europe and Asiatic U.S.S.R.



Map 7. *Andreaea rupestris* var. *papillosa*. Sporophytes not indicated.

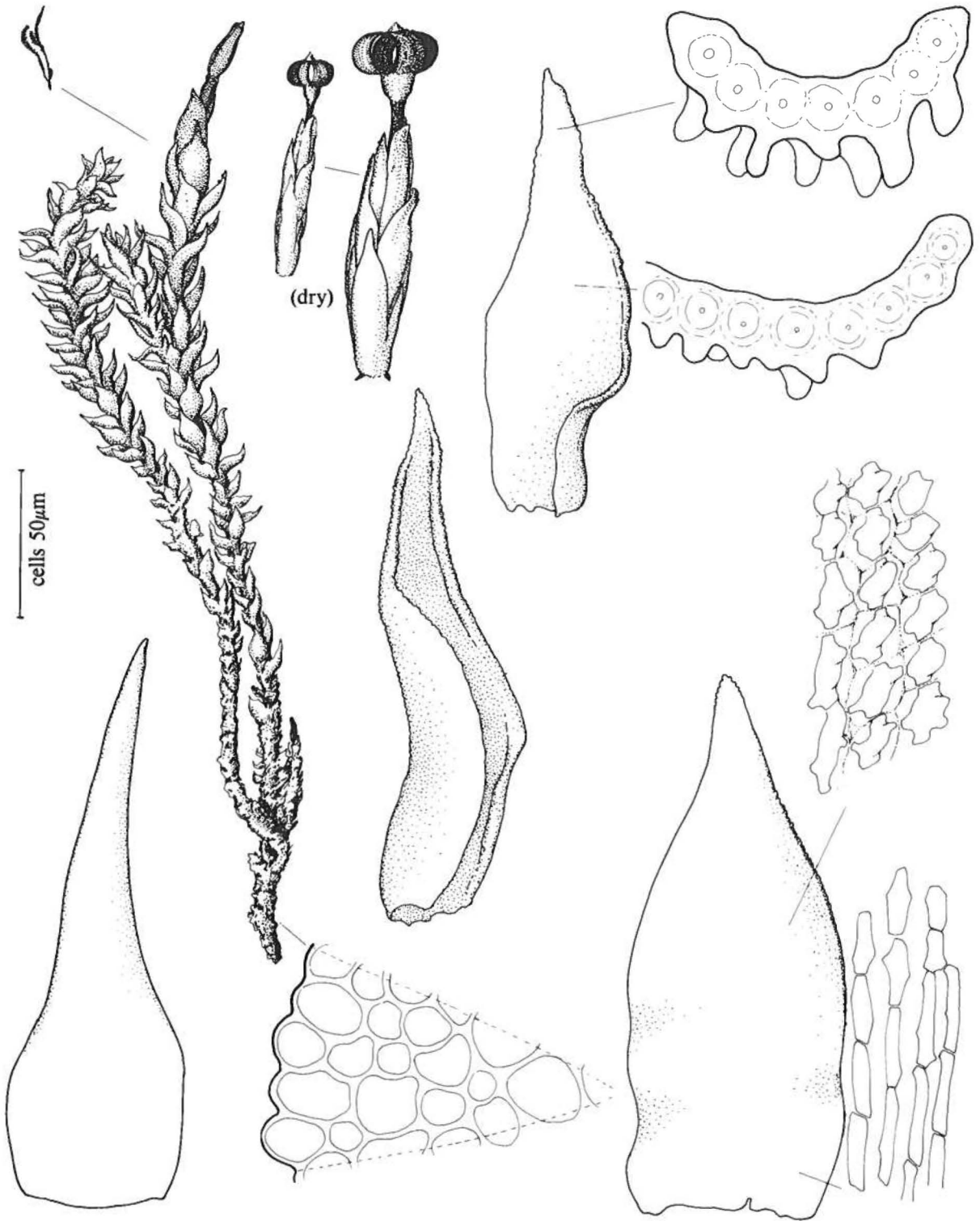


Fig. 8. *Andreaea rupestris* var. *papillosa*, Qaaguðlugssuit, W Greenland; leg. 1971 Holmen & Mogensen 71-1593, (C).

## Selected specimens seen:

Greenland. W5: Ritenbenk, 69°46'N, 51°20'W; 1870 Berggren *s.n.* (CANM, H, NY, S, TRH, UPS). – W6: 'Kekertok', 73°44'N, 56°30'W; 1886 Ryder 14 Sep. (ALA, ALTA, C, NY). – E5: Charcot Land, 71°54'N, 29°00'W; 1958 Holmen 18384 (ALA, ALTA, C, NFDL, NY).

Canada. Northwest Territories: Keewatin district, Chantry Inlet, Parsons Lake, 67°27'N, 95°10'W; 1959 Thomson and Larsen 5948 (NY). – Devon I., Truelove Lowland, 75°40'N, 84°40'W; 1972 Vitt 5464 (ALA, ALTA, CANM, MO, NFDL, NY, S). – Ellef Ringnes I., 1.5 mi SSW of Isachsen, 78°46'N, 103°35'W; 1960 Savile 4123 (NY). – Ellesmere I., The Dean Mt., 82°30'N, 62°20'W; 1973 Brassard 8152 (NY, NFDL).

Alaska. Ogotoruk Creek vicinity, Steep Mt. 68°05'N, 165°37'W; 1980 Murray 10,264 (ALA). – Brooks Range, Chandler Lake, 68°12'N, 152°47'W; 1966 Smith A926 (ALA, BM, CANM, NFDL, NY). – Arctic National Wildlife Refuge, Lake Peters, 69°19'N, 145°02'W; 1974 Murray 6868 (ALA).

Distinguished from var. *rupestris* by the much longer and more abruptly formed leaf apices and by its frequent occurrence on soil as well as rock. Small rock forms with some leaves with gradually formed long apices are difficult to treat, and taxonomic decisions are arbitrary.

Var. *papillosa* is just as variable in form as var. *rupestris*. Falcate forms that have been traditionally treated as *A. sparsifolia*, and which superficially resemble *A. nivalis*, occur most frequently in streams, but they also occur with straight-leaved forms on rocks. As in var. *rupestris* (and many other species of *Andreaea*) falcate or secund forms are common, and taxonomic recognition does not seem justified. Most of the robust material growing on wet soil presents little difficulty in identification, but occasionally populations with green-bronze, highly papillose but shorter tipped and strongly panduriform leaves are seen in Greenland (these forms are not uncommon in Scandinavia), and the leaf shape resembles *A. obovata*. Nyholm (Ill. Moss Fl. Fennoscand. 2: 691, 1969) has illustrated such a plant. Panduriform leaves are not uncommon in var. *rupestris* and well-developed whitish papillae are not characteristic of *A. obovata*, so I have treated var. *papillosa* as closer to var. *rupestris* than to *A. obovata*, but not without hesitation. I suspect that *A. rupestris*, *A. obovata* and *A. alpestris* may produce similar long-tipped forms; distinguishing them, however, will not be possible without experimental work. In Alaska the most common form of var. *papillosa* occurs on rock. It consists of material with a very long, abruptly formed subula from an ovate base. The basal cells have extremely thick longitudinal walls and relatively narrow lumina.

Other than the longer and more abruptly formed apices, there is little to distinguish var. *papillosa* from forms of var. *rupestris* morphologically, and it is possible that the variation is clinal. Var. *papillosa* has a more northern distribution and much greater frequency northward, and on that basis, as well as its distinctive robust appearance throughout much of its range, it seems deserving of taxonomic recognition.

6. *A. alpestris* (Thed.) Schimp.

Fig. 9. Map 8.

In Bruch, Schimper & Gumbel, Bryol. Eur. 66: 146. 1855. – *A. petrophila* Ehrh. var. *alpestris* Thed., Bot. Not. 5: 79, Fig. 45–47. 1849. – *A. rupestris* Hedw. var. *alpestris* (Thed.) Sharp., in Grout, Moss Fl. N. Amer. 1: 2. 1936. – *A. rupestris* Hedw. ssp. *alpestris* (Thed.) C. Jens., Skand. Bladmossfl. 4. 1939. – Type: Scandinavia; in S, UPS, ALTA, seen.

*A. filiformis* C. Müll., Bot., Centralbl. 16: 62. 1883 – Type: U.S.S.R., Chukchi Peninsula; isotype in BREM, seen.

Plants medium-sized to large, characteristically brown, brown-black to black, occasionally reddish. Stems up to 4 cm long. Leaves when dry imbricate and appressed, very rarely secund distally; lanceolate, usually little constricted above bases, rarely panduriform, 0.5–1.0 mm long, rarely longer, 0.25–0.4 mm wide, apices straight or occasionally oblique, short, incurved, obtuse, rarely acute. Costae absent. Upper laminae unistratose or often with irregular, central bistratose patches, cells regular,  $\pm$ quadrate, lumina rounded to oval, (7)8–10(11)  $\mu$ m wide, walls usually thin, 2–3 (rarely to 6)  $\mu$ m, not pitted, weakly collenchymatous, papillae present but low, usually inconspicuous. Cells very gradually becoming longer toward leaf bases. Basal cells short-rectangular, lumina often bulging, up to twice as wide as walls, walls weakly pitted. Basal marginal cells oblate, rounded or short-rectangular. Reportedly autoicous. Perichaetial leaves differentiated, sheathing, convolute, without or with low, very rarely whitish papillae.

Spore abortion frequent; shriveled brown spores 16–21  $\mu$ m, turgid green spores (21)22–26(32)  $\mu$ m, very rarely over 30  $\mu$ m.

In wet to dry, or seasonally wet habitats; forming large cushions on wet rock or on silt over rocks in  $\pm$ level snow flushes; occasionally mingled with *A. obovata*. In Alaska at least, it is the only *Andreaea* species that fills tundra pools and frost scars, and it is rare where water flows faster, on flushed slopes and in streams, where *A. rupestris* var. *papillosa* and large forms of *A. obovata* occur. Sporophytes uncommon.

Quite common in Greenland, but rare in arctic Canada and Alaska. Reported in Holocene lake sediments dating from about 8000–3000 B.P. and at present in southernmost Greenland (Fredskild, Jacobsen and Røen, Meddr Grønland 198(5):1–44, 1975). A northern species, occurring elsewhere in North America in mostly oceanic regions: in the East from Labrador and Newfoundland and in the West from subarctic Northwest Territories, the Yukon, Alaska, British Columbia and California. Known from northern Europe and arctic U.S.S.R. Reports from Madeira and southern North America need verification. Material named *A. alpestris* seen from Central and South America is misidentified.

## Selected specimens seen:

Greenland. S1: Head of Amitsuarssuk fjord, 60°46'N, 45°14'W; 1974 Holmen 74–436 (ALA, C). – W4: Christianshaab, 68°49'N, 51°10'W; 1956 Holmen 15,457 (C, CANM, H, S, UPS). – W5: Ritenbenk, 69°46'N, 51°20'W; 1870 Berggren *s.n.* (C, NY, S, UPS). – W7: Qânâq, Piulip Nunâ, 77°28'N, 69°30'W; 1979 Frahm 792393 (C). – E3: Tugtilik, 66°20'N, 35°00'W; 1971 Lewinsky 71–917 (C). – E5: Charcot Land, 71°54'N, 29°00'W; 1958 Holmen 18,402 (C).

Canada. Quebec: Ungava Bay, offshore island, 59°08'N, 65°45'W; 1975 Weber 1408 (H). – Northwest Territories: Ellesmere I., Glacier Valley, 1899 Simmons 944 (H).

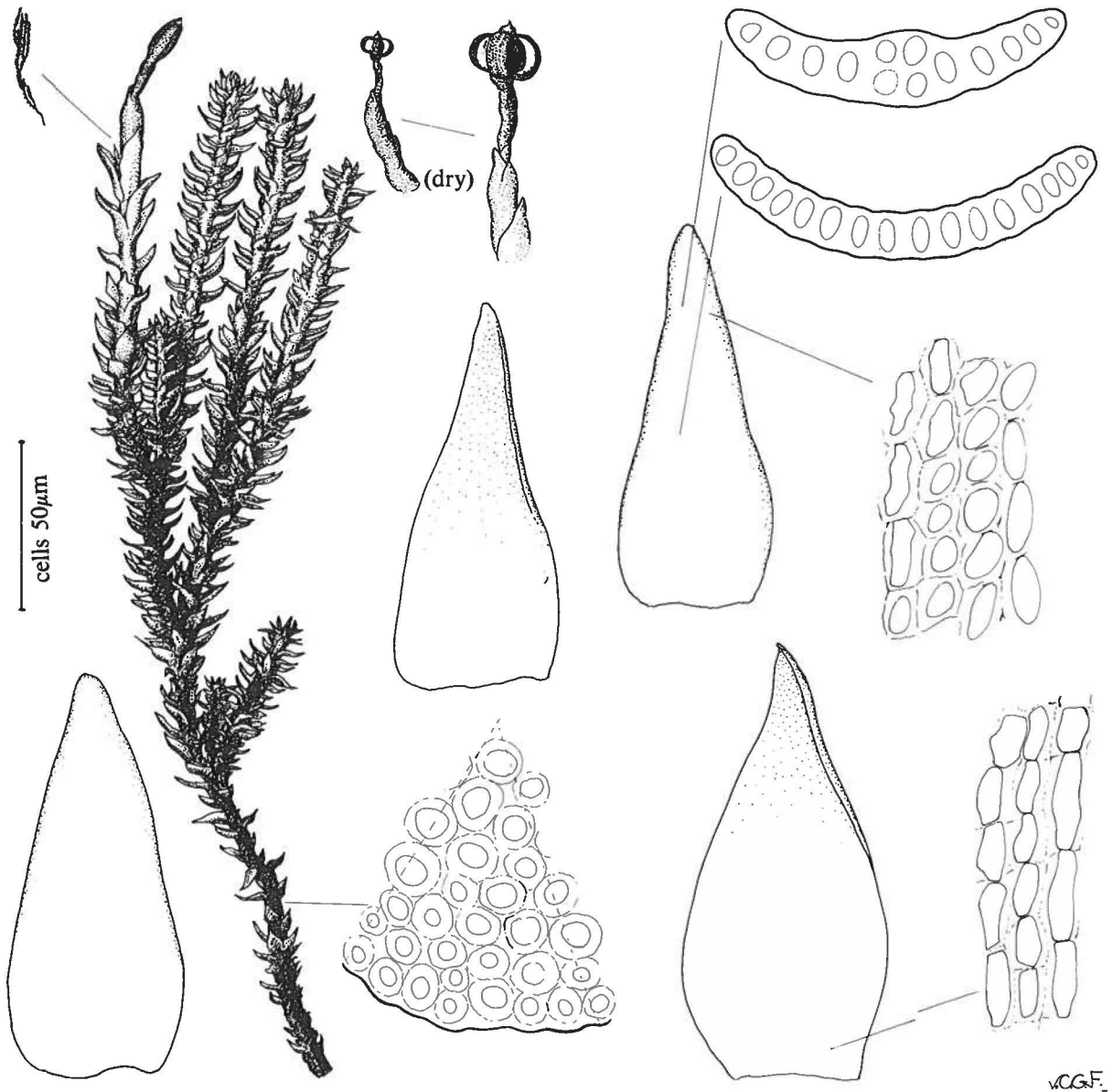
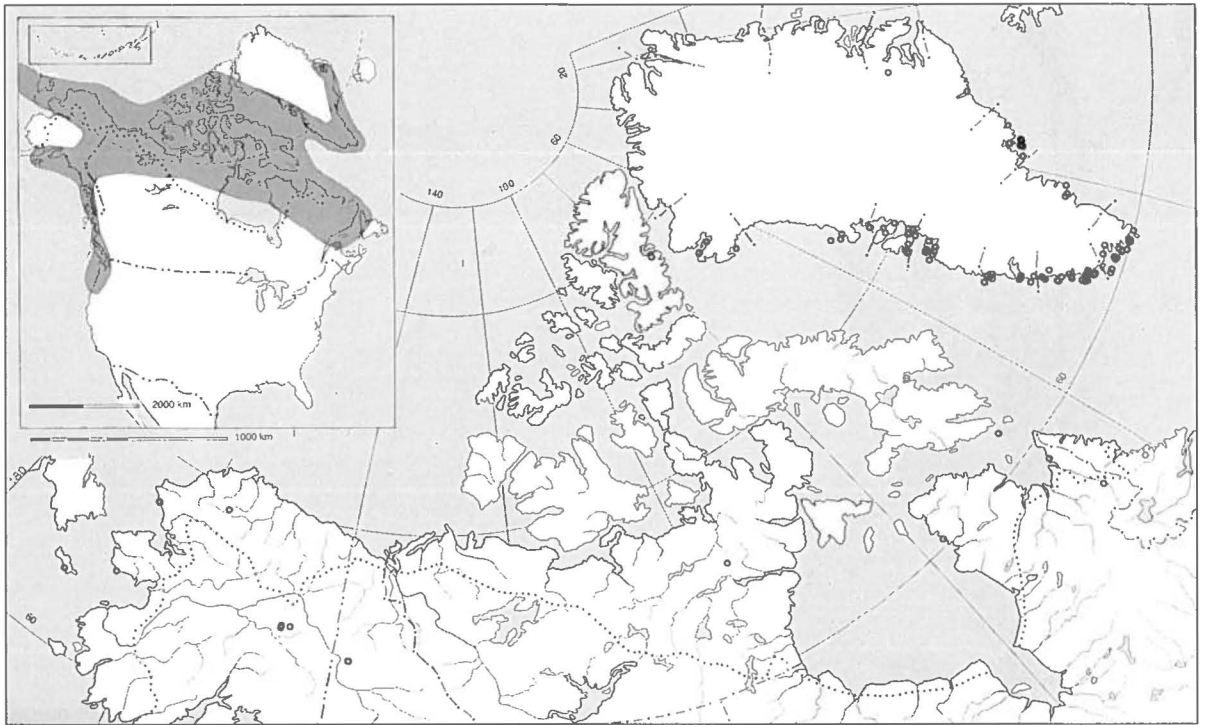


Fig. 9. *Andreaea alpestris*, Laksebugt, Arveprinsen Ejland, W Greenland; leg. 1971 Holmen & Mogensen 71-676, (C).

Alaska. St. Lawrence I., 63°30'N, 170°30'W; 1879 Kjellman 31 Jul. (S). – Ogotoruk Creek, 68°05'N, 165°40'W; 1959 Johnson, Viereck & Melchior 464 (ALA, S).

*Andreaea alpestris* is morphologically uniform. Important features are the slender, imbricate leaves that are usually a soft brown-black shade, occasionally a glossy black. The leaf apices are usually obtuse, straight and incurved; and papillae, though present, are low – not white or conspicuous. Microscopically, it is characterized by thin-walled, little pitted cells with rounded lumina, and in many specimens some leaves have bistratose patches in the upper lamina.

Size of plants is not a good character. *Andreaea alpestris* is frequently described as much smaller than other *Andreaea* species, but this is only relatively true. Its leaves are always much smaller and darker in color than *A. obovata* when they occur together, but on soil it forms long stems and its leaves may be as large as those of *A. rupestris* and *A. obovata* on rock. Similarly, leaf cell size is variable. Small forms of *A. alpestris* on rock can be very difficult to distinguish from forms of *A. rupestris*, and sometimes a satisfactory determination is impossible. Large soil forms with panduriform leaves and more porose cells are very near *A. obovata* but can often be distinguished by bistratose areas of the upper



Map 8. *Andreaea alpestris*. Sporophytes not indicated.



Map 9. *Andreaea obovata*. Sporophytes not indicated.



lamina and the less symmetrical shape and less strongly pitted and nodose cells.

7. *A. obovata* Thed.

Figs 10–11. Map 9.

Bot. Not. 5: 78, Fig. 27–36. 1849. – *A. rupestris* Hedw. ssp. *obovata* (Thed.) C. Jens., Skand. Bladmossfl. 4. 1939. – Type: Sweden; in S, H, UPS, BM, seen.

*A. hartmannii* Thed., Bot. Not. 5: 77, Fig. 1–17, 3–26. 1849. – *A. obovata* Thed. var. *hartmannii* (Thed.) Nyh., Ill. Moss Fl. Fennoscand. 2: 691. 1969. – Types: Sweden; in S, H, UPS, BM, seen.

*A. thedenii* Schimp., in Bruch, Schimper & Gumbel, Bryol. Eur. 6: 150, Pl. 8(630). 1855. – *A. obovata* Thed. var. *thedenii*

(Schimp.) C. Jens., Skand. Bladmossfl. 4. 1939. – Type: Norway; in BM, H, seen.

*A. obtusifolia* T. Jens., Vid. Medd. Naturh. For. Kjöbenhavn 1858: 55. 1859. – Type: Norway; isotypes in H, NY, seen.

*A. krauseana* C. Müll., Bot. Centralbl. 16: 63. 1883. – Type: Chukchi Peninsula; isotypes in BREM, S, seen.

Plants medium-sized to very large and robust, characteristically red-brown, purple-red to purple-brown, often with an orange tint; greenish when submerged. Stems up to 10 cm long. Leaves straight and crowded or, when submerged in streams, secund and distant; when dry  $\pm$  appressed; panduriform, broadest above constriction, or obovate, up to about 1.2 mm long,

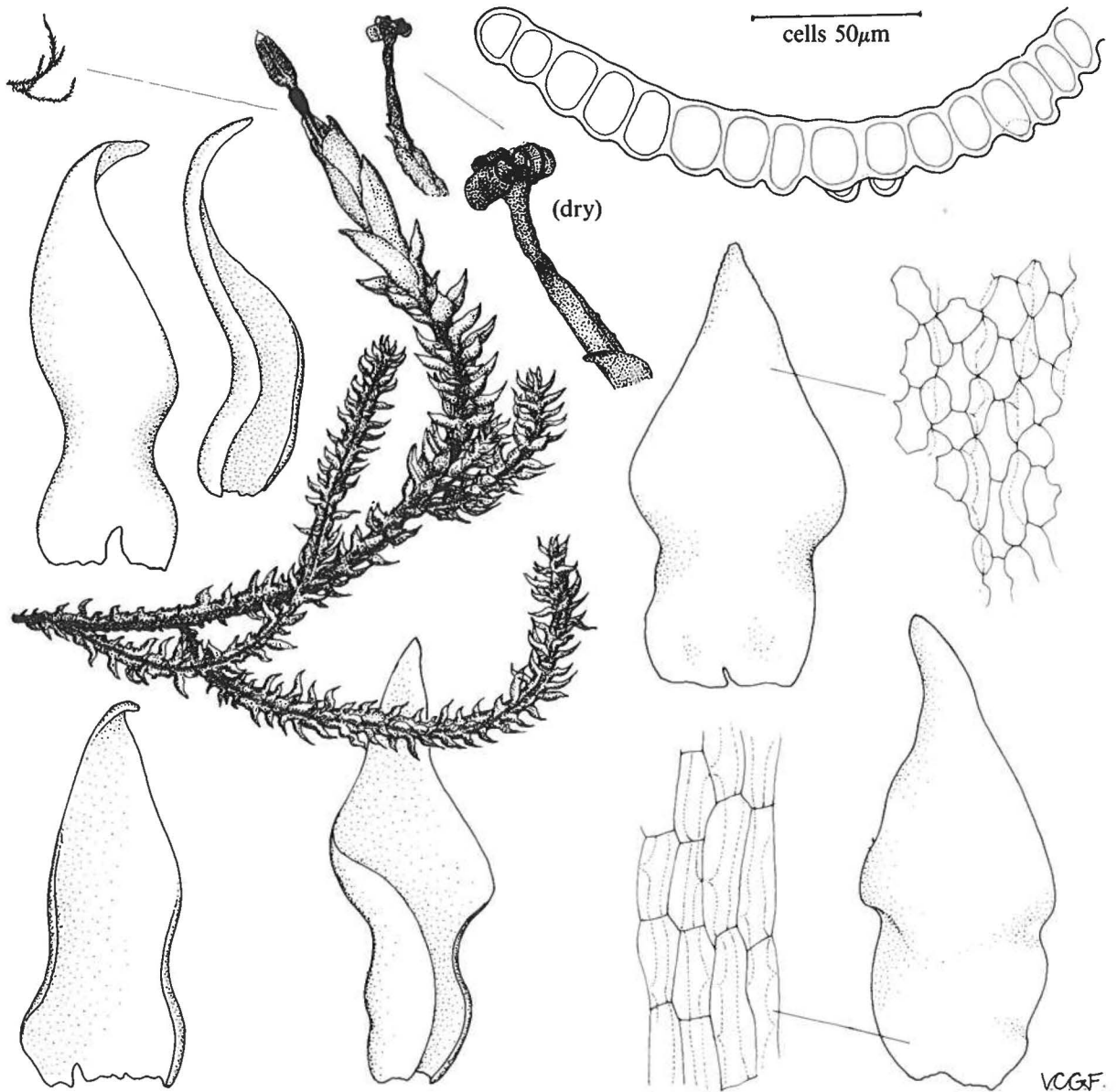


Fig. 10. *Andreaea obovata*, Ilivtiartik, E Greenland; leg. 1969 Holmen 69–393, (C).

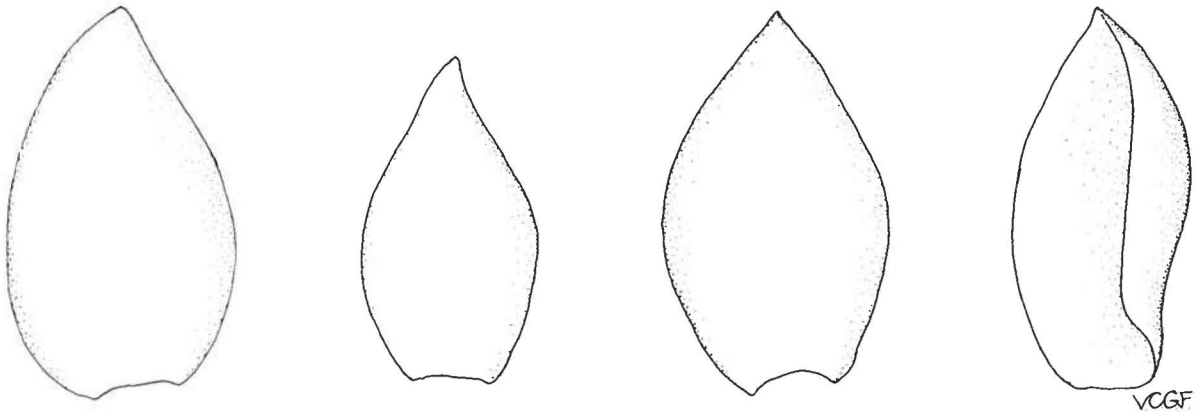


Fig. 11. *Andreaea obovata* (*hartmannii* form), Lake Peters, A Alaska; leg. 1974 Murray 6869, (ALA).

0.5–0.7 wide, apices usually symmetric,  $\pm$  abruptly formed and narrow, about 0.2–0.3 the length of leaves, or broad and short; margins plane or  $\pm$  incurved. Costae absent. Laminae unistratose, upper cells  $\pm$  quadrate, lumina stellate to rhomboidal, 8–10(11)  $\mu\text{m}$  wide, walls thick, 5–8  $\mu\text{m}$ , strongly pitted and collenchymatous, papillae very low, usually broader than high, usually inconspicuous or absent. Mid-leaf cells at constriction  $\pm$  distinct. Basal leaf cells rectangular to long-rectangular, lumina not bulging, usually as wide as or wider than walls, walls strongly pitted and nodose. Basal marginal cells rectangular. Autoicous. Perichaetial leaves differentiated, sheathing and convolute, usually without or with low papillae, rarely conspicuously papillose.

Spore abortion frequent; shriveled brown spores (17) 20–23(26)  $\mu\text{m}$ , turgid green spores (22) 26–35(40)  $\mu\text{m}$ .

Forming soft, orange-red, wine-colored or purple-black cushions on seasonally irrigated rocks or soil. Locally abundant in mountain streams are submerged forms with green-black,  $\pm$  distant leaves that are often secund at stem apices. Such forms are often associated with the falcate form of *A. rupestris* var. *papillosa*. Sporophytes occasional or frequent in populations of robust purple-black plants growing on permanently seeping slopes.

Very rare in North America and rare to occasional in Greenland. Found in low arctic and alpine regions, as far north as 76° in Greenland and not seen much south of 60° N in Labrador and British Columbia. Known also from northern Europe and Asia. Reported from equatorial Africa.

Selected specimens seen:

Greenland. S1: Igdlukasik Island, 60°47'N, 46°25'W; 1962 Holmen 62–234 (C). – W3: Itivdleg, 64°21'N, 50°27'W; 1973 Lewinsky 73–452 (C). – W4: Egedesminde distr., Inugsulik, 68°18'N, 53°30'W; 1887 Hartz 4 Aug. (NY). – W5: Riten-

benk, 69°46'N, 51°20'W; 1870 Berggren *s.n.* (C, H, NY, S, TRH, UPS). – W7: 'Thule'; 1953 Benninghoff & Robbins 7696 (NY). – E3: 'Torssukatak (Tunok)', 65°53'N, 36°53'W; 1969 Holmen 69–393 (C, CANM, H, NY). – E5: Liverpool Land, E side of Hartz Vig, 70°27'N, 21°48'W; 1971 Corner, Halliday & Waterston B55f/71 (NFLD).

Canada. Labrador: Nachvak Fjord, Tasuyiak Arm, 59°02'N, 64°03'W; 1975 Weber 1582 (ALTA, H, S). – Northwest Territories: Baffin I., Clyde River; 1950 Baird 500624 (NY).

Alaska. St. Lawrence I., SE of Paavokjaak [Povohok, ?Powoiliak Camp], 63°22'N, 171°17'W; 1933 Geist *s.n.* (S). – Arctic National Wildlife Refuge, Lake Peters, 69°19'N, 145°03'W; 1974 Murray 6867 (ALA).

A variable species. Small forms of *A. obovata* on rock are distinguished from other members of the *A. rupestris* group by their symmetrical, shortly apiculate, panduriform leaves that are clearly wider above the middle and usually lack obvious papillae. They have a characteristic soft wavy look, due to a strong contraction at the waist or mid-leaf region, and tend to be more orange and purple than the other taxa. Occasionally mingled with *A. alpestris*, leaves of *A. obovata* are always much larger and usually redder; in addition it can be distinguished microscopically by extremely pitted and collenchymatous cell walls. Symmetric, panduriform, papillose material that is intermediate between *A. obovata* and *A. rupestris* var. *papillosa* occurs occasionally in Greenland.

In permanently wet sites, material is larger and the leaf apicula are shorter and broader or sometimes lacking. In swiftly running water a very distinctive form, traditionally treated as *A. hartmannii*, occurs; it has a greenish color, long stems, distant leaves and short, secund leaf apices.

**Buxbaumiaceae**

by Barbara M. Murray

University of Alaska Museum, Fairbanks, Alaska 99775–1200, U.S.A.

Illustrations by Victoria G. Friis and Gert S. Mogensen, Botanical Museum, University of Copenhagen, Denmark.

A monogeneric family very closely related to the Diphysciaceae in sporophyte ontogeny and structure, but differing in the extremely reduced gametophyte, the lack of paraphyses and thallose protonematal appendages, and the sporophyte being elevated on a long seta. Unique among arthrodontous mosses in having a nematodontous parastome and the outer peristomial layer displaced sideways by half a cell (Edwards, in Schuster, ed. *New Manual of Bryology*, Vol. 2: 680, Hattori Bot. Lab., Nichinan, Japan, 1984). Because of the structure of the peristome, the Buxbaumiaceae and Diphysciaceae are often classified between nematodontous and arthrodontous mosses, but relationships within the Bryidae have also been suggested.

**1. Buxbaumia***Buxbaumia* Hedw., Sp. Musc. 166. 1801. – Type: *B. aphylla* Hedw.

Gametophytes minute, scattered or gregarious. Protonemata filamentous, green, perhaps perennial, without thallose appendages. Stems extremely short, without central strands. Leaves few, broadly ovate or ovate-lanceolate, minute, chlorophyllose only at base. Costae absent. Leaf cells oblong – hexagonal, marginal cells with rhizoid-like, multicellular projections that form a brown tomentum over the vaginulae. Dioicous. Perichaetial leaves not differentiated from stem leaves, usually only one terminal archegonium produced. Male plants minute, consisting of single shell-like structures enclosing usually single,  $\pm$ globose antheridia on cygneous stalks. Gametoecea without paraphyses.

Sporophytes terminal, conspicuously larger than gametophytes. Setae straight, elongate, stout,  $\pm$ densely warty-papillose. Capsules oblique, inclined to almost horizontal, very asymmetric above short necks;  $\pm$ ventricose, large, ovate, gradually narrowing to small mouths, appearing inflated, with large air spaces and filaments between walls and spore sacs. Stomata superficial or immersed, at extreme bases of capsules. Annuli absent, dehiscence aided by a nematodontous parastome. Opercula bluntly conic, small, falling with upper parts of massive columellae. Peristomes irregular; exostomes of several layers, partly adhering to endostomes; endostomes whitish, 32-pleated cones with vents above where spores are released. Spores spherical, small, finely papillose, green or tan. Calyptrae bluntly conic, small, often incompletely covering opercula, naked, falling early.

*Buxbaumia* comprises approximately 10 species, found mostly in temperate to subtropical regions, only one of which is known from the Arctic where it is very rare.

**1. *B. aphylla* Hedw.**

Fig. 12. Map 10.

Sp. Musc. 166. 1801. – Types: Europe; not seen

Plants identifiable only by sporophytes. Setae 4–11 mm long, brick-red, densely warty-papillose and appearing irregularly ridged due to many prorate epidermal cells, stout, to 0.25 mm in diameter, differentiated into 4 layers. Capsules  $\pm$ glossy, 3.2–5.0 mm long, 2.0–3.5 mm broad at widest point, almost horizontal at maturity; necks erect, bulbous, abruptly delimited from setae and urns; upper surfaces of urns often flattened and yellow or occasionally red-brown at maturity, lower surfaces red-brown; rims between upper and lower surfaces inflated, red-brown; mouths red-brown; outer cell layer near mouth rolls back like a collar when capsules mature. Exothecial cells irregular,  $\pm$ hexagonal,  $\pm$ isodiametric, 25–45  $\mu$ m, thick-walled and collenchymatous

on upper surfaces of capsules, thin-walled on lower surfaces. Stomata immersed. Peristomes double; with two reduced exostomes of smooth, brownish membranes, about 0.3 mm long, dissected above into short, uneven teeth; endostomes over twice the length of exostomes, about 0.7 mm long. Spores 10–11  $\mu$ m. High spore output of 3.0–5.5 million per capsule reported. Overwinter as immature green capsules, spores shed in summer. Chromosome number reported:  $n=8$  (eastern Europe).

The Alaskan arctic collection was found on a steep, E-facing, alpine shale slope with the rare, arctic polytrichaceous moss, *Oligotrichum falcatum*. Northern collections consist of solitary or scattered plants on acidic, often disturbed soil; frequently a pioneer in trails, old fields, and gravel pits, but may persist for many years in a site; often successional to fire and associated with species of Polytrichaceae, *Ceratodon purpureus*, and lichens in the genus *Cladonia*.

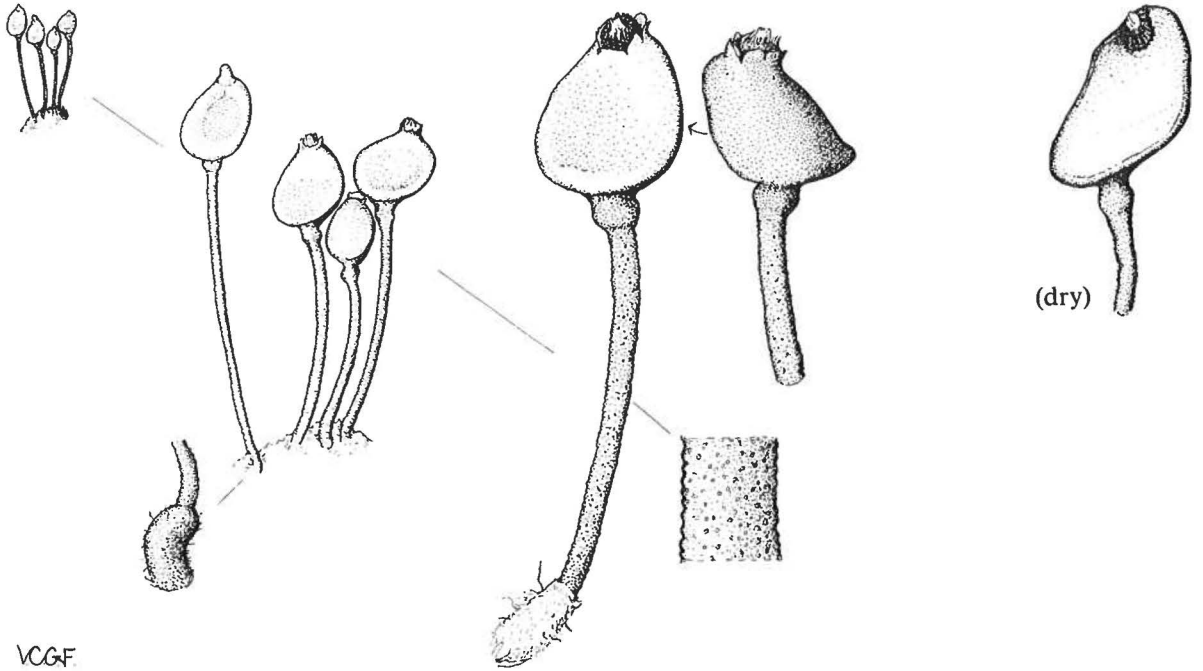


Fig. 12. *Buxbaumia aphylla*, Wickersham Dome, N of Fairbanks, C-Alaska; leg. 1973 Murray 6156, (ALA).



Map 10. *Buxbaumia aphylla*.

Known from one arctic North American locality, in Alaska; also in the Soviet Arctic and northernmost Fennoscandia. Inadvertently reported for, as well as correctly excluded from, Greenland (Crum and Anderson, Mosses of Eastern North America, Vol 2: 1236, Columbia Univ. Press, New York, 1981). Rare and local, but widely distributed in the Northern Hemisphere, from arctic Alaska south through interior Alaska and Yukon to the Pacific Northwest and western states and provinces south to Colorado. Found in midwestern states and provinces from Iowa east, north to Newfoundland and south to North Carolina. Known from Asia (Japan, U.S.S.R.) and Europe. A bipolar species, found also in New Zealand.

Specimens seen:

Alaska: Brooks Range, Franklin Mts., Schrader Lake,

69°19'N, 145°02'W; 1974 Iwatsuki 3206 (NY), 1974 Steere 74-780 (NY).

Unmistakable and remarkable because of its conspicuous and unusual sporophyte – an asymmetric, oblique capsule on a stout seta. The broad capsules orient toward light and when pelted by rain have been reported to emit spores in puffs through the opening in the pleated cone of the endostome. Due to the reduction of the gametophyte frequently considered a saprophyte. Chloroplasts are abundant in the plants, however, including young setae and capsules.

## Diphysciaceae

by Barbara M. Murray

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Illustrations by Victoria G. Friis and Gert S. Mogensen, Botanical Museum, University of Copenhagen, Denmark.

Gametophytes small to medium-sized, in dense turfs; perennial. Thallose protonematal appendages reported in two genera. Stems short, usually unbranched, central strands absent. Leaves contorted when dry, usually lingulate to ligulate, obtuse to acute. Costae present, single, strong, ending below or filling apices. Laminal cells usually more than one-layered, usually rounded-quadrate. Axillary hairs structurally similar to paraphyses. Dioicous or autoicous. Male plants similar to female. Upper and perichaetial leaves longer than lower leaves, perichaetial leaves differentiated, often fringed apically and awned. Gametoecia with numerous paraphyses that appear collared due to rupture of outer walls.

Sporophytes terminal, usually conspicuously larger than gametophytes. Setae straight, very short, sporophytes almost sessile. Capsules oblique, asymmetric,  $\pm$ ventricose, large, ovate, gradually or abruptly narrowing to small mouths, appearing inflated, with large air spaces and filaments between walls and spore sacs. Stomata usually present, superficial, at extreme bases or near mouths of capsules. Annuli present or absent. Opercula conic, small, falling with upper parts of massive columellae. Peristomes usually present, usually double, arthrodontous. Exostomes double, of 16 extremely reduced outer teeth alternating with teeth that adhere to the ridges of the endostome. Endostomes conical, with 16 pleats. Spores spherical, small, finely papillose, green or tan, dispersed through apical vents of endostomial cones. Calyptrae conic or campanulate, very small, often not covering opercula, naked, falling early.

A small family of three genera with about 25 species, many of which are Asiatic.

### 1. *Diphyscium*

*Diphyscium* Mohr, Obs. Bot. 34. 1803. – Type: *D. foliosum* (Hedw.) Mohr (*Buxbaumia foliosa* Hedw.).

Plants blackish green, becoming brown with age. Protonemata filamentous with funnel-shaped appendages. Leaves lingulate, ligulate to lanceolate, or subulate. Costae percurrent or ending below apices, cells little differentiated or with one to two stereid layers. Upper laminal cells rounded-quadrate or rounded-hexagonal, smooth to mammillose and often papillose on both surfaces, usually 2-3-stratose; basal cells rectangular, smooth, hyaline, unistratose. Dioicous or autoicous. Perichaetial leaves much larger than stem leaves, ovate, acuminate, usually ciliate and awned by the long-excurrent costae.

Annuli present. Opercula acutely conic. Calyptrae conic, long-apiculate.

A genus of about 20 species, most of which occur in temperate to subtropical regions of the Northern Hemisphere. Only one is known from the Arctic where it is very rare. The sporophyte is almost sessile in the leafy gametophyte.

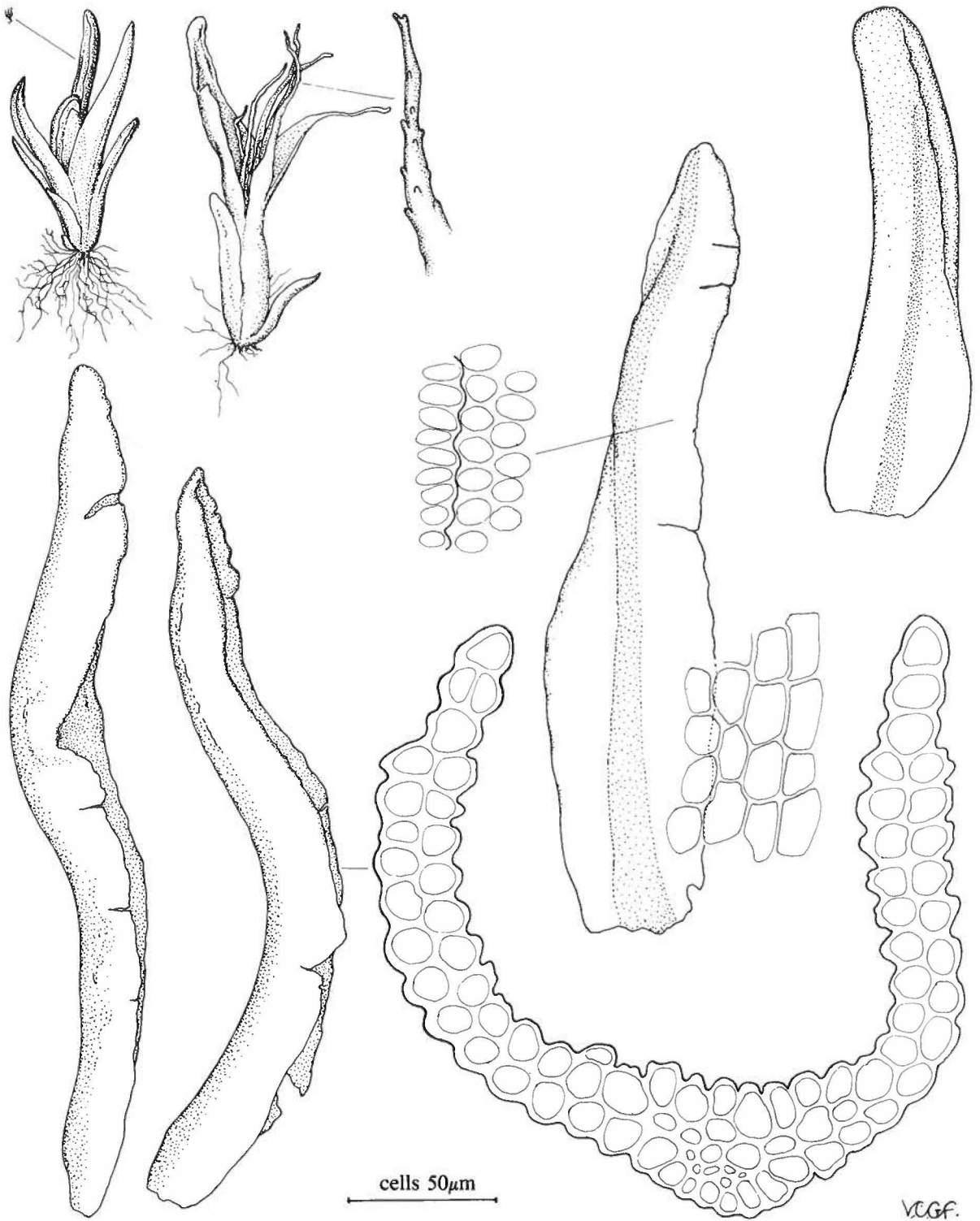
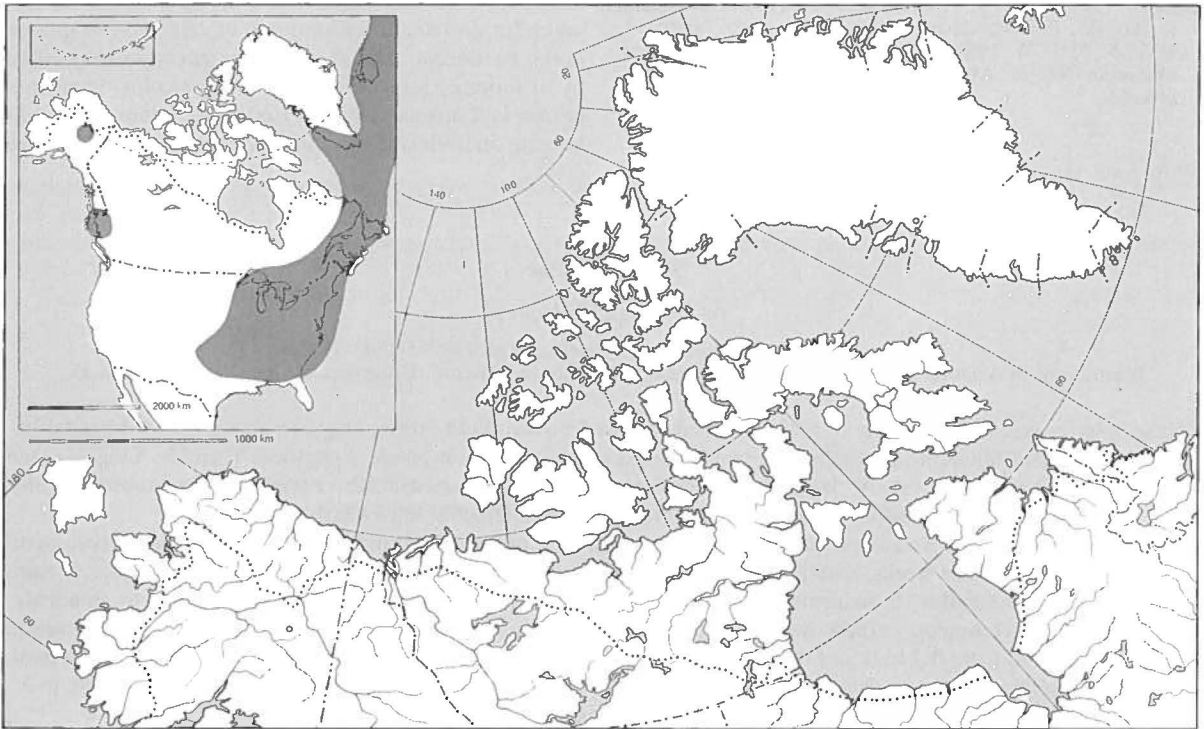


Fig. 13. *Diphyscium foliosum*, Tasiussaq avangnardleq, W Greenland; leg. 1965 Lægaard 3342t, (C).

Map 11. *Diphyscium foliosum*.

### 1. *D. foliosum* (Hedw.) Mohr

Fig. 13. Map 11.

Obs. Bot. 35. 1803; also Web. & Mohr, Index Mus. Pl. Crypt. 3. 1803. – *Buxbaumia foliosa* Hedw., Sp. Musc. 166. 1801. – Types: Europe; not seen.

Stems to 5 mm tall, with light brown basal rhizoids. Leaves 1–2.5 mm long, ligulate, erect-spreading when moist, often strongly curled and contorted when dry, apices obtuse, sometimes cucullate, margins plane or  $\pm$ inrolled, crenate. Costae ending in or below apices, strong but  $\pm$ indistinctly delimited, over 0.3 to 0.5 the width of leaf bases, becoming narrow above, in transverse section ventral cells large, dorsal cells often small, one dorsal stereid layer and a central layer of transversely elliptic cells occasionally well developed. Laminae 2–3-stratose above with occasional 4-stratose patches, margins often unistratose. Laminal cells for 0.6 to 0.8 the length of the leaves irregularly rounded or oblate, small, 10–12  $\mu$ m wide, mammillose to papillose on both surfaces, areolation  $\pm$ obscure; basal cells slightly longer than upper cells. Dioicous. Perichaetial leaves up to 8 mm long, with scarios margins; costae excurrent as long, brown, spinulose awns.

Capsules (not seen in arctic material) ovoid-conic, 3–4 mm long, only slightly angled, lower surface more bulging than upper, pale yellowish to brown. Exothecial cells irregular, longer than broad,  $\pm$ isodiametric or hex-

agonal, cells of upper surface of capsules slightly collenchymatous, with straight walls, cells of lower surface not collenchymatous, with very sinuose walls. Stomata superficial, at extreme bases of capsules. Annuli of 1–2(3) rows of round to ovate, vesiculose cells, persistent or deciduous. Opercula about 1 mm long. Endostomes up to 1 mm long. Spores 9–12  $\mu$ m, mature in summer. Chromosome numbers reported:  $n=8, 9$  (Europe);  $n=9$  (U.S.A.).

Arctic specimens are sterile and were growing as small, brownish patches on tundra and wet cliffs. Northern material is found mostly in exposed habitats on thin, acidic soil, occasionally in snow flushes. Also a pioneer on rails and tracks.

Very rare. In the North American Arctic known from several collections from southern and southwestern Greenland. In Alaska thus far known only from one subarctic alpine locality. From these northern sites southward there is a large gap in North American distribution. Widely distributed in eastern North America from Labrador and Newfoundland west to Wisconsin, south to Georgia and west to Louisiana and Oklahoma. Outside Alaska, known in western North America only from British Columbia. Reported from the Antilles and Central America. Reported from Jan Mayen in the European Arctic; other European distribution includes the Faroes, Iceland, and the Azores; Madeira; Africa; and Japan.

Specimens seen:

Greenland. S1: Hollænderø, 60°40'N, 46°30'W; 1971 Petersen H.74.c. (C). – Head of Amitsuarssuk fjord, 60°46'N, 45°14'W; 1974 Damsholt 74–1225 (C). – Narssaq, 60°56'N, 46°03'W; 1962 Steere 62–935, 62–948 (NY). – Narssarsuaq,

Murray: Tetraphidaceae

61°10'N, 45°25'W; 1974 Damsholt 74–100 (C). – ‘Kakarsuak at Narsak’, 1888 Rosenvinge 18 Jul. (C). – W5: Godhavn, 69°15'N, 53°32'W; 1962 Steere 62–135 (C, NY). – Godhavn, mountain NE of Arctic Station, 1985 Murray 17 Aug. (ALA).

and much contorted when dry, sterile plants can be mistaken for *Tortella*, *Trichostomum* or *Didymodon* species in the Pottiaceae. But *D. foliosum* can be distinguished by its more or less uniform dull brown color, its always obtuse leaf apices, its bi- or tristratose lamina, the cells bulging on both surfaces, and its less distinctly delimited costa.

With their strap-like, papillose leaves that are inrolled

**Tetraphidaceae**

by Barbara M. Murray

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Illustrations by Victoria G. Friis and Gert S. Mogensen, Botanical Museum, University of Copenhagen, Denmark.

Gametophytes perennial, minute to medium-sized, dull red-brown, light green, or green above and red-brown below. Protonemata filamentous, thallose appendages present. Stems with basal, ±papillose rhizoids. Leaves often conspicuously 3-ranked, ovate to lanceolate, ±keeled. Laminal cells unistratose, ±thick-walled, smooth. Autoicous, but reportedly some shoots producing only perigonia. Perichaetial leaves large.

Sporophytes terminal. Setae in surface view twisted to the left below and to the right above. Capsules erect, symmetrical, with very short necks, usually tapering abruptly to setae. Exothecial cells rectangular, elongate, ±thin-walled, at mouths smaller, ±quadrate. Annuli absent. Opercula conic, unistratose, red-brown; cells quadrate, oblate to short-rectangular, ±thick-walled. Peristomes of four, ±deeply inserted, erect, solid, triangular teeth, each tooth formed from 0.2 to 0.3 of the upper capsule, nematodontous, tan to brownish. Spores spherical to oval, very finely papillose, green or yellowish, mature from spring to fall. Calyptrae mitrate, appearing plicate due to localized thickenings, lobed, naked, sometimes scabrous apically.

This small family consists of two genera and five species three of which occur in the Arctic. Taxonomically isolated, the group is characterized by the production of thallose protonematal appendages and by the four peristome teeth composed of whole cells.

- 1. Plants small to medium-sized, 0.5–3.0 cm high. Costae strong. Upper laminal cells short, rounded-hexagonal. Capsules long-cylindric, stomata absent. Calyptrae covering upper 1/3–1/2 of capsules. Gemmiferous stems common. Usually on rotting wood . . . . . 1. *Tetraphis*
- 1. Plants minute, bud-like, up to 0.5 cm high. Costae weak or absent. Upper laminal cells rectangular to rhombic. Capsules short-cylindric, stomata present. Calyptrae almost completely covering capsules. Gemmiferous stems absent. Usually on rock. . . . . 2. *Tetrodontium*

**1. Tetraphis**

*Tetraphis* Hedw., Sp. Musc. 45. 1801. – Type: *T. pellucida* Hedw.

Plants small to medium-sized, forming dense turfs. Spatulate protonematal appendages not persistent. Stems elongate, 0.5–1.5(3.0) cm high, usually unbranched, shiny, red-brown, ±triangular in transverse section, with central strand. Lower parts of stems with minute, 0.4–1.0 mm long, distant leaves; leaves abruptly enlarged and dense on upper parts of stems, uppermost leaves the largest, up to 3 mm long. Leaves appressed to erect-spreading, sometimes twisted, occasionally ±secund, sometimes decurrent, margins entire, plane or broadly reflexed. Costae single, narrow, long, strong, ending below the apex in lower leaves, subpercurrent or rarely percurrent in upper leaves. Laminal cells irregularly rounded-hexagonal, 10–20 µm wide, ±isodiametric throughout or oblong in the bases of upper leaves. Perichaetial leaves up to 4 mm long. Gemmiferous stems common, gemmae cups terminal on sterile shoots, composed of rosettes of broadly obovate leaves; gemmae cups large, up to 1 mm in diam., or, in some populations, small, up to 0.3 mm in diam., gemmae ±globose, lenticular, up to 220 µm long, stalked, multicellular, mixed with paraphysis-like hairs.

Setae 5–18 mm long, in surface view twisted to the left below and to the right above, red-brown. Capsules long, narrowly cylindrical, straight or slightly curved, red-brown. Urns 1.5–3 mm long, contracted under mouths. Exothecial cells long-rectangular, at mouths with 5–6 rows of shorter, orange cells. Stomata absent. Opercula 0.7–1 mm long. Peristome teeth deeply inserted, narrowly triangular, 0.5–0.9 mm long, up to 0.2 mm wide at base, hyaline and often ±divided apically, cells elongate. Calyptrae covering upper 0.3 to 0.5 of capsules, up to 2 mm long, red-brown above, white in lower 0.5 to 0.7, often splitting to near apices.



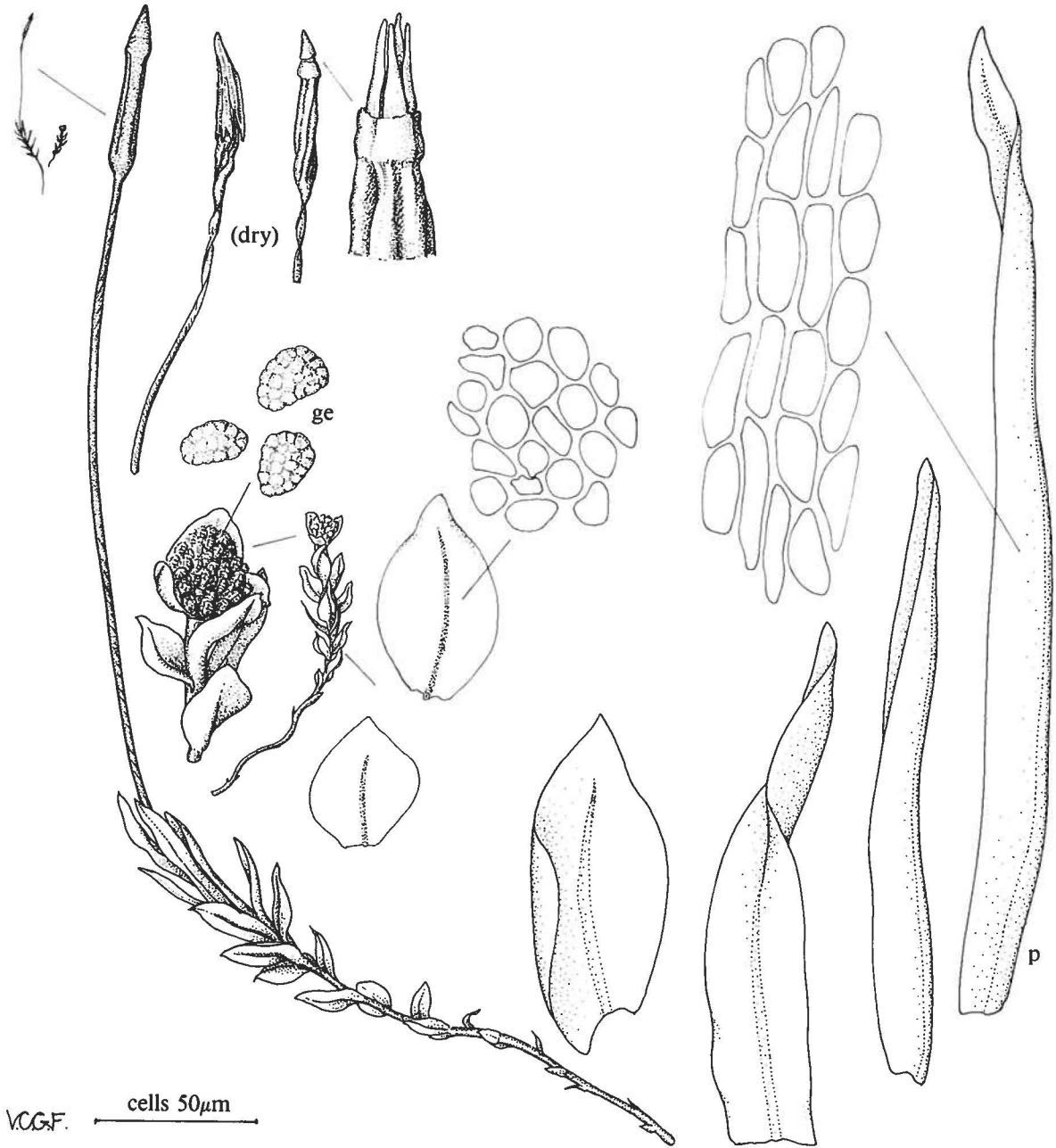
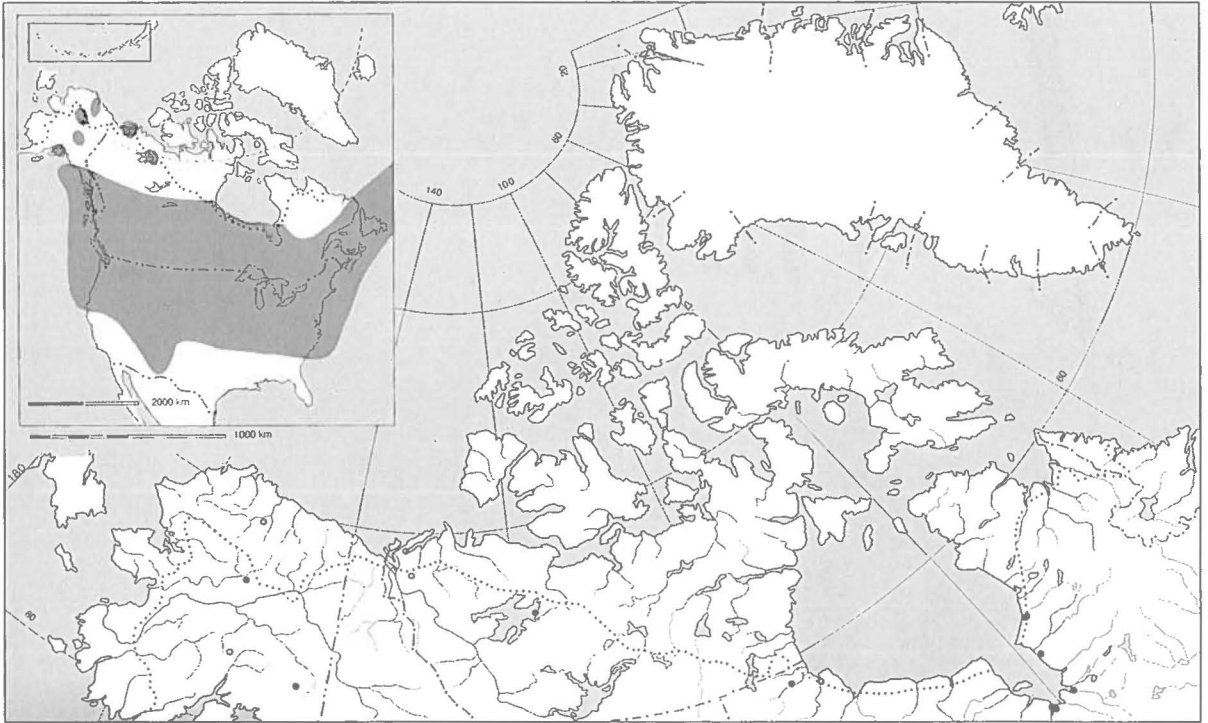


Fig. 14. *Tetraphis pellucida*, Eagle Creek, Oregon; leg. 1953 Culver & Namba *s.n.* (ALA), and Colville River, Umiat, A-Alaska; leg. 1951 Steere 16937, (ALA).

A genus of two species, both of which have outliers in the western North American Arctic with their main range in temperate regions.

- 1. Setae straight, smooth or weakly mammillose above. Perichaetial leaves  $\pm$ untwisted and appressed, neither squarrose nor widely spreading when wet, elongate-lanceolate, not ribbon-like. Spores 9–13  $\mu$ m. Upper stem leaves ovate, acute, rarely acuminate ..... 1. *T. pellucida*
- 1. Setae abruptly bent near the middle, always strongly mammillose above the bend. Perichaetial leaves irregularly twisted and spreading,  $\pm$ squarrose when wet, strap-like or linear, ribbon-like. Spores 12–19  $\mu$ m. Upper stem leaves ovate-lanceolate, acuminate..... 2. *T. geniculata*



Map 12. *Tetraphis pellucida*.

**1. *T. pellucida* Hedw.**

Sp. Musc. 45, Pl. 7, Fig. 1a-f. 1801. – *Georgia pellucida* (Hedw.) Rabenh., Deutsch. Krypt. fl. 2(3): 231. 1848. – Type: Europe; not seen.

*Georgia trachypoda* Kindb., Rev. Bryol. 20: 93. 1893. – Type: Canada, Columbia; not seen.

Fig. 14. Map 12.

Leaves ovate to ovate-lanceolate, mostly acute. Minute leaves on lower parts of stems ovate, obtuse, usually appressed. Perichaetial leaves ± appressed, linear-lanceolate.

Setae straight, in surface view loosely twisted to the left below, ± tightly twisted to the right above, ± terete, smooth or weakly mammillose above. Urns striate or ribbed. Exothecial cells often weakly twisted to the right. Spores 9–12(13) μm. Chromosome numbers reported: n=7 (western U.S.A., eastern Europe), n=8 (Umiat, Alaska; eastern U.S.A.; eastern Canada; U.K.).

Arctic collections usually lack sporophytes and grow as low, red-brown turfs on soil on moist, mostly shaded peaty banks, edges of hummocks, polygons and rarely in rock crevices. Within the boreal forest, usually found on rotting coniferous wood, occasionally on moist humus, and rarely in crevices or at the shaded edges of siliceous rocks.

The northern limit of *T. pellucida* in North America is near the northern limit of trees, and very few collections have been

made in the Arctic, from the east coast of Hudson Bay northwest to Alaska. From these northern outliers, *T. pellucida* occurs throughout North America as far south as Alabama, Arkansas, South Dakota, Colorado, Arizona, and California. Reported from the Soviet European and Siberian Arctic, Europe and Asia.

Specimens seen:

Canada. Quebec: Hudson Bay, E coast, Great Whale River: 55°14'N, 77°23'W; 1947 Tuomikoski 1901 (CANM). – E of Sandy Point, 55°17'N, 77°43'W; 1947 Kucyniak & Tuomikoski T 1589 (CANM). – Manitoba: Hudson Bay, W coast, Fort Churchill vicinity: 58°46'N, 94°10'W; 3–5 mi E; 1956 Crum and Schofield 6704 (CANM). – Between Fort Churchill and Cape Merry; 1956 Crum & Schofield 6925 (CANM). – Northwest Territories: Mackenzie River Delta, Hyndman Lake. 68°14'N, 132°06'W; 1966 Scotter 8922 (CANM). – Tuktoyaktuk Peninsula, Ibyuk Pingo, 69°23'N, 133°02'W; 1969 Dickson M135, M326 (CANM).  
Alaska. Umiat vicinity: 69°22'N, 152°08'W; 1974 Iwatsuki 2170 (NY); 69°23'N, 152°10'W; 1951 Steere 16937 (CANM, NY).

Sterile material can be distinguished from *T. geniculata* by the more ovate leaves that are acute but usually lack an apiculus. Additionally, *T. pellucida* is primarily a boreal species whose range does not overlap that of *T. geniculata* except in oceanic regions. Material with sporophytes can be distinguished easily by the straight and smooth, or only slightly mammillose seta. *Tetradontium* species are much smaller than *Tetraphis* species, grow on rock and lack gemmae.

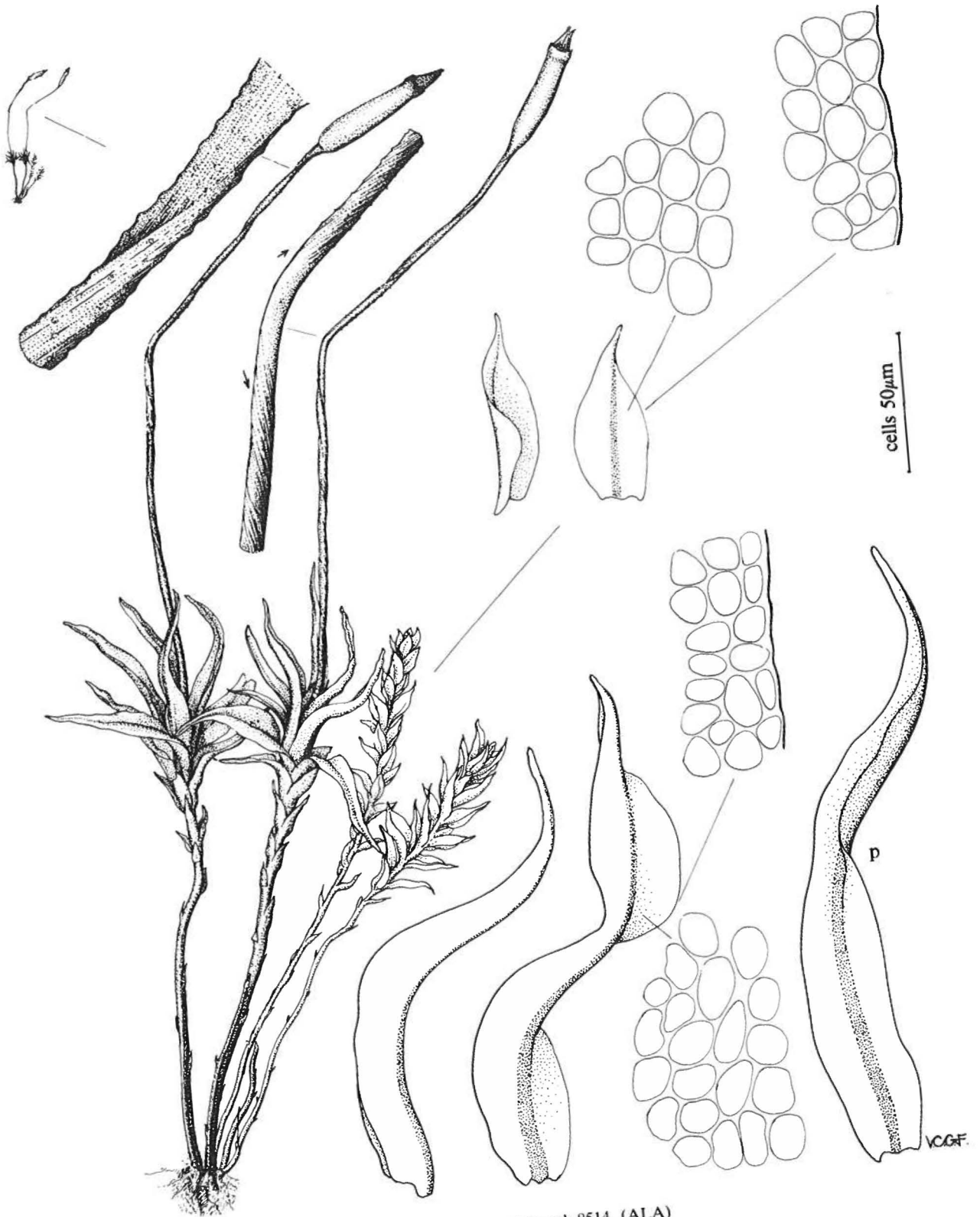


Fig. 15. *Tetrarhizaceae*, near Haines, Alaska; leg. 1967 Viereck 8514, (ALA)



Map 13. *Tetraxis geniculata*.

**2. *T. geniculata* Girg. ex Milde**

Fig. 15. Map 13.

Bot. Zeit. 23: 155. 1865. – Type: Sakhalin; not seen.

Leaves ovate-lanceolate to lanceolate, apiculate, often oblique. Lower leaves minute, acute, usually spreading. Perichaetial leaves flexuose, spreading, squarrose when wet, ribbon-shaped.

Setae geniculate near middle, in surface view tightly coiled to the left and terete below the bend,  $\pm$ loosely twisted to the right and  $\pm$ flattened above the bend, smooth below, sharply and strongly mammillose from projecting ends of cells above the bend, hygroscopic, setae of adjacent plants frequently coiled around each other. Urns striate. Exothecial cells mostly straight, not twisted. Spores (12)13–18(19)  $\mu$ m. Chromosome number reported:  $n=8$  (Japan; Washington, U.S.A.)

Usually found on rotting coniferous wood, rarely on siliceous rock. No habitat information was given for the one arctic specimen, but *T. geniculata* appears to have been growing at the base of tussocks on dead leaf bases of the cottongrass, *Eriophorum vaginatum*. *Polytrichum strictum*, *Sphagnum balticum*,

and *Cladonia* sp. are associates. The arctic collection has both sporophytes and gemmae.

Primarily oceanic and North American in distribution. Previously unknown from the Arctic; seen from a single arctic locality in Alaska. Otherwise occurring far to the south and widely disjunct in North America: in the East from Newfoundland south to New Hampshire and in the West from southern and southeastern Alaska south along the Pacific Coast to British Columbia and Oregon and east to Idaho. Outside North America *T. geniculata* is known from the southern Far East region of U.S.S.R. and from Japan. Yukon reports are unsubstantiated and very probably are based on a collection made by R. S. Williams, mislabeled Yukon territory but actually from a southeastern Alaskan locality: Canon City, Dyea Creek. The report from the Canadian Arctic Archipelago (Ireland et al., Checklist of the mosses of Canada, Nat. Mus. Canada Publ. Bot. 8: 36, 1980) was an error (R. R. Ireland, in litt. 1983).

Specimen seen:  
Alaska. Seward Peninsula, Candle, 65°55'N, 161°56'W; 1949  
Sigafoos 49–140 (NY).

Separated from *T. pellucida* by the geniculate, strongly mammillose seta.

## 2. *Tetrodontium*

*Tetrodontium* Schwaegr., Sp. Musc. Suppl. 2(1). 102. 1824.  
Type: *T. brownianum* (Dicks.) Schwaegr. (*Bryum brownianum* Dicks.)

Plants minute, bud-like, scattered to caespitose. Thallose protonematal appendages usually present. Stems very short, about 5 mm high, unbranched,  $\pm$ shiny, brownish, without central strands. Leaves appressed, lanceolate, minute, up to 1.2 mm long, margins entire or crenate above, plane. Costae single and weak or absent on leaves from the same plant. Laminal cells rhombic or rectangular, 12–30  $\mu$ m long, 9–12  $\mu$ m wide, narrower marginally, shorter apically. Gemmiferous stems absent.

Setae 3–8 mm long, straight or somewhat flexuose, smooth to weakly ribbed. Capsules ovate- or shortly oblong-cylindric, erect. Urns up to 1 mm long, slightly contracted under the wavy mouths. Stomata slightly immersed at extreme bases of capsules, surrounded by small,  $\pm$ isodiametric cells. Opercula apiculate, up to 0.5 mm high. Peristome teeth broadly triangular, 0.2–0.4 mm long, 0.15–0.18 mm wide at bases, cells short-rectangular. Calyptrae almost completely covering capsules, up to 1.2 mm long, red-brown, whitish only at extreme bases, splitting nearly to apices when capsules mature.

A genus of three species mainly from temperate regions. Much smaller than *Tetraphis* and found on rock rather than rotting wood. Frequently and incorrectly spelled *Tetradontium*; from the Greek *tetra-* and *-odontus*.

### 1. *T. repandum* (Funck) Schwaegr.

Sp. Musc. Suppl. 2(1): 102. 1824. – *Tetraphis repanda* Funck, in Sturm, Deutschl. Fl. 2(17): pages not numbered, pl. 24. 1819.

Fig. 16. Map 14.

– *T. brownianum* (Dicks.) Schwaegr. var. *repandum* (Funck) Limpr., Krypt. Fl. Schles. 1: 110. 1876. – Type: Germany; not seen.

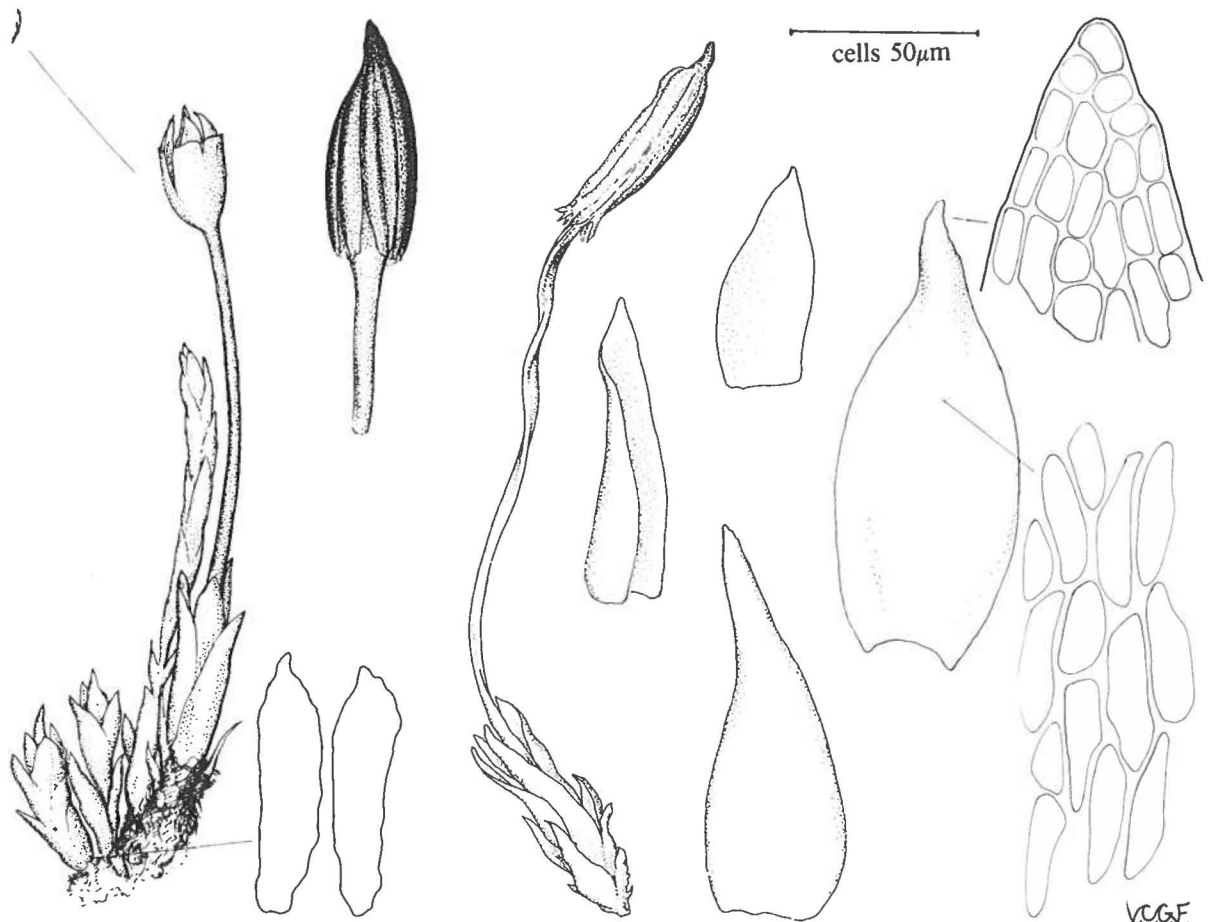
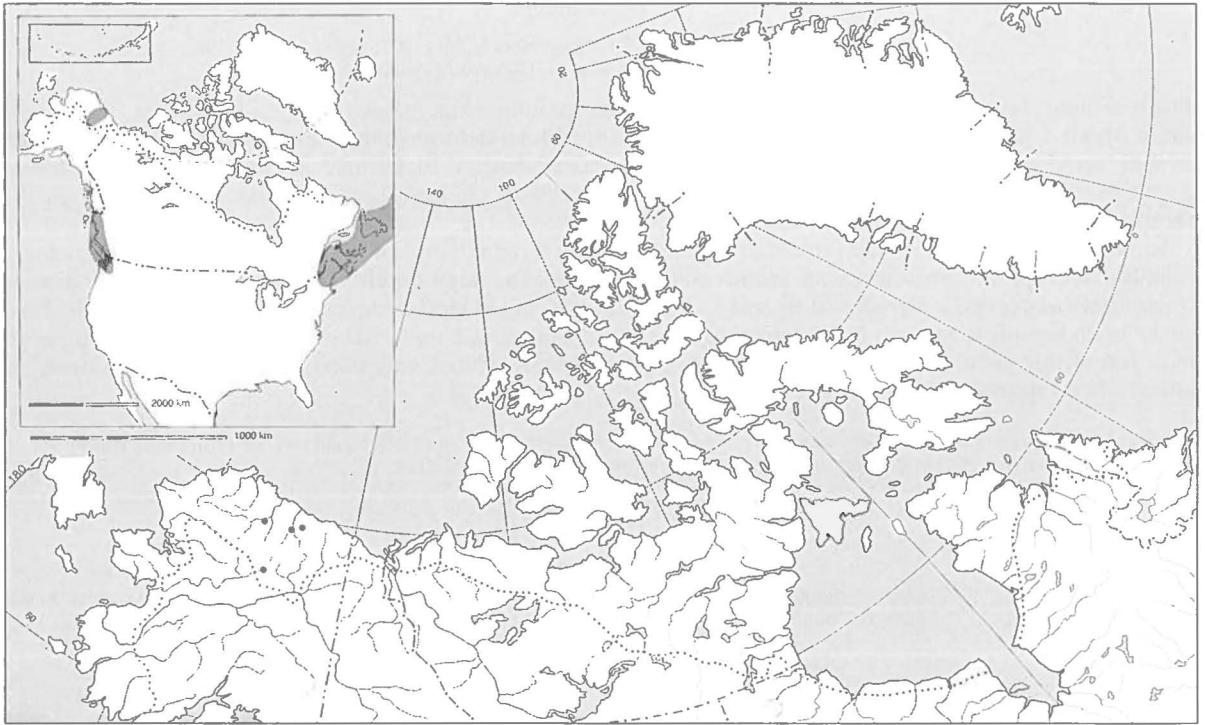


Fig. 16. *Tetrodontium repandum*, Colville River, Umiat, A-Alaska; leg. 1951 Steere 16980. (ALA).



Map 14. *Tetrodontium repandum*.

Protonematal appendages often seen, oblanceolate-spatulate, 0.2–1.2 mm long (in arctic material), with mucronate points of large apical cells, bistratose centrally, margins unistratose,  $\pm$ denticulate from projecting ends of cells. Flagelliform shoots usually abundant, 2–5 mm high, with minute, 0.1–0.6 mm long, lanceolate, ecostate leaves with  $\pm$ crenate margins. Perichaetial leaves acute or obtuse, up to 1.2 mm long, costae weak but present at least in largest leaves, margins entire or  $\pm$ crenate from projecting cells.

Setae in surface view loosely twisted to the left for 0.7 to 0.8 the length, uppermost parts twisted to the right, brown to wine-red, blackish and ridged with age,  $\pm$ flattened, oval in transverse section. Capsules red-brown to wine-red, sometimes whitish with age. Mouths reddish, cells in 3–4 rows, round-hexagonal, 10–12  $\mu$ m wide. Exothecial cells rectangular, slightly incrassate. Spores (11)13–17(19)  $\mu$ m.

Minute, bud-like plants with numerous sporophytes and flagelliform shoots, on shaded crevices and surfaces, often under surfaces, of non-calcareous sandstone outcrops. Reported on calcareous sandstone in Alaska (Steere, Bryophytorum Bibliotheca 14: 451, J. Cramer, Vaduz, 1978), but in all collections seen the substrate reacted negatively to dilute hydrochloric acid.

Very rare and disjunct in the far north; known from only three arctic Alaskan localities in the Northern Foothills and one sub-

arctic alpine locality. Generally found in alpine or subalpine localities far to the south in North America, in British Columbia and Washington. Reported from Newfoundland and New Hampshire. Alaskan material reported as *T. brownianum* is referable to *T. repandum*. Outside North America known from only one arctic locality in the European Arctic, Jan Mayen (Frisvoll, Bryologist 86: 332–341, 1983). Also known from Europe, Caucasus and Japan.

Selected specimens seen:

Alaska. Umiat vicinity: 69°22'N, 152°08'W; 1965 Steere 6507243 (NY), 1974 Steere 74–56 (CANM, NY), 1974 Iwatsuki 2270, 2292 (NY). – 69°23'N, 152°10'W; 1951 Steere 16963, 17170, 17202 (ALA, CANM, NY). – Sagwon Uplands, Mile 352 Dalton Highway, 69°23'N, 148°37'W; 1982 Murray 11,417 (ALA). – Kavik, 69°46'N, 147°10'W, W of camp across river; 1973 Iwatsuki 1097 (NY).

Easily identified by the four peristome teeth, minute size, and habit of growing inverted on undersides of outcrops but must be searched for in order to be detected.

Much North American material has protonematal appendages well developed and larger than reported for *T. repandum*, occasionally up to 2 mm long and sometimes lobed. Usually reported as *T. brownianum*, this material differs from typical *T. brownianum* in having broader, denticulate protonematal appendages frequently with a long apical cell and in the presence in most specimens of sparse or numerous flagelliform shoots. Similar material has been seen from Japan, Europe and New Zealand.

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