Gunneria

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Arne A. Frisvoll

A TAXONOMIC REVISION OF THE RACOMITRIUM HETEROSTICHUM *GROUP (BRYOPHYTA, GRIMMIALES) IN N. AND C. AMERICA, N. AFRICA, EUROPE AND ASIA*

TRONDHEIM 1988

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Universitetet i Trondheim
Vitenskapsmuseet

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ABSTRACT

Frisvoll, Arne A. 1988. A taxonomic revision of the *Racomitrium heterostichum* group (Bryophyta, Grimmiales) in N. and C. America, N. Africa, Europe and Asia. *Gunneria* 59: 1-289.

The *R. heterostichum* group or *Racomitrium* sect. *Laevifolia* includes many taxa. This is demonstrated by the presence of numerous mixed stands, as well as by differences in a number of slightly or not modifiable morphological characteristics (notably in the structure of the leaves). In all, 25 species, 1 subspecies, 2 varieties, and 4 forms are recognized from the area. The taxa are tentatively placed in 6 informal subgroups:

The *sudeticum* subgroup includes 4 species, 1 subspecies and 2 forms: *R. brevipes* Kindb. in Macoun, *R. macounii* Kindb. ex Kindb. in Macoun subsp. *macounii*, *R. macounii* subsp. *alpinum* (Lawt.) Frisv. comb. et stat. nov., *R. occidentale* (Ren. et Card.) Ren. et Card., *R. sudeticum* (Funck) Bruch et Schimp. in B., S. & G. f. *sudeticum*, *R. sudeticum* f. *kindbergii* Frisv. f. nov., and *R. sudeticum* f. *terricola* Frisv. f. nov.

The *laetum* subgroup includes 2 species: *R. laetum* Besch. et Card. in Card. and *R. lawtonae* Irel. The *heterostichum* subgroup includes 7 species and 1 form: *R. affine* (Schleich. ex Web. et Mohr) Lindb., *R. depressum* Lesq., *R. heterostichum* (Hedw. ex Hedw.) Brid., *R. obesum* Frisv. sp. nov., *R. obtusum* (Brid.) Brid. f. *obtusum*, *R. obtusum* f. *trichophorum* Frisv. f. nov., *R. pacificum* Irel. et Spence, and *R. venustum* Frisv. sp. nov.

The *microcarpon* subgroup includes 4 species, 1 variety and 1 form: *R. crispipilum* (Tayl.) Jaeg., *R. microcarpon* (Hedw.) Brid. f. *microcarpon*, *R. microcarpon* f. *afoninae* Frisv. f. nov., *R. verrucosum* Frisv. sp. nov. var. *verrucosum*, *R. verrucosum* var. *emodense* Frisv. var. nov., and *R. vulcanicola* Frisv. et Deguchi sp. nov.

The *subsecundum* subgroup includes 7 species and 1 variety: *R. capillifolium* Frisv. sp. nov. var. *capillifolium*, *R. capillifolium* var. *lorifolium* (Hampe) ex Frisv. var. nov., *R. cucullatulum* Broth. in Hand.-Mazz., *R. fuscescens* Wils. in Mitt. et Wils., *R. himalayanum* (Mitt.) Jaeg., *R. joseph-hookeri* Frisv. sp. nov., *R. nitidulum* Card., and *R. subsecundum* (Hook. et Grev. in Hook.) Mitt. et Wils.

The *emersum* subgroup includes 1 species: *R. emersum*. The distribution of the taxa fits into well-known geographical elements. Eight species are widespread, and have been found to possess a bipolar, tropical alpine, circumboreal/imperfectly circumboreal, or highly disjunct distribution pattern. The remaining 17 species are endemic to a relatively small area.

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1.0 INTRODUCTION

Many authors have commented on the variability of *Racomitrium heterostichum* (s.l.): "[*R. heterostichum*] kann in der gewöhnlichen Form mit keiner der Gattungsgenossen verwechselt werden, in ihren Abweichungen dagegen nähert sie sich bald *R. sudeticum* bald *R.* [*aquaticum*], oder auch *R. fasciculare*." (Bruch et al. 1845: 10). - "Planta valde protea et inter omnes congeneres maxime variabilis, ..." (Zetterstedt 1861: 119). - "*Rhacomitrium heterostichum* is our most variable species, and the multiple forms are so inconstant and so ill-defined as almost to defy classification." (Dixon & Jameson 1896: 153). - "Mit *Schistidium apocarpum*, *Grimmia trichophylla* und der *Grimmia-Doniana-sessitana*-Gruppe gehört [*Racomitrium heterostichum*] zu den formenreichsten der Familie und der europäischen Mooswelt überhaupt." (Loeske 1930: 205). - "With the possible exception of *Grimmia apocarpa* and *G. trichophylla*, it is the most variable species in the Grimmiaceae." (Jones 1933: 55). - "*R. heterostichum* is an exceedingly variable species, ..." (Noguchi 1974: 362).

The need for a taxonomic revision has also been pointed out many times: "*Rh. heterostichum* gehört mit *Rh. canescens*, *Grimmia alpestris* und *Schistidium apocarpum* zu denjenigen Grimmiaceen, die noch einer besonderen eingehenden Untersuchung und Bearbeitung bedürfen." (Loeske 1913: 186). - "*Rhacomitrium heterostichum* in British Columbia includes a series of related taxa seriously in need of careful study." (Schofield 1965: 30). - "Thus, *subsecundum-javanicum-crispulum-himalayanum* seems to be a complex needing more study." (Gangulee 1972: 816). - "The *Racomitrium heterostichum* complex is badly in need of a full taxonomic revision ..." (Corley et al. 1981: 650).

No authors have so far treated the *R. heterostichum* group in a satisfactory way. The difficulties seem to have been caused by a lack of understanding of which characters are taxonomically important.

This paper presents a revision of *Racomitrium* sect. *Laevifolia* in Am 1-3, Afr 1, Eur, and As 1-5 (cf. Index Muscorum, Wijk et al. 1967). The *R. heterostichum* group or complex is synonymous with *Racomitrium* sect. *Laevifolia*. For the sake of brevity, the names of the recognized taxa are often abbreviated, using the three first letters of the specific epithet and where appropriate the first letter of the subordinate epithet: aff = *R. affine*; bre = *R. brevipes*; cap = *R. capillifolium*, cap-c = *R. c.* var. *capillifolium*, cap-l = *R. c.* var. *lorifolium*; cri = *R. crispipilum*; cuc = *R. cucullatulum*; dep = *R. depressum*; eme = *R. emersum*; fus = *R. fuscescens*; het = *R. heterostichum*; him = *R. himalayanum*; jos = *R. joseph-hookeri*; lae = *R. laetum*; law = *R. lawtonae*; mac = *R. macounii*, mac-m = *R. m.* subsp. *macounii*, mac-a = *R. m.* subsp. *alpinum*; mic = *R. microcarpon*, mic-m = *R. m.* f. *microcarpon*, mic-a = *R. m.* f. *afoninae*; nit = *R. nitidulum*; obe = *R. obesum*; obt = *R. obtusum*, obt-o = *R. o.* f. *obtusum*, obt-t = *R. o.* f. *trichophorum*; occ = *R. occidentale*; pac = *R. pacificum*; sub = *R. subsecundum*; sud = *R. sudeticum*, sud-s = *R. s.* f. *sudeticum*, sud-k = *R. s.* f. *kindbergii*, sud-t = *R. s.* f. *terricola*; ven = *R. venustum*; ver = *R. verrucosum*, ver-v = *R. v.* var. *verrucosum*, ver-e = *R. v.* var. *emodense*; vul = *R. vulcanicola.*

2.0 MATERIAL AND METHODS

2.1 HERBARIUM MATERIAL

Material for the present study has been requested from the following 63 herbaria; the seven herbaria which are marked with an asterisk have not replied: ALA, ALTA, B, BC, BG, BM, BP, BREM, BRNM, C, CANB, CANM, *DR, E, FH, G, GJO, GLAM, GRO, GZU, H, HBG, ICEL, *IFP, JE, KOCH, KUN, KYO, L, LAU, LD, LE, *LILLE, M, MAK, MANCH, *MEXU, MSTR, NICH, NSW, NY, O, OP, OULU, PAV, PC, PE, PR, PRC, *REG, RO, S, *STR, TENN, TRH, TROM, UPS, W, *WA, WB, WTU, WU, ZT. Deguchi has studied specimens in KANA and NIPR (see *R. vulcanicola*).

I have tried to see type material of all names proposed in the group, including the specific, varietal and form names, and also the original material of the invalid names. I was able to study the type or original material of 130 names, whereas the type or original material of 30 names could not be studied (see Table 2, p. 225).

I have collected material of sect. *Laevifolia* from most of Norway (except Sørlandet and the southern parts of Vestlandet and Østlandet). I have also studied one of the northernmost populations of *R. sudeticum* at Jan Mayen, and the species of the group which grow in northern Wales, GB.

In all, about 11 000 specimens have been annotated.

2.2 TREATMENT OF THE TAXA

Description. The description of the taxa follows a standard scheme, and includes characterization of plants, stem, leaves, hair-point, margin, costa, lamina, lamina cells, alar cells, perichaetial leaves, seta, urn, peristome teeth, and spores. In six taxa (*cap-c, jos, mic-a, sud-t, ver-e, vul*), the perichaetial leaves and sporophyte are unknown. The plants and setae are described from dry material. The stem, leaves, hair-point and urn are described from both dry and wet material. The costa, lamina, lamina cells, perichaetial leaves and spores are described from wet material. The material, simply soaked in tap water, very rapidly recovers its live appearance. Cross-sections of a large number of specimens have been made by hand with a razor blade. All specimens not obviously belonging to a known taxon have been checked in that way, and also a large number of typical specimens from throughout the range of the taxa. It is a time-consuming procedure, which, however, cannot be replaced by a more simple study (except when the taxa of the group of an area are very well known). The size and/or structure of the stem, leaves, hair-point, margin, costa, lamina, and alar cells were investigated in detail in 135 specimens. The number of cells in the different layers of the costa, were counted in many cross-sections (10-20) from

a number of leaves of each specimen; and this was done for the basal, middle and upper part of the leaf. The middle part was defined as that part of the leaf where the cross sections appeared intermediate between the basal and upper part. The number of cell layers in the different parts were also noted. A third and a fourth layer, etc., was recognized as soon as a single cell appeared in such a position. Infrequent high or low values in the different positions were put in parenthesis. The measurements of lengths and widths of leaves, leaf cells and capsules were made as illustrated by Bremer (1981: Fig. 1). The urns were measured in the dry state, and the leaves in the wet state. Abbreviations: T = type specimen; d., c. and v. = dorsal, central and ventral costal cells, respectively.

Diagnostic characters. This paragraph includes - in a condensed form - the most important characteristics of a taxon taken from the description. Extreme measurements are omitted here. The characteristics are numbered from (1) to (12), and the same characteristic is given at the same number in all taxa, viz. (1) Plants, (2) Stem, (3) Leaf, (4) Hair-point, (5) Margin, (6) Costa, (7) Lamina, (8) Alar cells, (9) Perichaetial leaves, (10) Seta, (11) Urn, (12) Basal membrane. Most of the items are selfexplanatory; but the information about the structure of (4) Hair-point, (5) Margin, and (6) Costa is given in the following formate: Hair-point + tells that it is (usually) present; +/- usually present but sometimes absent; +/(-) usually present but rarely absent; +/((-)) usually present but sometimes absent in lower leaves; - absent; -/+ usually absent but sometimes present; -/(+) usually absent but rarely present; -/((+)) usually absent but very rarely present; see also chapter 4.4.1, Hair-point, length. - Margin "(long, long)" indicates that the recurved part of the margin is long on both sides, "(m. long, flat)" means that the recurved part is medium long on one side and none on the other, etc.; "bi (1-2, in upper part)/uni - three (in spots)" indicates that the margin is bistratose for one to two cell rows in its upper part and also frequently includes uni- and three- stratose spots, "uni/bi (1, in spots or rarely throughout)" indicates the margin is unistratose with bistratose spots in one cell row, and that it may be bistratose for one cell row throughout, etc. The stratosity of the margin is given more plainly in the main descriptions; see also chapter 4.4.1, Margin. - Costa "broad (85-115/50-70 µm)" indicates that the costa is broad throughout, and that it is 85-115 µm wide below and 50-70 µm wide towards the leaf apex, "broad below and m. broad above (80-120/50-65 µm)" indicates that the width of the costa is 80-120 µm below and 50-65 µm above, and that this is regarded as broad and medium broad, respectively, in the species group concerned; "stratosity/ventral cells ((2)3-4/4-8, 2-3/3-6, 2/2-4)" indicates that the costa is three- to four- (rarely bi-)stratose in its basal part and there possesses 4-8 ventral cells, bi- to three- stratose in its middle part and there possesses 3-6 ventral cells, etc. The stratosity and number of dorsal, central and ventral cells are indicated in detail in the main descriptions, see also chapter 4.4.1, Costa. Abbreviations: m = medium, pspp = pseudopapillose, Bmb = Basal marginal border, Pl = Perichaetial leaves. The paragraph is meant to make possible a rapid comparison of the most important characteristics of two or more taxa. Subordinate taxa are treated more shortly, and primarily compared with the main taxon.

Variation. All taxa vary to a certain degree, and the most important variation amplitudes are described.

Comparison with other taxa. Comparisons have been made, between all taxa which are likely to be confused. Closely related taxa are treated in detail, whereas more easily separated taxa are but briefly treated.

Habitat. Due to the confused taxonomy of the treated mosses, the literature cannot be utilized in a review of the habitats of the taxa. Some information is present on some labels, but often there is no indication of the habitat of a specimen. This paragraph is therefore short in most species.

Distribution. Distribution maps are made of all recognized species and two subordinate taxa; the maps are based solely on examined herbarium specimens. In addition, a summary of the distribution of the taxa is given.

Specimens examined. A list of specimens studied is given for 17 taxa (*bre, cap, cri, cuc, dep, eme, fus, him, jos, mic-a, nit, obe, obt, occ, pac, ver, vul*). In one instance I have given a list of selected specimens studied (*ven*). The rest of the taxa include no list of specimens (*aff, het, lae, law, mac, mic-m, sub, sud*).

3.0 HISTORICAL REVIEW

3.1 EUROPE

Dillenius (1741) described and figured three species of the *Racomitrium heterostichum* group:

Bryum hypnoides, hirsutie canescens, vulgare including var. *cum foliis magis reflexis* and var. *strigosior* (Dillenius 1741: 368, Table 47, Fig. 27 A-G). It has been shown that Dillenius' species is made up of four taxa, viz. *R. canescens* (Hedw.) Brid. subsp. *canescens*, *R. elongatum* Frisvoll, *R. ericoides* (Brid.) Brid., and *R. heterostichum*. *Racomitrium heterostichum* is a minor part of the main species, and the only part of var. *strigosior*; the herbarium (OXF-Dill.) includes seven tufts or much branched plants of *R. heterostichum* (Frisvoll 1983a: Fig. 2, 38).

Bryum hypnoides alpinum, setis et capsulis exiguis (Dillenius 1741: 370, Table 47, Fig. 29). The herbarium material (OXF-Dill.) is *R. sudeticum* (see Lindberg 1883, Frisvoll 1984a: 311); it is selected as the lectotype of *Bryum macrocarpon* With., see chapter 8.0.

Bryum hypnoides alpinum, operculis obtusis (Dillenius 1741: 371, Table 47, Fig. 30). The herbarium material (OXF-Dill.) was selected as the lectotype of *R. obtusum* by Frisvoll (1984a: 312, Fig. 4b-c).

Species of the *R. canescens* and *R. heterostichum* groups were confused by Dillenius, and some of the eleven European synonyms of his *Bryum hypnoides, hirsutie canescens, vulgare* (see Frisvoll 1983a: 11) may refer to species in the *R. heterostichum* group. However, this is not established, and Dillenius (1741) is so far the starting point of the taxonomic and nomenclatural history of sect. *Laevifolia.*

Hedwig (1789: Table 25) includes a large beautiful coloured plate of *R. heterostichum* (as *Trichostomum*) (Fig. 1). Hedwig (1801: Table 23) includes two plants of *R. microcarpon* and two of *R. sudeticum* (Frisvoll 1984a: Fig. 4).

Trichostomum heterostichum, T. microcarpon and *T. obtusum* were validly described in 1801 (Hedwig 1801, Bridel 1801). The fourth European species in sect. *Laevifolia* was described by Weber and Mohr (1807, *Trichostomum affine*), and the fifth by Funck (1820, *T. sudeticum*; but see chapter 8.0 - regarding the mixed state of *T. microcarpon* Hedw. and the status of *Bryum macrocarpon* With.).

Bryologia Europaea (Bruch et al. 1845) describes and figures in detail three species, viz. *R. sudeticum, R. heterostichum* including var. *alopecurum* and var. *gracilescens* var. nov., and *R. microcarpon*; they do not mention *R. obtusum.* This monumental work became mandatory, and since that time, *R. affine* has usually been treated as a variety of *R. heterostichum*, and *R. obtusum* has usually been neglected or treated as a subordinate and often dubious taxon. They also introduced the confusing var. *gracilescens* (see chapter 8.0).

There is one excellent treatment I want to draw attention to: Lindberg's (1875) paper - actually dealing with the liverworts of Ireland! - includes an Appendix which concentrates on the nomenclature and taxonomy of *Racomitrium.* Five species are recognized in sect. *Laevifolia*, viz. *R. ramulosum* sp. nov., *R. heterostichum, R. affine* comb. nov. including var. *gracilescens* comb. nov., *R. obtusum* including var. *subsimplex* var. nov., and *Grimmia microcarpa* emend. His use of the epithet *microcarpon* instead of *sudeticum*, as well as his placing of *R. sudeticum* (as *Grimmia microcarpa*) in *Grimmia*, and his new name (*R. ramulosum*) of *R. microcarpon* auct., are not accepted in this paper or in general. But his species concept is accepted here, as well as his placing of var. *gracilescens* close to *R. affine.* And his long, detailed synonym lists with many pre-Hedwigian names, are interesting. The same classification is presented by Lindberg (1879), but there all names are treated in the genus *Grimmia.*

The sixth European species (*R. macounii* subsp. *macounii*) was described as *R. sudeticum* var. *validior* by Juratzka (1882). It is uncertain whether the common taxon recognized here as *R. macounii* subsp. *alpinum* has been validly described

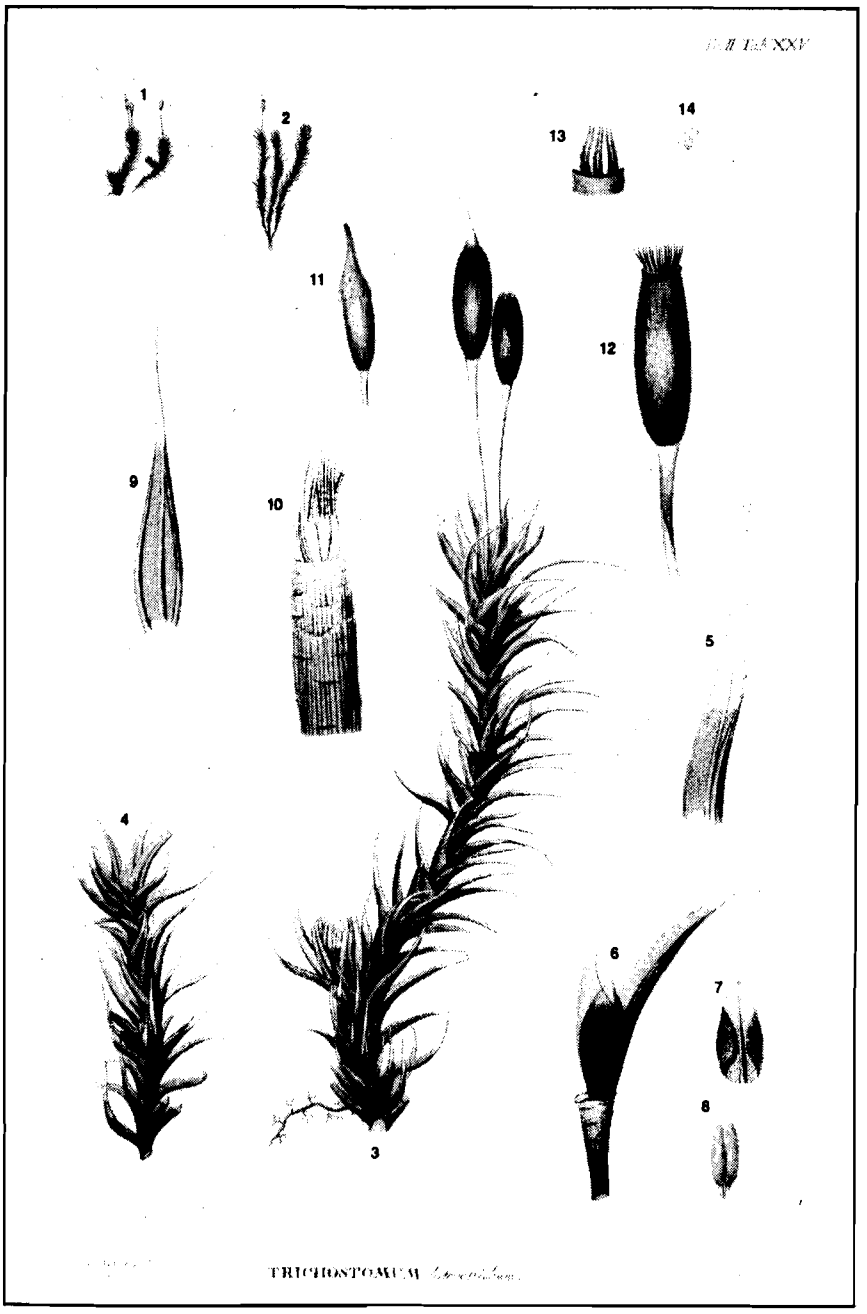

Fig. 1. Hedwig (1792) Table 25. *Trichostomum heterostichum*. 1-2. Plants. 3. The left plant in 1. 4. Part of male plant. 5. Apex of terminal leaf. 6-8. Perigonium, perigonial leaf and antheridia. 9-10. Perichaetial leaf and archegonial part of a perichaetium. 11. Young capsule with calyptra. 12. Deoperculate capsule. 13. Peristome teeth. 14. Spores. (x 0.5).

from Europe (but see *R. sudeticum* var. *aquaticum* and *Grimmia microcarpa* f. *procera* in chapter 8.0).

An important contribution to European moss taxonomy, is that of Limpricht (1890). He recognized four species in sect. *Laevifolia*, viz. *R. sudeticum* including var. *validior*, *R. affine* including var. *obtusum* comb. nov., *R. heterostichum*, and *R. microcarpon*. And this six names refer to all except one of the European species recognized in this paper (the Scottish taxon here included in *R. himalayanum*, has never been drawn attention to). However, Limpricht's description of *R. affine* refers to *R. obtusum* f. *trichophorum* (see *R. heterostichum* var. **alpestre* Schimp. ex Limpr. in chapter 8.0).

Hagen (1909) recognized five Norwegian species (and the sixth as a variety), viz. *R. obtusum*, *R. alopecurum* (= *R. affine*), *R. heterostichum*, *R. sudeticum* including var. *validior* (here: *R. macounii* subsp. *alpinum*), and *R. ramulosum* (= *R. microcarpon*) including var. *terrestre* var. nov. His contribution concentrates on the distribution of the species in Norway, and there is a key but no description of the taxa. His taxonomic concept is almost as in this paper. *Racomitrium obtusum* is distinguished by its epilose state ("Foliorum pilum nullum"), and includes therefore only *R. obtusum* f. *obtusum* sensu this paper. *Racomitrium alopecurum* and *R. heterostichum* are separated on the basis of characteristics in the costa and margin ("Costa bene [well] definita, margo foliorum bistratus" ... *R. alopecurum*; "Costa minus bene [not well] definita, folia unistrata" ... *R. heterostichum*). The key character of the costa (in dorsal view) is significant, and can be used to distinguish between typical specimens of the two when cross-sections are not available. Hagen's determinations can be checked on a large herbarium material, and they are quite good.

Loeske (1913, 1930) monographed the European species of Grimmiales. In the 1913-account he recognizes three species, viz. *R. sudeticum*; *R. heterostichum* var. *vulgare*, var. *limprichtii* var. nov. (= *R. affine*), var. *obtusum* and var. *gracilescens*; and *R. microcarpon*. In the 1930-account he recognizes but two species, viz. *R. heterostichum* subsp. *vulgare*, subsp. *affine* including var. *obtusum*, and subsp. *sudeticum* including f. *validior*; and *R. ramulosum* (= *R. microcarpon*). His treatments are long and wordy, and they must be regarded as indifferent contributions to the understanding of the group. But his comments on the many subordinate European names are of interest (notably in the frequent absence of type material).

The most commonly used European moss floras treat the *R. heterostichum* group in a collective and unsatisfactory way: Dixon and Jameson (1924, 1970) recognize one species, viz *R. heterostichum including var. alopecurum* (= *R. affine*), var. *gracilescens*, subsp. *sudeticum* and subsp. *ramulosum* (= *R. microcarpon*). Nyholm (1956) recognizes two species, viz. *R. heterostichum* including var. *affine*, f. *obtusum*, f. *gracilescens* and var. *sudeticum*; and *R. microcarpon* including var. *fastigiatum* and var. *terrestre*. Smith (1978) recognizes three species, viz *R. heterostichum*, *R. affine* (syn. *R. sudeticum*!) and *R. microcarpon*.

3.2 NORTH AND CENTRAL AMERICA

Michaux (1803) described *Trichostomum canadense*, which is a synonym of *Racomitrium microcarpon*. Bridel (1826) described *Grimmia ericoides* (another synonym of *R. microcarpon*) from Newfoundland; and in Bridel's world-embracing work the two mentioned new names are the only N. American ones which belong to sect. *Laevifolia*.

Müller (1849) described *Grimmia cylindrica* hom. illeg. (≡ *Racomitrium cylindricum* 1872 = *R. subsecundum*) from Mexico; and Müller (1851) described *Grimmia contermina* (= *R. crispipilum*) from Costa Rica.

Lesquereux (1868) introduced *R. depressum*, and reported *R. heterostichum* from western N. America. However, I am uncertain about the first N. American recognition of the latter species; it is not mentioned from there by Müller (1851). When Lesquereux and James (1884) published their Manual of the Mosses of North America, they knew only four species from sect. *Laevifolia*, viz. *R. depressum*, *R. sudeticum*, *R. heterostichum* and *R. microcarpon*. Some years later, this number was increased by the joint work of Macoun and Kindberg. Macoun and Kindberg (1892) listed eight specific names from Canada: *R. macounii* 1889, *R. robustifolium* 1890, *R. sudeticum*, *R. heterostichum*, *R. obtusum*, *R. affine*, *R. microcarpon*, and *R. micropus* sp. nov. (≡ *R. brevipes* 1890); of these, *R. robustifolium* is synonymous with *R. macounii*, and *R. obtusum* is so far not known from N. America. Kindberg (1897) treated all N. America, and listed in addition *R. depressum* and *R. jensenii* 1896 (= *R. sudeticum*); but he did not include *R. heterostichum* var. *occidentale* 1890 which had been described by Renault and Cardot. At the end of the ninteenth century, ten of the accepted fourteen N. or C. American species had been reported, either by their correct name sensu this paper or by a synonym.

Frye (1917-1918) recognized six species from western N. America, viz. *R. depressum*, *R. heterostichum*, *R. sudeticum* including var. *occidentale* comb. nov., *R. macounii*, *R. affine*, and *R. microcarpon*. It seems that he was able to distinguish between fairly natural entities; but this impression is strongly modified by his statement (1918: 3): "... the writer is inclined to believe that [var. *occidentale*], *R. sudeticum*, *R. affine*, and *R. macounii* are all largely if not entirely environmental forms of the same thing."

Jones (1933) recognized two N. American species, viz. *R. depressum*, and *R. heterostichum* including var. *affine* with f. *obtusum*, var. *graciliescens*, var. *sudeticum* with f. *occidentale* comb. nov. (syn.: *R. occidentale* and *R. brevipes*), var. *macounii* comb. nov., and var. *ramulosum* (= *R. microcarpon*). He was not capable of producing his own species concept fitting the N. American situation, but followed Loeske's (1930) account, stating: "To L. Loeske of Berlin I acknowledge with appreciation my indebtedness to his treatment of the European Grimmiaceae." (Jones 1933: 1, footnote). Later American authors have usually followed Jones' (1933) very collective treatment (e.g. Crum & Anderson 1981).

Banu (1969) studied the *R. heterostichum* complex in British Columbia. She saw much material, and described the variation of a number of taxa (including some tentative, undescribed new names). The work includes 16 Plates with excellent photos of plants, sporophytes, leaf cells and leaf cross sections, peristomes, etc., and 6 Plates with drawings of leaves, but it is nevertheless difficult always to know what is described and illustrated.

Ireland (1970) described the beautiful and distinctive *R. lawtonae.*

Lawton (1971) recognized two species from the Pacific Northwest, viz. *R. heterostichum* including var. *heterostichum* and var. *occidentale*, and *R. sudeticum* including f. *sudeticum*, f. *alpinum* f. nov., f. *americanum* f. nov., f. *brevipes* comb. nov. and f. *macounii* comb. nov. Her new f. *alpinum* is treated as a subspecies of *R. macounii* in this paper, whereas var. *occidentale*, f. *brevipes* and f. *macounii* are treated as species; regarding f. *americanum* see chapter 8.0. Lawton (1972) classified the N. American and Japanese (as well as some southern hemisphere) taxa of the *R. heterostichum* group which possess a predominantly *unistratose* margin. Because she did not treat taxa with predominantly bistratose margin, her study has many shortcomings. She uses six characteristics in her classification, viz. (a) cells near leaf apex (short/long); (b) hair-points (length); (c) leaf margins (unistratose/bistratose in spots); (d) (number of) differentiated (marginal) alar cells; (e) cross walls bulging; and (f) cells apparently papillose. Unfortunately, she was not particularly successful in selecting constant characteristics. Characteristics a-c and e are of insignificant importance, and d and f of some but not of superior importance. The structure of the costa is not considered, and the value of (d) is over-estimated (p. 258): "The differentiated alar cells are quite distinct and this seems to be the best character." Lawton's (1972) study is nevertheless an important contribution to the understanding of the taxonomy of the *R. heterostichum* group; she treated and figured, inter alia, the muticous plant which has been called *R. pacificum* (her plant D of Table 2).

3.3 NORTH AFRICA

The North African occurrence of *R. heterostichum* s.l. is summed up by Geheeb and Herzog (1910); only *R. heterostichum* is known, and it is reported from the Azores, Madeira and the Canary Islands (just as in the present work).

3.4 ASIA

Hooker (1836) described *Trichostomum subsecundum.* Müller (1849, 1851) does not mention this or other *Racomitrium* sect. *Laevifolia* species from Asia.

Racomitrium javanicum (= *R. subsecundum*) was described by Dozy and Molkenboer (1855); *R. fuscescens* by Wilson (in Mitten & Wilson 1857); and *R. himalayanum* by Mitten (1859). The last two species were based on specimens collected by J.D. Hooker (see chapter 10.0).

Jæger and Sauerbeck (1874) recognized six Asiatic species: *R. fuscescens*, *R. subsecundum*, *R. subheterostichum* nom. nud. (= *R. subsecundum*), *R. himalayanum*, *R. javanicum* (= *R. subsecundum*), and *R. lorifolium* nom. nud. (≡ *R. capillifolium* var. *lorifolium*); three of these are treated as species and one as a variety in the present study.

Cardot (1908) introduced four new names, viz. *R. nitidulum*, *R. diminutum*, *R. laetum* and *R. sudeticum* var. *subellipticum*; *R. diminutum* is treated as a synonym of *R. laetum* in the present work, whereas var. *subellipticum* is excluded from sect. *Laevifolia*.

Brotherus (1929) described *R. cucullatulum*, *R. dicarpum* (= *R. himalayanum*) and *R. angustifolium* (see chapter 8.0).

Sakurai (1937) reviewed the genus *Racomitrium* in Japan. He recognized five species, viz. *R. sudeticum*, *R. sakuraii* sp. nov. (= *R. laetum*), *R. nitidulum*, *R. heterostichum*, and *R. laetum* including var. *gracile* var. nov. and var. *olivaceum* var. nov.; four of the species are recognized here from Japan; *R. heterostichum* probably does not occur in Asia, and the new varieties are treated as synonyms of the main species.

Gangulee (1972) described and figured *R. crispulum*, *R. heterostichum*, *R. subsecundum*, *R. fuscescens* and *R. himalayanum* from Eastern India. The two first-mentioned species are not known from Asia, and Gangulee's descriptions and figures of these and of *R. fuscescens* refer to *R. subsecundum*.

Noguchi (1974) recognized but one polymorphous Japanese species in sect. *Laevifolia*, viz. *R. heterostichum* var. *heterostichum*, var. *sudeticum*, var. *diminutum* (syn. *R. laetum*), and var. *brachypodium* comb. nov. Of these, var. *brachypodium* does not belong to sect. *Laevifolia*, and var. *heterostichum* is excluded as stated above.

4.0 TAXONOMY, GENERAL PART

4.1 NOMENCLATURE, TAXONOMIC CONCEPT AND CITATION OF TYPES

The genus *Racomitrium* Brid. is heterogeneous and has frequently been divided into subordinate taxa above the rank of species.

Vilhelm (1925) recognized three subgenera, viz. subgen. *Canescentes* (*R. canescens*, *R. lanuginosum*); subgen. *Microcarpae* (*R. sudeticum*, *R. heterostichum*, *R. alopecurum*, *R. microcarpon*, *R.* x *tatrense*); and subgen. *Cataractae* (*R. protensum*, *R. aciculare*). Regarding subgen. *Dryptodon*, see below. The subgeneric rank has not been in use in *Racomitrium* for a long time.

Kindberg (1897) introduced four subgroups which have been interpreted as sections, viz. 1. Lanuginosa (*R. hypnoides*); 2. Canescentia (*R. canescens*, *R. panschii*); 3. Papillosa (*R. aciculare*, *R. neevii*, *R. varium*, *R. speciosum*, *R. levieri*, *R. protensum*, *R. depressum*, *R. macounii*, *R. fasciculare*, *R. tenuinerve*, *R. palmeri*, *R. jensenii*, *R. micropus*); 4. Laevifolia (*R. affine*, *R. heterostichum*, *R. microcarpon*). Four of the species in Kindberg's group 3 belong to sect. *Laevifolia*, viz. *R. depressum*, *R. macounii*, *R. jensenii* and *R. micropus* (see chapter 8.0 and below). Kindberg's (1897) names were definitely placed as sections by Noguchi (1974), and adopted by Frisvoll (1983a) and in this work.

The sections appear to be well marked, but can themselves be split into natural groups. Frisvoll (1983a) established two subsections of sect. *Racomitrium* (≡ 2. Canescentia Kindb. *nom. illeg.*). In this paper, the species of sect. *Laevifolia* are tentatively placed in six subgroups, which are given no formal rank. A definite subgrouping must await a revision of the southern hemisphere taxa.

One species, viz. *R. sudeticum*, has been separated from *Racomitrium* by many authors: Bridel (1826) made it a member of his new genus *Dryptodon*; and Bruch et al. (1845) placed it in *Racomitrium* [subgen.] *Dryptodon*. Lindberg (1875) considered it a *Grimmia*; he called it *G. microcarpa*, as did Kindberg (1897: 228). However, it is now accepted that *R. sudeticum* is a true member of sect. *Laevifolia*. As stated above, Kindberg (1897) treated four species of sect. *Laevifolia* in sect. *Papillosa*, and among them *R. depressum*. This species has also been placed in *Racomitrium* subgen. *Dryptodon* (Jones 1933: 53). But no doubt it belongs to sect. *Laevifolia*.

Bremer (1981) and Horton (1982) reviewed the three basic species concepts, viz. the taxonomic, the biological, and the evolutionary concept. The present treatment is mainly based on a taxonomic species concept. Only structural similarities and differences have been considered in the grouping of the material. But the extensive use of mixed stands incorporates aspects of the biological species concept in the treatment.

According to ICBN Art. 4.1 (Voss 1983), there are five taxonomic groups below the rank of species, viz. *subspecies*, *varietas*, *subvarietas*, *forma*, and *subforma*. Of these, subvarieties and subforms have never been introduced in sect. *Laevifolia*. No subspecies have been described, but a few names have been treated as such by later authors. Numerous varieties and forms have been described (Table 2).

There is no agreement about a "correct" concept of species, subspecies, varieties and forms, respectively. It appears that the treatment may vary in different

plant groups and between different genera of the same group. Many taxonomic revisions tend to reduce the number of species, but in *Racomitrium* the number appears to have been underestimated in recent times.

The present revision includes Asia, Europe, N. Africa, C. and N. America, as well as some material from Australia, Africa, S. America and Antarctica. I have tried to recognize comparable (corresponding) morphological entities as species, throughout this very large area. The European situation was studied first, and finally it became clear that in this area there are seven discontinuous morphological groups which must be treated as species. All except the Scottish *R. himalayanum* are known from field studies; and the study of mixed stands contributed much to the understanding of the taxonomy of sect. *Laevifolia* in Europe. The only alternative to the above grouping would be to set up fewer, much more heterogeneous species corresponding to the recognized subgroups; but such a treatment would be highly theoretical and have no support from field studies. When the many new and well-marked morphological entities of America and Asia appeared in the herbarium material, they had to be recognized in the same way, viz. as species. Because of lack of specimens, the status of one or two Asiatic taxa recognized as species is not quite clear.

The use of subordinate taxonomic ranks below the rank of species, is somewhat pragmatic in this study. I recognize one subspecies, two varieties and four forms.

The *subspecific* rank is used in a widely distributed species made up of two widely distributed, partly and broadly sympatric taxa (*R. macounii* subsp. *macounii* and subsp. *alpinum*). The rank denotes fairly well-defined, partly allopatric taxa.

The *varietal* rank is used in two species known from a small area; the varieties may be growing together, but because of few known specimens it is at present difficult to know their geographical and taxonomic relationship (*R. capillifolium* var. *capillifolium* and var. *lorifolium*; *R. verrucosum* var. *verrucosum* and var. *emodense*). The rank denotes fairly well-defined sympatric taxa.

The *forma* rank is used (1) in a species made up of sympatric taxa whose only difference seems to be the lack or presence of a hyaline hair-point (*R. obtusum* f. *obtusum* and f. *trichophorum*); (2) in a widely distributed and variable species, where I consider it practical to have a name of two interesting morphotypes (*R. sudeticum* f. *sudeticum*, f. *kindbergii*, and f. *terricola*); and (3) in a widely distributed species with a deviating subordinate taxon known from a small area (*R. microcarpon* f. *microcarpon* and f. *afoninae*). The rank denotes less well-defined sympatric or allopatric taxa.

I have treated all *nomina nuda*, and placed them in the synonym lists whenever I have seen original material. However, these names have no types; the quoted material in the original publication is named the *original material*, and the studied material the *original specimen(s)*.

The citation of the types follows ICBN Art. 7.3-8 (where the *holotype, isotype, lectotype, syntype* and *neotype* are defined) and T. 1-5 (where the *paratype* and *isosyntype* are defined). Some authors (e.g. Horton 1983, Vitt & Ramsay 1985) use the term isotype about duplicates of both holo- and lectotypes, but this is contrary to ICBN Art. 7.6 where it is stated to be "any duplicate of the holotype". I have used the terms *isolecto-* and *isoparatype* about duplicates of the lecto- and paratypes. In accordance with Hansen and Seberg (1984) I have used the term *paralectotype* about those "syntypes" remaining after lectotypification. The term *topotype* is used about non-original material from the type locality.

When necessary and possible I have selected lecto- and neotypes. The type of all taxa is cited in full from the protologue, and the label of the type or original specimen is also quoted. It is therefore easy to make a direct comparison between the literature reference and the quoted type specimen(s).

4.2 MIXED STANDS

My interest in mixed stands in *Racomitrium* sect. *Racomitrium* led to the publication of a taxonomic revision (Frisvoll 1983a). In that work, a mixed stand was recognized when stems of different plants grew (or had been growing) intermingled in the field. And it was considered that the different plants in frequent mixed stands preferably should be treated as species (Frisvoll 1983a: 16). A few rare mixed stands, consisting of a familiar taxon and an obviously related plant differing in some minor characteristics, were described and illustrated (Frisvoll 1983a: Fig. 10-11). The deviating plant in these mixed specimens was not given any name, because it was always known from few specimens, and because it was found to be *very* close to a recognized species (p. 29). A similar treatment is adopted in this paper.

The mixed stands should preferably be studied in the field. In sect. *Laevifolia* this has been done for a various number of different constellations in seven Norwegian taxa (*aff, het, mac-a, mic, obt-o, obt-t, sud*). When the variation amplitude of the taxa is known from field work, it is my experience that also mixed herbarium specimens can be used in the same meaningful way. And when some taxa in the group are well known, I have got full value out of mixed herbarium specimens of non-European taxa (which could not be studied in the field). Two possible constellations did then occur: (1) One taxon was familiar and the other was not (e.g. *het + obe, aff + law, sud + lae, sud + occ*), and (2) both taxa were unfamiliar (e.g. *him + sub, fus + sub, eme + sub, bre + occ*). The frequency and practical usefulness of mixed stands in sect. *Laevifolia* have been found to be approximately the same as in sect. *Racomitrium*. The autecology of the taxa in the different sections is so similar, that all possible combinations of taxa in a given area are likely to occur. In the supposed absence of mixed stands, the revisions of *Racomitrium* sect. *Racomitrium* and sect. *Laevifolia* would probably never have been written. This has led me to believe

that all similar, so-called critical complexes or taxonomically difficult bryophyte groups, can be successfully treated by employing the mixed stand method.

It is very interesting that the mixed stand method recently has been found useful in quite unrelated plants, viz. in the genus *Botrychium* (Ophioglossaceae, Pteridophyta) (Wagner & Wagner 1983: 55): "The most valuable tool for solving the taxonomic problems of *Botrychium* takes advantage of the tendency for species to co-exist in the same habitats. This method of study, which we shall call the genus community method, offers essential information and clarifies many difficult problems." Their "method of mutual associations" is closely related: "If taxon A grows with taxon C in one habitat, and taxon B grows with C in another, and if taxon C remains uniform in both habitats, then the differences between A and B are probably genetically fixed" (p. 55). (E.g.: The constellations *bre* + *occ* and *occ* + *sud* are known, but so far not the constellation *bre* + *sud*). The described situation before and after the investigations of Wagner and Wagner (1983) is *exactly* as in *Racomitrium* sect. *Racomitrium* and sect. *Laevifolia*: "... the taxonomy of these plants remains in an extremely unsettled state. The identifications of many ... herbarium collections border on the chaotic, and the classifications presented in many manuals are at variance with the natural populations." (p. 51). "We believe now, because of our recent work ... , that the genus [*Botrychium*] is not nearly so confusing and hopeless taxonomically as some workers believe. The solutions lie simply in [among other things] ... interpreting mixed populations, genus communities." (p. 61). I fully agree with them when they state that "The usefulness of the genus community and mutual associates methods cannot be overestimated" (p. 60).

Wyatt, Lane and Stoneburner's (1982) paper "The misuse of mixed collections in bryophyte taxonomy" may be mentioned in this context. Every taxonomic method can be misused by incompetent workers, and their statement (in the Summary) that "The mixed collection method should be abandoned entirely" is absurd. By studying mixed stands in the field (and also in the herbarium as outlined above), one is much better prepared for the difficulties which in any case are met with in the herbarium material. I have studied mixed stands, in e.g. *Tetraplodon* (Frisvoll 1978), *Schistidium* (Frisvoll 1975, 1981a), Mniaceae (Frisvoll 1981b), *Ditrichum* (Frisvoll 1985b), and *Racomitrium* (Frisvoll 1983a, b), and in every instance I have come to a better taxonomic conclusion *with* the mixed stands than without them. Also their statements about mixed herbarium specimens (p. 700) are questionable. It is usually not difficult to see whether the specimen is a real mixture or not (cf. Frisvoll 1983a: 16: "Specimens composed of different cushions or stems of two taxa are not considered mixed stands.").

The mixed stand method is very accurate, and sometimes leads to the discovery of minor morphological differences which might otherwise have been neglected:

(1) Many pilose species in sect. *Laevifolia* include epilose specimens. These are often epilose modifications of normally pilose genotypes. But sometimes pilose and epilose plants are mixed, and the epilose plant is genetically fixed and pro-

bably unable to grow a hair-point. Otherwise, the gametophyte (and sporophyte, if present) of the two are slightly or not different, and the possible differences are entirely covered by the variation amplitudes of other specimens. Such mixtures have been seen in *R. affine* (where the epilose plant has been called var. *gracilescens*), *R. microcarpon*, *R. obtusum* (where the *pilose* plant is named f. *trichophorum* in this paper), *R. subsecundum*, and *R. sudeticum* (where the epilose plant has been called var. *obtusifolium*). The reasons for naming the pilose *R. obtusum* is given under that species. Otherwise, I do not recognize the other much rarer epilose genotypes as taxonomic entities. Horton (1983: 454) reported mixed stands of pilose and muticous *Encalypta longicolla* Bruch, as well as a large variation in the length of the hair-point of different specimens; the brevi- or epilose ecads were thought to represent "a sporadic expression of variation that is inherent within the gene pool of *E. longicolla*". A similar variation is described in *E. alpina* Smith (Horton 1983: 401).

(2) Mixed stands of different (pilose) plants of *R. sudeticum* (q.v.) have been seen several times. In these, it is usually possible to find differences in the structure of the leaves including hair-point, lamina cells and costa. But the morphological variation of the collective species is large, and I have so far been unable to describe taxa on the basis of such mixed stands. Similarly, I have seen mixed stands of *R. subsecundum*, which is an equally variable taxon. Such mixed stands probably occur in many other taxa in the section. But this does not imply that the recognized species in the section are poorely marked or indistinct. I am convinced that similar mixed stands occur in many well-known moss species in many genera, but the microvariation is usually masked by the large genetic and/or phenetic variation of the taxa. The only easy way to detect them is probably by the mixed stand method.

I have studied one mixed stand including five taxa in sect. *Laevifolia*, viz. *aff + het + obt-o + obt-t + sud*:
NORWAY: Hordaland, Bergen, Svartediket, 14.VIII.1985 Blom (TRH).

Three mixed stands between four taxa have been studied, viz. of (1) *aff + het + obt-o + sud*; (2) *aff + obt-o + obt-t + sud*; (3) *aff + het + obt-o + obt-t*. (1) and (2) have the same data as the above specimen with five taxa, whereas (3) comes from:
NORWAY: Hordaland, Sund, Golta, 5.VIII.1985 Blom (TRH).

Mixed stands between three taxa are not uncommon; the following are known: (1) *aff + het + obt-o*; (2) *aff + obt-o + obt-t*; (3) *aff + het + sud*; (4) *het + mac-a + sud*; (5) *het + obt-o + sud*; (6) *het + mic + sud*; (7) *obt-o + obt-t + sud*. Localities:
NORWAY: (1) Hordaland, Sund, Golta, 5.VIII.1985 Blom (TRH); Sør-Trøndelag, Frøya, Kunna, 15.VIII.1982 Frisvoll (TRH). (2) Hordaland, Sund, Goltaosen, 5.VII.1985 Blom (TRH); Bergen, Svartediket, 14.VIII.1985 Blom (TRH). (3) Hordaland, Bergen, Svartediket, 14.VIII.1985 Blom (TRH); Møre og Romsdal, Ørskog, Dyrkorn, 14.VII.1984, Frisvoll (TRH). (4) Rogaland, Forsand, Lysedalen, 28.VIII.1985 Blom (TRH). (5) Hordaland, Os, Møsnuken, 27.VIII.1985 Blom (TRH).

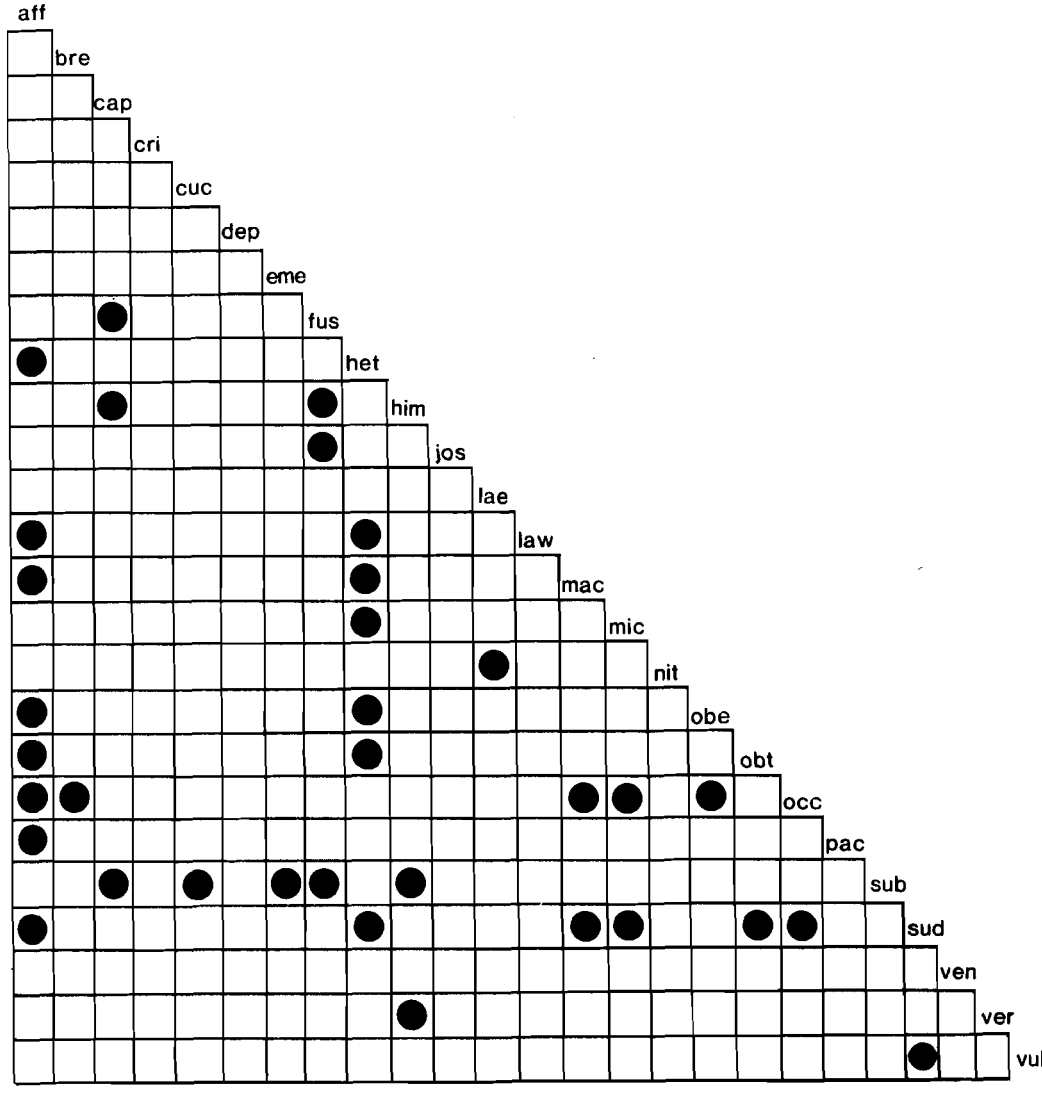

Fig. 2. The known occurrence of mixed stands in sect. *Laevifolia*; subordinate taxa are included in the main species.

(6) Nord-Trøndelag, Stjørdal, Sonlia, 27.VII.1982 Frisvoll (TRH); Sogn og Fjordane, Luster, Røym, 30.VIII.1985 Frisvoll (TRH); Luster, For, 29.VIII.1985 Frisvoll (TRH). (7) Hordaland, Bergen, Svartediket, 14.VIII. 1985 Blom (TRH).

Mixed stands between two species are very numerous, and are therefore not listed separately (Fig. 2).

4.3 ENVIRONMENTAL MODIFICATIONS

The length of the hair-point varies greatly in the pilose species in the section. In dry sites, the hair-point is long, and in moist sites it is short or absent. The same modifications occur in sect. *Laevifolia* as in sect. *Racomitrium* (Frisvoll 1983a: 30ff.), viz. mod. *longipilum*, *pilosum*, *brevipilum*, *subepilosum* and *epilosum*. About 13 infraspecific names have been described on the basis of longipilose, subepilose or epilose specimens (e.g. *R. javanicum* var. *incanum*, *R. ramulosum* f. *subepilosum*, *R. sudeticum* f. *epilosum*).

Also the branching habit of the taxa in sect. *Laevifolia* varies as in sect. *Racomitrium* (Frisvoll 1983a: 33ff.). About 6 names have been based on this characteristic (e.g. *R. ramulosum*, *R. microcarpon* var. *ericoides*, *R. obtusum* var. *subsimplex*).

Gracile or small specimens have often been given new names; all taxa produce gracile shoots in certain (especially moist and shady) habitats. Three robust specimens have also been named. About 18 names allude to the size or robustness of the plants (e.g. *Trichostomum gracile*, *Racomitrium heterostichum* var. *elongatum*, *R. laetum* var. *gracile*, *R. sudeticum* var. *tenellum*, *R. sudeticum* var. *robustum*).

The colour of the specimens varies to a great extent, and especially the black modifications have been given new names. (Herzog 1926: 107: "Dunkle Färbungen in exponierten Lagen, zum Teil atrata-Formen, sind di Regel, ...".) About 9 names are of this kind (e.g. *R. heterostichum* var. *nigrescens*, *R. ramulosum* f. *atrum*, *R. laetum* var. *olivaceum*).

The habit of the plants is also variable, and creeping plants have been named twice (e.g. *R. microcarpon* f. *repens*). Falcate leaves have been thought to be of taxonomic value once (*R. heterostichum* f. *falcatum*).

In this paper, a distinction is made between epilose and pilose plants of a few taxa (and especially of *R. obtusum*). Otherwise, the mentioned characteristics are considered of no taxonomic value. Most of the taxa named in this way are modifications of the main species, but a few belong to a different species (e.g. *R. heterostichum* var. *nigrescens* which is *R. sudeticum*).

4.4 TAXONOMIC CHARACTERS

An explanation of the supposed variability of *R. heterostichum* has been put forward by Anderson (1963: 113-114): A large number of mosses never produce capsules; and of those known to produce them, a substantial number produces them only rarely. With the emphasis on asexual reproduction, we begin to get a species make-up that corresponds somewhat to that of some asexual genera of higher plants, such as *Crataegus*, *Hieracium*, and *Rubus*. The result is the establishment of pure lines or clones, whose individuals are similar in genotype to each other and to their ancestors. And if successful mutations occur in such lines, this would lead to a large number of lines or populations differing in small ways. ... If the mutation should take place in an antheridial or archegonial branch, however, and if sexual reproduction should occur, a heterozygous capsule might arise. But homozygosity would be obtained in the next generation if the spores should become established. "One thinks immediately of almost countless species complexes in mosses in which the species is composed of an almost infinite number of biotypes differing from each other in minor but often distinctive ways, frequently by a single character, but the biotypes often merging imperceptably. In some species the biotypes are characterized by different combinations of characters so that the number of biotypes is equal to the number of possible combinations of the basic characters involved. If specific or subspecific names are applied to the biotypes, a chaotic taxonomic situation results. *Rhacomitrium heterostichum* is an excellent example of this kind of complex. Here five characters - [1] shape of upper leaf cells, [2] presence of short lateral brances, [3] unistratose or bistratose upper lamina [or rather margin], [4] presence of a hair point, and [5] smooth versus papillose [or rather pseudopapillose] leaf cells (a geographically restricted character) - can be found in nearly all the expected combinations. Because particular combinations are apt to be fairly uniform throughout a single population, there has been a strong temptation to name them."

I am unable to confirm the supposed chaotic taxonomic situation of the *R. heterostichum* group. The "pure-line-hypothesis" may seem to be a simple theoretical solution to major problems in bryophyte taxonomy. It is also presented by Bremer (1981) with regard to the *Schistidium apocarpum* complex. However, the theory has got no - or at best very slight - support from my work with the *R. heterostichum* and *R. canescens* groups. Many taxa in sect. *Laevifolia* are frequently fertile (as for instance the most variable species in the section: *R. subsecundum* and *R. sudeticum*). Moreover, the five varying character states of the *R. heterostichum* group mentioned by Anderson (l.c.), are considered of (almost) no taxonomic importance in the present revision. And the "impressive list of names associated with the *R. heterostichum* complex" (Anderson l.c.) is split up and divided on many well-defined species. Not a single one of the many studied type specimens have been difficult to place. *Racomitrium* sect. *Laevifolia* is a group rich in species and not a group with a chaotic taxonomy. And the taxonomic problems met with are, I think, the same as in most plant groups of a similar size.

The gametophyte of the taxa in sect. *Laevifolia* includes some stable taxonomic characteristics, which do not vary much in different modifications of the taxa. They are very useful when defining and recognizing species in the section. Few of the stable characteristics have previously been recognized or used in a meaningful way. The most important ones are found in the *structure* - of the costa; the alar cells including the supra-alar marginal cells; the margin; and the perichaetial leaves. In addition, there are some less stable but still useful characteristics, like the size, form and structure of the sporophyte and the structure of the hair-point. Finally, there are many much used characteristics, which have been found to be of almost no taxonomic value in this study; the most well-known of these are the length of the leaf cells and hair-point, and the branching of the plants.

Below, the gametophyte and sporophyte characteristics are commented on separately. But firstly, one general characteristic is mentioned.

Chromosome number. A summary is given by Fritsch (1982). The following numbers are known in sect. *Laevifolia*, in specimens from the treated area:

R. brevipes	n = 12	(Canada: B.C. 1981)
R. depressum	n = 14	(U.S.A.: California 1954)
R. heterostichum	n = 14	(Finland 1949)
R. heterostichum	n = 13	(Great Britain 1967)
R. h. subsp. *affine*	n = 13	(Canada 1958, referred by Ramsay & Schofield 1981)
R. h. var. *gracilescens*	n = 13 + m	(Great Britain 1967)
R. javanicum	n = 13 + m	(India 1959, 1960)
R. javanicum	n = 12	(India 1960)
R. ramulosum	n = 14	(Finland 1949)
R. ramulosum	n = 14	(USSR: Ukraina 1975)
R. sudeticum	n = 14	(USSR: Ukraina 1975)

The voucher specimens have to be studied before these counts can be evaluated, but some are clearly based on correctly named material. Now (when *Racomitrium* sect. *Racomitrium* is entirely revised, and sect. *Laevifolia* is revised in approximately the northern hemisphere), chromosome counts in the sections will be much more interesting than before.

4.4.1 Gametophyte

The most important taxonomic characteristics of sect. *Laevifolia* are gametophytic, and are mentioned above. All are observed in the leaves (vegetative and perichaetial), which therefore, taxonomically, are the most important part of the moss. The leaves are simple, but their different characteristics are combined in an interesting manner. All the 32 taxa recognized in this paper can be known from one or a few (typical) leaves. Before leaves are examined, they should be reversed and flattened out. It may be of importance to examine a number

of leaves from each plant or specimen. When taxonomic characteristics are exemplified by references to species' names, the corresponding Figures are easily found and are usually not given explicitly.

Colour. The names of the colours used in the descriptions are defined with the aid of an atlas of colours (Revold 1963). The colour of a *specimen* may be established rather precisely, but the variation from specimen to specimen is large. The main colour of the chlorophyllous part of the taxa in the section includes different nuances of olive, ranging from olive yellow to olive brown. The yellowish and brownish colours may sometimes predominate (e.g. in *R. laetum* and *R. fuscescens*, respectively). The lower part of the cushions is usually dark brownish or blackish, and the whole cushion of all species may be similarly coloured. A few taxa may be jet-black throughout (e.g. *R. sudeticum*). The colour of the intact *cushions* varies with the length of the hyaline point. Epilose or short-haired cushions have the same colour as the plants, but some long-haired modifications or ecads may be quite grayish (e.g. *R. heterostichum* and *R. capillifolium* var. *capillifolium*).

Robustness and size. The plants or stems of some taxa are usually more robust than in other closely related taxa (e.g. *R. sudeticum* f. *terricola* more robust than f. *sudeticum*, *R. affine* than *R. venustum*, and *R. lawtonae* more robust than *R. laetum*). But gracile modifications of most robust taxa occur. The length of the stems varies in the same way; the taxa which usually are small may sometimes occur with elongate stems, and vice versa.

Branching. Some species are usually much branched (*cri*, *him*, *mic*, *nit*, *ver*, *vul*), whereas others are usually slightly or not branched (*dep*, *lae*, *law*, *mac*, *obe*, *occ*, *sud*). The other species vary more in their branching habit. The mode of branching ranges from dichotomous to irregular, subpinnate and pinnate. The variation in the branching habit of most taxa is large.

Rhizoids. Stems creeping on rocks may bear abundant bundles of brownish red rhizoids (noted especially in *R. microcarpon*). Erect stems and epigeic plants have fewer or no rhizoids.

Stem. The stem is made up of three or more incrassate epidermal cell rows and wider inner (cortical) cells (t.s.); there is no central strand.

Leaf, size. The length and breadth (at the broadest part) of the leaves have been measured in a number of specimens of all taxa. The possible recurved part of the margin was not added to the breadth of the flattened leaf. The hair-point is always included in the length. The stipulated average length and breadth are indicated (and in parenthesis extreme values - of small, usually epilose, and unusually large, longipilose leaves), for example in *R. himalayanum*: (1.7)2.6-3.4(4.5) x (0.4)0.55-0.7(0.9) mm. The relative size of the leaves is classified as follows: They are said to the *long* if > 3 mm; *medium* (abbreviated m.) *long* if 2.5-3.5 mm; and *short* if < 2.5(-2.8) mm. They are said to be *broad* if > 0.7mm;

m. broad if 0.5-0.9 mm; and *narrow* if < 0.6 mm. (Long - broad: > 3 : > 0.7 = 4.3 : 1; m. long - m. broad: 2.5-3.5 : 0.5-0.9 = 4-5 : 1; short - narrow : < 2.5 : < 0.6 = 4.1 : 1; see next paragraph.) The measured extremes of normal leaves are as follows: longest (*cap-c*: 8 mm), shortest (*mic*, *sud-s*, *ven*, *vul*: 1.5 mm), broadest (*dep*: 1.5 mm), narrowest (*vul*: 0.3 mm).

Leaf, shape. The standardized terms for simple symmetrical plane shapes are reproduced by Stearn (1980: Fig. 19). According to this scheme the leaves of most taxa in the section (e.g. Fig. 27a, 29a, 31a) are narrowly ovate-triangular (length : breadth = 3-6 : 1). A few taxa may have a slightly narrower leaf (e.g. *R. capillifolium* var. *capillifolium* and *R. lawtonae* where the length : breadth ratio is 6-7 : 1, cf. Fig. 21a and 47a). And some epilose taxa and some epilose modifications of pilose taxa have a broader leaf (especially *R. depressum* where length : breadth = 2.6-3.2 : 1, cf. Fig. 25a). Because the shape of the leaves of the taxa is so similar, I have not tried to name their form, but have indicated their simplified length/breadth proportions according to the previous paragraph. The leaves of *R. obesum* are, e.g. long and broad, of *R. capillifolium* long and m. broad, of *R. macounii* short to m. long (given as short/m. long) and m. broad, and the leaves of *R. verrucosum* are short and narrow. The exact form of the leaves will be evident from the figures.

Leaf, orientation. When dry, the leaves of most taxa are loosely or closely imbricate. They may be erect, secund, or even falcato-secund (in *R. lawtonae*). The only taxon with contorted leaves is *R. macounii* subsp. *macounii*. When wetted, the leaves bend strongly backward - and then suddenly forward again, and when wet they are erect- (or secund-)spreading.

Hair-point, length. Three taxa lack a hyaline hair-point (*dep*, *pac*, *obt-o*). In five it is frequently lacking and never long - usually less than 0.25 mm (*cuc*, *eme*, *fus*, *mac*, *ver-v*). In six it is usually present in the upper leaves, and sometimes it is long (to 0.4-1.0(1.5) mm), but it is also frequently short, or sometimes absent (*aff*, *nit*, *obt-t*, *sub*, *sud*, *ven*). Thirteen taxa usually have long hair-points (0.3-0.7 mm or much longer), and it is very rarely or never absent (*bre*, *cap*, *cri*, *het*, *him*, *jos*, *lae*, *law*, *mic*, *obe*, *occ*, *ver-e*, *vul*). The longest points have been seen in *R. capillifolium* var. *capillifolium* (6 mm), *R. crispipilum* (3 mm) and *R. lawtonae* (2.5 mm). The hair-point may be decurrent down margin of lamina (Fig. 47-48) or not; the characteristic has some taxonomic significance. Regarding mixed stands of pilose and epilose ecads of the same species, see chapter 4.2.

Hair-point, orientation. The point of most leaves is erect and moderately flexuose when dry. In some taxa it is often squarrose (e.g. in *R. laetum*, *R. macounii* subsp. *alpinum* and *R. sudeticum*). The points of some taxa are never strongly flexuose (notably *cap-c*, *fus*, *lae*, *law*, *obt-t*, *occ*, *sud*). Short points are usually not or slightly flexuose.

Hair-point, structure. a. *Form.* The point is usually thin and delicate, and frequently canaliculate and even like a tube (in spirally-flexuose points). The upper part of such points is (very) capillaceous, and made up of elongate cells with a needle like end cell (especially *aff*, *cap*, *cri*, *het*, *him*, *jos*, *lae*, *law*, *mic*, *sub*, *vul*). Some taxa have a stouter point, which may be less canaliculate and even terete, and have a less capillaceous upper part with a thorn-like end cell (especially *bre*, *eme*, *mac*, *nit*, *obe*, *occ*, *sud*, *ven*).

b. *Dentation.* The point may be distinctly denticulate (usual in *aff*, *bre*, *het*, *lae*, *law*, *mac*, *mic*, *obe*, *obt*, *occ*, *sud*, *ven*, *vul*). Or it may be from slightly denticulate to edenticulate (usual in *cap*, *cri*, *cuc*, *eme*, *fus*, *him*, *jos*, *nit*, *sub*). Some taxa have a strongly spinulose point (especially *bre*, *mac*, *obe*, *occ*, *ven*).

Margin. a. *Recurvature.* The leaf margin is recurved on one or usually on both sides. The length of the recurved part has been noted; it is either recognized as being *long* (i.e. reaching (almost) to the hair-point or apex), *m. long*, or *flat* (wanting). In Diagnostic characters of each species, the length of the recurved margin is indicated (see chapter 2.2). In the following taxa, the recurved margin is (long, long) or (long, long/m. long): (*aff*, *bre*, *cap*, *het*, *him*, *obe*, *obt*, *ven*, *ver*). In the following taxa it is (m. long or short, m. long or short or flat): (*cri*, *cuc*, *dep*, *eme*, *fus*, *jos*, *lae*, *law*, *mac*, *nit*, *occ*, *pac*, *sud*, *vul*). The following taxa usually match the second group, but the recurved part of their margin is sometimes long on one side: (*mic*, *sub*). In *R. obesum* and *R. obtusum* the margin is revolute rather than recurved. Not infrequently, the margin is broadly folded backwards on one side (in the broadest part of the leaf); this is very pronounced in *R. subsecundum*.

b. *Stratosity.* The margin may be uni (unistratose) or more or less bi (bistratose). In Diagnostic characters of each species, the stratosity of the margin is indicated by a 'formula' (see chapter 2.2). (1) The following species have the simplified formula 'uni/bi (in rare spots)': (*cap*, *cri*, *dep*, *eme*, *fus*, *het*, *him*, *law*, *mic*, *nit*, *pac*, *vul*); these species are usually recognized as having a unistratose margin. (2) The following species have the simplified formula 'uni/bi (in spots or throughout)': (*aff*, *lae*, *obt*, *sub*, *sud*); these species are intermediate between the previous and the next group, and include plants with quite unistratose as well as plants with largely bistratose margin; but often their margin is found to have a mixture of uni- and bistratose areas. (3) The following species have the simplified formula 'bi (1-x)/uni (in spots)': (*bre*, *cuc*, *jos*, *mac*, *obe*, *occ*, *ven*, *ver*); these species are usually recognized as having a bistratose margin (at least in the upper part). The stratosity of the margin may be studied in leaf transections. But the stratosity of the marginal cell row in not two broadly recurved margins (and therefore especially in the upper part of the leaf) is most easily and exactly studied on the erect margin of reversed flattened leaves in the microscope (e.g. Fig. 35i).

c. *Outline.* The outline of the marginal wall of the marginal (and dorsal costal) cells is usually smooth, but in a few taxa (viz. *lae*, *law*, *obe*, *occ*, *ven*, and rarely *sud*) it is distinctly uneven (e.g. Fig. 35i). Lawton (1972: 255): "The leaf

cells ... may appear to be papillose when sections show no papillae and no bulging of the cross walls. This papillose appearance may be evident in the surface view on the upper leaf margins which are slightly uneven ..." This "apparent papillosity" is recognized in plant C (= *R. lawtonae*) and in the Japanese plants F, G and H (= *R. laetum*) in Lawton's (1972) Table 2. The cells of these taxa are sinuose as usual, and their marginal wall is equally thick and bulges into the cells. In the other taxa the marginal wall is thicker where it bulges into the cells. It must be stressed that the difference between the listed and some other taxa are quantitative rather than qualitative, and plants of *R. affine* and *R. microcarpon*, among others, may have an evident indication of the same structure.

Costa. The structure of the costa is perhaps the most important taxonomic characteristic in sect. *Laevifolia*, and no difficult specimen can be named before cross-sections of leaves have been studied. Below, I comment on the length, width, form, and structure of the costa.

a. *Length.* The costa is long in all species, reaching approximately to or slightly into the hyaline point or ending shortly before the apex in epilose leaves. In a few taxa it (usually) reaches distinctly into the hyaline point (especially in *cap*, *jos*, *lae*, *law*, *sud*). Such costae may be hyaline in the point (as in *sud*), or chlorophyllous for some distance. It is usually difficult to ascertain where the hyaline upper part of the costa ceases in the point.

b. *Width.* The width of the costa of all taxa has been measured at its base (avoiding the extreme base where the costa sometimes is slightly narrower), and at its apex (either close to the hyaline point, or where the lamina on both sides of the costa is as broad as the costa). Extreme measurements are given in parenthesis. The relative width of the costa is classified as follows: At the base the costa is said to be *very broad* if > 100 µm, *broad* if 75 - > 100 µm, m. broad if 70-100 µm, and *narrow* if < 75(-85) µm. At the apex it is said to be *very broad* if > 70 µm, *broad* if ≥ 50 - ≥ 70 µm, *m. broad* if ≥ 45 - < 70 µm, and *narrow* if < 50(-55) µm (see also chapter 2.2). According to this classification, the species have the following width of costa: very broad (*bre*); very broad (below)/broad (above) (*dep*); broad (*him*, *obe*, *obt*, *ver*); broad/m. broad (*het*, *jos*, *pac*); broad/narrow (*cap*, *sub*); m. broad/broad (*aff*); m. broad (*mac*, *mic*, *nit*, *occ*); m. broad/narrow (*cri*, *fus*, *law*); narrow (*eme*, *lae*, *sud*, *ven*, *vul*); and m. broad to narrow (*cuc*). It is apparent that some species (in a geographical area) may be known by this characteristic alone.

c. *Form in cross-section.* In the upper part all costae are dorsally convex, but some are approximately hemispherical whereas others are less convex. Towards the base the costae are dorsally flatter, and especially in *R. subsecundum* it may be quite flat. One species, viz. *R. occidentale*, possesses dorsal costal wings and furrows, and this feature is therefore not restricted to the genus *Grimmia* in the family Grimmiaceae (cf. Deguchi 1979: 137, and key characteristic p. 155). The ventral side of the costa is concave in most taxa, and some broad costae are distinctly canaliculate (notably in *bre*, *het*, *obt*, *pac*). One species, viz. *R.*

Table 1. The stratosity of the basal, middle and upper part of the costa of the species in sect. *Laevifolia*

a-b. Frequently more than three-stratose.
c-d. Predominantly three-stratose.
e. Bistratose with a frequent third layer of few cells.
f-g. Predominantly or quite bistratose.

a	b	c	d	e	f	g
(3)4(5) 3-5 3-4(5) (3-)4	3-4 (2)3-4	3(-4) (2)3(4)	3 (2-)3	2-3	2(-3)	2
			BASAL PART			
dep mac obe occ	aff het obt pac	him law sud	bre lae sub ven ver	cap cuc fus jos mic	cri eme nit vul	
			MIDDLE PART			
mac dep	occ	sud	aff bre jos	fus het him law obe obt pac ven ver	cap cuc lae mic nit sub	cri eme vul
			UPPER PART			
		mac		aff cuc dep jos occ sud	law obe ver	bre cap cri eme fus het him lae mic nit obt pac sub ven vul

depressum, frequently possesses a biconvex costa, and this is also sometimes seen in *R. obesum* and *R. obtusum*.

d. *Structure*. The costa is made up of two or more cell layers, which can be studied in cross-sections of leaves. The basic works on the structure of moss costae in Grimmiales and in general, are those of Kawai (e.g. 1963, 1965, 1968). The *ventral* (v) cells of the costa are called the a-part by Kawai (1968), the *central* (c) cells the b-part, and the *dorsal* (d) cells are called the c-part. Kawai (1968) distinguishes between six types of costae; the classification is based on the dissimilar differentiation and structure of the ventral, central and dorsal cells. The types are named the A-, B-, ... F-type. All *Racomitrium* species belong to Kawai's (1968: 128) B-type, where "the distinction between [central and dorsal cells] is not clear, but distinctions between [ventral and central], and between [ventral and dorsal cells] are somewhat clearer". This is a simple type of costa without stereids or guide-cells. - A simplified survey of the stratosity of the costa of all species is given in Table 1. The structure (i.e. the stratosity and number of dorsal, central and ventral cells) of the costa is a very important characteristic of a taxon, and it must always be studied in order to identify a specimen from a new area. And differences in the structure of the costa, in ecads from different areas, indicate genetic heterogeneity (see e.g. Variation of *R. heterostichum*, *R. subsecundum* and *R. sudeticum*). The costa seems to be one of the least modifiable structures of the gametophyte of the taxa in sect. *Laevifolia*. The number of ventral cell in the costa is more stable than the number of central and dorsal cells. In the Diagnostic characters of each species I have (therefore) given the stratosity and number of ventral cells in the basal, middle and upper part of the leaf (e.g.: 3/3-4, 2/2-3, 2/2 - in a species whose costa is three-stratose with three to four ventral cells in its basal part, bistratose with two to three ventral cells in its middle part, etc.).- The width of the cell lumen (in t.s.) varies somewhat throughout the costa of one species, and from species to species. The basal dorsal costal cells are usually narrow, the basal central cells are frequently narrow, and the other cells are usually wide.

Lamina. The leaf lamina is usually unistratose in most taxa. Very occasional bistratose spots may occur in modifications of many taxa, and are not mentioned in the description. The laminae of other species are unistratose with less rare bistratose spots in certain (especially epilose) modifications (notably *aff*, *him*, *mac*, *obe*, *obt*, *occ*, *sud*). Two taxa usually include bistratose laminal spots (*cuc*, *ver-v*). - The lamina is often somewhat contracted at the connection with the hair-point; this is especially pronounced in not too pilose specimens of *R. obesum*.

Lamina cells. The length (and width) of the lamina cells varies greatly in one and the same species. Firstly, it varies much in different (epilose to longipilose) modifications of the same taxon from the same area (e.g. subepilose *R. microcarpon* with short upper leaf cells versus normally pilose plants with long cells). Secondly, it may vary much in genetically different ecads of one species from the same area (noticed especially in *R. sudeticum*). And thirdly, it may vary

in ecads of the same species from different areas (e.g. European and some western N. American *R. affine* and *R. heterostichum* with short and elongate upper cells, respectively). The size of the cells can only be taken into account, when other characteristics have been used to define the taxon. Then the cell size may be shown to have some value in some taxa. Because of the variability and slight taxonomic importance of the size of the leaf cell, I have only given their size in the type specimen (T) in the descriptions. - But the *structure* of the cells, viz. the sinuosity, porosity and to some extent the thickness of the walls in different parts of the leaf, are of more value. The basal cells of *R. microcarpon* are thick-walled, esinuose and porose, whereas the same cells of *R. sudeticum* are less thick-walled, more sinuose and less porose; in fact, this is an important differential characteristic between these much confused species. The upper cells of *R. laetum* are strongly sinuose and porose, whereas the same cells of *R. sudeticum* are less sinuose and less porose. *Racomitrium emersum* has thick, strongly sinuose but not much porose walls; etc. - The walls may bulge dorsally and ventrally; in this paper such bulgings are called *pseudopapillae*, and the cells are said to be *pseudopapillose*. The taxa in the section possess no true leaf papillae, but have sometimes been said to do so ("Leaves very faintly papillose" - Kindberg in Macoun 1890, when describing *R. brevipes*; cf. also *G. papillulata* and *R. sudeticum* var. *papillosum*). Lawton (1972: 254, Fig. 25) recognized whether the cross walls were bulging or not, and used the characteristic in her *Racomitrium* key (Lawton 1971: 141). Deguchi (1979: Fig. 5a) coined the term "joint thickenings" for the same structure. Distinct pseudopapillae are (almost) always present in some taxa (especially *bre*, *him*, *jos*, *nit*, *ver*), whereas it is (almost) always lacking in others (especially *cap*, *lae*, *law*, *sub*). They are usually less distinct or absent in the European ecad of *R. microcarpon*, but very pronounced in the western N. American ecad of that species (Fig. 39c-g). The same situation exists in different ecads of *R. sudeticum*. The taxa not mentioned above may sometimes be not or moderately pseudopapillose, and sometimes more distinctly pseudopapillose. The characteristic is of slight taxonomic importance but it is very useful when distinguishing between modifications of *R. himalayanum* (pseudopapillose) and *R. subsecundum* (not or slightly pseudopapillose) in Asia.

Alar cells. The alar cells of the leaf may be differentiated in one or more marginal rows. One species, viz. *R. lawtonae*, can be said to possess undifferentiated alar cells. A number of species have a slightly differentiated alar group, i.e. they possess some shorter, wider and less sinuose cells in one or a few marginal rows (*aff*, *dep*, *het*, *obe*, *obt*, *ven*). Others usually have more differentiated cells in the same position, and especially some more in the marginal row (*bre*, *cuc*, *mac*, *occ*, *sud*). One species usually possesses an inflated and auriculate, reddish alar group (*sub*), but the same structure is sometimes indicated also in other species (noted in *aff*, *het*, *him*, *nit*!, *pac*). The rest of the species possess a differentiated basal marginal border of usually esinuose, thin-walled (or occasionally more thick-walled) pellucid or hyaline, cells (*cap-c* 20-30 differentiated cells; *cap-l* 10-20; *eme* 15-20; *fus* 12-17; *him* 4-12; *jos* 7-12; *lae* 12-20; *mac* p.p. 15-40; *mic* 10-20; *ver* 16-22; *vul* 15-25). A few of these species may have a second shorter row of similarly differentiated cells (noted

in *eme*, *mic*, *vul*). The structure of the alar cells (including the basal marginal cells), is an important taxonomic characteristic in sect. *Laevifolia*.

Gemmae. One species, viz. *R. vulcanicola*, possesses gemmae (see Description and Fig. 45h).

4.4.2 Bracts and sporophyte

The structure of the bracts and sporophyte of two species (*R. joseph-hookeri*, *R. vulcanicola*) is unknown. The description of the sporophyte of many taxa is based on a few or sometimes only one specimen (with many or few, sometimes only one or two, fine capsules), and this is clearly unsatisfactory. Some sporophyte measurements are therefore put in parenthesis. The sporophyte does not seem to include important differential characteristics which can be used in an internal classification of sect. *Laevifolia*. But at the species level, the size and structure of the sporophyte may be of taxonomic importance.

Bracts. a. *Female bracts* (Fig. 3-5). The perichaetium seems to reveal important differences with regard to a natural classification of the taxa in sect. *Laevifolia*. The bracts may be grouped according to their structure: (1) Innermost bracts slightly differentiated, thin-walled, hyalin and sheathing at the base but chlorophyllous and like vegetative leaves above, usually with hyaline point; outer bracts not squarrose when wet. (2) Innermost bracts strongly modified and sheathing, hyaline below but not above, epilose (except in western N. American *R. microcarpon*); outer bracts not squarrose when wet. (3) Innermost bracts strongly modified, strongly sheathing and pellucid below but not above, epilose; outer bracts squarrose when wet. (4) Innermost bracts strongly modified, hyaline and epilose; outer bracts not squarrose when wet. - This results in the following subgroups, which are named after their oldest specific name. (1) The *sudeticum* subgroup: *bre*, *law* (p.p.), *mac*, *occ*, *sud* (Fig. 3A); (2) the *microcarpon* subgroup: *cri*, (*law* p.p.), *mic* (Fig. 5A), *ver*, (*vul*, perichaetial l. not seen); (3) the *subsecundum* subgroup: *cap*, *cuc*, *fus*, *him*, (*jos*), *nit*, *sub* (Fig. 5B); (4) the *heterostichum* subgroup: *aff*, *dep*, *eme*, *het* (Fig. 4B), *lae*, *obe*, *obt*, *pac*, *ven*. Three species seem to be misplaced. The closely related *R. laetum* (Fig. 4A) and *R. lawtonae* (Fig. 3B) must be kept together, and it may be best to place them in their own subgroup (the innermost bracts of the two are yellowish and sometimes similar); it is named the *laetum* subgroup. The gametophyte of *R. emersum* is very different from those of the other species in the *heterostichum* subgroup. It seems to be more related to southern hemisphere taxa, and is treated in a subgroup of its own. The structure of the perichaetial leaves *may* be the key to a natural grouping of the species in the section, and in default of a better system it is modified as above and adopted in this paper. I am well aware that the grouping is preliminary; it may partly break down when the southern hemisphere taxa are revised. This comprehensive work remains, but a final internal classification of sect. *Laevifolia* has to wait for such a revision. The present system is based on the gametophyte, in that the perichaetial leaf is a gametophyte structure.

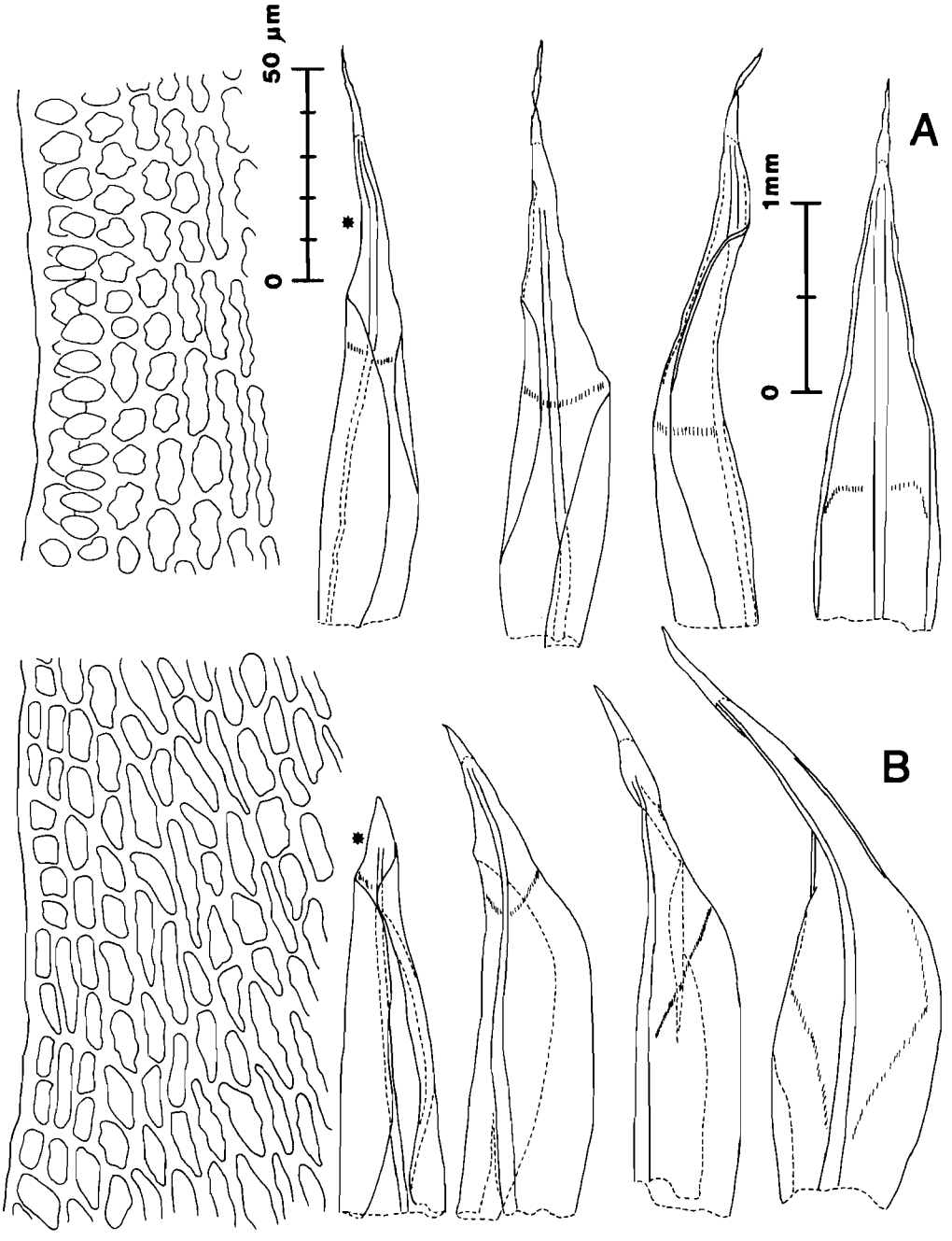

Fig. 3. The four innermost perichaetial leaves, and the cell structure (at the asterisk) of the innermost bract. A. *Racomitrium sudeticum* (Canada: B.C., Mt. Seymour, Schofield 12427 - CANM). B. *Racomitrium lawtonae* (Canada: B.C., above Horseshoe Bay, Howe Sound, Schofield & Godfrey 67756 - CANM).

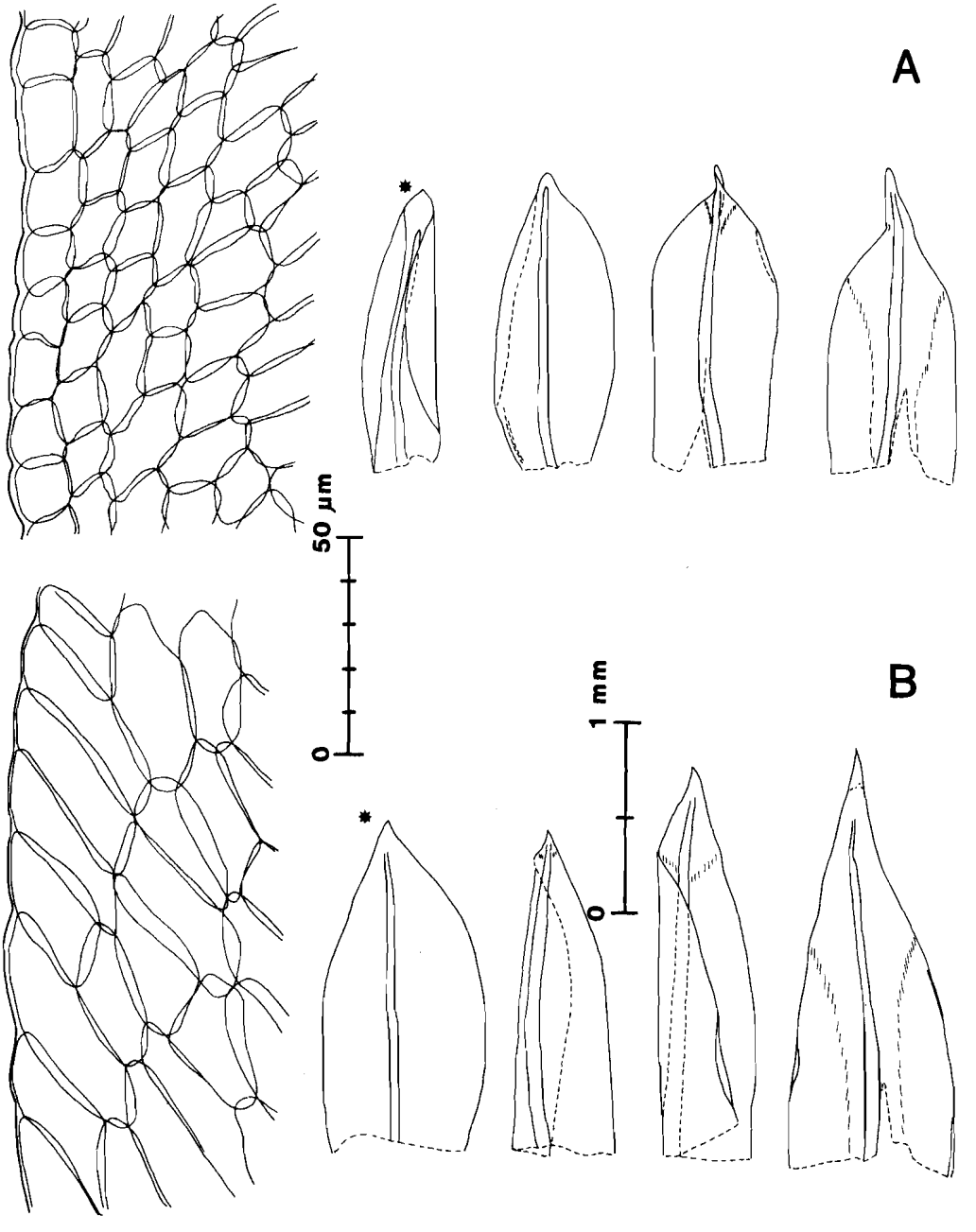

Fig. 4. The four innermost perichaetial leaves, and the cell structure (at the asterisk) of the innermost bract. A. *Racomitrium laetum* (Japan: Honshu, Pref. Mie, Owasetsuji - Kaminari Pass, Deguchi 10111-TRH). B. *Racomitrium heterostichum* (Norway: Sør-Trøndelag, Frøya, Froan, Nordøya, 16.VIII.1982 Frisvoll - TRH).

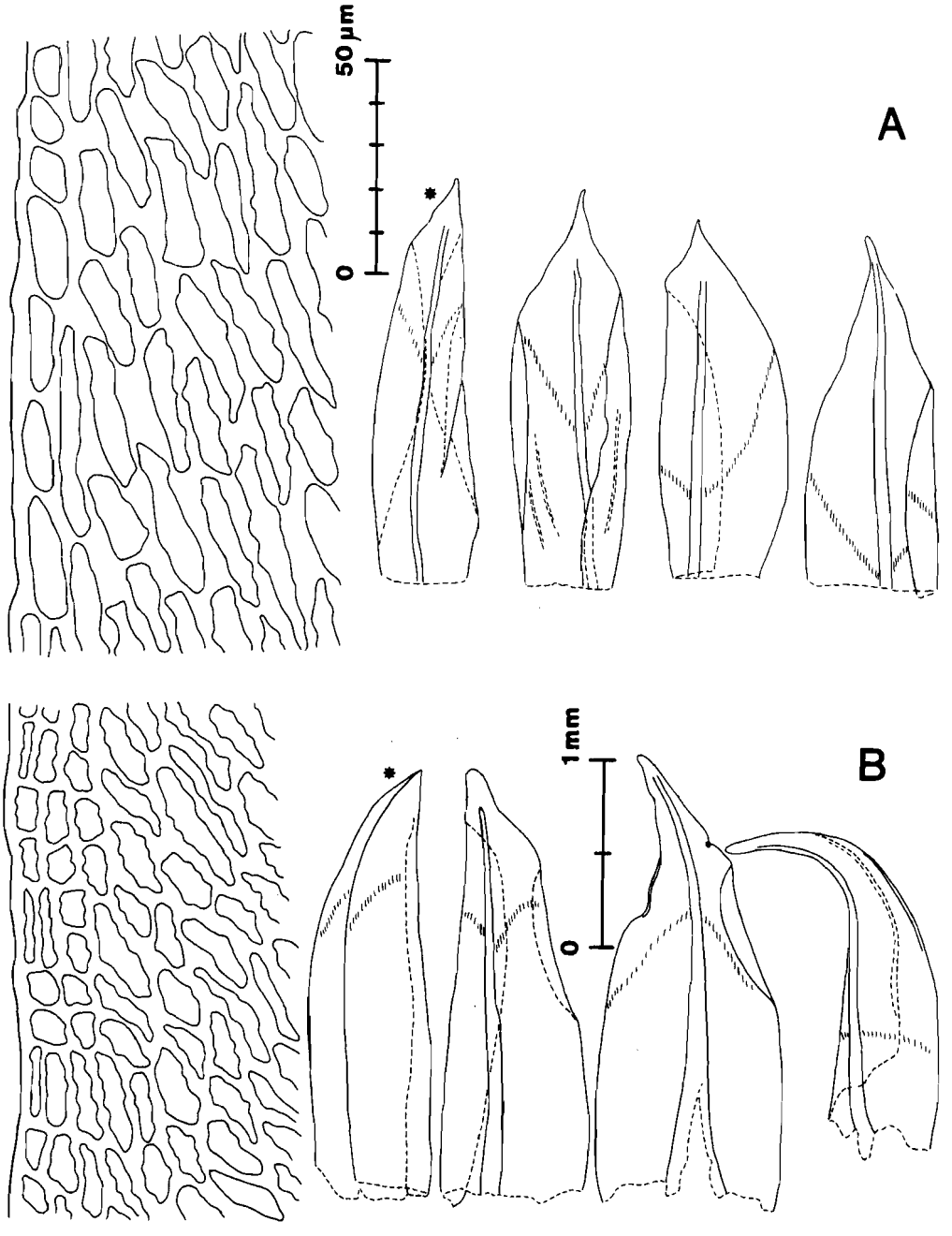

Fig. 5. The four innermost perichaetial leaves, and the cell structure (at the asterisk) of the innermost bract. A. *Racomitrium microcarpon* f. *microcarpon* (Canada: Ontario, 3 km N of Thunder Bay City, Garton 19522 - CANM). B. *Racomitrium subsecundum* (Sikkim: Darjeling distr., Jongri, Ribu 40 - BM).

b. *Male bracts*. The perigonium is bud-like and its bracts strongly sheathing; they are hyaline in the sheathing part, and more or less green at their apex.

Seta. The seta is smooth and twisted clock-wise. Its length varies much in most species, and I have probably not measured the shortest and longest seta in a given taxon. The measured values include the vaginula. The seta has been said to be *long* if > (4-)5 mm (viz. in *aff*, *cap*, *cri*, *dep*, *eme*, *fus*, *het*, *him*, *law*, *mac*, *mic*, *nit*, *pac*, *sub*, *ven*), and *short* if < 5(-5.5) mm (viz. in *bre*, *cuc*, *lae*, *obe*, *occ*, *sud*, *ver*); it has been said to be *medium long* in one species (*obt*, 3.2-6.5 mm). When young, the seta is yellowish above and orange below; when old it is darker in all parts and usually brown. When young it is often curved, but when mature it is usually erect. The setae of a few species may be arcuate also when mature; this is noted in *R. laetum*, *R. macounii* and *R. sudeticum*. Some taxa have robust setae (e.g. *R. obtusum* and other species of the *R. heterostichum* subgroup); in others it is less robust (e.g. *R. microcarpon*, *R. laetum* and other gracile species).

Urn, size and form. a. The *length* of the urn may vary much in one species, and the measurements probably do no cover the whole variation. Aberrant capsules have not been included. The longest measured urn is sometimes (more than) twice as long as the shortest measured urn in one species (1.5-3.2 mm in *R. affine*, 1.5-3.0 mm in *R. heterostichum*, 1.2-2.4 mm in *R. lawtonae*, 1.7-3.5 mm in *R. subsecundum*, and 0.7-1.6 mm in *R. sudeticum*). In the following eleven taxa I have not measured urns *longer* than 2 mm (*bre*, *cap*, *cuc*, *fus*, *lae*, *mac*, *mic*, *occ*, *sud*, *ven*, *ver*). In the following three taxa I have not measured urns *shorter* than 1.9 mm: (*cri*, *dep*, *pac*). The shortest urn has been measured in *R. sudeticum* (0.7 mm) and the longest in *R. pacificum* (3.7 mm). The urns (of a given species) are said to be *long* if frequently > 3 mm (*aff*, *het*, *pac*, *sub*); *m. long* if 2-2.75 mm (*cri*, *dep*, *law*, *obe*), *m. long to short* in three species (*him*, *obt*, *nit*, reaching to 2.25 mm); and *short* if < 2(-2.25) mm (*bre*, *cap*, *cuc*, *eme*, *fus*, *lae*, *mac*, *mic*, *occ*, *sud*, *ven*, *ver*).

b. The *width* of the urn is also variable. In the following twelve taxa I have not measured urns *broader* than 0.6 mm (*bre*, *cap*, *cri*, *cuc*, *him*, *lae*, *mic*, *nit*, *obe*, *occ*, *ven*, *ver*); and in the following I have not measured urns *narrower* than 0.6 mm (*aff*, *dep*, *fus*, *law*, *obt*, *sub*).

c. I have used the following terms about the *form* of the urns of the species: (1) oblong-cylindrical (= obloid), ovoid, obovoid, ellipsoid (length : breadth = < 3 : 1); (2) *narrowly* oblong-cylindrical, etc. (length : breadth = 3-6 : 1) (Stearn 1980: Fig. 19). In addition, I have used a few other terms (like subspherical, cylindrical). The urn is usually symmetrical, but is sometimes curved in *R. depressum*. The apophysis is usually gradually narrowed into the seta; but sometimes it is slightly more distinct, this is especially noted in *R. venustum*.

Operculum. The operculum is moderately long-beaked, and its length varies according to the length of the peristome of the species. It is often difficult to find mature opercula in herbarium specimens, and they have not been seen

in all taxa. However, they are probably of slight or no taxonomic value. I have the following measurements of the *length* of the operculum: (*aff* about 1 mm, *bre* 800 µm, *cap-l* 940 µm, *cri* 1.3 mm, *cuc* 1.0 mm, *fus* 1.2 mm, *het* 850-940 µm, *law* 1.13 mm, *mac-a* 750 µm, *mic* 850 µm, *sub* 1.13-1.5 mm, *sud* 700 µm). The beak of the operculum is ± oblique.

Calyptra. Mature calyptrae are even more rare than mature opercula. The calyptra is usually mitrate, and lobed at the base; the generic name *Racomitrium* means *torn cap* (Crum & Anderson 1981), and is derived from this structure. The calyptra is made up of 3-4 layers of thick-walled cells in the middle part (Noguchi 1974, Deguchi 1979).

Exothecial cells (Fig. 6). At the capsule mouth there are a few rows of small incrassate cells. The number of such cell rows varies from 1-2 to 6-7. It is not particularly constant within one taxon, but a special study would perhaps show that it has some taxonomic significance. The main part of the exothecium is usually a mixture of oblong and semi-quadrate cells. The cells are from thin-walled to thick-walled, and from straight to curved (see Descriptions). At the poorely marked neck there are one or two ill-defined rows of stomata, surrounded by small cells. - The exothecium of some species has a firm appearance and do not change much when drying after the lid has fallen. In other species it appears to be thinner, and after the fall of the lid it becomes wrinkled. This is especially seen in *R. microcarpon*. The urn never becomes ribbed.

Peristome (Fig. 6). The peristome is made up of 16 filiform teeth, which are usually partly or entirely split into two from the top to the base. Sometimes, single teeth are made up of one or three prongs. The mode of splitting varies in some species, but are more constant in others. The length of the teeth may vary much in the same species. The teeth are very fragile, and it is (almost) necessary to have ripe, operculate capsules to be sure that their uppermost part has not been lost. (Such capsules are put in water, and when wet the operculum is easily removed.) Most fertile specimens have been collected with ripe capsules without lids and with broken teeth, and the length and complete structure of the peristome of several species are therefore incompletely known or unknown. The length of the teeth are defined as the distance from the capsule mouth to the tip of the longest tooth/teeth. (The teeth are inserted below the mouth.) The length is usually between 200-500 µm. Only *R. subsecundum* has longer teeth, 530-600 µm. (Because of few usable capsules in many species, the length of the teeth has sometimes been placed in parenthesis.) The teeth are papillose, usually distinctly so but sometimes less distinctly. The base of the teeth includes a basal membrane; its height is measured above the capsule mouth (basal membrane absent = no basal membrane visible above the flattened mouth in the microscope). *Racomitrium obtusum* possesses a particularly high basal membrane (± 75 µm); and otherwise it is from 35 to 50 µm in many taxa. Seven taxa (*cap*, *cri*, *cuc*, *eme*, *lae*, *law*, *sub*) seem to have no basal membrane above the capsule mouth. The basal membrane is always less papillose than the teeth and frequently epapillose. A fragile, hyaline preperistome has been observ-

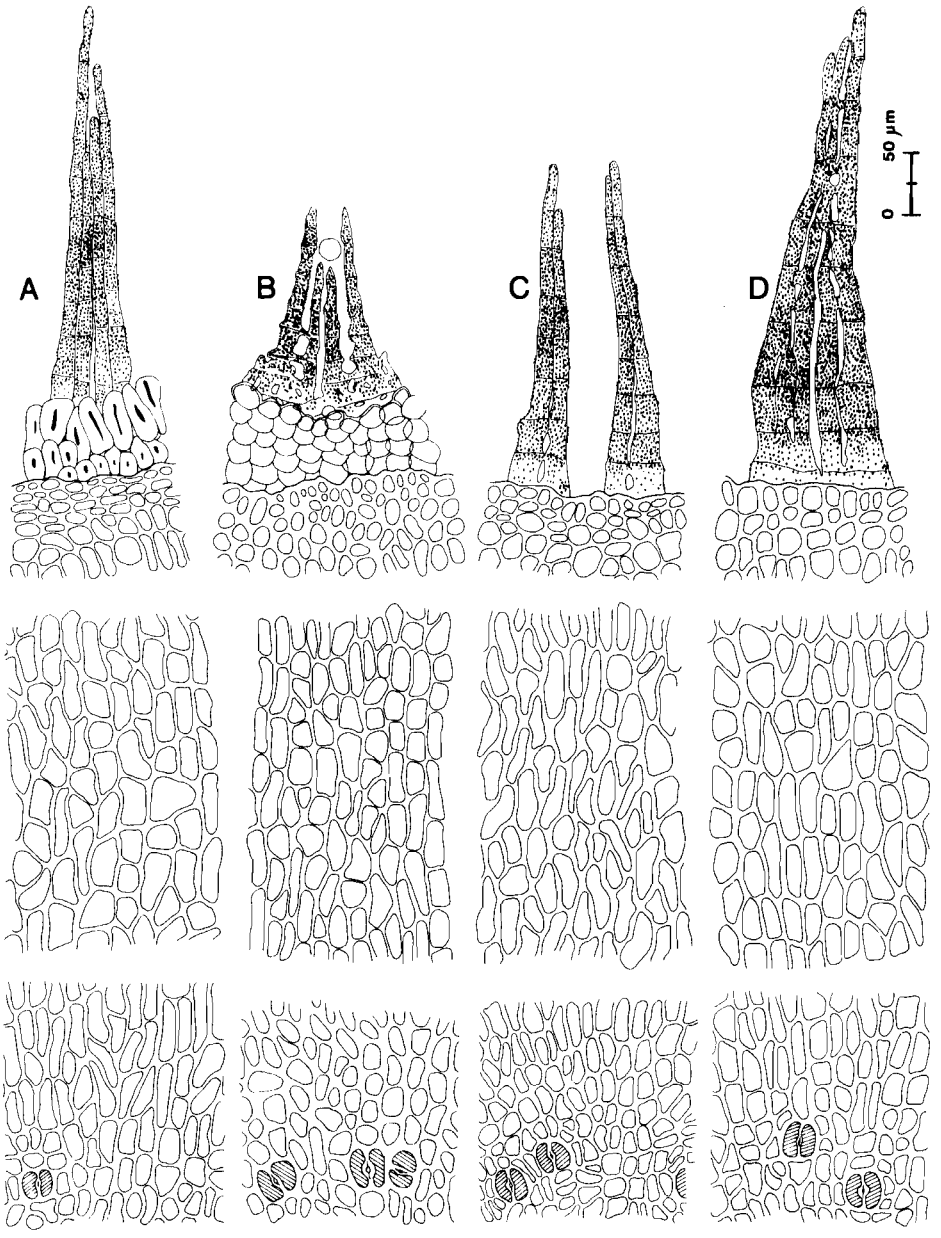

Fig. 6. Peristome teeth, and exothecial cells at the mouth, at the central part of the urn, and at the neck. A. *Racomitrium himalayanum*; note annulus (Nepal: Col de Hadengi-La, Zimmermann 1457 - BM). B. *Racomitrium obtusum* f. *obtusum*; note preperistome and high basal membrane (Norway: Hordaland, Sund, Golta-osen, 5.VII.1985 Blom - TRH). C. *Racomitrium laetum* (Deguchi 10111, cf. Fig. 4A). D. *Racomitrium macounii* subsp. *alpinum* (Norway: Nord-Trøndelag, Meråker, Gruvefjellet, 25.VII.1982 Frisvoll - TRH).

ed in many species, and is probably present in all (Fig. 6B, where it is somewhat schematically illustrated).

Spores. When studied in a high-powered microscope, the *Racomitrium* spores appear finely granular on the surface (cf. the one spore in Fig. 6B). Hirohama (1978) includes scanning electron microscope pictures of "*R. heterostichum* var. *diminutum*, *R. heterostichum*, *R. heterostichum* var. *ramulosum*, *R. microcarpon*, and *R. heterostichum* var. *sudeticum*". All quoted specimens except *R. microcarpon* are Japanese, and may be referable to *R. laetum*, *R. nitidulum* and/or *R. sudeticum*. It is therefore premature to comment on the structure of the spore surface in Hirohama's (1978: Pl. 2, Fig. 17-18, 21-24; Pl. 3, Fig. 29-32) pictures.

5.0 TAXONOMY, TREATMENT OF SPECIES

The type species of *Racomitrium* sect. *Laevifolia* is *R. heterostichum* (Noguchi 1974). A number of taxa are apparently close to *R. heterostichum*, and have often been treated as infraspecific taxa or synonyms of that name. They are characterized by having no true leaf papillae. However, the exact delimitation of the section is not clear. In the southern hemisphere, there are a few epapillose *Racomitrium* taxa (with very robust costa and strongly thickened lamina and margin) which seem to be less closely related to *R. heterostichum* (e.g. *R. bartramii* (Roiv.) H. Robins., *R. lamprocarpum* (C. Müll.) Jaeg., cf. Deguchi 1984). In the northern hemisphere I know of two such taxa; they are not treated here, but may nevertheless belong to sect. *Laevifolia* s.l.: *Racomitrium ellipticum* (Turn.) Bruch et Schimp. is a European endemic known from Norway, Great Britain, the Faeroe islands and Iceland (Størmer 1969). It has frequently been placed in the genus (Bridel 1826) or subgenus (Bruch et al. 1845, Dixon & Jameson 1896) *Dryptodon*. It has never been seriously confused with *R. heterostichum* s.l. (but see *Dryptodon *ellipticiformis* and *D. ellipticus* var. *tatrensis* in chapter 8.0, and Frisvoll 1985a with regard to *Grimmia fuscoviridis* Stirt.). The species taxonomy of *R. ellipticum* is not problematic. - The other taxon is the Asiatic *R. angustifolium* Broth., the type material of which is thoroughly described elsewhere (see chapter 8.0 and Fig. 65). So far it is only known from the type material, but is clearly a species in its own right.

5.1 *RACOMITRIUM* SECT. *LAEVIFOLIA* (KINDB.) NOG.

Racomitrium 4. *Laevifolia* Kindb., Eur. N. Am. Bryin. 2: 235. 1897. - *Racomitrium* sect. *Laevifolia* (Kindb.) Nog., J. Hatt. Bot. Lab. 38: 361. 1974. - Lectotype: *R. heterostichum* (Hedw.) Brid. (cf. Noguchi l.c.).

Racomitrium subgen. *Microcarpae* Vilh., Vestn. K. Cesk. Spol. Nauk Tr. 2, 1925: 22. 1925. - Lectotype nov.: *R. sudeticum* (Funck) Bruch et Schimp.

Plants small to robust, usually dark to light olivaceous green, but sometimes yellowish, greenish, brownish or blackish, and pilose plants frequently grayish due to long hair-points, in loose or dense, small or wide cushions or mats. **Stem** 0.5 - > 15 cm, from creeping to erect, unbranched or dichotomously, fastigiately (frequently) irregularly, pinnately and intricately branched, without central strand. **Leaves** usually narrowly ovate-triangular, imbricate, usually erect but also secund or rarely falcate or contorted. **Hair-point** absent or present, erect or often slightly or distinctly squarrose, from edenticulate to strongly denticulate and spinulose, strongly flexuose or not, and from not to distinctly decurrent down margin of lamina. **Margin** longly or shortly and broadly or narrowly recurved, unistratose or bistratose in spots or throughout for one or more cell rows, rarely in spots three- to four-stratose. **Costa** usually reaching to or (slightly) into the hair-point, (strongly) dorsally convex above and flatter or rarely quite flat below, and at the ventral side from flat to broadly canaliculate, below from bistratose to five-stratose or more, the ventral, central and dorsal cells slightly differentiated or the dorsal and central cells with narrower lumen than the ventral cells. **Lamina** usually unistratose or more rarely with bistratose spots or areas. **Lamina cells** sinuose, elongate below and (usually) shorter (sometimes transversely rectangular) above, cell walls from flat to strongly bulging (i.e. pseudopapillose) dorsally and ventrally, and from almost aporose to strongly porose almost throughout. **Alar cells** from almost undifferentiated to auriculate and hyaline, with or without a short or long (pellucid or hyaline) less sinuose or esinuose basal marginal border.

Dioicous, male and female plants similar. **Perichaetial leaves** (Fig. 3-5) squarrose or not when wet, the outer ones or all larger than the vegetative leaves, inner perichaetial leaves with wide convolute base of esinuose and wide thin-walled cells, sometimes pilose and almost like vegetative leaves, or usually more strongly differentiated (from subhyaline with chlorophyllous apex to hyaline and esinuose throughout), costa weak, and margin flat or recurved above the sheathing base. **Seta** short or elongate (2.4-14 mm), twisted clock-wise, smooth, when young usually curved and when mature usually erect (sometimes curved in a few taxa). **Capsule** usually oblong-cylindrical, but also ovoid, obovoid, ellipsoid and subspherical as well as *narrowly* oblong-cylindrical etc., usually symmetrical (rarely curved), not ribbed when dry; annulus of large separating cells; exothecial cells (Fig. 6) from irregularly quadrate to rectangular and irregularly rectangular, at the mouth some rows of narrow incrassate cells, at base 1-2 indistinct rows of phaneropore stomata about 30-35 µm in diameter; operculum with erect or usually oblique beak, its length dependent on the length of the teeth. **Peristome** brown or reddish brown, of 16 filiform teeth which are more or less regularly split in two parts from the top to the base, rarely almost undivided or cribrose, very fragile, papillose, basal membrane present and usually less papillose than the teeth, of varying height, preperistome present. **Calyptra** mitriform. **Spores** finely granular on the surface, usually 12-16 µm in diameter.

5.2 KEYS

It has proved difficult to make reliable keys for the taxa in the section, primarily because they are all easily modified by differences in environmental factors. When there is no self-evident choice between two alternatives in the key, both should be tried. In the more difficult cases, the same taxon is treated two or more times in the same key. In spite of this, I think it is a prerequisite to have some knowledge of the taxa of an area, before all their modifications and supposed microgenetically different ecads can be correctly named. Because the specimens are often sterile, the keys concentrate on gametophyte characteristics. It is important to get an impression of the *average* state of the characteristics of a specimen. The most important taxonomic characteristics are found in the leaves. They should be stripped off a typically robust main stem, preferably at its uppermost part - avoiding the immature apical leaves. Many leaves (at least 4-5) should be studied. The structure of the recurved margin and alar cells are best seen from the dorsal side, and therefore all prepared leaves should be reversed as a matter of routine.

Nine keys are presented, viz. one to each of the three main continents; one key to the six recognized informal subgroups (based on fertile specimens); and one key to the taxa of five of the subgroups.

Key to the N. and C. American taxa ..... p. 40
Key to the European taxa ..... p. 43
Key to the Asiatic taxa ..... p. 45
Key to the subgroups ..... p. 48
Key to the taxa in the *sudeticum* subgroup ..... p. 49
Key to the taxa in the *laetum* subgroup ..... p. 87
Key to the taxa in the *heterostichum* subgroup ..... p. 98
Key to the taxa in the *microcarpon* subgroup ..... p. 141
Key to the taxa in the *subsecundum* subgroup ..... p. 171

5.2.1 Key to the N. and C. American taxa of sect. *Laevifolia*

1 All leaves with chlorophyllous apex without any trace of a hyaline or subhyaline hair-point (only *R. depressum* and *R. pacificum* are consistently epilose) 2

1 Some (or at least one) leaves with hair-point; point long or short, and hyaline or subhyaline 7

2 Leaves contorted when dry; margin 2-stratose for 2-4 cell rows far down the leaf; plant usually (reddish) brown (Fig. 9)
(2a) *R. macounii* subsp. *macounii* (epilose ecads)

2 Leaves erect-appressed (including falcate) when dry; margin often 1-stratose and at most 2-stratose for 1-3 cell rows in its upper part; plants usually not (reddish) brown 3

3 Apex usually broadly rounded and crenulate (many leaves!); margin shortly recurved and often nearly or quite flat on one side, 1-stratose; never

pilose but sometimes dorsally spinulose apically 4

3 Apex less broadly rounded and never crenulate; margin recurved towards the apex, or less recurved (and then apex narrow), often ± 2-stratose 5

4 Leaves concave, most leaves larger than 3 x 1 mm; alar group not well-defined, of large, usually thin-walled (sometimes decurrent) cells; a mountain plant (Fig. 25) (8) *R. depressum*

4 Leaves not concave, most leaves smaller than 3 x 1 mm; alar group well-defined and sometimes auriculate, of short, thick-walled and porose cells; a lowland plant (Fig. 33) (12) *R. pacificum*

5 Leaf narrow towards the apex and there with costa strongly convex dorsally; margin recurved to about 1/2(-3/4) the leaf length on one side and more shortly recurved or flat on the other side; innermost perichaetial leaves slightly differentiated (Fig. 3A, 15-17) (4) *R. sudeticum* (epilose ecads)

5 Leaf broader towards the apex and there with costa less convex dorsally; margin recurved towards the hair-point or somewhat shorter; innermost perichaetial leaves hyaline 6

6 Margin uneven, usually 2-stratose for 1-3 cell rows (± 1-stratose spots) in upper part; costa narrow (50-80 µm) below, and there usually 3-stratose (Fig. 35) (13) *R. venustum* (epilose ecads)

6 Margin smooth, 1- (or in part 2-)stratose in upper part; costa medium broad (80-100 µm) below, and there (3-)4-stratose (Fig. 66) (7) *R. affine* (epilose ecads)

7 Costa at least in part with low dorsal wings and/or furrows, strongly dorsally convex with 3-4 ventral cells; leaf apex narrow; hair-point strongly spinulose, terete and not flexuose; margin uneven, 2-stratose for 1-3 cell rows; usually green and slightly branched plant (Fig. 13) (3) *R. occidentale*

7 Costa without such dorsal wings or furrows; the combination of the other characteristics different 8

8 Leaf margin regularly 2-stratose throughout for 2-4 cell rows (sometimes sporadically 3-stratose); hair-point short (0-200 µm) and usually subhyaline, squarrose when dry; costa 4-stratose and strongly dorsally convex; plants usually (reddish) brown and slightly branched 9

8 Leaf margin from 1-stratose to 2-stratose for 1 cell row or (at most) sporadically 2-stratose for 2(-3) cell rows (rare 3-stratose spots may occur); the combination of the other characteristics different 10

9 Leaves contorted when dry, usually dull; hair-point (usually) < 100 µm (Fig. 9) (2a) *R. macounii* subsp. *macounii*

9 Leaves erect-appressed when dry, usually glistening; hair-point usually longer (up to 200 µm) (Fig. 11) (2b) *R. macounii* subsp. *alpinum*

10 Leaf with basal cells esinuose, thick-walled and porose; with a differentiated basal marginal border of 10-20 usually esinuose (sometimes slightly sinuose) and hyaline or sometimes more thick-walled and pellucid cells; costa below 2- or 3-stratose, and narrow (60-90 µm) with 3-4 ventral cells 11

10 Leaf with basal cells sinuose and usually less thick-walled (± porose); without such a basal marginal border; basal part of costa at least in some t.s. with 5 or more ventral cells (except *R. sudeticum*, see 22) 13

11 Plant robust; leaves long and broad (≥ 3.0 x 0.7 mm); urn 2.0-2.5 mm;

southern (Fig. 37) (14) *R. crispipilum*

11 Plant less robust; leaves smaller (≤ 3.0 x 0.7 mm); urn 1.3-2.0 mm; northern 12

12 Cells of the basal marginal border usually short, wide and hyaline (Fig. 39) (15a) *R. microcarpon* f. *microcarpon*

12 Basal marginal cells usually elongate, narrow and more or less sinuose and/or thick-walled (Fig. 40) (15b) *R. microcarpon* f. *afoninae*

13 Costa broadly canaliculate in mid-leaf, and there with many (4-8) ventral cells, moderately dorsally convex (some gracile ecads which may be difficult to place here are treated also below) 14

13 Costa not or less obviously canaliculate in mid-leaf, and there with few (3-4) ventral cells, strongly dorsally convex 17

14 Hair-point coarsely and acutely spinulose and denticulate; costa very broad above (70-90 µm) and there with 5-8 ventral cells; lamina strongly pseudopapillose; innermost perichaetial leaves slightly differentiated, pilose (Fig. 7) (1) *R. brevipes*

14 Hair-point not or low-denticulate-and-spinulose; costa narrower above (≤ 75 µm) and there with 2-4 ventral cells; lamina cells not or moderately pseudopapillose; innermost perichaetial leaves strongly differentiated 15

15 Leaf base usually orange-red, usually with inflated, thin-walled (auriculate or decurrent) alar cells; costa dorsally flat towards the base; hair-point edenticulate; outer perichaetial leaves squarrose, the innermost not hyaline (Fig. 5B, 60-61) (24) *R. subsecundum*

15 Leaf base usually not reddish, without such alar cells; costa dorsally convex; hair-point denticulate and spinulose (except Aleutian *R. heterostichum*); perichaetial leaves not squarrose, the innermost hyaline 16

16 Leaf margin 2-stratose for 1-3 cell rows in its upper part, uneven; lamina distinctly narrowed at the connection with the hair-point, which is stiff and not flexuose; seta short (3-4.5 mm); coarse, slightly branched plant (Fig. 29) (10) *R. obesum*

16 Leaf margin 1-stratose or less 2-stratose, smooth; lamina not much narrowed at the connection with the hair-point, which is soft and (usually) flexuose; seta long (4-8 mm); moderately robust, usually (much) branched plant (Fig. 27) (9) *R. heterostichum*

17 Leaf base usually orange-red; costa dorsally flat towards the base; (at least some) alar cells inflated and thin-walled, ± auriculate or sometimes decurrent; outer perichaetial leaves squarrose (Fig. 60-61) (24) *R. subsecundum*

17 Leaf base usually not orange-red; costa dorsally convex; alar cells different; outer perichaetial leaves not squarrose 18

18 Margin recurved towards the hair-point or (especially on one side) somewhat shorter (many leaves!); hair-point frequently not squarrose when dry 19

18 Margin recurved to about 1/2(-3/4) the leaf length on one side and shorter or almost (or quite) flat on the other side; hair-point frequently squarrose when dry 22

19 Leaf margin uneven, usually 2-stratose for 1-2(3) cell rows (sometimes with 1- or 3-stratose spots) in the upper part; hair-point stout, slightly or not flexuose and strongly spinulose 20

19 Leaf margin not uneven, usually 1-stratose or sporadically 2-stratose for 1(-2) cell rows in the upper part; hair-point soft, usually flexuose and less spinulose 21

20 Plant robust; lamina strongly contracted at the connection with the hair-point; costa broad (85-120 µm) with 4-9 ventral cells below; leaf long and broad (> 3.2 x 0.75 mm) (Fig. 29) (10) *R. obesum*

20 Plant medium robust to small; lamina not much contracted at the connection with the hair-point; costa narrow (50-80 µm); leaf short and narrow (< 2.4 x 0.7 mm) (Fig. 35) (13) *R. venustum*

21 Costa canaliculate and predominantly bistratose in its middle and lower upper part (Fig. 27) (9) *R. heterostichum*

21 Costa not canaliculate and predominantly 3-stratose in its middle and lower upper part (Fig. 23) (7) *R. affine*

22 Hair-point broad and long (usually 0.5-1.5 mm), decurrent down margin of lamina; leaf long (> 3.0 mm); robust plant (Fig. 21) (6) *R. lawtonae*

22 Hair-point narrow and short (up to 0.4 mm but usually much shorter), not decurrent; leaf short (≤ 3.0 mm); gracile or moderately robust plants. *R. sudeticum* s.l. 23

23 Costa below 3-4-stratose; margin (1)2(3)-stratose for 1-3 cell rows (Fig. 16) (4b) *R. sudeticum* f. *kindbergii*

23 Costa below (2)3(4)-stratose; margin from 1-stratose to 2-stratose for 1(-2) cell rows 24

24 Widespread, gracile or moderately robust, predominantly epilithic plant; margin predominantly 1- or 2-stratose for 1(-2) cell rows throughout; upper leaf cells short or elongate (Fig. 15) (4a) *R. sudeticum* f. *sudeticum*

24 Robust, predominantly epigeic plant of the northern tundra; margin 1-stratose or weakly thickened; upper leaf cells usually elongate (Fig. 17) (4c) *R. sudeticum* f. *terricola*

5.2.2 Key to the European taxa of sect. *Laevifolia*

1 All leaves with chlorophyllous apex without any trace of a hyaline or subhyaline hair-point (only *R. obtusum* f. *obtusum* is consistently epilose) 2

1 At least some (or one) leaves with hair-point; point long or short, and hyaline or subhyaline 5

2 Margin broadly recurved/revolute towards the apex; costa broad and ventrally canaliculate throughout, in mid-leaf with many (4-8) ventral cells (Fig. 31) (11a) *R. obtusum* f. *obtusum*

2 Margin less broadly and often more shortly recurved, costa not canaliculate (but frequently furrowed), in mid-leaf with few (2-4) ventral cells and there more strongly dorsally convex 3

3 Apex relatively broad; costa ventrally flat towards the base and there (usually) 4-stratose (Fig. 66) (7) *R. affine* (epilose ecads, 'var. *gracilescens*')

3 Apex relatively narrow; costa ventrally furrowed towards the base and there 2- og 3- (very rarely 4-)stratose 4

4 Basal leaf cells esinuose, thick-walled and strongly porose; basal marginal border of 10-20 esinuose and hyaline cells (Fig. 39) (15a) *R. microcarpon f. microcarpon* (epilose ecads)

4 Basal leaf cells sinuose; with (rarely without) a short row of esinuose and pellucid (but less thin-walled and often narrower) basal marginal cells (Fig. 15) (4) *R. sudeticum* (epilose ecads)

5 Leaf margin regularly 2-stratose for 2-4 cell rows (rarely sporadically 3-stratose); hair-point short (0-200 µm), stiff and usually subhyaline, squarrose when dry; costa 4-stratose (with ± 3-stratose spots) and strongly dorsally convex; plants usually (reddish) brown and slightly branched 6

5 Leaf margin from 1-stratose to 2-stratose for 1 cell row and (at most) sporadically 2-stratose for 2(-3) cell rows (rare 3-stratose spots may occur); the combination of the other characteristics different 7

6 Leaves contorted when dry, usually dull; hair-point (usually) < 100 µm (Fig. 9) (2a) *R. macounii* subsp. *macounii*

6 Leaves erect-appressed when dry, usually glistening; hair-point usually longer (up to 200 µm) (Fig. 11) (2b) *R. macounii* subsp. *alpinum*

7 Basal leaf cells esinuose, thick-walled and strongly porose; basal marginal border of 10-20 (wide,) esinuose and hyaline cells (exceptional plants have a shorter border of less hyaline or slightly sinuose cells); costa narrow (60-80 µm), 2- or 3-stratose below and there with 3-4 ventral cells (Fig. 39) (15a) *R. microcarpon* f. *microcarpon*

7 Basal leaf cells sinuose and usually less thick-walled; without such a basal marginal border; costa usually broader with more ventral cells below (except *R. sudeticum*, see 11) 8

8 Costa ventrally canaliculate and moderately dorsally convex, in mid-leaf predominantly 2-stratose with many (4-8) ventral cells 9

8 Costa not canaliculate, strongly dorsally convex, in mid-leaf predominantly 3-stratose (except sometimes in *R. sudeticum*), with few (2-4) ventral cells 11

9 Hair-point strongly flexuose or crisped, narrow (at its base) and edenticulate, short; upper leaf cells long and narrow; outer perichaetial leaves squarrose, the innermost not hyaline above (Fig. 54) (21) *R. himalayanum*

9 Hair-point less flexuose, usually broader (at its base) and denticulate; upper leaf cells short or mixed short and elongate; perichaetial leaves not squarrose, the innermost hyaline 10

10 Capsule usually ellipsoid or obovate, with short cribrose teeth and high (to 75 µm) basal membrane; hair-point usually short and not much flexuose, with some upper leaves brevipilose or epilose; margin broadly recurved/revolute towards the apex, frequently with 2-stratose spots or more 2-stratose (Fig. 31) (11b) *R. obtusum* f. *trichophorum*

10 Capsule usually oblong-cylindrical, with longer not cribrose teeth and shorter (to 50 µm) basal membrane; hair-point usually long, with all (upper) leaves pilose; margin less broadly recurved, usually 1-stratose or with infrequent (very rarely more frequent) 2-stratose spots (Fig. 27) (9) *R. heterostichum*

11 Leaf broad towards the apex and there with costa less strongly dorsally convex; costa ventrally flat below; hair-point broad at its base and often soft, elongate and flexuose; innermost perichaetial leaves strongly differen-

tiated (Fig. 23) (7) *R. affine*

11 Leaf narrow towards the apex and there with costa strongly dorsally convex; costa furrowed below; hair-point narrow at its base and usually stout, short and not flexuose; innermost perichaetial leaves slightly differentiated. *R. sudeticum* s.l. 12

12 Costa below 3-4 stratose; margin (1)2(3)-stratose for 1-3 cell rows (Fig. 16) (4b) *R. sudeticum* f. *kindbergii*

12 Costa below (2)3(4)-stratose; margin from 1-stratose to 2-stratose for 1(-2) cell rows 13

13 Widespread gracile or moderately robust, predominantly epilithic plant; margin predominantly 1- og 2-stratose for 1(-2) cell rows throughout; upper leaf cells short or elongate (Fig. 15) (4a) *R. sudeticum* f. *sudeticum*

13 Robust, predominantly epigeic plant of the northern tundra; margin weakly thickened; upper leaf cells usually elongate (Fig. 17) (4c) *R. sudeticum* f. *terricola*

5.2.3 Key to the Asiatic taxa of sect. *Laevifolia*

(Pilose and epilose ecads; no Asiatic taxon is consistently epilose, but *R. cucullatulum*, *R. fuscescens* and *R. nitidulum* more often than not possess epilose leaves, and *R. verrucosum* var. *verrucosum* is nearly always epilose.)

1 Basal marginal leaf border distinct, of 10-20 or more differentiated, usually hyaline and thin-walled but sometimes more thick-walled pellucid or slightly sinuose cells (many leaves!) 2

1 Basal marginal leaf border absent or indistinct, at most made up of 7-10 usually (moderately) thick-walled cells 13

2 Hair-point of the upper leaves extremely long and capillaceous, up to 4(-6) mm, not or faintly flexuose when dry; basal marginal leaf border of 20-25(40) thin-walled rectangular or quadrate cells (Fig. 47) (18a) *R. capillifolium* var. *capillifolium*

2 Hair-point less capillaceous or absent; basal marginal leaf border usually shorter, rarely of more than 20 cells 3

3 Leaf margin recurved to about 1/2 the chlorophyllous part of the leaf or shorter on one side, and more shortly recurved or often flat on the other side (many leaves!) 4

3 Leaf margin recurved towards the hyaline point or apex on both sides or more shortly recurved (to about 1/2 the chlorophyllous leaf length) on one side 11

4 Margin 2-stratose for 1-3(4) cell rows from apex and far down the leaf; leaf cells usually distinctly bulging 5

4 Margin 1-stratose or 2-stratose for 1 cell row (especially towards the base); cell walls rarely bulging 6

5 Hair-point usually long (≥ 0.9 mm); basal marginal border of usually rounded and moderately thick-walled pellucid cells (Fig. 56) (22) *R. joseph-hookeri*

5 Hair-point short or absent; border cells hyaline or slightly thick-walled (Fig. 43) (16b) *R. verrucosum* var. *emodense*

6 Leaf margin uneven; plant yellow-olivaceous (if not dirty brownish), and not or slightly branched; hair-point not flexuose, usually long (0.5-1.5 mm, very rarely almost absent) (Fig. 19) (5) *R. laetum*

6 Leaf margin smooth or slightly uneven; plants brownish/fuscous, light-coloured or olivaceous (green), usually much branched; hair-point (if long) flexuose 7

7 Plant light-coloured apically (rarely more brownish); hair-point absent or stout and very short, up to 75 µm, yellowish-hyaline (Fig. 63) (25) *R. emersum*

7 Plants brownish/fuscous or olivaceous apically; hair-point absent, or short and capillaceous, or usually much longer if present 8

8 Upper leaf cells moderately elongate with irregular (nodulose) walls; leaf margin 1-stratose; plants never of a warm brown colour 9

8 Upper leaf cells elongate and narrow with parallel sinuose walls; leaf margin with frequent 2-stratose spots (in lower part); plants often of a warm brown colour 10

9 Spherical gemmae present in the upper leaf axils (Fig. 45) (17) *R. vulcanicola*

9 Gemmae absent (Fig. 39) (15a) *R. microcarpon* f. *microcarpon*

10 Gracile plant; hair-point often absent and at most 0.5(-0.7) mm long, narrow; leaf up to 2.6 mm long but often shorter (Fig. 52) (20) *R. fuscescens*

10 More robust plant; hair-point usually long, up to about 3.0 mm, broad basally; leaf longer, 2.25-5.1 mm (Fig. 48) (18b) *R. capillifolium* var. *lorifolium*

11 Costa narrow (60-80 µm) below, and there with 3-4 ventral cells (Fig. 39) (15a) *R. microcarpon* f. *microcarpon*

11 Costa broad (80-120 µm) below, and there with 5-9 ventral cells 12

12 Basal marginal border of 4-12 pellucid but not hyaline and sometimes even thick-walled esinuose cells; hair-point usually present (0.3-1.0 mm long); leaf cells moderately thick-walled and slightly porose (Fig. 54) (21) *R. himalayanum*

12 Basal marginal border of 16-22 hyaline esinuose cells; hair-point usually absent (0-0.15 mm long); leaf cells thick-walled and strongly porose (Fig. 42) (16) *R. verrucosum* var. *verrucosum*

13 Leaf margin uneven; plant yellow-olivaceous and not or slightly branched; hair-point not flexuose, usually long (0.5-1.5 mm, or very rarely almost absent) (Fig. 19) (5) *R. laetum*

13 Leaf margin smooth; plants (normally) brownish, olivaceous green, or blackish apically, variously branched; hair-point from absent to long 14

14 Leaf margin recurved towards the hyaline point or apex on both sides or somewhat shorter on one side 15

14 Leaf margin recurved to about 1/2 the chlorophyllous part of the leaf on one side and more shortly recurved or often flat on the other side 17

15 Leaf base usually reddish-orange; some or many alar cells inflated and thin-walled (± auriculate), or the alar group made up of strongly nodulose and porose (stellate) cells; costa broad below and rapidly narrower (35-50 µm) in the apex (Fig. 60-61) (24) *R. subsecundum*

15 Leaf base not (or less) reddish; no or exceptional alar cells inflated and thin-walled; costa relatively broad (50-70 µm) also above 16

16 Costa canaliculate, with many ventral cells in the middle and upper part of the leaf (5-8 and 3-6 cells, respectively); hair-point (usually) edenticulate, strongly flexuose (Fig. 54) (21) *R. himalayanum*

16 Costa not canaliculate, with fewer ventral cells in the middle and upper part of the leaf (3-4 and 2-3 cells, respectively); hair-point denticulate, less flexuose (Fig. 23) (7) *R. affine*

17 Costa broad (85-130 µm) below and there with 5-8 ventral cells (many leaves!) 18

17 Costa narrower (55-85 µm) below and there with 3-5 ventral cells 20

18 Leaf cell walls very strongly bulging dorsally and ventrally; basal marginal border of 7-12(16) usually rounded and moderately thick-walled (at the base sometimes enlarged) cells (Fig. 56) (22) *R. joseph-hookeri*

18 Leaf cell walls not or slightly bulging dorsally and ventrally; basal marginal border present or not 19

19 Basal marginal border of (5)10-20 esinuose pellucid cells; a few basal cells (in 1-2 rows) frequently rounded and slightly enlarged (Fig. 48) (18b) *R. capillifolium* var. *lorifolium*

19 Basal marginal border absent; many or some alar cells inflated and thin-walled (± auriculate), or the alar group made up of strongly nodulose and porose (stellate) cells [small brownish plants with no or short *capillaceous* hair-point may belong to *R. cucullatulum*, q.v.] (Fig. 60-61) (24) *R. subsecundun*

20 Basal laminal cells thick-walled and porose but not sinuose; the other leaf cells also usually strongly porose 21

20 Basal laminal cells moderately thick-walled, and sinuose (± porose); the other leaf cells moderately porose 22

21 Leaf margin 1-stratose (Fig. 40) (15b) *R. microcarpon* f. *afoninae*

21 Leaf margin 2-stratose for 2 or more cell rows (Fig. 43) (16b) *R. verrucosum* var. *emodense*

22 Leaf margin 2(-3)-stratose for 2-4 or more cell rows (not only in spots) far down the leaf 23

22 Leaf margin 1-stratose or with 2-stratose spots for 1-2 cell rows (very rarely more bistratose) 24

23 Costa 2-3-stratose; lamina often with 2-stratose spots, leaf cells elongate; outer perichaetial leaves squarrose, innermost perichaetial leaves much differentiated, obtuse (Fig. 50) (19) *R. cucullatulum*

23 Costa 3-4-stratose; lamina unistratose, leaf cells short; outer perichaetial leaves not squarrose, innermost perichaetial leaves slightly differentiated, acuminate (Fig. 11) (2b) *R. macounii* subsp. *alpinum*

24 Alar cells frequently orange and enlarged and (sub)auriculate (at least in some leaves); outer perichaetial leaves squarrose, inner perichaetial leaves much differentiated, obtuse (Fig. 58) (23) *R. nitidulum*

24 Alar cells not orange, enlarged or auriculate; outer perichaetial leaves not squarrose, inner perichaetial leaves slightly differentiated, acuminate 25

25 Gracile or moderately robust, predominantly epilithic plant; margin predominantly 1- or 2-stratose for 1(-2) cell rows throughout; upper leaf cells

short or elongate (Fig. 15) (4a) *R. sudeticum* f. *sudeticum*

25 Robust, predominantly epigeic plant of the northern tundra; margin weakly thickened; upper leaf cells usually elongate (Fig. 17) (4c) *R. sudeticum* f. *terricola*

5.2.4 Key to the subgroups - fertile material

1 Bracts (= ♀-bracts) and sporophyte never observed 2
1 Bracts and sporophyte known 3
2 Strongly pseudopapillose Himalayan plant without gemmae: *R. joseph-hookeri* (Fig. 56), treated in the *subsecundum* subgroup
2 Less pseudopapillose Japanese plant with gemmae: *R. vulcanicola* (Fig. 45), treated in the *microcarpon* subgroup
3 Outer bracts squarrose when wet, the innermost not hyaline (above) (Fig. 5B) The *subsecundum* subgr., chapter 5.7
3 Outer bracts not squarrose when wet, the innermost hyaline or not 4
4 Innermost bracts not or slightly differentiated, moderately sheathing below, and chlorophyllous, acuminate and frequently pilose (Fig. 3A-B) 5
4 Innermost bracts strongly differentiated, sheathing, the obtuse apex with or without an apiculus or rarely (in *aff*, *het*, *mic*) a short hair-point (Fig. 4A-B, 5A) 7
5 Hair-point of vegetative leaves flexuose, basal leaf cells esinuose, thick-walled and porose; *R. microcarpon* (Fig. 39) in the *microcarpon* subgroup
5 Hair-point of vegetative leaves not flexuose, basal leaf cells sinuose 6
6 Large, yellow-olivaceous plant with long decurrent hair-point: *R. lawtonae* (Fig. 21) in the *laetum* subgroup
6 Smaller, more greenish or brownish plants with short, not or less decurrent hair-point The *sudeticum* subgr., chapter 5.3
7 Innermost bracts hyaline below but not above, often large, epilose (except western N. American *R. microcarpon*) (Fig. 5A) The *microcarpon* subgr., chapter 5.6
7 Innermost bracts hyaline or yellowish hyaline, often relatively small (Fig. 4A-B), epilose (except sometimes in strongly pilose ecads of a few taxa) 8
8 Plants yellow-olivaceous, (almost) unbranched; innermost bracts yellowish-pellucid (Fig. 4A); hair-point of vegetative leaves usually distinct, not flexuose, slightly or not denticulate The *laetum* subgr., chapter 5.4
8 Plants rarely yellow-olivaceous, usually much branched, innermost bracts more hyaline (Fig. 4B); hair-point of vegetative leaves absent, short, or usually long and then flexuose and denticulate 9
9 Basal marginal border long, of hyaline cells; hair-point of vegetative leaves short and stiff; plant of a light (yellowish) colour (Fig. 63) The *emersum* subgr., chapter 5.8
9 Distinct basal marginal border lacking; hair-point of vegetative leaves absent or usually long; plants olivaceous or brownish The *heterostichum* subgr., chapter 5.5

5.3 THE *SUDETICUM* SUBGROUP

Innermost bracts slightly differentiated, thin-walled, hyaline and sheathing at the base but chlorophyllous and like vegetative leaves above, usually with hyaline point; outer bracts not squarrose when wet. Stem often slightly branched; hair-point not flexuose, usually denticulate and spinulose; margin usually bistratose; costa three- to four-stratose below; cells tending to be short or very short in the upper part of the leaf.

Four species: *R. brevipes*, *R. macounii*, *R. occidentale*, *R. sudeticum*. *Racomitrium sudeticum* and *R. macounii* are closely related. *Racomitrium occidentale* seems to be more taxonomically isolated. And the broad, canaliculate costa of *R. brevipes* indicates a distant relationship with the other species in the subgroup.

5.3.1 Key to the taxa in the *sudeticum* subgroup

1 Costa canaliculate, very broad (100-120 µm) below with 6-9 ventral cells; leaf cells strongly pseudopapillose; hair-point broad and decurrent, coarsely denticulate and spinulose (Fig. 7) (1) *R. brevipes*

1 Costa not canaliculate, narrower (60-100 µm) below with 3-4(5) ventral cells; leaf cells not or usually less pseudopapillose; hair-point not decurrent and less coarsely spinulose and denticulate 2

2 Costa at least in part with low dorsal wings and/or furrows; margin uneven; hair-point terete (grimmioid) and acutely spinulose (Fig. 13) (3) *R. occidentale*

2 Costa without dorsal wings and/or furrows; margin smooth; hair-point not terete 3

3 Leaf margin regularly 2-stratose throughout for 2-4 cell rows (sometimes sporadically 3-stratose); costa predominantly 4-stratose; hair-point short (usually < 200 µm) and yellowish-hyaline; plants usually (reddish) brown. *R. macounii* s.l. 4

3 Leaf margin from 1-stratose to 2-stratose for 1 cell row or (at most) sporadically 2-stratose for 2(-3) cell rows (rare 3-stratose spots may occur); costa predominantly (2-)3-stratose (sometimes with 4-stratose spots); hair-point hyaline and frequently longer; plants usually not (reddish) brown. *R. sudeticum* s.l. 5

4 Leaves contorted when dry, usually dull; hair-point < 100 µm (Fig. 9) (2a) *R. macounii* subsp. *macounii*

4 Leaves erect-appressed when dry, usually glistening; hair-point usually longer (up to 200 µm) (Fig. 11) (2b) *R. macounii* subsp. *alpinum*

5 Costa below 3-4-stratose; margin (1)2(3)-stratose for 1-3 cell rows (Fig. 16) (4b) *R. sudeticum* f. *kindbergii*

5 Costa below (2-)3-stratose (± rare 4-stratose spots); margin from 1-stratose to 2-stratose for 1(-2) cell rows 6

6 Widespread, gracile or moderately robust, predominantly epilithic plant; (margin from 1-stratose to 2-stratose for 1 cell row throughout; leaf cells

short or elongate) (Fig. 15) (4a) *R. sudeticum* f. *sudeticum*

6 Robust, predominantly epigeic plant of the northern tundra; margin weakly thickened; upper leaf cells usually elongate (Fig. 17) (4c) *R. sudeticum* f. *terricola*

(1) *Racomitrium brevipes* Kindb. in Macoun
Fig. 7-8.

Racomitrium brevipes Kindb. in Macoun, Bull. Torr. Bot. Cl. 17: 272. 1890. - *R. *brevisetum* Kindb., Öfv. K. Vet. Ak. Förh. 47: 453. 1890 *nom. nud. err. pro R. brevipes* Kindb. - *R. sudeticum* f. *brevipes* (Kindb.) Lawt., Moss Fl. Pacific Northw. 147. 1971. - Type: "On sloping garnetiferous rocks near the summit of the Gold Range, north of Griffin Lake, British Columbia; alt. 6.700 feet. Aug. 8, 1889. Coll. John Macoun. No. 395, Canadian Mosses." (Holotype: "395. *Racomitrium ~~brevisetum~~ micropus* Kindb. n. sp. N. Amer., Brit. Columbia, Gold Range 7000 f., rocks, 9/8 89 J. Macoun. Leaves papillose; costa percurrent." - S-Kindberg. Isotypes: "395. *R. brevipes*, on rocks, Mts. N. of G. Lake, 9/8/89 Macoun." - CANM; "614. *R. micropus* Kindb." (outside label), "395, 9/8/89" (inside label) - CANM, NY; "*R. brevipes*. On rocks summit of the Gold Range at Griffin Lake, B. C., Alt 7000 feet 9/8/89" ('Rec. Jan 17th 90', manu E.G. Britton). - NY; ? "614. *R. micropus*" - FH, NY).

*Racomitrium *micropus* Kindb. in Macoun et Kindb., Cat. Canad. Pl. 6: 77. 1892 *nom. illeg. incl. spec. prior.* [*R. brevipes*, 1890]. - Homotypic with *R. brevipes*.

Plants olivaceous green, sometimes darker with light apices and frequently grayish due to distinct hair-points, in loose cushions or mats. **Stem** up to 5 cm or more, slightly to irregularly or sometimes subpinnately branched. **Leaves** rigid and somewhat fragile, frequently slightly to distinctly falcate, 2.5-3.0(3.4) x 0.5-0.9 mm. **Hair-point** present, 0.4-1.1 mm (T: 0.4-0.7 mm), sharply and strongly denticulate at the margin and very spinulose at the dorsal side, frequently distinctly squarrose, and moderately decurrent down margin of lamina. **Margin** broadly recurved up to the hyaline point on one side, and narrowly recurved to the point or somewhat shorter on the other side, from apex down to the broadest part of the leaf bistratose in one to two cell rows, or bistratose with scattered unistratose spots. **Costa** dorsally convex and ventrally canaliculate from base to apex, in lower and central part (90)100-120(135) µm broad, in upper part (60)70-90(100) µm broad, reaching well into the hyaline point, in basal part three-stratose (d. 14-18, c. 4-11, v. 6-9), in middle part three-stratose (d. 11-17, c. 1-7, v. 6-9), in upper part bistratose (d. 9-14, c. 0., v. 5-8). **Lamina** unistratose. Basal **laminal cells** elongate (T: 15-30(50) x 14 µm), middle and upper cells shorter to isodiametric (T: 7-20 x 16 µm), upper marginal cells often isodiametric or transversely elongate (T: 7-12 x 12 µm), all cells porose and with strongly nodulose and pseudopapillose walls. **Alar cells** slightly differentiated, but often present as a small yellowish group of short and wide cells, up to 10-12 esinuose or slightly sinuose cells in the marginal row, but usually fewer or none.

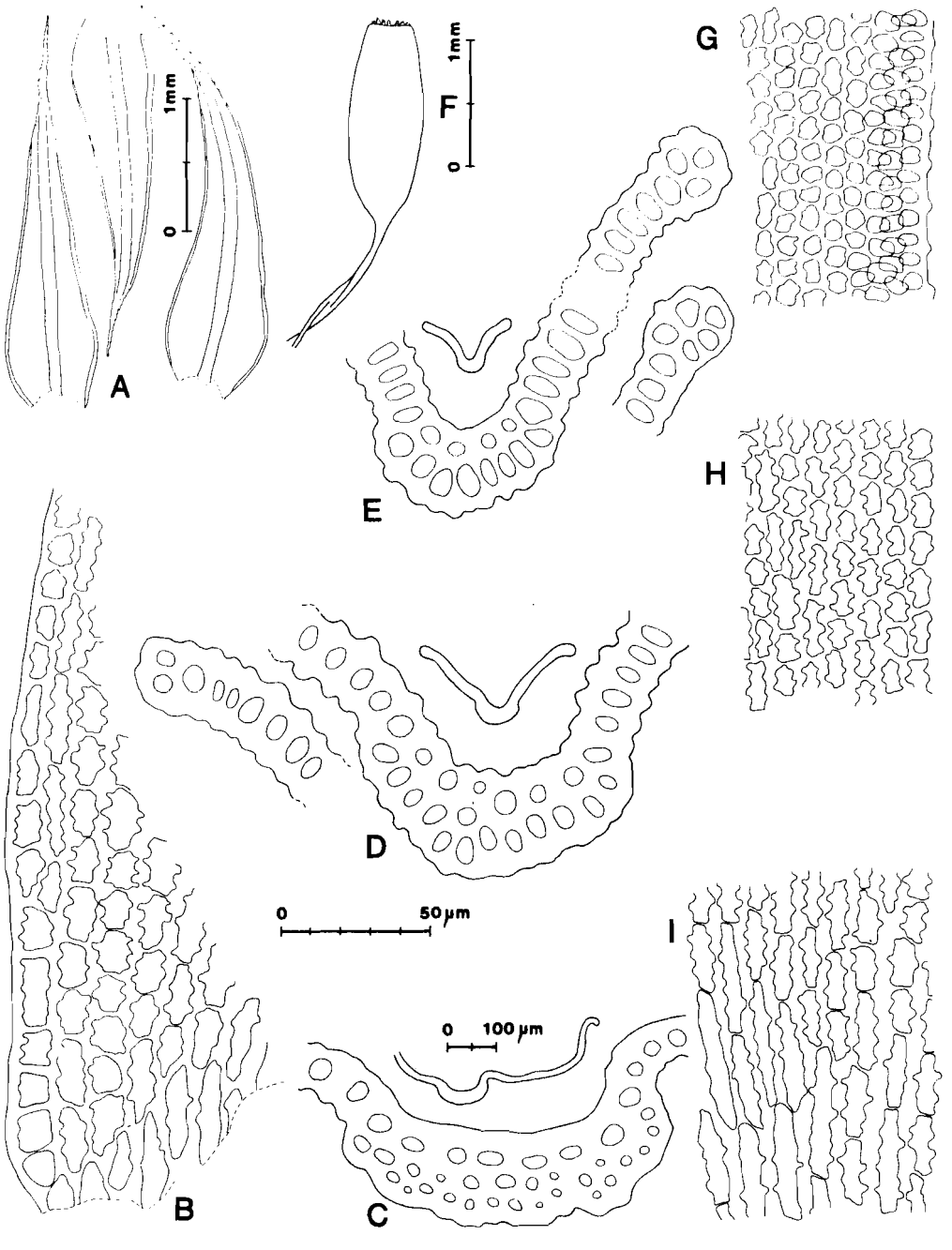

Fig. 7. *Racomitrium brevipes*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (a-e, g-h. Holotype - S. f. U.S.A.: Washington, Kittitas Co., Ireland & Largent 9510 - CANM.)

Perichaetial leaves not squarrose when wet, pilose with upper part chlorophyllous (cells sinuose) and lower part hyaline, ovate-lanceolate and comparatively slightly differentiated. **Seta** about 2.5-5.5 mm. **Urn** oblong-cylindrical (1.3-1.9 x 0.6 mm), wrinkled when dry, exothecial cells relatively wide, quadrate or rectangular, 2-4 rows of comparatively wide cells at the mouth. **Teeth** about 240-460 µm long, of 2(-3) prongs, with median line perforated or sometimes continuous, irregularly papillose, basal membrane present (10-35 µm). **Spores** 14-16.5 µm.

Diagnostic characters

(1) Plants olivaceous and often grayish (due to distinct hair-points). (2) -. (3) Leaf m. long and m. broad (2.5-3.0 x 0.5-0.9 mm), somewhat fragile. (4) Hair-point +, 0.4-1.1 mm, stout, sharply denticulate and spinulose, decurrent. (5) Margin recurved (long, long), bi (1-2, down to the broadest part of the leaf)/uni (sometimes in spots). (6) Costa very broad (100-120/70-90 µm), stratosity/ventral cells (3/6-9, 3/6-9, 2/5-8), canaliculate. (7) Lamina cells including dorsal cells of costa strongly pspp, and with strongly nodulose and porose walls. (8) Alar cells often short and wide and differentiated into a small, yellowish group. (9) Pl not squarrose, pilose. (10) Seta short (2.5-5.5 mm). (11) Urn short (1.3-1.9 mm). (12) Basal membrane + (10-35 µm).

Variation

Racomitrium brevipes is a stenotypic taxon, and I have not seen difficult modifications or other unusual variations. It does not seem to have any very close relatives, and this is indeed remarkable in *Racomitrium* sect. *Laevifolia*!

Comparison with other taxa

1. Lawton (1972: 255) considered *R. brevipes* to be clearly a form of *R. sudeticum*. *Racomitrium sudeticum* (Fig. 15-16) may have a consistently bistratose leaf margin and short upper pseudopapillose lamina cells. But the structure of the costa of the two is very different, and they are surely not very closely related. But because of their slightly differentiated perichaetial leaves, they are placed in the same subgroup within the section.

2. The structure of the costa of *R. brevipes* is not unlike that of *R. himalayanum* (Fig. 54 c-e). In both it is broad, bistratose and canaliculate in the upper part. Moreover, *R. himalayanum* also has distinctly pseudopapillose leaf cells (but the bulging walls are less high in this). *Racomitrium himalayanum* differs from *R. brevipes* in its flexuose, slightly denticulate and non-spinulose hair-point and its narrowly elongate and slightly sinuose upper lamina cells, and in having a completely or predominantly unistratose leaf margin, and epilose and squarrose perichaetial leaves.

3. *Racomitrium verrucosum* (Fig. 42) has a broad costa, a bistratose leaf margin, and pseudopapillose and porose leaf cells like *R. brevipes*. But it has a short smooth hairpoint (if any), and a long, hyaline basal marginal border.

4. *Racomitrium heterostichum* (Fig. 27) has a soft, much less spinulose hairpoint; a unistratose leaf margin with or without bistratose spots; and not or slightly pseudopapillose leaf cells. The canaliculate upper part of the costa is not unlike in the two.

5. *Racomitrium macounii* (Fig. 9, 11) has a very short hairpoint (if any); a flat margin on one side; a more or less four-stratose costa; and not or slightly pseudopapillose leaf cells.

6. *Racomitrium occidentale* (Fig. 13) has, e.g., a narrower hair-point (see Description), and a thicker costa. It is very different from *R. brevipes*.

7. For differences with regard to *R. joseph-hookeri*, see that species.

Habitat

Racomitrium brevipes grows on rocks, in the mountains to 2000 m or higher (Lawton 1971).

Distribution

Racomitrium brevipes is known from the mountains of western N. America (Washington, British Columbia, SE Alaska) (Fig. 8).

Specimens examined

U.S.A.: Oregon. Cascade Mts., Mt. Hood, 1871 Hall (FH, S), VIII.1880 Howell (NY); Rooster Rock, IV.1880 Howell (NY). - Washington. Chelan Co., summit of Stevens pass, ab. 8 mi E of Scenic, trail on E side of Pass, Ireland 6208 (CANM); Stevens Pass, Cascade Mts., VI.1928 Grant (H); Clallam Co., Olympic National Park, Boulder Lake trail, Ireland 6573 (CANM); Olympic Mts., 15.X.1890 Frye (WTU), Piper 68 (FH; NY, 3 sp.); Kittitas Co., ab. 15 mi NW of Ronald, along road to Fish Lake near Salmon la Sac, Ireland & Largent 9510 (CANM, H, NY); near the summit of Mt. Margaret, Bailey 573 (NY, 2 sp.); Mason Co., Hoodsport, upper Lake Lena, Conrad 52083110 (WTU); s. loc., Piper 59 p.p. (NY); Whatcom Co., Winchester Mt., ab. 14 mi NE of Glacier, Douglas 770 (WTU); Lewis Co., Mts. Rainier, Stevens Canyon Road, Box Canyon area, Lawton 4863 (WTU). - Alaska: Wrangel, 25.VIII.1900 Cripe (O; mixed with *R. occidentale* and *Dryptodon patens* - NY). CANADA: British Columbia. Cypress Bowl area, gully near base of Mt. Strachan, 49°20'N, 123°10'W, Schofield & Tan 74451 (ALTA, CANM).

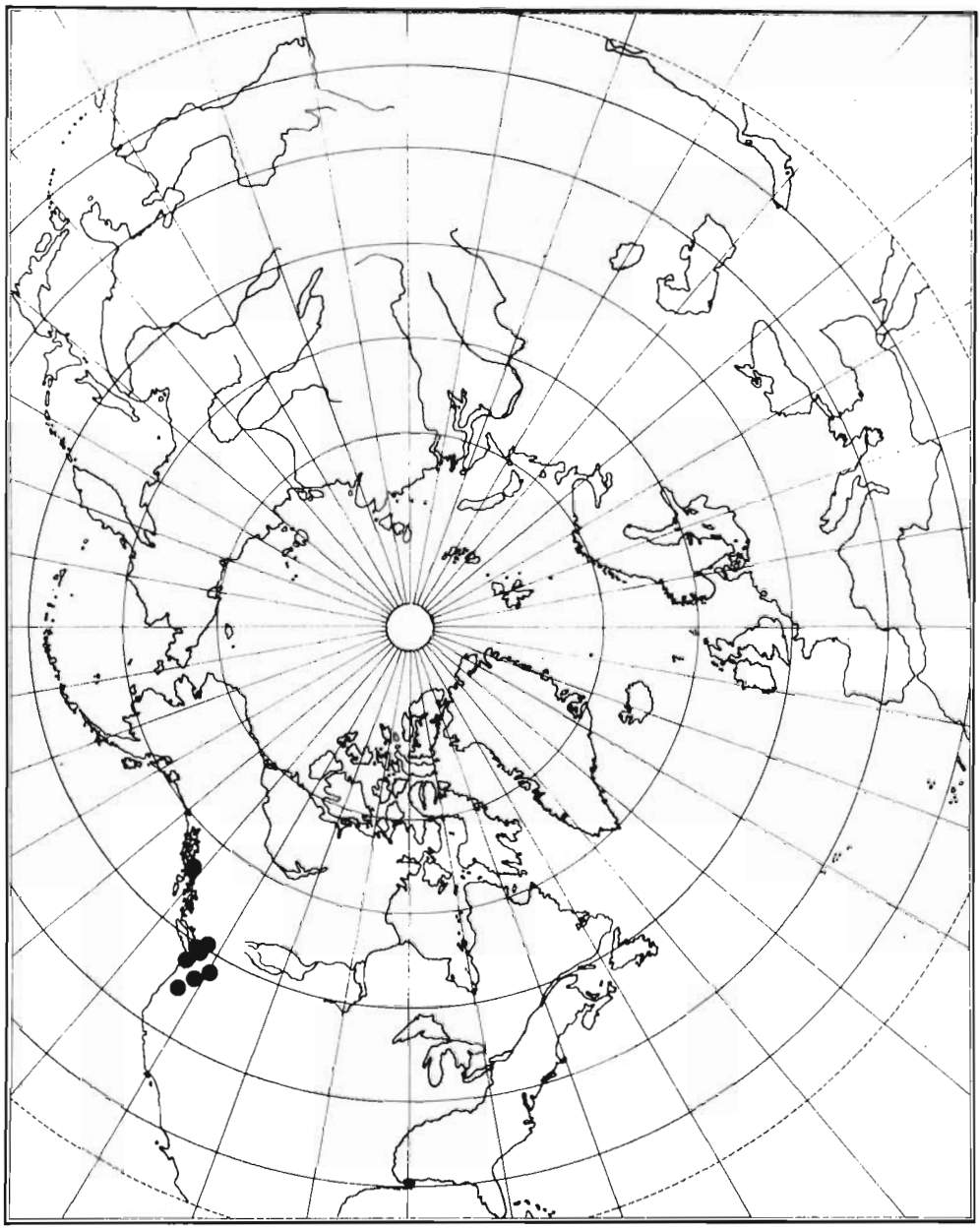

Fig. 8. Distribution of *Racomitrium brevipes*.

(2a) *Racomitrium macounii* Kindb. ex Kindb. in Macoun subsp. *macounii*
Fig. 9-10.

Racomitrium sudeticum var. ß *validior* Jur., Laubm. Fl. Oest. Ungarn 179. 1882.- *Grimmia microcarpa* var. *validior* (Jur.) Möll., Bot. Not. 1907: 143. 1907. - *R. heterostichum* var. *sudeticum* f. *validior* (Jur.) Bauer, Musci Eur. Am. Exs. ser. 41: n. 2022. 1929. - *R. heterostichum* subsp. *sudeticum* f. *validior* (Jur.) Loeske, Biblioth. Bot. 101: 214. 1930 *nom. illeg.* - Type: "Steierm.: Sölkfeld b. Donnersbachwald 1900 m., Schimpelkar u. Knallstein in der Sölk 1900-2000 m., Neualm u. Eiskar b. Schladming 1600-2200 m. (B.). - Tirol: Rothmoosthal b. Obergurgl im Oetzthal 2300 m. (B.)." (Lectotype nov.: "*Racomitrium sudeticum* var. *validior* Jur. Ostabhang des Knallstein in der Sölk. Steierm. 1900-2000 m. 4/8 1877. J. B." - GJO-Breidler 25.178/11.965. Paralectotypes: GJO-Breidler 25.178/11.963, .968, .970, .981).

Racomitrium **obscurum* Kindb., Bull. Torr. Bot. Cl. 15: 185. 1888 *nom. nud.*, et Enum. Bryin. Exot. 74. 1888 *nom. nud.* - Orig.: "Vancouver Island." (Orig. spec.: Same as the type of *R. robustifolium*, q.v.).

Racomitrium macounii Kindb. ex Kindb. in Macoun, Bull. Torr. Bot. Cl. 16: 93. 1889 (*R.* **macounii* Kindb., Bull. Torr. Bot. Cl. 15: 185. 1888 *nom. nud.* ('*Macounii*'). - Orig.: "Rocky Mountains."). - *R. heterostichum* var. *macounii* (Kindb. ex Kindb. in Macoun) Jones in Grout, Moss Fl. N. Am. 2: 57. 1933. - *R. sudeticum* f. *macounii* (Kindb. ex Kindb. in Macoun) Lawt., Moss Fl. Pacific Northw. 147. 1971. - Type: "In large masses, on huge boulders between Cathedral Mountains and Mount Stephens near Field, Rocky Mountains; also on rocks near the Glacier Hotel, Selkirk Mountains, B. C. Collected August, 1885, by John Macoun." (Lectotype nov.: "*Canadian Musci. No.* 28. Name *Racomitrium Macounii*, Kindb. *Hab. & Loc.* Dry rocks. Selkirk Range B. C. *Coll. Macoun. Date* Aug. 24th 1885." - CANM (numbered 1584). Paralectotypes: 29.VII.1885. - TRH; 1885, Comm. Kindberg. - FH-Renauld).

Racomitrium robustifolium Kindb. in Macoun, Bull. Torr. Bot. Cl. 17: 272. 1890. - *Grimmia robustifolia* (Kindb. in Macoun) Kindb., Eur. N. Am. Bryin. 2: 225. 1897. - Type: "Mount Arrowsmith, Vancouver Island, alt. 5.700 feet, July 17, 1887." (Lectotype nov.: "*Racomitrium* ~~*obscurum*~~ *robustifolium* Kindb. n. sp. N. Amer., Vancouver Island, mount Arrowsmith, 5000 feet, 17/7 87 J. Macoun." - S-Kindberg. Paralectotypes: CANM, FH, TRH).

Racomitrium sudeticum var. *robustum* Lindb. ex Vent., Muscin. Trent. 44. 1899. - Type: "Sulle pietre dei rigagnoli, che passano per Campisol di Rabbi; ..." (Lectotype nov.: "*Grimmia microcarpa* var. *robusta* Lindb. Tyrolia, Alp. elat. in Pejo, s. d. Sforzelline-alpen. Aug. 77 Venturi." - H-SOL. Isolectotype: S. Paralectotype: "*Racomitr. sudeticum* var. *robusta*. Pejo, Hochalpe der Venez. 2700 met. Aug. 77." - H-SOL.)

Plants darker or lighter dull brown or olivaceous at the apices and brown, reddish brown or blackish below, rarely more greenish. **Stem** fairly robust, up

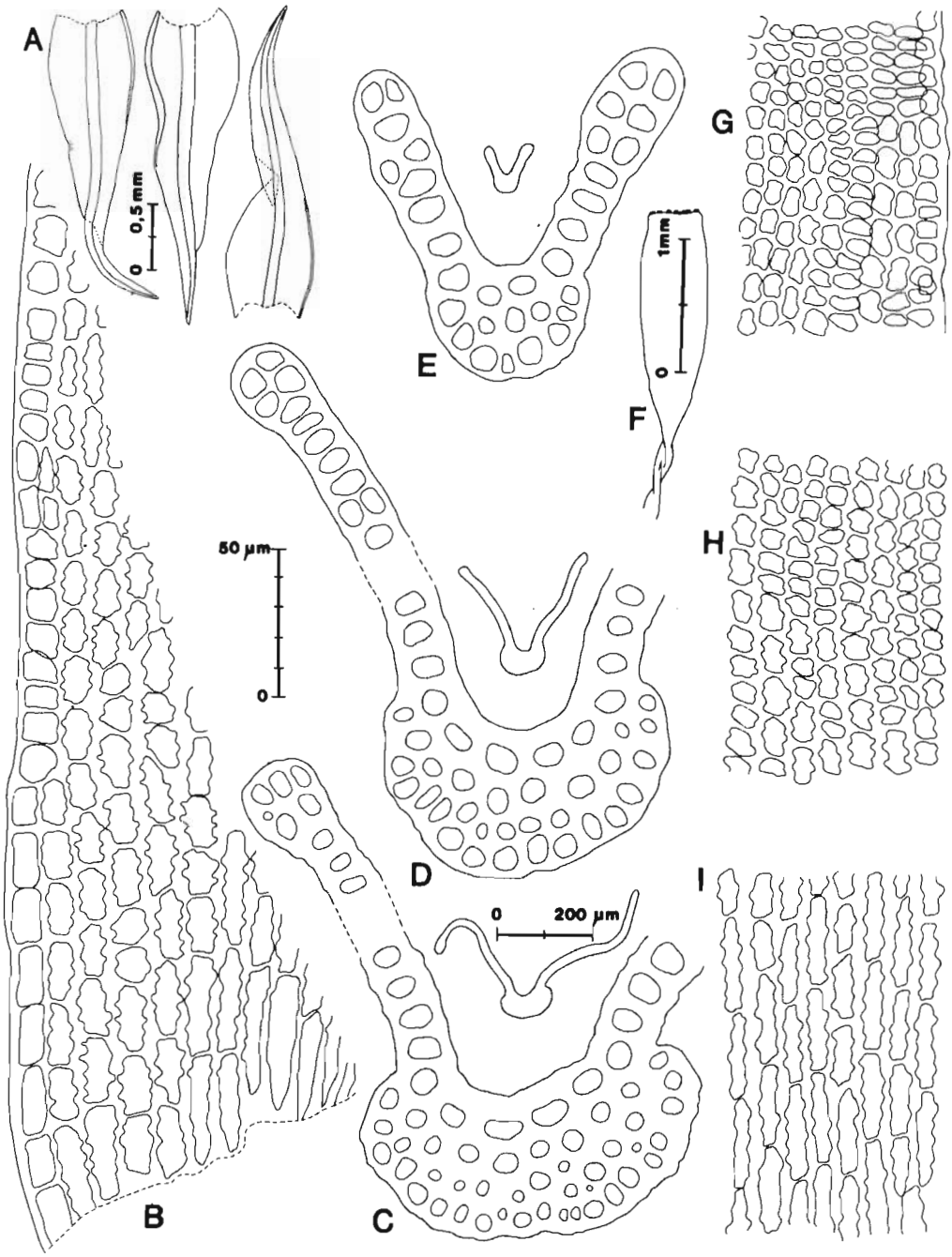

Fig. 9. *Racomitrium macounii* subsp. *macounii*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. - Lectotype (CANM).

to 5 cm or more, not or slightly branched. **Leaves** contorted, (2.0)2.25-2.8(3.0) x 0.5-0.75 mm, base sometimes sheathing. **Hair-point** absent or short, 0-0.1 mm or rarely longer, strongly spinulose, erect or in the longer points somewhat squarrose. **Margin** broadly or narrowly recurved to 1/2-2/3 the leaf length on one side, and usually flat or faintly recurved in the broadest part of the leaf on the other side, strongly thickened, in upper part bistratose in (1)2-3(6) cell rows, sometimes with three- to four-stratose spots, in lower part bistratose in 1-3(4) cell rows, unistratose close to the base. **Costa** strongly convex at the dorsal side, in lower part 80-100(150) µm broad, in upper part 45-70 µm broad, reaching to the hyaline point or apex, in basal part (three- to) four- (to five-) stratose (d. 15-20, c. 12-19, v. 4-6), in middle part (three- to) four-stratose (d. 12-18, c. 5-16, v. 4-5(6)), in upper part (bi- to) three- (to four-)stratose (d. 6-13, c. 0-5(9), v. 2-4). **Lamina** unistratose or with bistratose spots. Basal **laminal cells** rectangular (T: 25-55 x 9 µm), middle and upper cells transversely elongate to short-rectangular (T: 5-12 x 9 µm), upper marginal cells transversely rectangular to quadrate (T: 4-9 x 10 µm), cells moderately or rarely more strongly pseudopapillose. **Alar cells** not differently (or slightly more yellowish) coloured, usually numerous (15-40) short, pellucid, not or moderately sinuose basal cells in the marginal row.

Perichaetial leaves not squarrose when wet, ovate-lanceolate and slightly differentiated, with very short or no hair-point, in the ovate base with thin-walled cells, and in the apex with chlorophyllous sinuose cells. **Seta** about 4.5-7 mm. **Urn** oblong-cylindrical (1.7-1.9 x 0.55-0.8 mm), exothecial cells relatively short and wide, 3-4 rows of rounded incrassate cells at the mouth. **Teeth** (ca. 330 µm long,) of 1-2 prongs which are perforated or more or less split (sometimes down to the base), papillose, basal membrane present (35-50 µm). Spores 12-14 µm.

Diagnostic characters

(1) Plants rather large, frequently reddish or olivaceous brown. (2) Stem slightly or not branched, sometimes robust. (3) Leaf short/m. long and m. broad (2.25-2.8 x 0.5-0.75 mm), contorted when dry, dull. (4) Hair-point +/-, less than 0.1 mm, stout, yellowish-hyaline, often squarrose, spinulose. (5) Margin recurved (m. long/short, flat), bi (2-4)/three (1-2, spots in upper part). (6) Costa m. broad (80-100/45-70 µm), stratosity/ventral cells ((3)4(5)/4-6, (3-)4/4-5, (2)3(4)/2-4). (7) Lamina sometimes with bistratose spots. (8) Alar cells slightly differentiated, but usually many (15-40) pellucid short, esinuose or sinuose, basal cells in the marginal row. (9) Pl not squarrose, not much differentiated, not hyaline. (10) Seta long (4.5-7 mm). (11) Urn short (1.7-1.9 mm). (12) Basal membrane + (35-50 µm).

Variation

Most species in the section are variable with regard to the stratosity of the leaf margin and also to a certain degree in the robustness of the costa. In *R. macounii* the stratosity of the margin and costa is of superior taxonomic importance, and it is therefore necessary to know how it varies in both: Sometimes, the *margin* includes three- to four-stratose spots and is more than unistratose for 2-6 cell rows; and sometimes it is only bistratose for 2-4 cell rows. Such plants are unambiguous *R. macounii*. But the margin may also be bistratose for 1-3 rows and the specimen still show all characteristics of typical *R. macounii*. More rarely the margin is predominantly bistratose for 1-2 cell rows and in spots for three cell rows; but then the specimen should match *R. macounii* completely in all its other characteristics. It is assumed that the *costa* in the above examples is predominantly four-stratose in the lower and middle part of the leaf, or eventually that it includes three- or five-stratose spots. But the costa (in weak specimens) may also be predominantly three-stratose with frequent four-stratose spots (the fourth stratum is sometimes present as 1-2 cells in t.s.). Rarely, the costa is three-stratose with some four-stratose spots; and, as stated above, it is important that such unusual specimens match *R. macounii* completely in other characteristics (of which the structure of the leaf margin and hair-point are the most important). In the microscope, the reddish brown colour of *R. macounii* is evident in leaves and leaf cross sections, and can be considered as a characteristic which rarely is wanting. But in unusual habitats *R. macounii* may be greenish and blackish etc., like the other species in the section. The above comments on the structure of the margin and costa, and on the colour of the plants, are true of both subspecies of *R. macounii*. - The stems of subsp. *macounii* are usually robust, but gracile stems occur. The hair-point is usually almost absent (0-100 µm) and erect and not quite hyaline, but rarely it is slightly longer (200 µm) and hyaline, and then it is frequently squarrose; it is always strongly spinulose. The laminal cells are usually very short above the broadest part of the leaf.

Comparison with other taxa

1. The differences between subsp. *macounii* and subsp. *alpinum* (Fig. 11) are usually striking and well-defined. Both subspecies have a wide distribution in Europe and western N. America, and they maintain their characteristics throughout this large distribution area. Mixed stands are known from N. America (Washington). They therefore seem to satisfy the requirements of independent species. However, the differences between them are quantitative and macroscopical rather than qualitative and microscopical, and a few specimens seem to combine characteristics from both. The subspecies can be separated by the following characteristics: **Plants**, colour (*mac-m*: frequently dull and olivaceous above; *mac-a*: frequently glistening and more reddish brown above), robustness (subsp. *macounii* is a slightly more robust plant than subsp. *alpinum*), **leaves** (*mac-m*: contorted, relatively broad towards the apex; *mac-a*: imbricate and not or faintly contorted, relatively narrow towards the apex), **hair-point**

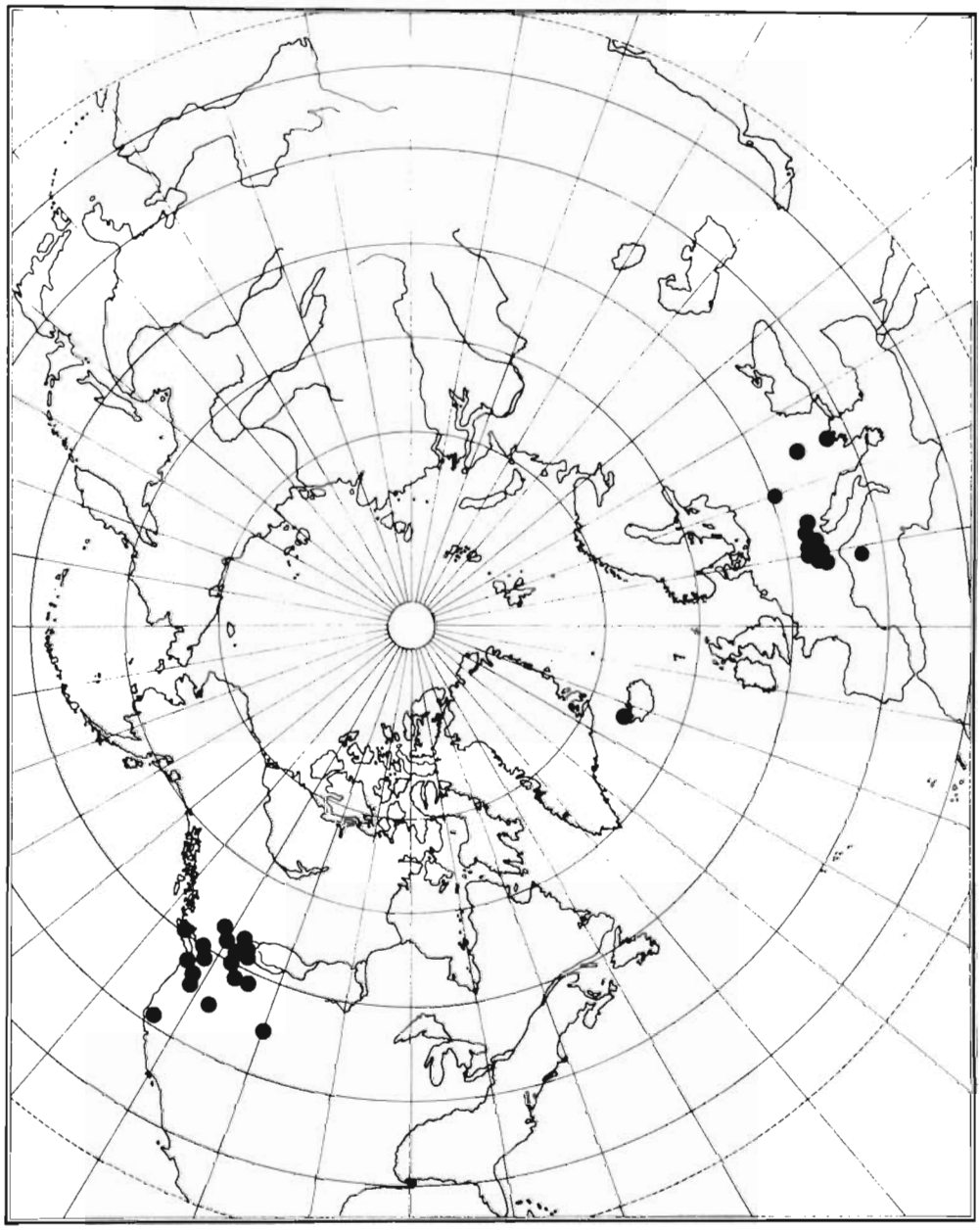

Fig. 10. Distribution of *Racomitrium macounii* subsp. *macounii*.

(*mac-m*: absent or short, 0-100 µm, rarely longer, usually erect or subsquarrose, but squarrose in some long points, strongly spinulose; *mac-a*: usually present and often longer than 100 µm, squarrose, denticulate but less spinulose), cells (*mac-m*: usually very short in the upper part of the leaf, predominantly transversely elongate and quadrate; *mac-a*: frequently longer in the upper part, predominantly quadrate to short-rectangular).

2. *Racomitrium sudeticum* (Fig. 15-17) is different from *R. macounii* subsp. *macounii* in being less robust and lighter olivaceous green above (when not entirely black or discoloured), and in having not or slightly contorted leaves with distinct hyaline hair-point (when not epilose); a predominantly three-stratose costa (sometimes largely bistratose or with four-stratose spots); and a uni- to bistratose margin (for 1 or 2 cell rows) which usually is distinctly recurved on both sides (sometimes plane on one side). The differences in the costa, leaf margin and leaf apex including hair-point are the most significant, and they usually place a specimen at once. For differences between *R. macounii* and *R. sudeticum* f. *kindbergii*, see that taxon.

3. For differences between *R. macounii*, and *R. brevipes*, *R. microcarpon* and *R. occidentale*, see these species.

Habitat

Racomitrium macounii subsp. *macounii* is collected from a large variety of rock habitats including "moist stones in rivulet", and from "wet tundra". More exact habitat information must be obtained from field studies. It is a mountain plant, which is known from 2225 m a.s.l. in Montana.

Distribution

Racomitrium macounii subsp. *macounii* is known from Europe and western N. America (Fig. 10). In Europe it grows in many localities in the Alps (Austria, Italy, Switzerland) and in isolated sites in Czechoslovakia (Hohe Tatra), Romania (Carpatii Meridionali), Bulgaria (Mt. Musala), France (Corsica, Mte Cinto),and Iceland. In western N. America it is known from U.S.A. (northern California, Washington, Oregon, northern Idaho, northern Montana, NW Wyoming) and Canada (British Columbia: some coastal sites and from Rocky Mountains).

(2b) *Racomitrium macounii* subsp. *alpinum* (Lawt.) Frisvoll *comb. et stat. nov.*
Fig. 6D, 11-12, 68A.

Racomitrium sudeticum f. *alpinum* Lawt., Moss Fl. Pacific Northw. 147. *77 f. 5-8.* 1971. - Type: "Washington, Whatcom County, near Mt. Baker Lodge, on rock, at 1400 m, Lawton 3676." (Holotype: As above, "on rock above snow bank, July 19, 1960." - WTU. Isotypes: H, NY, O; WTU - 2 sp.).

Racomitrium sudeticum f. *americanum* Lawt., Moss Fl. Pacific Northw. 147. *78 f. 1-7.* 1971. - Type: "Washington, Pierce County, Mt. Rainier, on rock, at 1900 m, Lawton 4813." (Holotype: As above, "Paradise Park, Alta Vista Trail, about 1/2 mile from ranger station, alt. about 5800 ft., July 5, 1963." - WTU. Isotype: WTU).

Racomitrium affine f. **luxurians* Hag., Musci Norvegiæ Bor. 68. 1899 *nom. nud.* - Orig: "No. Lødingen: F." (Orig. spec.: "*Racomitrium protensum* A. Br. ~~*affine*~~ (Schleich.) *sudeticum*. Norvegia borealis: Prov. Nordlandia, Lødingen in insula Hindoe. Lat. 68° 25' Legit 18/7 1887 R. E. Fridtz" - O).

Plants as in subsp. *macounii*, but less dull and often glistening. **Stem** usually less robust, but often elongate. **Leaves** erect and not (or slightly) contorted, (1.5)2.4-3.0(3.2) x (0.3)0.5-0.65 mm. **Hair-point** short, usually present but often reddish, up to about 0.2 mm, squarrose when dry, denticulate (sometimes down margin of lamina) and moderately spinulose. **Margin** broadly or narrowly recurved to 1/2-2/3 the leaf length on one side, and flat on the other side, variously bistratose as in subsp. *macounii*. **Costa** in lower part 60-85 µm broad, in upper part 40-65 µm broad, in basal part (three- to) four- (to five-)stratose (d. 11-21, c. 5-19, v. 3-5), in middle part three- to four-stratose (d. 10-23, c. 3-15, v. 3-4), in upper part three- to four-stratose (d. 7-12, c. 2-7, v. 3-4). Basal **laminal cells** rectangular (T: 28-50 x 9 µm), middle and upper cells quadrate to short-rectangular (T: 7-23 x 9 µm), upper marginal cells transversely elongate to quadrate (T: 5-14 x 12 µm), not or moderately pseudopapillose. **Alar cells** not differently coloured, a basal marginal border absent or present, of up to about 20 short (sometimes moderately sinuose), pellucid cells.

Seta short (4.0-5.5 mm). **Urn** short (1.0-1.75 x 0.5-0.7 mm). **Teeth** 380-450 µm, of 2(-3) prongs with median line partially perforated. Other characteristics of perichaetial leaves and sporophyte as in subsp. *macounii*.

Diagnostic characters

(2) Stem usually less robust (than subsp. *macounii*). (3) Leaf m. long and narrow (2.4-3.0 x 0.5-0.65 mm), not contorted, glistening. (4) Hair-point ± 0.1 mm, moderately spinulose. (6) Costa narrow below and narrow to m. broad above (60-85/40-65 µm). (10) Seta short (4.0-5.5 mm). (11) Urn short (1.0-1.75 mm).

Variation

Regarding variation in the stratosity of the leaf margin and costa, see subsp. *macounii*. Some plants with less imbricate and sometimes slightly contorted leaves must be referred to subsp. *alpinum*; they seem to approach subsp. *macounii* in these characteristics, but have a narrow leaf apex and a typical hair-point. Generally, subsp. *alpinum* is an easily recognized taxon.

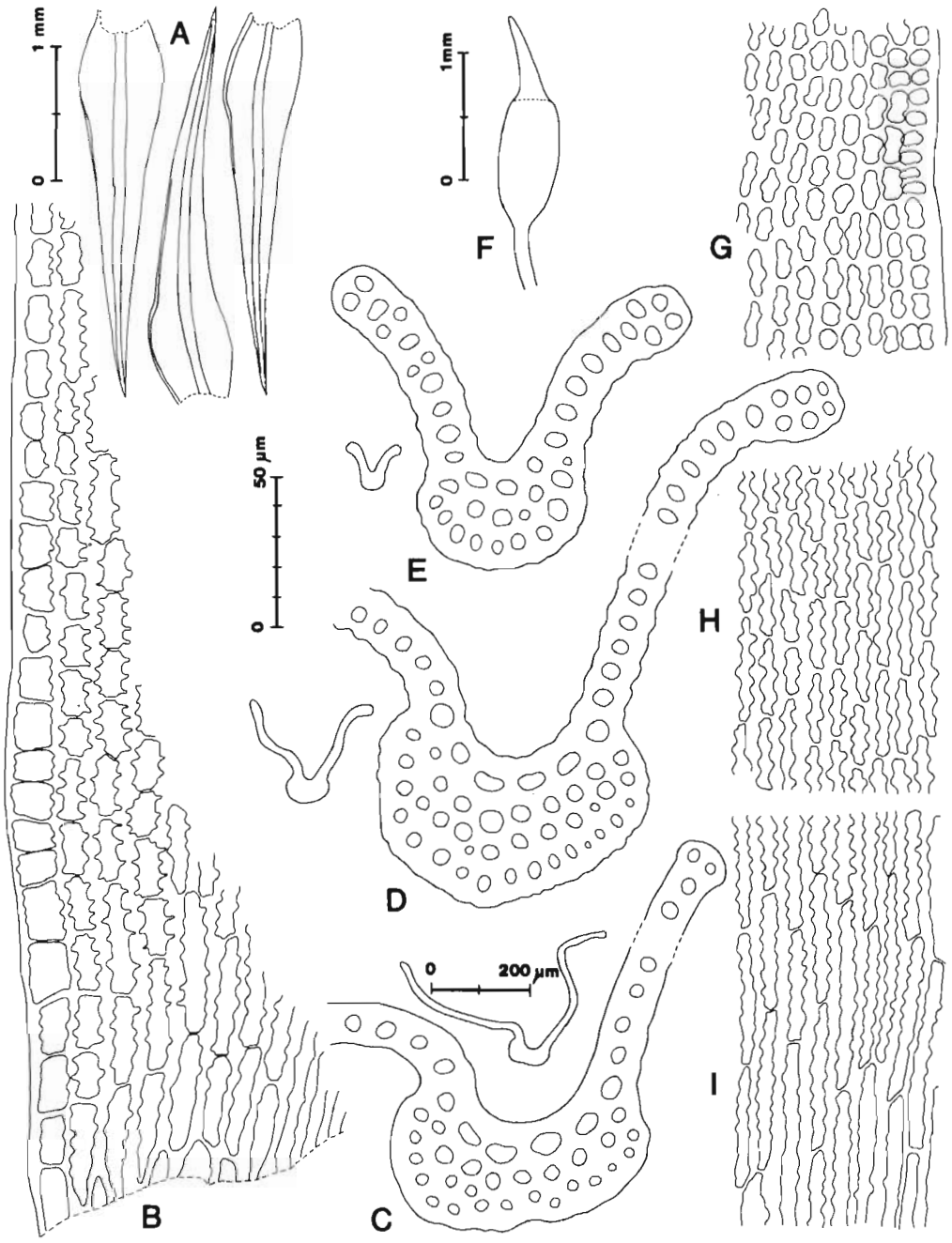

Fig. 11. *Racomitrium macounii* subsp. *alpinum*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (Norway: Sør-Trøndelag, Rennebu, by the stream Ila, 13.VI.1982 Frisvoll - TRH.)

F. *americanum* is included in subsp. *alpinum*, but may represent a separate taxon. It consist of depauperate plants (1.5 cm) and has small leaves (1.5-2.4 x 0.3-0.4 mm) with short erect hair-point. It has a strongly thickened leaf margin (bistratose for 4-8 cell rows including frequent three- and four-stratose spots); frequent bistratose areas and spots in the leaf lamina; and a comparatively very robust and strongly dorsally convex costa (four-stratose throughout). Subsp. *macounii*, subsp. *alpinum* and f. *americanum* are all known from Mt. Rainier in Washington, the type locality of f. *americanum*, and are promising subjects for mixed stand hunting. See also chapter 8.0.

The Japanese specimens referred to subsp. *alpinum* are brown (not olivaceous), and have small leaves (1.7-2.05(2.25) x 0.4-0.55 mm) with short hair-point (up to 120 µm); one plane leaf margin; bistratose margin for 2-3(4) cell rows (including rare unistratose spots and more regularly occuring bistratose spots for one cell row; it is important that the margin in spots is bistratose for more than one cell row far down the leaf); and three- to four-stratose costa. See also *R. sudeticum*, Variation.

Comparison with other taxa

1. Within *R. macounii* s.l., subsp. *alpinum* is most similar to *R. sudeticum* s.l. (Fig. 15-17). Usually, they can be recognized by differences in colour (brown in subsp. *alpinum*, different nuances of dark green or olivaceous in *R. sudeticum*); robustness (with subsp. *alpinum* the coarser of the two); and branching (subsp. *alpinum* not or very slightly dichotomously branched, *R. sudeticum* often - but not always - more branched). The hair-point of subsp. *alpinum* is short, sub-hyaline and very abruptly and typically squarrose when dry; in *R. sudeticum* it is longer (if not brevipilose) and hyaline and erect-squarrose to squarrose. The leaf margin is plane on one side in subsp. *alpinum*, whereas in *R. sudeticum* it is recurved in both (except in some gracile ecads which on other grounds are unlikely to be confused with *R. macounii*). The leaf margin is principally uni- to bistratose for one (rarely for two) cell rows in *R. sudeticum*, and bistratose for two to four cell rows in subsp. *alpinum* (sometimes even more strongly thickened). Sporadic three-stratose marginal spots or bistratose spots for three cell rows, occur in some plants of *R. sudeticum* f. *sudeticum* (and are common in f. *kindbergii*, Fig. 16). If the costa is three-stratose the specimen belongs to *R. sudeticum*. Some robust plants, with three-stratose costa including four-stratose spots, and uni- to bistratose margin for one cell row, clearly belong to *R. sudeticum*. Regarding the variation in the stratosity of the margin and costa, see subsp. *macounii*, Variation. It is usually easy to differentiate between subsp. *alpinum* and *R. sudeticum*, but in Japan there is perhaps a less clear-cut situation (see *R. sudeticum* and *R. macounii* subsp. *alpinum*, Variation).

2. *Racomitrium affine* (Fig. 23) is olivaceous or blackish (not reddish brown) and has a broader leaf and (especially) leaf apex, with broadly recurved margins up to the hair-point (or apex when subepilose), and it has never such a strongly thickened leaf margin as *R. macounii*. The two are very different.

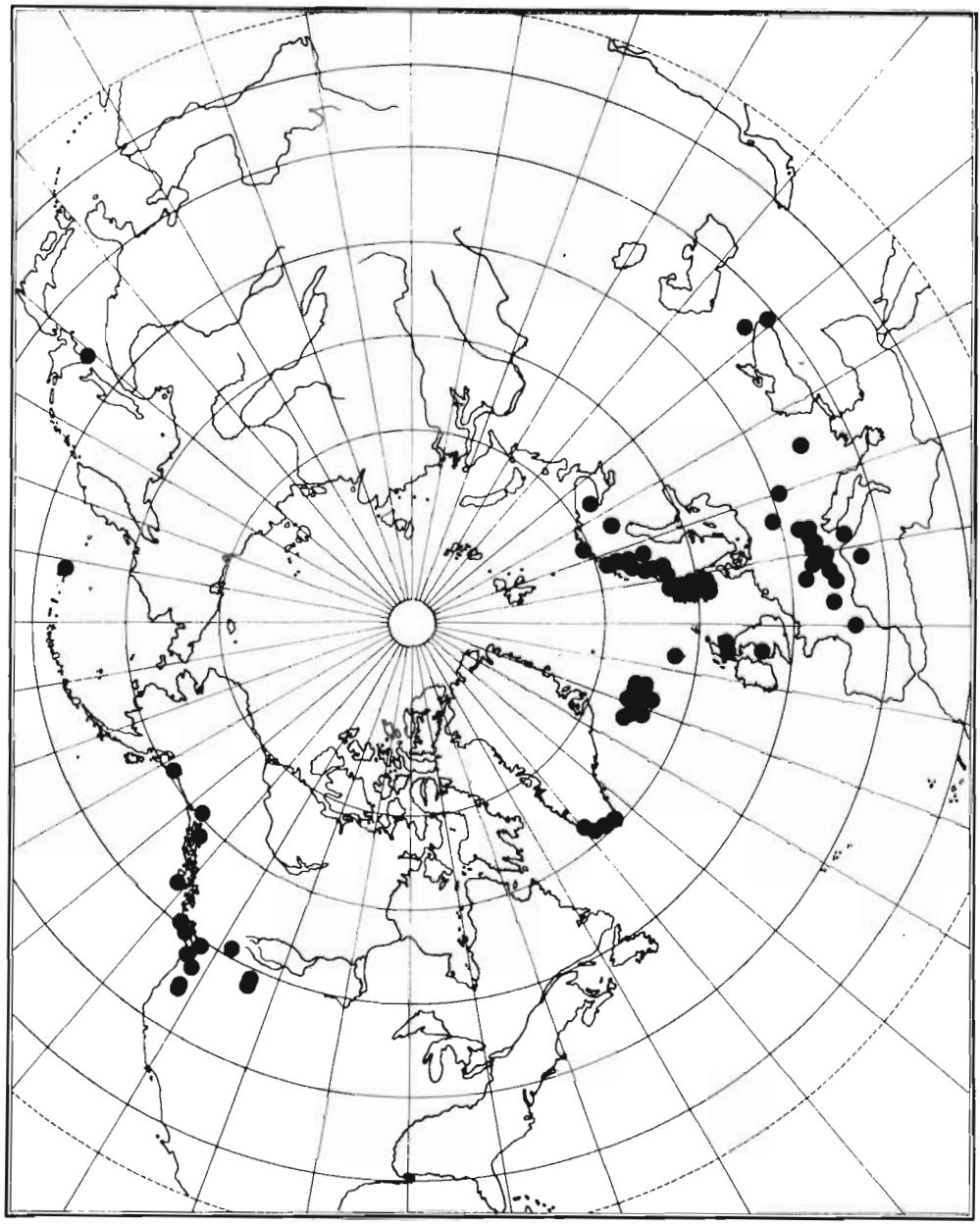

Fig. 12. Distribution of *Racomitrium macounii* subsp. *alpinum*.

3. For differences between *R. macounii*, and *R. brevipes*, *R. microcarpon*, *R. occidentale*, and *R. sudeticum* f. *kindbergii*, see these taxa. For differences between *R. macounii* subsp. *macounii* and subsp. *alpinum*, see the former.

Habitat

Racomitrium macounii subsp. *alpinum* grows on flat or steep moist rocks. It is frequent along mountain rivers and brooks, and on sloping rocks with trickling water. Where it grows with *R. sudeticum*, the latter inhabits the dry tops and surfaces without trickling water, whereas subsp. *alpinum* thrives on the wet surfaces. When they meet they form intermingled mixed stands. Subsp. *alpinum* is especially common in low- and subalpine areas with a high precipitation. In the alpine region it may grow on soil in snow-beds. Unlike many other species in the section, it seems to tolerate or prefer less acid or slightly calciferous rocks.

Distribution

Racomitrium macounii subsp. *alpinum* has a wide distribution in Europe and N. America, and is also recorded from Asia (NE Turkey and Japan) (Fig. 12). In Europe it grows in the Caucasus; the high mountains of central and (in part) south Europe (the Carpathians, Tatry, Sudety, the Alps, Vosges, Massif Central, the Pyrenees, northern Appennini, and Corsica); Wales and Scotland; the Scandinavien mountains including Finland and nortwesternmost USSR; the Faroe Islands; and Iceland. In America it is known from S. Greenland in the east; and in the west it grows in a few localities in the Rocky Mountains and in more localities from Oregon to SE Alaska (Prince William Sound), with an isolated locality on Attu Island, SW Alaska. The most typical Japanese occurrence is on Rishiri Island.

(3) *Racomitrium occidentale* (Ren. et Card.) Ren. et Card.
Fig. 13-14.

Racomitrium heterostichum var. *occidentale* Ren. et Card., Bot. Gaz. 15: 41. 1890. - *R. occidentale* (Ren. et Card.) Ren. et Card., Rev. Bryol. 19: 87. 1892. - *R. sudeticum* [var.] *occidentale* (Ren. et Card.) Frye, Bryol. 21: 3. 1918. - *R. heterostichum* var. *sudeticum* f. *occidentale* (Ren. et Card.) Jones in Grout, Moss Fl. N. Am. 2(1): 57. 1933. - Type: "Oregon; Lost Lake, on rocks (L.F. Henderson)." (Lectotype nov.: "76. Herb. J. Cardot. Mousses de l'Amerique du Nord. *Rhacomitrium heterostichum* Brid. var. *occidentale* Ren. et Card. Oregon: Lost Lake, rocks in wood. Leg. Henderson." - FH. Isolectotypes: BM - 2 sp., NY, S).

Plants (dark) olivaceous green in upper part and lighter or darker brown below. **Stem** rather robust, up to 6 cm or more but frequently 2-4 cm, not or slightly

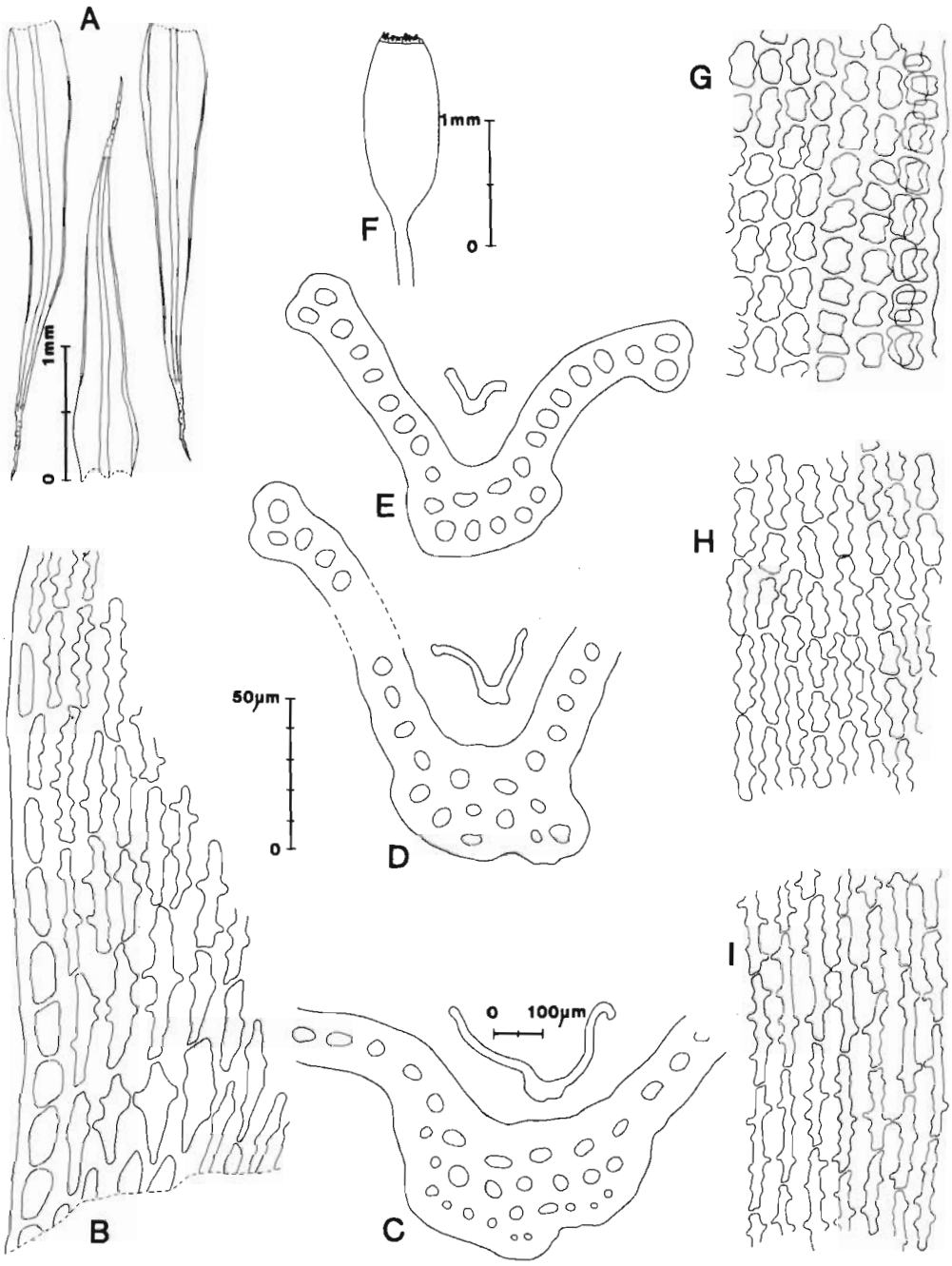

Fig. 13. *Racomitrium occidentale*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (a-e, g-i. Isolectotype - NY. f. U.S.A.: Washington, Jefferson Co., Mt. Olympus, Lawton 5309956 - WTU.)

ramified with elongate branches and few or no branchlets. **Leaves** slightly secund or not, (2.25)2.8-3.5(3.75) x 0.5-0.75(0.8) mm. **Hair-point** (usually) present, 0.3-0.8 mm, terete, not or faintly flexuose or recurved when dry, sharply spinulose-denticulate, not decurrent down margin of lamina. **Margin** on one side broadly recurved below and more narrowly above to 2/3-3/4 the leaf length, on the other side narrowly recurved to 1/2-3/4 the leaf length, in upper part usually bistratose in one or two cell rows, sometimes bistratose in two to four rows and rarely including three- or four-stratose spots, in lower part variously uni- and bistratose, uneven. **Costa** strongly convex dorsally, above with a more or less continuous central dorsal furrow and sometimes even in spots with indistinct lateral furrows, in lower part (60)70-90(110) µm broad, in upper part (40)45-65 µm broad, reaching to the hyaline point, in basal part three- to five-stratose (d. 10-17(22), c. (1)4-9(17), v. (2)3-4(5)), in middle part three- to four-stratose (d. 7-14(16), c. 1-9, v. 2-4), in upper part bi- to three-stratose (d. 4-12, c. 0-5, v. 2-3). **Lamina** unistratose or with bistratose spots in upper part. Basal **laminal cells** elongate (T: 23-60 x 9 µm), middle and upper cells quadrate to rectangular (T: 9-25 x 9 µm), upper marginal cells transversely elongate to short-rectangular (T: 7-19 x 12 µm). **Alar cells** yellowish, slightly differentiated, a basal marginal border present, of 5-15(20) differently shaped, but often mixed elongate and short, hyaline and esinuose cells.

Perichaetial leaves not squarrose when wet, pilose, slightly differentiated, the innermost (1-2) with ovate, (sub)hyaline base. **Seta** about 4-5 mm. **Urn** oblong-cylindrical or (narrowly) ovoid (1.1-2.0 x 0.5-0.6 mm), exothecial cells irregulary rectangular, thin-walled, 2-3 rows of small incrassate cells around the mouth. **Teeth** (ca. 410 µm long,) papillose, of 1-2 often badly separated prongs, basal membrane present (20-35 µm). Spores 12-16.5 µm.

Diagnostic characters

(1) Plants (dark) olivaceous green. (2) Stem rather robust, slightly branched. (3) Leaf m. long and m. broad (2.8-3.5 x 0.5-0.75 mm). (4) Hair-point +, 0.3-0.8 mm, terete (not flexuose), acutely spinulose and denticulate. (5) Margin recurved (m. long, short/m. long), bi (1-3)/three (1, in rare spots), uneven. (6) Costa m. broad (70-90/45-65 µm), stratosity/ventral cells (3-5/3-4, 3-4/2-4, 2-3/2-3), strongly convex and with low dorsal wings and furrows. (7) Lamina sometimes with bistratose spots in upper part. (8) A short bmb present. (9) Pl not squarrose, pilose and not much differentiated. (10) Seta short (4-5 mm). (11) Urn short (1.1-2.0 mm). (12) Basal membrane + (20-35 µm).

Variation

The stems are usually elongate, but dwarf plants have also been seen. They may lack hair-point on some leaves, but have usually a short point on the upper ones. The dorsal side of the costa possesses a central furrow and lateral wings

much as in *Dryptodon patens* (Hedw.) Brid, but the wings are much lower and parts of the costa may lack them.

Comparison with other taxa

The ridged asymmetrical upper part of the costa of *R. occidentale* is unique within sect. *Laevifolia*. The hair-point is terete and spinulose-denticulate, and is more like the common *Grimmia* than the common *Racomitrium* type of point. However, a similar point is sometimes seen in *R. sudeticum*. The presence of an uneven leaf margin, a winged costa, and a spinulose-denticulate hair-point makes *R. occidentale* a remarkable and easily recognized species in the section.

1. *Racomitrium sudeticum* f. *sudeticum* (Fig. 15) is (much) less robust than *R. occidentale*. Sometimes its margin is slightly uneven (usually smooth), and sometimes its point is spinulose-denticulate (usually flatter and with less spinulae), but it has a dorsally symmetrical costa. There are few difficulties in distinguishing between the two, except, perhaps, when *R. occidentale* occurs as very small, starved plants.

2. *Racomitrium heterostichum* (Fig. 27) has, e.g., a broad flat hair-point and a costa which is as different from that of *R. occidentale* as it can be in the section. *Racomitrium occidentale* was described as a variety of *R. heterostichum*, and recently treated as such by Lawton (1971).

3. The leaf margin of *R. occidentale* is uneven as in *R. lawtonae* (Fig. 21). Except for this common characteristic they are so different that it is hard to believe that they should be closely related.

4. *Racomitrium macounii* (Fig. 9, 11) is (reddish) brown, and has (e.g.) a very short and very different hair-point; a costa which is not furrowed at the dorsal side (in both it is frequently four-stratose); and a leaf margin which is flat on one side.

5. *Racomitrium affine* (Fig. 23) has a hair-point like that of *R. heterostichum* (see 2), and it has a broader leaf with a less strongly thickened margin, and a quite different costa (t.s.).

6. Regarding the differences between *R. occidentale*, and *R. brevipes* and *R. obesum*, see these species.

Habitat

Racomitrium occidentale has been collected from rocks and boulders. It appears to be a mountain plant.

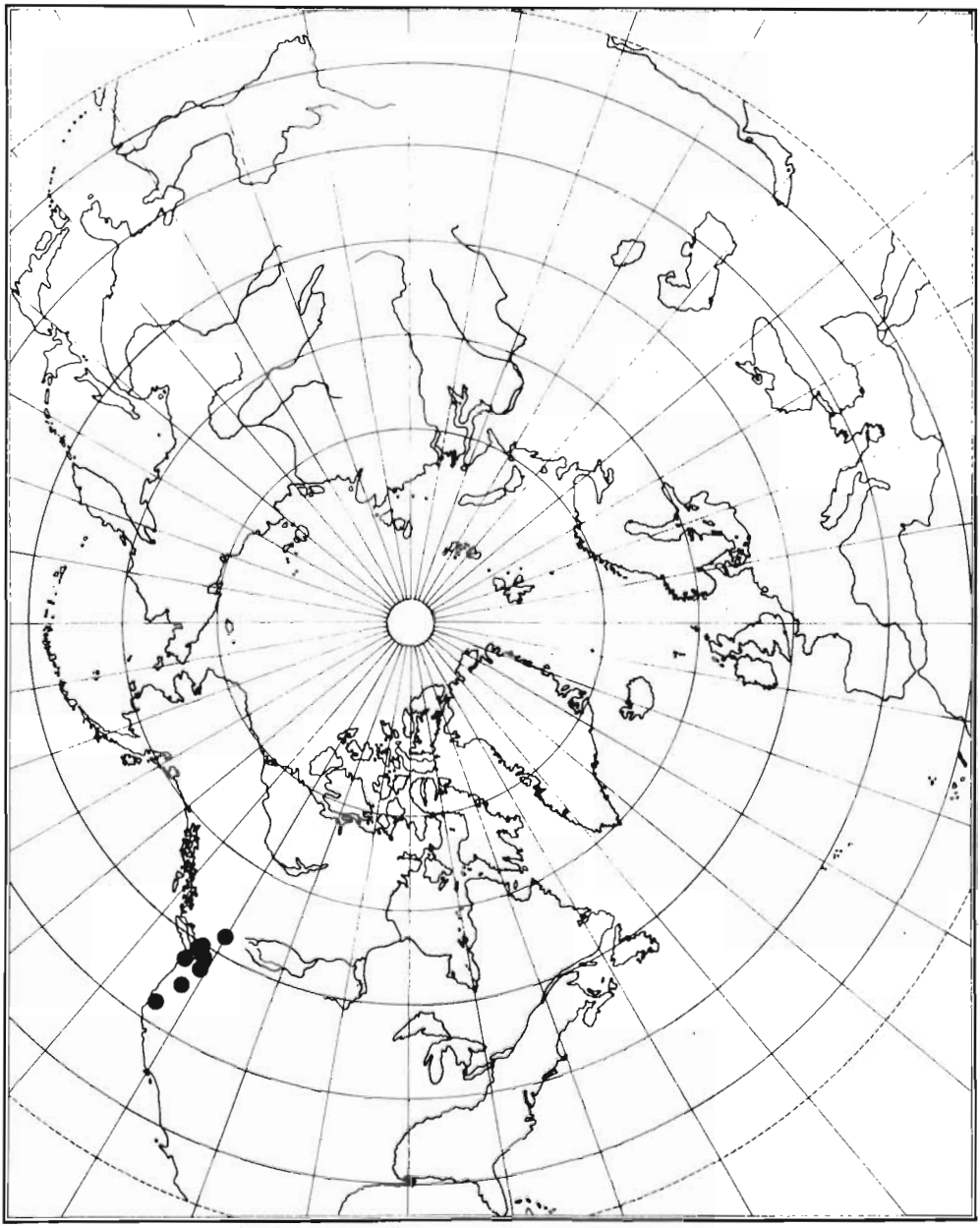

Fig. 14. Distribution of *Racomitrium occidentale*.

Distribution

Racomitrium occidentale is known from western N. America (Fig. 14). Specimens have been seen from Oregon, Washington and British Columbia. One specimen from Alaska (Wrangel, 25.VIII.1900 Cripe - NY) includes *R. brevipes*, a little *R. occidentale*, and *Dryptodon patens*. The *R. occidentale* element is perhaps not from that locality, and it is therefore not plotted on the map.

Specimens examined

U.S.A.: Oregon. Josephine Co., Oregon Caves, Svihla 1089 (WTU); Hood River Co., Mt. Hood, Henderson s.n. (FH), 1871 Hall (S); Mt. Hood National Forest, route 35, ab. 6 mi N of Bennett Pass, Mitchell Creek, Lawton 3217 (FH; WTU, 2 sp.); Multnomah Co., Larch Mt., trail from picnic grounds through woods, Lawton 4434 (WTU), near summit, Flowers 9015 (NY), basin N side, Flowers 9012 (NY); ab. 15 mi S of Warrendale, Ireland 7008 (CANM); Bohemia Mine and Canyon, Bactus 10.XI.1939 (NY). - Washington. Jefferson Co., Blue glacier, Mt. Olympus, Becking 5309956 (WTU); Olympic Mts., Piper 68 (NY); Snohomish Co., Mt. Pilchuck, Lawton 5204 (WTU, 2 sp.), 28.VI.1929 Grant (WTU); Whitechuck River road ab. 16 mi E of Darrington, Meadow Mountain Trail, Lawton 4772 (WTU, 2 sp.); King Co., ab. 1 mi E of Scenic, 3.IX.1954 Frye (WTU); Scenic, 47°43'N, 121°8'W, Frye 3220 (H, NY, S); Deception Creek, Flowers 8487 (NY); Clallam Co., Olympic Peninsula, Trail from Olympic Hot Springs to Boulder Lake, Lawton 2559 (WTU); Boulder Lake trail, Ireland 6562 (CANM); Olympic National Park, Bogachiel Peak Trail, Harthill 1796 (WTU); Monte Cristo, just outside town, Frye 3234 (WTU, S); Stevens Pass, Schofield 12398 (CANM), Leiberg & Sandberg 846 (NY); along road to summit of Mt. Baker, ab. 3 mi from Lodge, Ireland 7473 (CANM); Hamilton, 4.VIII.1905 Foster (NY); Iron Mt. near Hamilton, Foster 159 (S); Trail to Mt. Angeles, 29.VI.1908 Jenks (NY); Wellington, 17.VI.1898 s. leg. (NY). CANADA: British Columbia. Vancouver distr., summit of Mt. Seymor, just N of Vancouver, Ireland 6003, 6006 (CANM); Stanley Park, Vancouver, near creek draining from Douglas Lake, Schofield 12459 (CANM); Vancouver Isl., Mt. Arrowsmith, Macoun 168 (CANM); Wells Gray Prov. Park, along trail to Murtle Lake, 15.8 mi W of Blue River on Hwy 5, Vitt 17948 (ALTA); trail from Brandywine Falls towards Brew Lake, 49°50'N, 123°10'W, Schofield 56933 (ALTA).

(4a) *Racomitrium sudeticum* (Funck) Bruch et Schimp. in B., S. et G. f. *sudeticum*

Fig. 3A, 15, 18, 69B.

Bryum **macrocarpon* With., Syst. Arr. Brit. Pl. ed. 4, 3: 805. 1801 *hom. illeg. non* Hedw., Spec. Musc. 178. 1801 [≡ *Leptostomum macrocarpon* (Hedw.) Pyl.]. - Type: "On Snowdon. Mr. Griffith"; references: Dillenius (1741: Table 47, Fig. 29), Oeder (1770: Table 476), Happ. III. 3. [= ?], and Hudson (1762: 410, *Bryum Hypnoides* γ). (Lectotype nov.: *Bryum hypnoides alpinum, setis et capsulis exiguis*

Dill. In culmine montis Widhva (Snowdon Anglis) ... Augusto mense cum capsulis novis & veteribus. - OXF-Dill., Herb. fol. 118, n. 29. Isolectotype: H-SOL).

Trichostomum sudeticum Funck, Deutschl. Moose 26. *18.* 1820. - *Dryptodon sudeticus* (Funck) Brid., Bryol. Univ. 1: 195. 1826. - *Campylopus sudeticus* (Funck) Fürnr., Flora 12: 595. 1829. - *Racomitrium microcarpon* [var.] ß. *sudeticum* (Funck) Hüb., Musc. Germ. 202. 1833. - *R. sudeticum* (Funck) Bruch et Schimp. in B., S. et G., Bryol. Eur. 3: 141. *264* (fasc. 25-28 Mon. 7. *1.*) 1845. - *R. heterostichum* [subsp.] ☆*R. sudeticum* (Funck) Dix. in Dix. et Jameson, Handb. Brit. Moss. 154. 1896. - *R. heterostichum* var. *sudeticum* (Funck) Dix. ex Bauer, Musci Eur. Am. Exs. ser. 41: n. 2023. 1929. - Type: "Ad saxa in Sudetis (am Weisswasser im Teufelsgrund). Jun. Funck, H. Chr., Deutschlands Moose (Ein Taschenherbarium), Baireuth 1820." (Lectotype: Same as Type reference. - M. Isolectotype: L. Frisvoll 1984a: 314, Fig. 6).

Trichostomum gracile Hornsch. ex Fürnr., Flora 10 (Erg. bl.): 50. 1827. - *Racomitrium* **gracile* (Hornsch. ex Fürnr.) Hornsch. ex Fürnr., Flora 12: 595. 1829 *comb. inval. in synon.* - Type: "... als *T. sudeticum* ... von Funck zum Theil unter diesem Namen vertheilt wurde, die wir dann später von Freund Müller als *T. gracile* Hornsch. aus dem Kärnthner Alpen erhielten, ..." (Lectotype nov.: "*Racomitrium gracile* Hornsch. Alpes Salisburiae, 11.7.1826 August Müller." - BM-Hookerianum. Isolectotypes: BM-Hampe, BM-Wilson, JE).

Grimmia **procera* Bals. et De Not., Mem. R. Acc. Torino Cl. Fis. Mat. 40: 339. 1838 *nom. illeg. incl. spec. prior.* [*Trichostomum sudeticum* Funck, 1820 ≡ *Racomitrium sudeticum*]. - Type: "Ad rupes in montibus editioribus Provinciae Novariensis passim." Syntypes (RO).

Racomitrium heterostichum f. *repens* Chal., Grimm. Tatr. 99. 1882. - Type: "Dolina Malego Kolbachu wprost Lomnicy ... Dolina Jaworzynska pod Lodowym. Ponizej Zawratu od strony Zmarzlego. Wierchcicha ku Przehybie." (Lectotype nov.: "Musci Tatrenses. *Racomitrium heterostichum* Brid. f. *repens*. Kleinkolbachthal 1-VIII-1878 l. Dr. Chalubinski." - H).

Grimmia sublurida Stirt., Scott. Natural. 9: 36. 1887. - Type: "in August in Harris, in the Outer Hebrides." (Lectotype: "Scotland, Tarbert in Harris, Aug. 1886." - GLAM, NHB-1927-8-2023. Paralectotypes: GLAM, NHB-1927-8-2024/2025. Frisvoll 1985a: 337, Fig. 1a-f).

Racomitrium sudeticum [var.] ß, *papillosum* C. Jens., Medd. Grønland 3: 344. 1887. - *R. jensenii* Kindb., Rev. Bryol. 23: 20. 1896 ('*Jenseni*'). - *R. sudeticum* f. *papillosum* (C. Jens.) Möll., Rev. Bryol. n.s. 2(56): 84. 1929. - Type: "Ø. Gr.: Serketnoua (E.)!" (Holotype: "*Racomitrium Jensenii* Kindb. *Racomitrium sudeticum* (Funck) var. *papillosa* C. Jens. Grønl. 500' oppe paa Jord og smaa Sten i Jorden, Serketnoua, 28/6 85 leg. P. Eberlin." - C. Isotypes: S, 3 sp.).

Racomitrium sudeticum f. *compactum* Limpr., Laubm. Deutschl. 1: 800. 1889.- Type: "An der Felsen der Schneekuppe in Riesengebirge 1600 m." (Lectotype

nov.: "38830 *Racomitrium sudeticum* (Funck) forma. Schneekoppe, 3. Aug. 1879 [Limpricht]." - BP-Limpricht).

Grimmia (Dryptodon) austro-patens C. Müll. in Neum., Deutsch. Exp. Int. Polarforsch. 2: 316. 1890 [*non* C. Müll. ex Rehm., Exs. Musc. Austro-Africani (1875-1877) No. 137. 1878 *nom. nud.* - *Racomitrium austro-patens* C. Müll. in Rehm. ex Broth., Nat. Pfl. 1(3): 454. 1902]. - *R. austro-georgicum* Par., Ind. Bryol. 519. 1896. - Type: "Austro-Georgia, Bach-Grund oberhalb des Pinguin-Thales, 26. Januario 1883." (Lectotype: "No. 53 *Dryptodon austro-patens* C. Müll. n. sp. Fundort: Bachgrund oberhalb des Pinguinbay. Süd-Georgien, 26.I.83 Will." - HBG. Frisvoll 1986: 340, Fig. 1a-f).

Grimmia microcarpa [fide Lindberg 1875] f. *subheterosticha* Sæl. in Broth. et Sæl., Act. Soc. F. Fl. Fenn. 6(4): 80. 1890. - Type: "E Subovi (Fellman)." (Holotype: "*Racomitrium sudeticum* Funck. ('*R. heterostichum* f. *simplicior brevipila*' Zett. in litt.) Subovi, d. 11/VII. 61 N.I. Fellman." - H).

Racomitrium sudeticum var. *subepilosum* Warnst., Schrift. Naturwissensch. Ver. Harzes in Wernigerode 1893: 29. 1893 (as '*R. sudeticum* var. *subepilosum* Warnst. f. *compacta* Limpr.'). - Type: Not indicated, but collected on "Exkursionen in der Nähe von Wernigerode und über Schierke nach dem Brocken." [p. 27]. (Topotype: "62a Flora Germanica. ~~*Grimmia unicolor* Grev~~. *Racomitrium sudeticum* f. *subepilosa*. Harz: Gipfel der Brocken, 1885 14/V. leg. J. Bornmüller." - JE).

Grimmia (Racomitrium) amoena Broth., Öfv. Finsk. Vet. Soc. Förh. 42: 99. 1900. - *Racomitrium amoenum* (Broth.) Par., Ind. Bryol. Suppl. 293. 1900. - Type: "New South Wales, Mt. Kosciusco (J.H. Maiden et W. Forsyth n. 202, 204)." (Lectotype: "204 *Grimmia amoena* Broth. N S Wales, Mt. Kosciusco 1/1899 J.H. Maiden et W. Forsyth." - H-BR. Paralectotype: "202 *Grimmia amoena* Broth. N S Wales, Mt. Kosciusco 1/1899 legg. J.H. Maiden et W. Forsyth, com. Brotherus" - TRH. Frisvoll 1986: 340, Fig. 1h-n).

*Grimmia *calvescens* Stirt., Ann. Scott. Nat. Hist. 10(38): 112. 1901 *hom. illeg. non* Kindb., Forh. Vid. Selsk. Christiania 1888(6): 19. 1888 [= *G. funalis* (Schwaegr.) B., S. et G.]. - Type: "Tarbert in Harris, Aug. 1900." (Lectotype: "Scotland, Tarbert in Harris, Aug. 1900." - GLAM, NHB-1927-8-2001. Paralectotype: BM-Dixon. Frisvoll 1985a: 378, Fig. 1g-l).

Grimmia papillulata Stirt., Ann. Scott. Nat. Hist. 11(42): 110. 1902. - Type: "Tarbert in Harris." (Lectotype: "Tarbert in Harris" - GLAM, NHB-1927-8-2018. Paralectotypes: GLAM, NHB-1927-8-2015/2016/2017; BM-Dixon. Frisvoll 1985a: 380, Fig. 3a-f).

Racomitrium sudeticum var. *alaskanum* Card. et Ther., Proc. Washington Ac. Sc. 4: 307. 1902. - Type: "Hidden Glacier Inlet, Yakutat Bay (Trelease, 2508 in part)." (Isotype: "The Harriman Alaska Expedition. Mosses collected by Wm. Trelease & De Alton Saunders. *Rh. sudeticum*, Br. eur. var. *alaskanum* C. et

T. Hidden Glacier Inlet, Yakutat Bay. Coll. T. No. 2508 in part, 20.6.1899 (var. nova)." - NY).

Racomitrium **austro-sudeticum* Broth. ex Watts et Whitel., Proc. Linn. Soc. N. S. Wales Suppl. 27: 85. 1902 *nom. nud.* - Orig.: "Given in Melb. Census for VIC." (Orig. spec.: "No. 78. *Racomitrium (Dryptodon) austro-sudeticum* Broth. c. fr. Australia: Mt. Kosciusko, leg. Dr. Sullivan. Dr. Müller misit 1886." - H-BR; MEL (the latter named *austro-sudeticum* Sp. Nov. Broth., and dated 23.VIII.1886)).

Racomitrium sudeticum var. *molle* Röll, Hedwigia 42 (Beibl.): 300. 1903 (*'mollis'*). - *R. heterostichum* subsp. *sudeticum* f. *molle* (Röll) Podp., Consp. 296: 1954.- Type: "Transsilvanischen Alpen, auf Glimmerschieferfelsen am Besineu im Cibingebirge." (Holotype: ~~*Racomitr. heterostichum* Brid.~~ *sudeticum* Br. & Sch. v. *molle* m. v. *tenell.* Boul. Transsilvan. Alpen, Besineu, 1950 m, Glimmerschiefer, 15/7 00." - WB-Röll. Isotypes: WB (similarly labelled, but finally named *microcarpon!*), JE (as *R. heterostichum* var. *molle*)).

Racomitrium sudeticum var. *obtusifolium* Loeske, Moosfl. Harz. 195. 1903. - *R. heterostichum* subsp. *sudeticum* f. *obtusifolium* (Loeske) Loeske, Bibl. Bot. 101: 215. 1930. - Type: "Var. *obtusifolium* fand ich wiederholt auf Granit an felsreichen Stellen von der Brockenkuppe bis zum Schneeloch herab; steril. Ferner an feuchten Felsen im Okerthal gegen Romkerfall (Oert.!, als *Dryptodon patens*) bei nur etwa 400 m." (Neotype nov.: "Ex Herbarium bryologicum L. Loeske. *Rhacomitrium sudeticum* v. *obtusifolium* Loeske. Hercynia silva, mons Bructerus, 1135, swischen Granitklüften dicht am Gipfel, auf Granit, 13/7 1911 L. Loeske" - S).

Racomitrium substenocladum Card., Rev. Bryol. 38: 127. 1911. - Type: "Terre de Graham: cap Tuxen" [p. 126]. "Je possède également cette espèce de la Terre de Feu" [p. 127]. (Lectotype: "200 *Rhacomitrium substenocladum* Card. sp. nova. Terre de Graham: cap Tuxen, lieux humides, alt. env. 100 m, 2ème expéd. Charcot, leg. Gain, 8/1 1909." - PC. Isolectotypes: BM, H, S. Paralectotypes: "404. *Rhacomitrium substenocladum* Card. sp. nova. Terre-de-Feu: Almirantazgo in alpinis pr. Rio Azopardo, ad 600 m, 3/3 1908. T. Halle et C. Skottsberg. - H-BR, S. Frisvoll 1986: 341, Fig. 2a-f).

Racomitrium sudeticum var. *atratum* Hesselb., Bot. Iceland 1(2): 461. 1918 (*'atrata'*). - Type: "The forms from mountain heights are often jet-black (var. *atrata*) ..." (Lectotype nov.: "Plantae islandicae. *Racomitrium sudeticum* f. *atrata.* Alm. paa Sten paa Fjardarhedr (Seydisfjord), c. 600 m, 4/7 09 leg. August Hesselbo." - C).

Racomitrium heterostichum var. *nigrescens* Amann, Fl. Mouss. Suisse 2: 143. 1919. - *R. heterostichum* subsp. **vulgare* f. *nigrescens* (Amann) Podp., Consp. 294. 1954. - Type: "Graubünden: Seewald, Davos, 1700 m. (Amann) (BH 94.4.6)." (Lectotype nov.: "Musci Helvetici. *Rhacomitrium heterostichum* Br. var. *nigrescens* mihi. Grisons. Davos. Obere ... im Seewald. 1700 m, auf gneiss. 17.5.89. Legt. Amann. Bryotheca Helvetica 94.4.6." - ZT).

Racomitrium skottsbergii Card. et Broth., Vet. Ak. Handl. 63(10): 29. *4f. 3a-e.* 1923 (*'Skottsbergli'*!). - Type: "Fuegia: Lago Fagnano, Expedition Bay (f. minor, nigrescens). Georgia austr.: Cumberland Bay, Moraine Fiord." (Lectotype: "36 *Rhacomitrium Skottsbergii* Card. sp. nova. Georgia australis. Cumberland bay: Moraine fiord, in pratis, 18.4.1909. C. Skottsberg." - PC. Isolectotypes: BM, H-BR, S. Paralectotypes: "386. *Rhacomitrium Skottsbergii* Card. Terre-de-Feu: lac Cami, baie de l'Expedition, Sierra de la Costa, 10.3.1908 C. Skottsberg." - H, PC, S. Frisvoll 1986: 342, Fig. 2g-l).

Racomitrium substenocladum f. **nigrescens* Card. et Broth., Vet. Ak. Handl. 36(10): 30. 1923 *nom. nud.* - Orig.: "Fuegia: supra ost. fl. Rio Azopardo, 600 m. s.m." (Orig. coll.: Same as paralectotypes of *R. substenocladum*, q.v.)

Dryptodon ellipticus var. *tatrensis* Vilh., Act. Bot. Bohem. 2: 53. 1923. - *D. *ellipticiformis* Vilh., Act. Bot. Bohem. 2: 53. 1923 *nom. inval. in synon.* - *Racomitrium ellipticum* var. **tatrense* '(Vilh.) Loeske' in Wijk et al., Regn. veg. 48: 267. 1967 *comb. inval. err. pro Dryptodon ellipticus* var. *tatrensis* Vilh.- Type: "Habitat in detritu rupium graniticarum, decompositarum, humidarum regionis alpinae in Tatris (Malá studená dolina, an. 1919 Vilh.)." (Holotype: *Dryptodon ellipticus* Br. eur. var. *tatrensis* Vilh. (covered original label: *Dryptodon ellipticiformis* n. sp. Vilh.). Vyz. Tatry. Malá stud. ..., 27/8 1919 Vilhelm."- PRC).

Racomitrium sudeticum f. *terrestre* Bauer, Musci Eur. Exs. ser. 33: n. 1616. 1924 (*'terrestris'*). - Type: "Riesengebirge, an oberen Weisswasser unter der Weisenbaude, ca. 1400 m s.m., Aug. 1923 legit E. Bauer." (Lectotype nov.: As above. - S. Isolectotypes: ALTA, S).

Racomitrium sudeticum f. *epilosum* Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 24. 1925 (*'epilosa'*). - Type: "Habitat ad rupes umbrosas montium Tatrensium et Corconticorum (Zeleny potok, Mlinica circum lacum Skok ad 1820 m; Labsky vodapád, Snezka, Certova Zahrádka, 1919 Vilh.)." (Lectotype nov.: *Racomitrium sudeticum* f. *epilosum*. Bohemia septentr.-or., mts. Krkonose, mons Snezka, inter aquaeductum in monte Snezka et deversorium Obri bouda, declive ad convexum Obri dul, 31.VII.1919 J. Vilhelm." - PRC. Paralectotypes: 6.VII. and 25.VIII.1919 Vilhelm - PRC).

Racomitrium sudeticum f. **obtusifolium* Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 24. 1925 (*'obtusifolia'*) *hom. illeg. non* var. *obtusifolium* Loeske, Moosfl. Harz. 195. 1903. - *R. sudeticum* var. **obtusum* Velen. ex Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 24. 1925 *nom. nud. in synon.* - Type: "(pro var. *obtusum* Velenovsky in herbario)." "Habitat in saxis cacuminis Javor in Sumava (Velen. herbarium)." (Holotype: *Racomitr. sudet.* var. *obtusum* ... Javor, VIII.1894 Vel." - PRC).

Racomitrium sudeticum f. *fastigiatum* Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 24. 1925 (*'fastigiata'*). - Type: "Habitat ad rupes montium Tatrensium (Osterva ad 1985 m, 1919, Vilh.)." (Lectotype nov.: *Racomitrium sudeticum* f. Vys. Tatry,

cacumen montis Osterva, 1985 m, 23.VIII.1919 Vilhelm." - PRC. Paralectotype: PRC (1 or possibly 4 sp.)).

Racomitrium sudeticum f. **epilosum* Mönkem., Laubm. Eur. 4: 377. 1927 ('*epilosa*') *nom. nud.* - Orig.: Not indicated.

Racomitrium sudeticum f. **subepilosum* Möll., Ark. Bot. 24A(2): 108. 1931 ('*subepilosa*') *hom. illeg. non* var. *subepilosum* Warnst., Schrift. Naturwissensch. Ver. Harzes in Wernigerode 1893: 29. 1893. - Type: "Västergötland, Nödinge, Surte 1900 C. Hjärne." [p. 109]. (Lectotype nov.: "Musci ex Herb. C.E. Hjärne. Nom. *Racomitrium obtusum* (Lindb.) ster. *Hab.* Vg. Surte, vid sandrännan, 4/11 1900 *leg.* ipse." - S. Isolectotype: O).

Racomitrium sudeticum f. **atratum* Sak., Bot. Mag. Tokyo 51: 105. 1937 *hom. illeg. non* var. *atratum* Hesselb., Bot. Iceland 1(2): 461. 1918. - Type: "Honshiu: Prov. Mutsu, Berg Hakkoda in alpiner Lage (Leg. M. Tsujibe in Herb. K. Sakurai Typus Nr. 2000 Juli 1936)." Holotype: "*Rh. sudeticum* f. *atratum* Sak. f. nov. 21-VII-1936 Herb. Dr. K. Sakurai Nr. 2000" - MAK).

Racomitrium austro-georgicum var. *kranckii* Roiv., Arch. Soc. Zool. Bot. Fenn. Vanamo 9: 88. *1f.2; 2h-j.* 1955 ('*Kranckii*'). - Type: "Type no. 2619: Fuegia occ.: Monte Buckland, on humid, phyllitic sand and gravel soil on the border of alpine rivulet, ca. 600 m. above sea level, where it forms very elegant colonies." (Holotype: "Bryophyta Fuegiana 2619. Fuegia occ., Monte Buckland, in ripa rivuli alpini, 600 m s.m. 1929, 23.II." - H. Isotype: S. Frisvoll 1986: 342).

Plants often brownish or blackish below and olivaceous or greenish at the top, but also more yellowish or jet-black throughout, rarely reddish brown, in dense cushions or mats. **Stem** not robust, frequently about 1.5-4 cm, but often shorter or much longer, usually dichotomously branched but also unbranched or with (much) more branches and branchlets. **Leaves** erect or secund, narrow towards their apex, (1.5)1.7-2.7 x 0.4-0.7(0.8) mm. **Hair-point** frequently absent or short, 0-150 µm, but sometimes to 0.4 mm or longer, usually stout and not decurrent down margin of lamina, denticulate and (usually) spinulose, erect-squarrose or squarrose and not or slightly flexuose when dry. **Margin** broadly recurved to 1/2-3/4 the leaf length on one side, and more narrowly and shortly recurved or rarely flat on the other side, in upper part bistratose (for 1 or in spots for 2 cell rows; bistratose with unistratose spots; unistratose with bistratose spots) or unistratose, in lower part less bistratose than in the upper part. **Costa** strongly convex at the dorsal side, in lower part (50)60-85(100) µm broad, in upper part 40-55 µm broad, reaching to and into the point, in basal part (bi- to) three- (to four-)stratose (d. 9-14(18), c. (0)2-6(10), v. 3-4), in middle part (bi- to) three- (to four-)stratose with homogeneous cells, (d. 6-10(13), c. (0)1-4(7), v. 2-3), in upper part bi- to three-stratose (d. 4-7(11), c. (0)2-4, v. 2(-3)). **Lamina** unistratose, sometimes with bistratose spots. Basal **laminal cells** rectangular (T: 20-42 x 10 µm), middle and upper cells from transversely elongate to usually mixed quadrate and rectangular (T: 10-20 x 10 µm), upper marginal cells transversely elongate to short-rectangular (T: 7-15 x 12 µm), cell

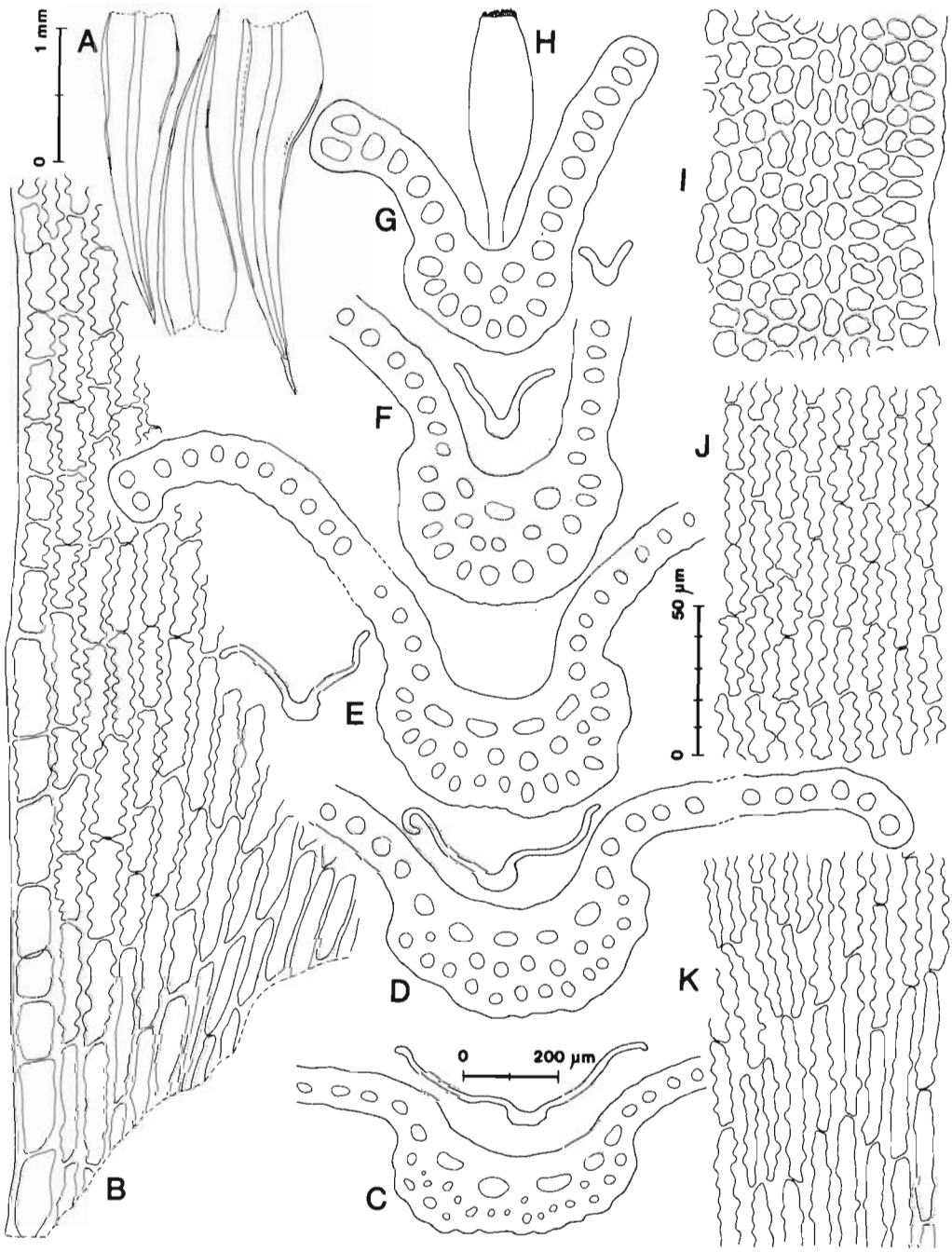

Fig. 15. *Racomitrium sudeticum* f. *sudeticum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. (U.S.A.: Maine, Piscataquis Co., Mt. Katahdin, Hermann 19237 - CANM.)

walls usually distinctly bulging dorsally and ventrally. **Alar cells** slightly differentiated, sometimes yellowish, a row of basal marginal cells moderately thick-walled and pellucid, of about 5-15 cells.

Perichaetial leaves not squarrose when wet, usually pilose, and slightly differentiated, the innermost (1-3) ovate-lanceolate with (sub)hyaline base. **Seta** about 2.5-3.5 mm, sometimes arcuate. **Urn** from subspherical to ovate and oblong-cylindrical (0.7-1.6 x 0.4-0.65 mm), exothecial cells short and wide, thin-walled, 1-2 rows of relatively wide and slightly incrassate cells at the mouth. **Teeth** about 280-410 µm, variably split (from almost 1-pronged and cribrose to 2-pronged and regularly split down to the base), basal membrane present (35-50 µm). Spores 12-16.5 µm.

Diagnostic characters

(1) Plants frequently in dense cushions. (2) Stem usually not robust, and slightly branched. (3) Leaf short and narrow/m. broad (1.7-2.7 x 0.4-0.7 mm). (4) Hair-point +/-, 0-0.4 mm, stout and not or slightly flexuose, squarrose, denticulate. (5) Margin recurved (m. long, m. long/short/flat), bi (1, or 2 in spots)/uni (in spots or throughout). (6) Costa narrow (60-85/40-55 µm), stratosity/ventral cells ((2)3(4)/3-4, (2)3(4)/2-3, 2-3/2), with homogeneous cells (t.s.). (7) Lamina sometimes with bistratose spots. (8) Alar cells slightly differentiated, usually some short and wide basal marginal cells. (9) Pl not squarrose, slightly differentiated (usually pilose), not hyaline. (10) Seta short (2.5-3.5 mm). (11) Urn short (0.7-1.6 mm). (12) Basal membrane + (35-50 µm).

Variation

Racomitrium sudeticum s.l. is very widely distributed and inhabits many different kinds of localities, and it varies correspondingly; it is the most widespread and, together with *R. subsecundum*, the most variable species in the section. The stems of *R. sudeticum* may be from few mm to about 10 cm long; the leaves from about 1.5 to 3.2 mm; the hair-point from absent to about 0.5 mm; the margin from unistratose to strongly thickened throughout; the costa from predominantly bistratose to (rarely) frequently four-stratose; the lamina cells from short in the whole leaf to elongate throughout, and the basal marginal border from ill-defined to distinct. And no doubt, *R. sudeticum* as treated here includes many genotypes. From Norway I have obtained several mixed collections between dissimilar plants of *R. sudeticum* from different parts of the country including the mountains and the lowland. The differences between such plants usually include various colour, dissimilar length of hair-point and leaf cells, and variously thickened leaf margin. But the variation in the entire material is large, and a separation into subordinate taxa has proved difficult. *Racomitrium sudeticum* is the taxon in the section that has got the longest synonym list, but not a single name has been found to be of taxonomic value in this study.

The variation of *R. sudeticum* s.l. is certainly striking. But the similarities in leaf characteristics of the various ecads are equally obvious, and it is important to state that *R. sudeticum* as defined in this paper always is well separated from the other species in the section (except sometimes *R. macounii*): The leaf is keeled and narrow towards the apex; the hyaline hair-point is stout, denticulate and spinulose, and usually short, and it is erect-squarrose or squarrose and not or slightly flexuose or decurrent down margin of lamina; the margin is more or less strongly recurved to 1/2-3/4 the leaf length (but not quite to the hyaline point) on one side, and more narrowly and shortly recurved but rarely (yet sometimes) quite flat on the other side; the costa is strongly dorsally convex and reaches the hair-point, it is made up of homogeneous cells except at the leaf base (t.s.), and shows a typical three-stratose *sudeticum* transection throughout or in part. Below, I introduce two form names (f. *kindbergii*, f. *terricola*). The new taxa are so different from the common variation of f. *sudeticum* including modifications, that they may easily be confused with other species or eventually thought to be something new. The two widespread forms are clearly genetically different from the main f. *sudeticum*. But what is left in f. *sudeticum* is still genetically heterogeneous, and the same may be the case with f. *kindbergii* and f. *terricola*. However, I consider it conveniant to have a name for these two phenotype groups.

A minor part of the Japanese *R. sudeticum* s.l. is difficult to treat. Many Japanese specimens approach the European type of the name; they have denticulate and spinulose hair-point if not epilose; recurved leaf margins (broadly on one side, and more shortly and narrowly on the other); bistratose margin for one cell row (including unistratose and rarely three-stratose spots, and sometimes bistratose spots for two cell rows); a three-stratose costa; and mixed quadrate and rectangular cells in the upper part of the lamina (if not depauperate). There is a pronounced tendency in otherwise typical Japanese specimens to have relatively strongly thickened spots in the leaf margin. Some specimens have predominantly unistratose margin, and this is in accordance with the European situation. But the difficult specimens are those with shorter hair-point (when pilose); a quite flat leaf margin on one side; bistratose margin for two to three or more cell rows (not only in spots); a three- to four-stratose costa; and shorter, often transversely elongated lamina cells. Such specimens may approach *R. macounii* subsp. *alpinum*, and have also the warm brown colour of that taxon. And, indeed, a few specimens are so similar to depauperate European and American specimens that they have tentatively been referred to that taxon (they would have been named so if they originated from these continents). But no quite typical large specimen of *R. macounii*, with strong four-stratose costa and regularly bistratose margin for 3-4 cell rows, has been seen from Japan. The actual specimens are gracile or small, their hair-point is less stout and less squarrose when compared with the European and American subsp. *alpinum*, and the other characteristics are as desribed above. The habitats of the Japanese specimens referred to subsp. *alpinum*, seem to have been relatively dryer than the habitats of the European subsp. *alpinum*; and smaller, less typical European plants are always from unusually dry habitats. Both *R. sudeticum* and untypical *R. macounii* subsp. *alpinum* have been collected from

the same Japanese mountain, and mixed stands may occur and should be searched for. The Japanese *R. sudeticum* s.l. should be studied in the field, and the habitats of the Japanese *R. macounii* subsp. *alpinum* made clear. Some Japanese specimens seem to combine characteristics from both *R. sudeticum* and *R. macounii*. Perhaps these deviating plants could be described as a separate Japanese taxon. The variation amplitudes of the Japanese *R. sudeticum* s.l. are different from the European and American *R. sudeticum* s.l. The Japanese taxon has probably been isolated for a very long time, and this may account for the differences.

Comparison with other taxa

Racomitrium sudeticum has been confused with almost all species in the section, and its differentiation is treated in connection with these species. It has been compared with *R. affine*, *R. brevipes*, *R. heterostichum*, *R. himalayanum*, *R. laetum*, *R. macounii*, *R. microcarpon*, *R. nitidulum*, *R. obtusum*, *R. occidentale*, *R. venustum*, *R. verrucosum* and *R. vulcanicola*. For differences between *R. sudeticum* f. *sudeticum*, and f. *kindbergii* and f. *terricola*, see the latter two.

Habitat

Racomitrium sudeticum grows on all kinds of dry and periodically moist, acid rocks. It occurs from the lowland and up into the middle alpine and middle arctic region. Hagen (1909: 83) postulated (translated): 'There is nowhere indicated that it ... occurs on soil, and it can therefore be said to grow exclusively on rocks.' Nevertheless, in the mountains it is common on soil, especially in snowbeds.

Distribution

Racomitrium sudeticum is a widely distributed bipolar species which is known from all continents except Africa. The map (Fig. 18) presents the known distribution of *R. sudeticum* s.l. in the northern hemisphere. Two specimens from the interior of Siberia (Altay Mts.) indicate that it may be more common in the southern mountains of Asiatic USSR. Otherwise it has an almost completely circumboreal distribution. In the south it grows in the mountains, and in the north it is common also in the lowland. The northern limit of species in sect. *Laevifolia* is held by *R. sudeticum*; this is on Bear Island, 74°30'N (Frisvoll 1983b: Fig. 5a). *Racomitrium sudeticum* seems to be unable to grow in the inner lowland parts of the continents. The epigeic plants of the northern tundra are to a large extent referable to f. *terricola*.

(4b) *Racomitrium sudeticum* f. *kindbergii* Frisvoll *f. nov.*
Fig. 16.

A typo *R. sudetici* differt margine foliorum magis incrassato atque costa robustiore.

Holotype: "*Racomitrium sudeticum*. [France] Sommet du Sancy (1900 m), Puy de Dôme, legit R. du Buysson, 2. Juillet [18]84" - S. Isotype: JE.

Plants dark brown or black below, and olivaceous or dark green above. **Stem** as in f. *sudeticum*. **Leaves** as in f. *sudeticum*, but perhaps never so long (up to 2.25 mm). **Hair-point** short (up to 150 µm). **Margin** recurved as in f. *sudeticum*, in upper part irregularly bi- to four-stratose (bistratose for one to three or sometimes five cell rows, with three- and sometimes four-stratose spots for one to two cell rows), with or without unistratose spots, in lower part bistratose for one to two (to four) cell rows, with more frequent unistratose areas and sometimes with three-stratose spots. **Costa** 70-90 µm broad below and 45-55 µm broad above, sometimes irregular in outline and cross-section, in basal part three- to four-stratose (d. 12-19, c. 3-12, v. 3-5), in central part three- or, more rarely, four-stratose (d. 9-15, c. 2-7, v. 3-4), in upper part bi- to more commonly three-stratose (d. 7-14, c. 0-3, v. 2-3(4)). **Lamina** frequently with bistratose spots in upper and sometimes in lower part. Basal **laminal cells** rectangular (T: 16-44 x 12 µm), middle and upper cells short (T: 5-9 x 12 µm), upper marginal cells approximately as the upper laminal cells (T: 5-9 x 12 µm), cells distinctly pseudopapillose. **Alar cells** slightly differentiated, about 5-15 pellucid cells in the basal marginal row. Bracts and sporophyte as in f. *sudeticum*.

Diagnostic characters

(3) Leaf slightly shorter than in f. *sudeticum* (up to 2.25 mm). (4) Hair-point +/-, 0-0.15 mm. (5) Margin bi (1-3)/three (1-2, in spots)/uni (sometimes in spots). (6) Costa m. broad below and narrow above (70-90/45-55 µm), stratosity/ventral cells (3-4/3-5, 3(-4)/3-4, (2-)3/2-3). (7) Lamina frequently with bistratose spots in upper and sometimes in lower part, cells distinctly pspp.

Variation

The taxon is variable, but has always a strong costa and a strongly thickened leaf margin. The fourth stratum of the costa may be indicated by one or two cells, and may be almost or entirely lacking. The costa is sometimes asymmetrical (spots in transection). The margin may approach that of f. *sudeticum*, except that it is bistratose for 2-3 cell rows in its upper part. But it may also be bistratose for 2-4 cell rows almost throughout. Parts of such strongly thickened margins may be spherical in transection, and three- to four-stratose. F. *kindbergii* seems to be (somewhat) intermediate between f. *sudeticum* and

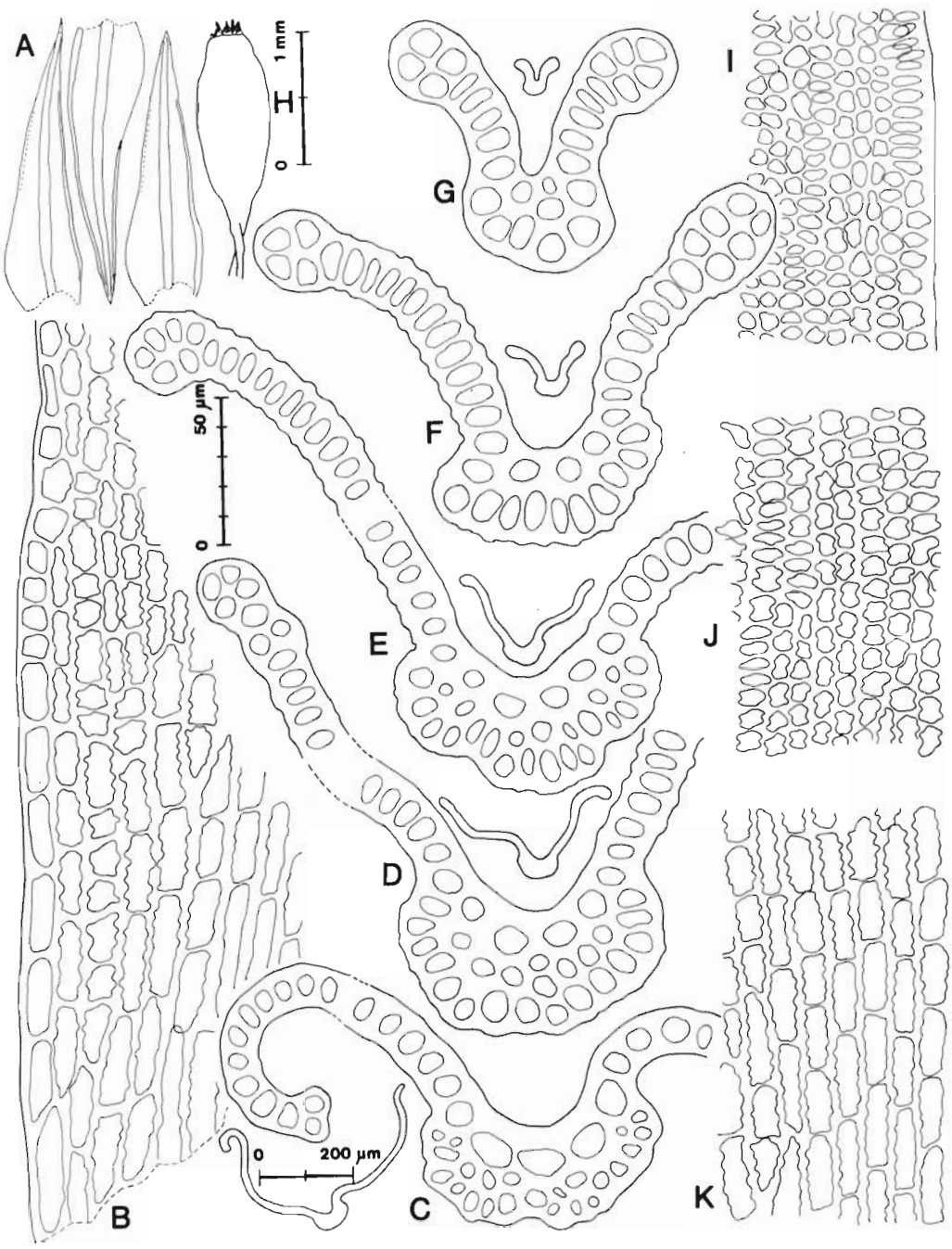

Fig. 16. *Racomitrium sudeticum* f. *kindbergii*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. - Holotype (S).

R. macounii, and it could be of hybridogenous origin. But it may also be (entirely or largely) a part of the normal variation of f. *sudeticum* s.l. As far as I know, *R. macounii* is absent from eastern N. America, but plants approaching f. *kindbergii* (four-stratose costa, bistratose margin in spots for 2-3 cell rows) occur there.

Comparison with other taxa

1. F. *kindbergii* may be mistaken for *R. macounii* (Fig. 9, 11), and they are separated as follows: **Plants**, colour (*sud-k*: usually dark green or dark olivaceous above; *mac*: usually brownish, the colour is evident in leaves and leaf cross-sections in the microscope), **stems** (*sud-k*: gracile, and with the branching and appearance of f. *sudeticum*; *mac*: usually more robust and less branched), **hair-point** (*sud-k*: hyaline and like short points of f. *sudeticum*; *mac*: golden brownish and usually not quite hyaline), **margin** (*sud-k*: usually recurved on both sides, usually variously and irregularly thickened; *mac*: flat on one side, usually regularly thickened), **costa** (*sud-k*: often three-stratose with or without four-stratose spots, but sometimes more regularly four-stratose, difficult plants with consistently three-stratose costa usually belong here; *mac*: regularly four-stratose or in weak stems with the fourth stratum indicated by 1-2 cells), **laminal cells** (*sud-k*: usually strongly pseudopapillose; *mac*: usually slightly pseudopapillose).

2. F. *kindbergii* is separated from f. *sudeticum* (Fig. 15) by having a shorter hair-point, a more bistratose margin, and a stronger costa. F. *kindbergii* approaches and integrates with f. *sudeticum*. Actually, it may be necessary to make leaf cross-sections before f. *kindbergii* can be distinguished. I have obtained one mixed stands between the two (Canada: Alberta, Jasper Nat'l Park, Mt. to E of Mt. Edith Cavell, Vitt 14173 - ALTA).

Habitat

F. *kindbergii* appears to grow on rocks in the same habitats as f. *sudeticum*.

Distribution

Racomitrium sudeticum f. *kindbergii* is a rare plant known in scattered localities from throughout the southern distribution area of *R. sudeticum* s.l. No distribution map is prepared (cf. Fig. 18).

(4c) *Racomitrium sudeticum* f. *terricola* Frisvoll *f. nov.*
Fig. 17

A typo *R. sudetici* differt habitu robustiore, margine foliorum minus forte incrassato atque costa tenuiore.

Holotype: "Plantae Islandicae. *Racomitrium sudeticum* (Funck) B. & S. *Loc.* 3536 Hljodabunga i Drangajókli, 20. juli 1978. *Leg.* Eyþor Einarsson No. 16015. Det. Bergþor Johannsson." - ICEL. Isotypes: TRH, UBC.

Plants reddish brown or dark brown throughout, or olivaceous above, rarely more yellowish or jet black. **Stem** robust, not or slightly branched, up to 8 cm long but often 3-5 cm. **Leaf** comparatively large, 2.4-3.0(3.2) x 0.5-0.75 mm, the upper leaf lamina is usually especially narrow and elongated. **Hair-point** narrow, short (up to 170 µm), slightly or not denticulate or spinulose, and not flexuose. **Margin** broadly recurved to 1/2-2/3 the leaf length on one side, and narrowly recurved in the broadest part of the leaf or to 1/2-2/3 the leaf length on the other side, usually unistratose with rare or very rare bistratose spots. **Costa** less dorsally convex than in f. *sudeticum*, and relatively thin, in lower part 55-85 µm broad, in upper part 45-55 µm broad, in basal part bi- to three-stratose (d. 6-12(14), c. 0-3, v. 2-4(5)), in middle part bi- to three-stratose (d. 6-11, c. 0-3, v. 2-4), in upper part bistratose (d. 4-7, c. 0(-2), v. 2(3)). **Lamina** unistratose. Basal **laminal cells** elongate and thick-walled (T: 35-68 x 12 µm), middle and upper cells rectangular (T: 14-35 x 10 µm), upper marginal cells transversely elongate to short-rectangular (T: 9-23 x 12 µm), cells incrassate and walls slightly bulging dorsally and ventrally. **Alar cells** sligthly differentiated, 5-15 basal marginal cells yellowish-pellucid, and usually thick-walled, esinuose and elongate. Sterile.

Diagnostic characters

(1) Plants (usually) epigeic. (2) Stem robust. (3) Leaf m. long and m. broad (2.4-3.0 x 0.5-0.75 mm), with a narrow and elongated apex. (4) Hair-point +/-, 0-0.15 mm, narrow, slightly or not denticulate or spinulose. (5) Margin uni/bi (1, rare or very rare spots). (6) Costa, stratosity/ventral cells (2-3/2-4, 2-3/2-4, 2/2). (7) Lamina unistratose, with elongate cells in upper part.

Variation

The taxon is variable and difficult to delimit with regard to epigeic plants of f. *sudeticum*. And no doubt, f. *terricola* also may grow on rocks and become smaller. Its main characteristics are the long leaves with the elongate leaf apex; the narrow and slightly denticulate hair-point; the weakly thickened margin; the thin costa (often irregular in t.s.), and the elongate cells in the upper part of the leaf.

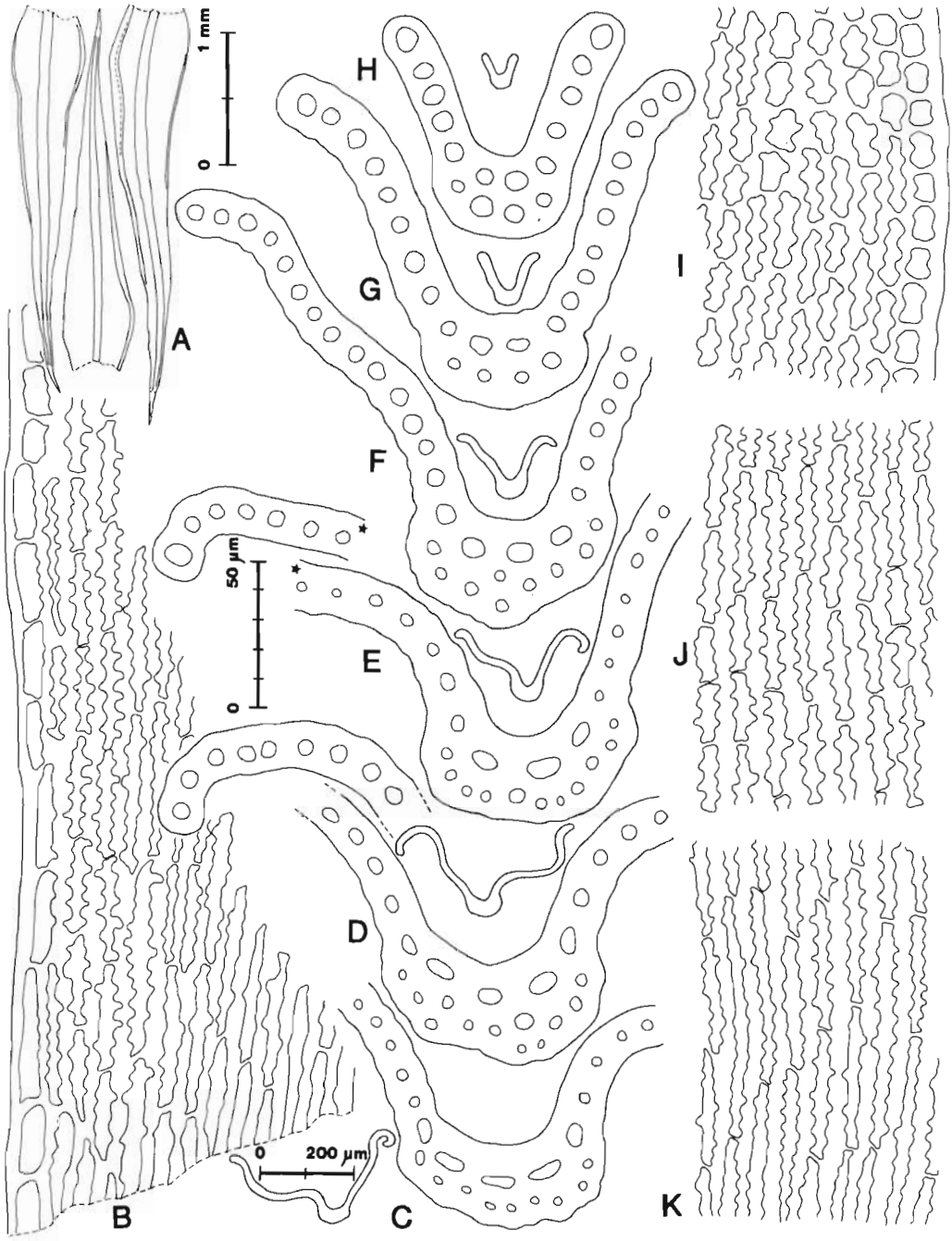

Fig. 17. *Racomitrium sudeticum* f. *terricola*. a. Leaves. b. Alar and supra-alar cells. c-h. Leaf cross sections. i-k. Cells from the upper, lower middle and basal part of the leaf. - Holotype (ICEL).

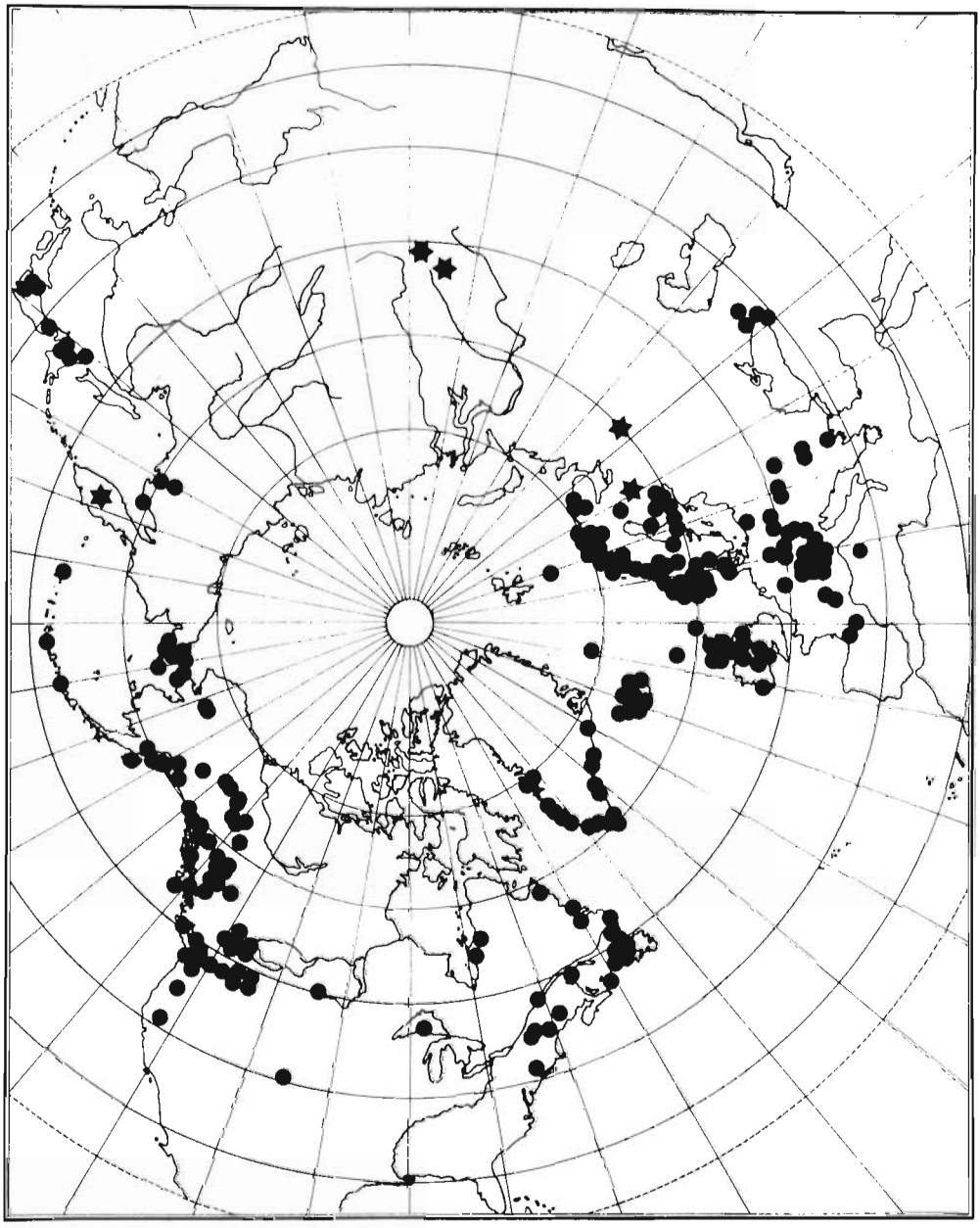

Fig. 18. Distribution of *Racomitrium sudeticum* s.l. in the northern hemisphere. ★ locality inexact.

Comparison with other taxa

1. Typical plants of f. *sudeticum* (Fig. 15) are less robust than f. *terricola*, and may have a more bistratose margin, a less flat costa, and shorter lamina cells. But f. *sudeticum* includes (gracile) ecads with a predominantly bistratose costa and a predominantly unistratose margin, and also ecads with elongate upper leaf cells. Not or slightly branched, robust, epigeic plants with the characteristics of f. *terricola* are unambiguous, whereas plants with more robust costa, more bistratose margin, and shorter leaf cells are less typical. And there are also small epigeic Arctic ecads (e.g. the Jan Mayen and Bear Island populations) that should be referred to f. *sudeticum* and not to f. *terricola*. *Racomitrium austro-georgicum* var. *kranckii* from Tierra del Fuego exhibits the macroscopical characteristics of fo *terricola*, but it is hard to know whether they are identical or not (var. *kranckii* possesses a slightly more robust costa; Frisvoll 1986: Table 1).

2. *Racomitrium microcarpon* f. *microcarpon* (Fig. 39) is strongly branched, and has a flexuose hair-point, less sinuose cells towards the base of the leaf, and a hyaline basal marginal border. See also 4.

3. Some specimens of f. *terricola* were named *R. affine*. However, that species has a broader leaf apex, and a different hair-point and costa, see Description and Fig. 23.

4. For differences between f. *terricola* and *R. microcarpon* f. *afoninae*, see the latter.

Habitat

F. *terricola* is a plant of tree-less areas, where it usually grows on the ground. It is probably this plant which is mentioned from Iceland by Hesselbo (1918: 461): "The forms ... on damp gravelly flats [are] yellowish green at the top, and grow in extensive discontinuous mats, a few cm. thick." It is typically developed and common on Iceland, and a specimen from there has been selected as the type of the name.

Distribution

The epigeic plants of *R. sudeticum* from the northern tundra are for the most part referable to f. *terricola*. No distribution map is prepared (cf. Fig. 18).

5.4 THE *LAETUM* SUBGROUP

Innermost bracts strongly modified, hyaline or with chlorophyllous apex and sometimes a short hair-point; outer bracts not squarrose when wet. Plants yellowish; stem not or slightly branched; hair-point not flexuose, distantly but acutely denticulate; margin uni- og more rarely bistratose; costa predominantly three-stratose below.

The two species in the subgroup, *Racomitrium laetum* and *R. lawtonae*, are closely related.

5.4.1 Key to the taxa in the *laetum* subgroup

1 Robust plant with leaf 4-5.5 x 0.6-0.8 mm; without basal marginal leaf border (Fig. 21) (6) *R. lawtonae*

1 Less robust to gracile plant with leaf 2.5-3.6 x 0.45-0.55 mm; basal marginal leaf border of 12-20 hyaline or pellucid, sometimes slightly sinuose cells (Fig. 19) (5) *R. laetum*

(5) *Racomitrium laetum* Besch. et Card. in Card.
Fig. 4A, 6C, 19-20.

Racomitrium laetum Besch. et Card. in Card., Bull. Herb. Boiss. ser. 2, 8: 335. 1908 ('*lætum*'). - Type: "Japon: Nikko (n. 504, 506, 515); Sobosan (n. 732); Ichifusa (n. 1060, 1061); Ubayu, rochers (n. 2812); Komagatake, rochers, à 2200 m. (n. 3471); Tokachiyama, à 1500 m. (n. 3384). Corée: Pomasa (n. 238 in parte); île Quelpaert, 700-2000 m. (n. 87, 611, 630, 720)." (Lectotype nov.: "*Rhacomitrium laetum* Bescherelle sp. nov., Japon, Nikko, Juni 1898, Faurie 506" - PC. Paralectotypes: Nos. 515, 1060, 1061, 2812 - PC; 2812, 87 - S; 3384 - H-BR).

Racomitrium diminutum Card., Bull. Herb. Boiss. ser. 2, 8: 335. 1908. - *R. heterostichum* var. *diminutum* (Card.) Nog., Misc. Bryol. Lich. 1(15): 1. 1958. - Type: "Japon: Tokachiyama, à 1500 (n. 3383)." (Lectotype nov.: "Herb. J. Cardot. *Rhacomitrium diminutum* Card. sp. nova. Japon: Tokachiyama, 1500 m. Leg. Faurie 1905, no. 3383." - H-BR. Isolectotypes: PC, S).

Racomitrium pergracile Broth. ex Ihs., Classif. Moss. Japan 93. 1932. - *R. laetum* var. *pergracile* (Broth. ex Ihs.) Sak., Bot. Mag. Tokyo 51: 138. 1937. - Type: "Komono." "Mt. Iide and a part of Nagano Prefecture." (transl. by H. Deguchi in litt.) (Lectotype nov.: "No. 175. *Rhacomitrium pergracile* Broth. n. sp. Mt. Iide, Japan. Collected by A. Yasuda July 29, 1910" - H-BR. Paralectotypes: "1656. *R. pergracile* forma. Japan, prov. Ise, Komono, 29/3 1914 leg. H. Sasaoka." - H-BR. "597. *R. pergracile* Broth. Prov. Ise: Komono (on rocks). Mar. 29th 1914 Coll. H. S." - O).

Racomitrium sakuraii Broth. ex Sak., Bot. Mag. Tokyo 51: 137. *11.* 1937 ('*Sakuraii*'). - Type: "Honshiu: Prov. Shimotsuke, Shiobara (Leg. K. Sakurai Typus Nr. 508, 511 Nov. 1920)." (Lectotype nov.: "510 *Sakuraii* Broth." - MAK. Isolectotype: H-BR. Paralectotypes: "508 *Rhacomitrium Sakuraii* Broth. n. sp. Japan, prov. Shimotsuke, Shiobara, 11/1920 leg. K. Sakurai." - H-BR, MAK, S).

Racomitrium laetum var. *gracile* Sak., Bot. Mag. Tokyo 51: 138. 1937. - Type: "Honshiu: Prov. Tamba, Ashio (Leg. R. Toyama in Herb. K. Sakurai Nr. 6984 Juli 1934). Prov. Ohmi Ohishi-Dorf (Leg. K. Yamamoto in Herb. K. Sakurai Nr. 7084 Febr. 1932) ebenso Prov. Ise, Suzuka-pass (Leg. K. Sakurai Nr. April 1928)." (Lectotype nov.: "6984 *Rhacomitrium laetum*, var. *gracile* Sak. 1934.7.14. auf Felsen, Leg. R. Toyama." - MAK. Paralectotype: "7084. *R. laetum*, var. *gracile* Sak. Omi, Kuritagun, Oishi-village, Otaki on the moist rock, 1933 (sic) 2.26." - MAK).

Racomitrium laetum var. *olivaceum* Sak., Bot. Mag. Tokyo 51: 138. *12.* 1937. - Type: "Honshiu: Prov. Hitachi, Berg Tsukuba (Leg. K. Sakurai Nr. 599 Mai 1921). Prov. Shimotsuke, Nikko (Leg. T. Osada in Herb. K. Sakurai Nr. 7354. Nr. 7357 Mai 1935). Prov. Settsu, Berg Minomo (Leg. H. Ui in Herb. K. Sakurai Nr. 7789 29. Dez. 1933). Prov. Yamoto, Berg Ohdaigahara (Leg. R. Toyama in Herb. K. Sakurai Nr. 9127 Aug. 1934 Nr. 7816 April 1935). Kiushiu: Prov. Higo, Berg Kunimi (Leg. H. Kaneda in Herb. K. Sakurai Nr. 7113 29 Sept. 1935) ebenso Yoshio-Dorf (Leg. H. Kaneda in Herb. Sakurai Nr. 7614). Prov. Bungo, Berg Kuju (Leg. H. Arao in Herb. K. Sakurai Nr. 7033 Juli 1934). Hokkaido: Prov. Ishikari, Berg Daisetsu (Leg. M. Tsujibe in Herb. K. Sakurai Nr. 9143 Juli 1936)." (Lectotype nov.: "9127 *R. laetum* var. *olivaceum*. Mt. Ohdaigahara, Prov. Yamato, ad saxa, 13.VIII.34 Leg. R. Toyama." - MAK. Paralectotypes: Nos. 599, 7033, 7354, 7357, 7789, 9143 - MAK; 7033, 7113, 7614 - BM).

Plants yellowish, olivaceous or brownish, rarely green or blackish, in loose or moderately dense cushions. **Stem** up to 10 cm or more, but usually 3-6 cm, from unbranched to slightly, irregularly or dichotomously, branched. **Leaves** narrow with distinct shoulders, (2.1)2.5-3.6 x 0.45-0.55(0.65) mm. **Hair-point** erect-squarrose to squarrose when dry, not flexuose, capillaceous in upper part and broader below, and usually distinctly decurrent down margin of lamina, distantly denticulate with low but sharp marginal teeth, sometimes with a few low dorsal spinulae, from absent to usually 0.5-1.5 mm long. **Margin** recurved on one side to 1/3-1/2 the leaf length, and narrowly recurved in the leaf's broadest part or quite flat on the other side, from unistratose to predominantly bistratose for one cell row or rarely in spots for two (to three) cell rows. **Costa** strongly convex at the dorsal side from base to apex, in lower part (50)60-80(90) µm broad, in upper part 35-45 µm broad, reaching into the hyaline point, in basal part three- or rarely bistratose (d. 10-16, c. (0)1-3(4), v. 3-4) with narrow dorsal and central cells, in middle part bi- or rarely three-stratose (d. 8-12, c. 0-2(3), v. 2-4), in upper part bistratose (d. 4-8, c. 0, v. 2). **Lamina** unistratose (or with exceptional single bistratose spots in mod. *subepilosum*). Basal **laminal cells** elongate (T: 23-47 x 8 µm), middle and upper cells rectangular to quadrate (T: 9-28 x 7.5 µm), upper marginal cells short (T: 7-17 x 11 µm) or

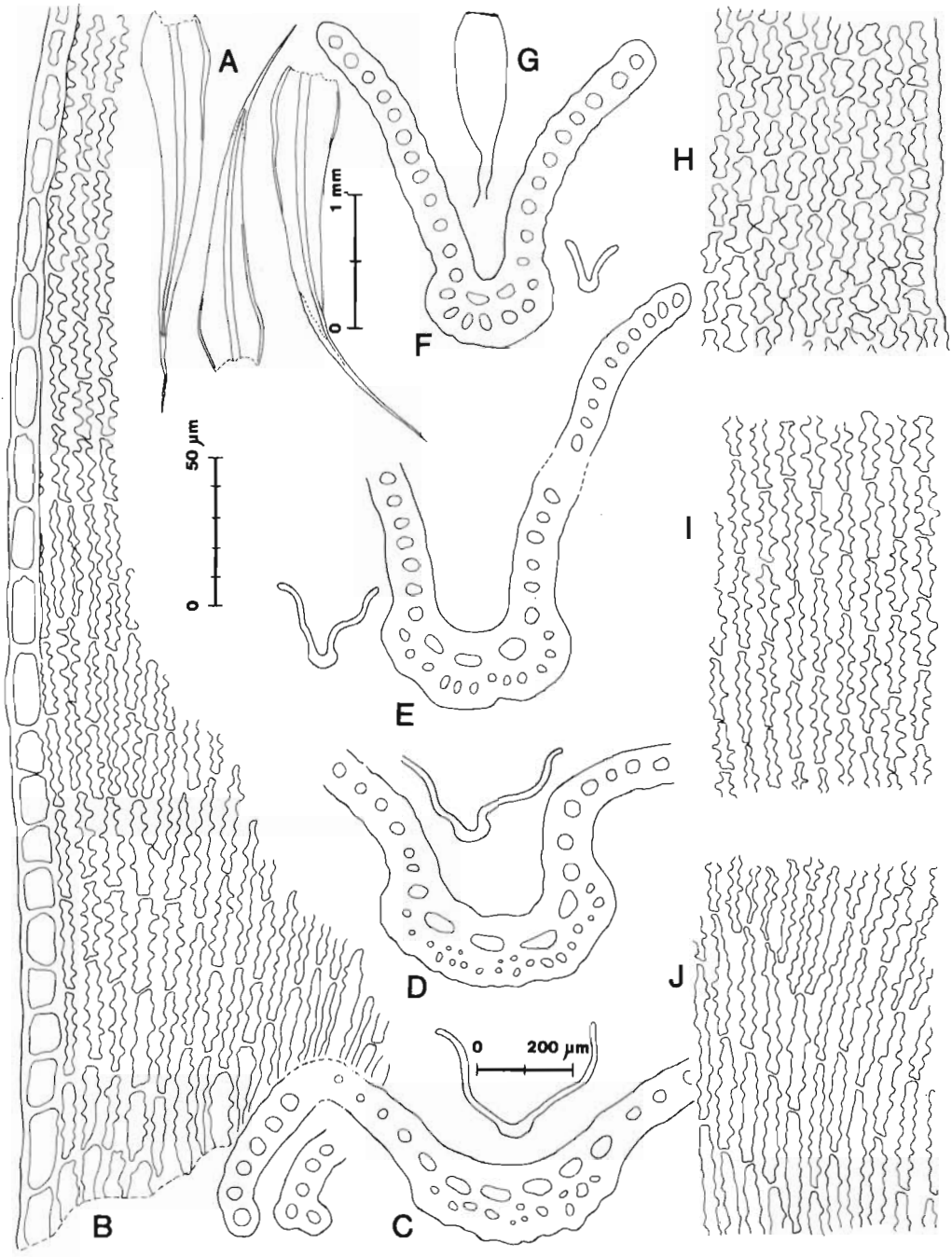

Fig. 19. *Racomitrium laetum*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g. Capsule. h-j. Cells from the upper, lower middle and basal part of the leaf. (a-f, h-j. Lectotype - PC. g. Japan: Kyushu, Mt. Yufu-dake, Musci Jap. ser. 33, No. 1640. 1982 - NICH.)

in mod. *longipilum* sometimes more elongate, cell walls thick, usually yellowish and strongly sinuose and porose throughout the leaf, the outline of the margin uneven, cells not or very slightly pseudopapillose. **Alar cells** yellowish, not enlarged or auriculate, one row of wide yellowish-hyaline and esinuose or slightly (sometimes more distinctly) sinuose, thin-walled (but sometimes more thick-walled and pellucid) cells extending as a border up along the margin, (7)12-20(27) cells in the marginal row, sometimes also a few cells in the second row similarly differentiated.

Perichaetial leaves not squarrose when wet, the inner (2-4) leaves epilose, hyaline, ovate, comparatively short, the next leaves slightly differentiated. **Seta** about 3.0-3.5 mm, ± arcuate. **Urn** ovate, 1.0-1.4 x 0.5-0.6 mm, exothecial cells variable, ± elongate, thick-walled. **Teeth** (ca. 300 µm long,) of 2(-3) prongs (which are more or less regularly split down to the base), distinctly papillose, no basal membrane. Spores 14-16.5 µm.

Diagnostic characters

(1) Plants almost always yellow-olivaceous in upper part. (2) Stem not or slightly branched, and usually elongate and not robust. (3) Leaf m. long and narrow (2.5-3.6 x 0.45-0.55 mm). (4) Hair-point +/(-), 0.5-1.5 mm, not flexuose, erect-squarrose to squarrose, distantly but acutely low-denticulate, decurrent. (5) Margin recurved (short, short/flat), uni/bi (1, rarely 2), uneven. (6) Costa narrow (60-80/35-45 µm), stratosity/ventral cells ((2-)3/3-4, 2(-3)/2-4, 2/2), running into the point. (7) Lamina with exceptional bistratose spots (in mod. *epilosum*), cells yellowish, strongly sinuose, not pspp. (8) Bmb of 12-20 hyaline or pellucid, sometimes slightly sinuose cells. (9) Pl not squarrose, the innermost (2-4) epilose, hyaline. (10) Seta short (3.0-3.5 mm). (11) Urn short (1.0-1.4 mm). (12) Basal membrane -.

Variation

Racomitrium laetum varies like many other species in the section: The plants may be very gracile, or sometimes fairly robust. The hair-point may be long, short or absent; and mod. *longipilum* possesses elongate lamina cells, mod. *subepilosum* short cells. The majority of the specimens have a predominantly unistratose leaf margin, but sometimes it is more - or predominantly - bistratose for one cell row. One specimen (Iwatsuki et al. 11187, NICH) has up to four bistratose marginal cell rows in the upper part of the leaf, and also some bistratose laminal spots there. Typical *R. laetum* with unistratose leaf margin and longer hair-point is also in the packet, but the two do not seem to have grown intermingled. Once, I thought the aberrant plant might be intermediate between *R. laetum* and *R. sudeticum*, but now I do not think so because it has the typical hair-point, marginal outline and costa (t.s.) of *R. laetum*. - The number of differentiated cells in the basal marginal border varies, and this is also the same as in other species with such a border. The areolation of *R.*

laetum is distinctive, including the broad, porose, strongly sinuose-nodulose yellow cell walls. The leaf form is also distinctive, the leaves being broadest with pronounced shoulders close to the base, and comparatively narrow and elongate from above the shoulders and towards the apex.

Comparison with other taxa

1. *Racomitrium laetum* mod. *brevipilum-vel-epilosum* may be confused with *R. sudeticum* (Fig. 15). The latter has a stout, denticulate and spinulose hair-point which is not decurrent down margin of lamina, whereas in *R. laetum* it is capillaceous with distant teeth, not (or slightly) spinulose, and distinctly decurrent (although less so in brevipilose leaves). The differences in the structure of the point seem to be constant, and is an easily observed characteristic. The upper part of the costa of *R. laetum* is bistratose, whereas it is usually three-stratose in *R. sudeticum*. Sometimes, *R. sudeticum* has a weaker, more bistratose costa; but its dorsal and central cells (t.s.) are wider than the same cells of *R. laetum*. The costa of *R. sudeticum* is also more dorsally convex towards the base than in *R. laetum*. The areolation is more regular and less porose in the upper part of the leaf in *R. sudeticum* than in *R. laetum*. The Japanese *R. sudeticum* is usually distinctly pseudopapillose, whereas the cell walls of *R. laetum* hardly bulge at all. Uneven marginal cell walls in a specimen is also indicative of *R. laetum*, but I have seen plants of Japanese *R. sudeticum* with a slight similarity, and this characteristic should not be used alone. The inner perichaetial leaves of *R. sudeticum* are large and slightly differentiated, whereas they are hyaline in *R. laetum*. Typical pilose plants of *R. laetum* are unlikely to be confused with *R. sudeticum*, and the two are not considered to be closely related.

2. *Racomitrium laetum* was treated as a variety of *R. heterostichum* (Fig. 27) by Noguchi (1958, 1974; as *R. heterostichum* var. *diminutum*). Now, when the group has been revised, it is clear that *R. heterostichum* does not grow in Japan, and Noguchi's (1974) var. *heterostichum* is merely plants of *R. laetum* with less elongate upper leaf cells (cf. his key, p. 363).

3. Regarding the differences between *R. laetum*, and *R. lawtonae*, *R. nitidulum*, *R. occidentale*, and *R. vulcanicola*, see these species.

Habitat

Most labels mention rocks or soil on rocks as the substrate of the moss, and the rock is sometimes stated to be granite. A few labels mention soil as its substrate. The species is known from the highest mountain tops and down to the sea level (60 m, according to one label).

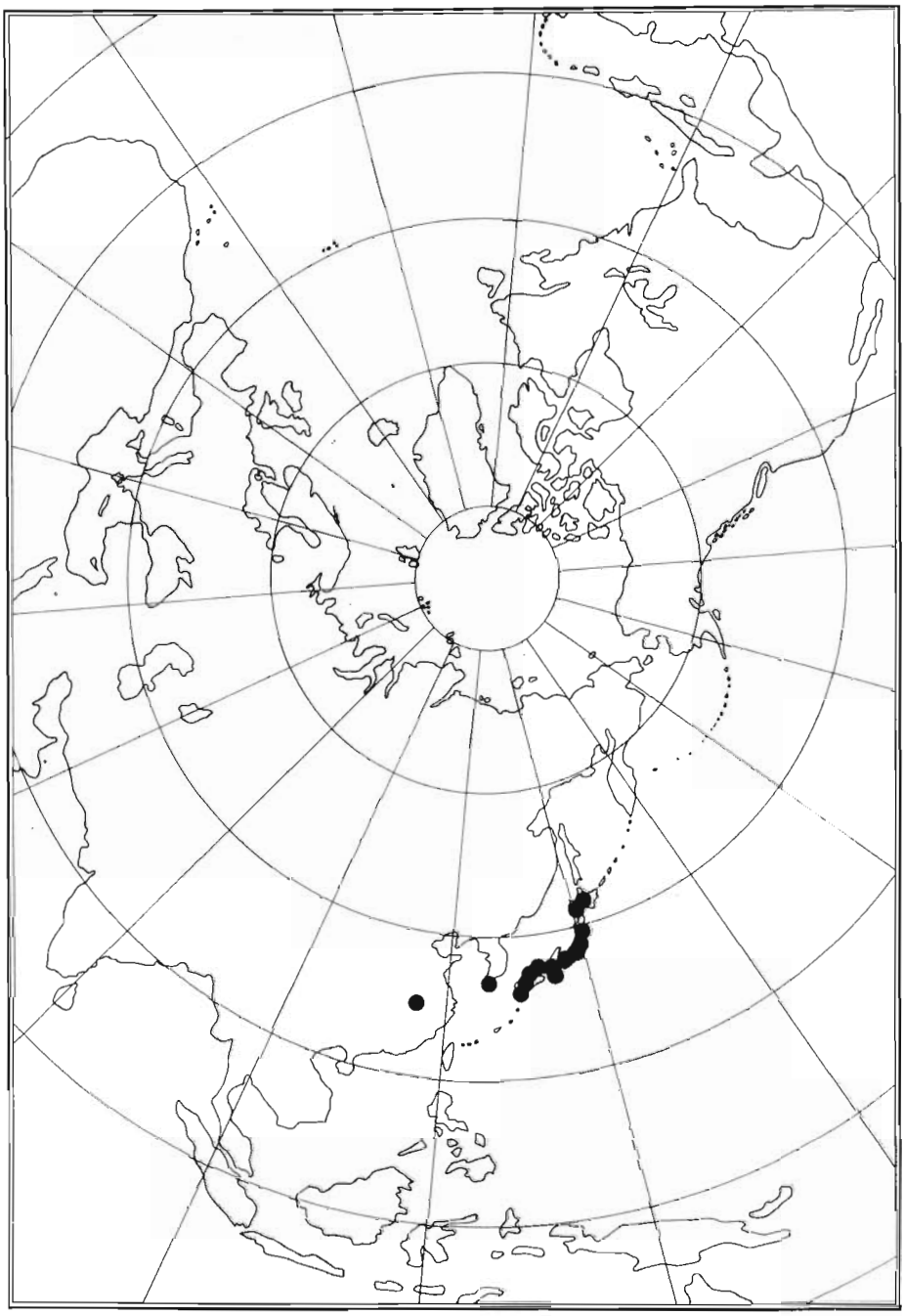

Fig. 20. Distribution of *Racomitrium laetum*.

Distribution

This is the common species of sect. *Laevifolia* in Japan. Noguchi (1974: Map. 3) mapped the distribution of *R. heterostichum* var. *heterostichum* and var. *diminutum* in Japan, and the map should therefore give the distribution of *R. laetum* sensu this paper. Otherwise it is known from Korea (Cheju Do) and China (Anhwei prov., Huang Shan, Chen 7072, 7077 - PE).

(6) *Racomitrium lawtonae* Irel.
Fig. 3B, 21-22.

Racomitrium lawtonae Irel., Bryol. 73(4): 707. 1970. - Holotype: "Canada. British Columbia: Queen Charlotte Islands, northwest coast of Moresby Island, Mitchell Inlet, Schofield 15433 (CANM 160062)." Isotype: WTU. Numerous paratypes from Canada: British Columbia, and U.S.A.: Washington (cf. protologue).

Plants brownish below and yellow green or olivaceous green above, sometimes grayish due to long hair-points, in loose tufts. **Stem** up to 15 cm or more, but usually ± 10 cm, from unbranched to slightly, irregularly or dichotomously, branched. **Leaves** (3.5)4.0-5.5(6) x (0.5)0.6-0.8(0.85) mm, usually straight and closely upright but sometimes strongly falcate to circinate along the whole shoot. **Hair-point** from erect-squarrose to squarrose when dry, not at all flexuose, sometimes short or almost absent but usually long (T: 0.4-1.5 mm) to very long (up to 2.6 mm), distantly but usually acutely denticulate at the margin, not dorsally spinulose, distinctly decurrent down margin of lamina. **Margin** broadly recurved to (1/3)1/2(3/4) the leaf length on one side, and more narrowly recurved to 1/3-1/2(3/4) the leaf length on the other side, unistratose or rarely with bistratose spots in upper part. **Costa** strongly dorsally convex, in lower part 75-100(115) µm broad, in upper part 40-50 µm broad, reaching into the point, in basal part three- (to five-)stratose (d. 12-20(24), c. (0)3-10(20), v. (3)4-5), in middle part bi- to three-stratose (d. 10-16, c. 0-5, v. 3-5), in upper part bi- (rarely three-)stratose (d. 6-13, c. 0-1, v. 2-3(4)). **Lamina** unistratose. Basal **laminal cells** elongate (T: 25-55 x 10.5 µm), middle and upper cells rectangular (T: 12-35 x 7.5 µm), upper marginal cells quadrate to rectangular (T: 6-15 x 9 µm), cell walls not bulging dorsally and ventrally, the outline of the marginal cells uneven. **Alar cells** not or slightly yellowish coloured, 1-6 basal cells in the marginal row slightly wider than the adjacent cells, and not or slightly sinuose but still thick-walled.

Perichaetial leaves not squarrose when dry, inner (2-3) leaves epilose, broadly ovate (cells yellowish-hyaline) with short obtuse point (cells chlorophyllous and sinuose), or all leaves pilose, the pilose leaves slightly differentiated (except that their base is wider and sheathing). **Seta** about 4.5-7.5 mm. **Urn** oblong, (1.2)1.5-2.4 x 0.6-0.8 mm, exothecial cells short, (2)5-7 rows of incrassate, ± transversely elongated cells at the mouth. **Teeth** up to 480 µm long, of 2 prongs which are regularly split, no basal membrane. Spores 12-16.5 µm.

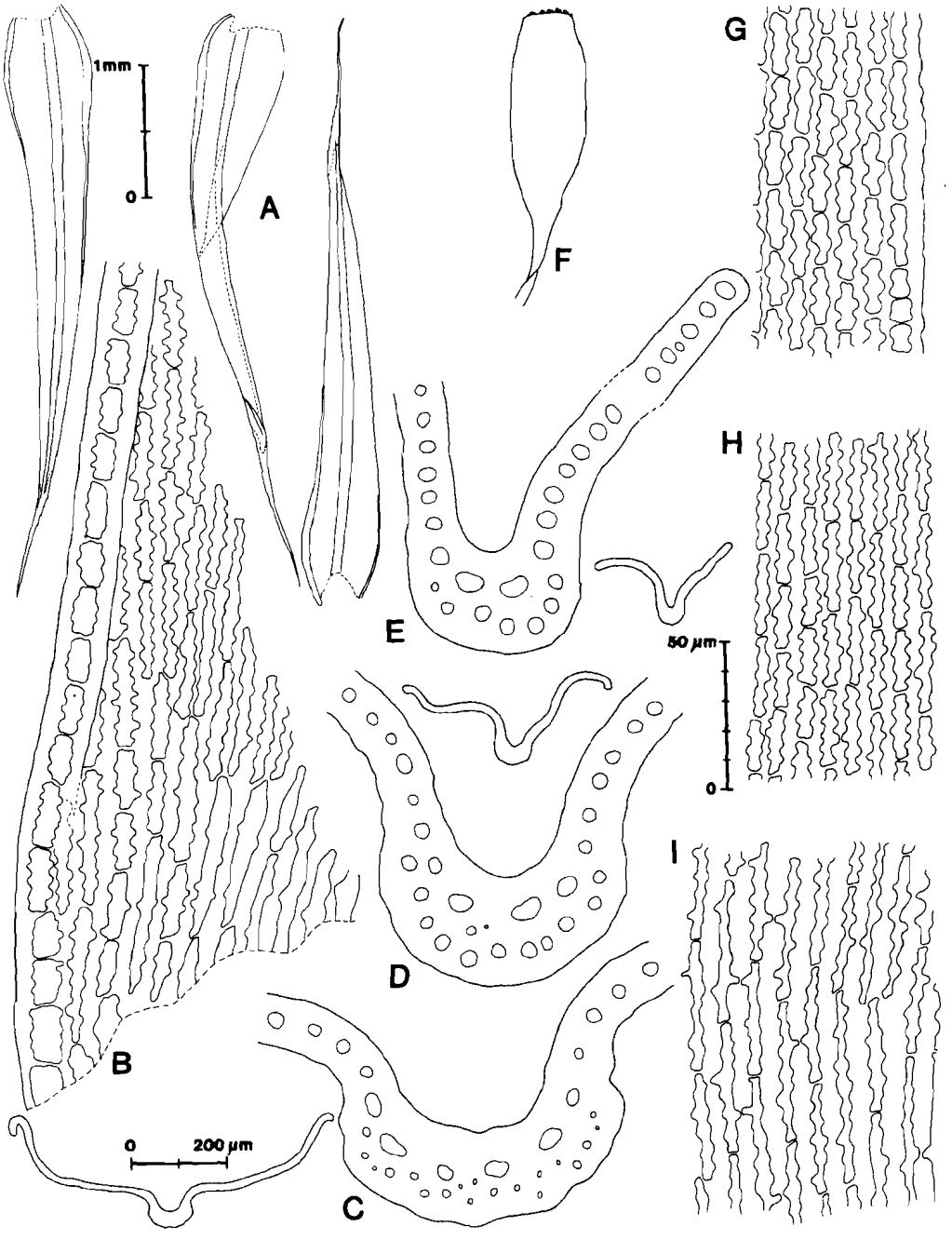

Fig. 21. *Racomitrium lawtonae*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (Canada: B.C., Louise Isl., Queen Charlotte Isls., Schofield 37323 - CANM.)

Diagnostic characters

(1) Plants large, yellowish or olivaceous in upper part, sometimes grayish (due to long hair-points). (2) Stem very robust, elongate and little branched. (3) Leaf long and m. broad (4.0-5.5 x 0.6-0.8 mm). (4) Hair-point +, 0.5-1.5(2.6) mm, not flexuose, distantly and acutely denticulate, not spinulose. (5) Margin recurved (m. long/short, short), uni/bi (1, rare spots in upper part), uneven. (6) Costa m. broad below and narrow above (75-100/40-50 µm), stratosity/ventral cells (3(-4)/4-5, 2-3/3-5, 2(-3)/2-3), running into the point. (7) Lamina cells not pspp. (8) Alar cells not differentiated. (9) Pl not squarrose, pilose or the innermost (2-3) epilose and sub-hyaline. (10) Seta long (4.5-7.5 mm). (11) Urn m. long (1.2-2.4 mm). (12) Basal membrane -.

Variation

This seems to be the largest species in sect. *Laevifolia*. It exhibits the section's standard variation with regard to the length of the stems (long or short, here: from 1 to 15 cm or more), colour (usually olivaceous, but also green, brown and blackish), length of hair-points (from absent to 2.6 mm) and cell structure (usually elongate, but shorter in mod. *epilosum*). The costa is usually robust, with numerous narrow dorsal and central cells (t.s.), but sometimes it is weaker with fewer dorsal and especially fewer ventral cells. Some plants have strongly falcate or quite circinate leaves (cf. Ireland 1970: Fig. 3). This may perhaps be a modification from certain wet habitats. Usually, the leaves are evenly erect-appressed or slightly falcate when dry. There is no differentiated basal marginal leaf border, but sometimes a few shorter and wider thick-walled cells (Ireland 1976: Fig. 2-3). *Racomitrium lawtonae* is one of the least variable and most distinctive of the species in sect. *Laevifolia*.

Comparison with other taxa

1. The Asiatic counterpart of *R. lawtonae* is *R. laetum* (Fig. 19). The two have in common the yellow-olivaceous colour of the plants; the form of the leaves and the structure of the hair-point; the main structure of the costa; and the shortly recurved, uneven leaf margin. But *R. lawtonae* is about twice as robust as *R. laetum*, and therefore larger in all respects. The two are easily separated by the naked eye, and I have never met with plants which could not be placed at once. Microscopically, the differentiated basal marginal border of *R. laetum* forms a contrast to the total lack of such a border in *R. lawtonae*. The leaf margin is slightly more broadly and longly recurved in *R. lawtonae*. The inner perichaetial leaves of *R. laetum* is small, ovate and hyaline, and in *R. lawtonae* they are less differentiated (see Descriptions and Figs. 3B, 4A). The seta and urn are shorter in *R. laetum* than in *R. lawtonae*. No doubt, the two should be treated as different species.

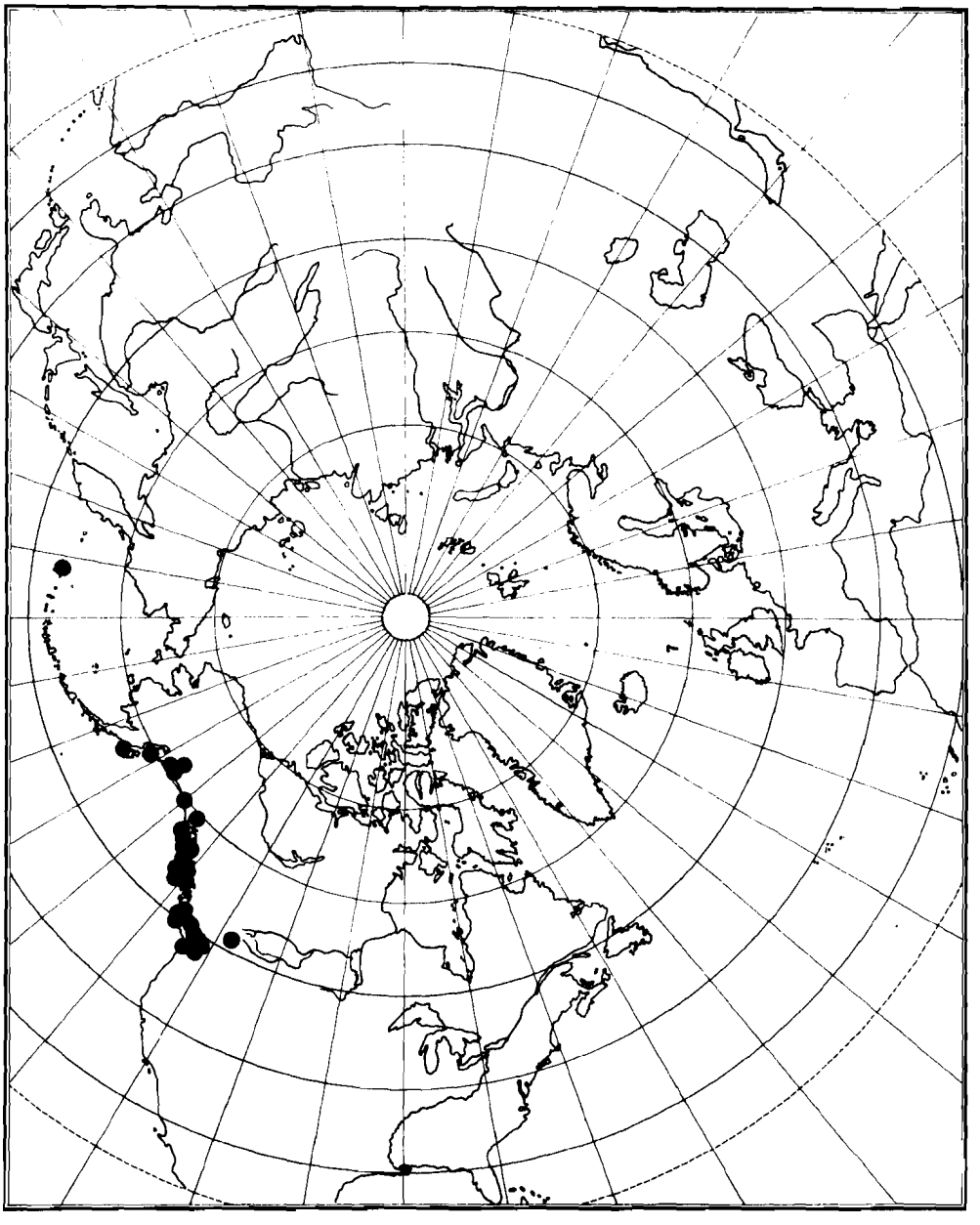

Fig. 22. Distribution of *Racomitrium lawtonae*.

2. In the Pacific Northwest including SE Alaska, *R. affine* (Fig. 23) is often made up of elongate plants which in habit and colour imitate *R. lawtonae*. Several such herbarium specimens of *R. affine* were named *R. lawtonae*. Some mixed specimens have also been seen, and the two may really be similar. But they are not closely related, and there are no real problems in distinguishing between them. *Racomitrium affine* has, e.g., less straight and less closely upright leaves; a flexuose, slightly decurrent hair-point; more longly recurved and not uneven leaf margin; and different structure of cells, cell walls (more pseudopapillose in *R. affine*) and costa (see Descriptions).

3. Ireland (1970) compared *R. lawtonae* with several quite unrelated *Racomitrium* species, as well as with *R. heterostichum* (Fig. 27) "with its many varieties and forms which some bryologists recognize as distinct species". Regarding *R. lawtonae/R. affine*, see 2. Much the same differences exist between *R. lawtonae* and *R. heterostichum*, as between it and *R. affine*. The costa of *R. heterostichum* is usually broad, and bistratose and canaliculate in the middle and upper part of the leaf.

4. For differences between *R. lawtonae* and *R. occidentale*, see the latter species.

Habitat

In the protologue (Ireland 1970) *R. lawtonae* is said to grow on noncalcareous boulders and cliffs, mostly in wet situations near streams and waterfalls, and to occur from sea level and up to 830 m a.s.l.

Distribution

Racomitrium lawtonae is known from western N. America (Fig. 22); its distribution has previously been mapped by Ireland (1976: Fig. 1, q.v.). The species is known from coastal localities in Washington and British Columbia; SE Alaska north to Yakutat Bay; from Prince William Sound to Kodiak Isl.; and from Attu Isl., SW Alaska. In addition it is known from the interior of British Columbia ("Near crossing of Eagle River on Hwy I, ca. 22 mi W of Revelstoke, ca. 51°00'N, 118°22'W, Schofield & Tan 60533" - ALTA, CANM); this and some other localities were not known by Ireland (1970, 1976).

5.5 THE *HETEROSTICHUM* SUBGROUP

Innermost bracts strongly modified, hyaline and epilose or rarely with a short hair-point and then chlorophyllous close to the point; outer bracts not squarrose when wet. Hair-point (when present) often long and flexuose, denticulate;

margin unistratose or more rarely bistratose; costa three- to four-stratose; no distinct basal marginal border.

Seven species: *R. affine*, *R. depressum*, *R. heterostichum*, *R. obesum*, *R. obtusum*, *R. pacificum*, *R. venustum*. The species in the subgroup appears to constitute a natural assemblage of related taxa.

5.5.1 Key to the taxa in the *heterostichum* subgroup

1 Leaf epilose (does not include very rare epilose ecads of *R. heterostichum* and *R. obesum*) 2
1 Some or at least one leaf pilose 6
2 Margin distinctly uneven, 2-stratose for 1-3 cell rows in upper part (sometimes less 2-stratose); costa narrow (50-80 µm) below, and there 3-stratose; leaf < 2.25 mm long (Fig. 35) (13) *R. venustum* (epilose ecads)
2 Margin smooth (or slightly uneven), 1-stratose or sometimes more 2-stratose; costa broader (80-120 µm or more) below and there at least 3-4 stratose; leaf > 2.25 mm long 3
3 Margin recurved to about 1/2 the leaf length on one side and more shortly recurved or nearly or quite flat on the other side 4
3 Margin recurved towards the apex on both sides or slightly shorter on one side 5
4 Leaves concave, usually distantly set, all or most leaves larger than 3 x 1 mm; alar group not well-defined, of elongate, thin-walled and slightly differentiated cells (Fig. 25) (8) *R. depressum*
4 Leaves not concave, densely set, all or most leaves smaller than 3 x 1 mm; alar group well-defined and sometimes auriculate, of short, more thick-walled and porose cells (Fig. 33) (12) *R. pacificum*
5 Margin broadly recurved/revolute towards the apex; costa broad and canaliculate throughout, with 4-7 ventral cells in the middle part (Fig. 31) (11a) *R. obtusum* f. *obtusum*
5 Margin less broadly and sometimes more shortly recurved; costa not canaliculate, and ventrally flat towards the base, with 3-4 ventral cells in the middle part (Fig. 66) (7) *R. affine* (epilose ecads)
6 Costa broadly canaliculate in mid-leaf, and there with 4-8 ventral cells, moderately dorsally convex 7
6 Costa not or less obviously canaliculate in mid-leaf, and there with 3-4 ventral cells, strongly dorsally convex 9
7 Leaf margin bistratose for 1-3 cell rows in the upper part, uneven; lamina distinctly narrowed at the connection with the hair-point, which is subterete above (Fig. 29) (10) *R. obesum*
7 Leaf margin unistratose or less bistratose, smooth; lamina slightly narrowed at the connection with the hair-point, which is broader and flatter 8
8 Capsule usually ellipsoid or obovate, with short cribrose teeth and high (to 75 µm) basal membrane; hair-point usually short and not or slightly flexuose, with some upper leaves brevipilose or epilose; margin broadly recurved/revolute towards the apex; upper leaves frequently yellow-oliva-

ceous (Fig. 31) (11b) *R. obtusum* f. *trichophorum*

8 Capsule usually oblong-cylindrical, with longer not cribrose teeth and shorter (to 50 µm) basal membrane; hair-point usually long and flexuose, with all (upper) leaves pilose; margin less broadly recurved; upper leaves normally olivaceous green (Fig. 27) (9) *R. heterostichum*

9 Leaf margin uneven, usually 2-stratose for 1-2(3) cell rows (sometimes with 1- or 3-stratose spots) in the upper part; hair-point stout, slightly or not flexuose and strongly spinulose 10

9 Leaf margin not uneven, usually 1-stratose or sporadically 2-stratose for 1(-2) cell rows in the upper part; hair-point softer, usually flexuose and less spinulose 11

10 Plant robust, not or slightly branched; lamina strongly contracted at the connection with the hair-point; costa broad (85-120 µm) with 4-9 ventral cells below (Fig. 29) (10) *R. obesum*

10 Plant medium robust to small, much branched; lamina not or slightly contracted at the connection with the hair-point; costa narrow (50-80 µm) with 3-5 ventral cells below (Fig. 35) (13) *R. venustum*

11 Costa canaliculate and predominantly bistratose in its middle and lower upper part (Fig. 27) (9) *R. heterostichum*

11 Costa not canaliculate and predominantly 3-stratose in its middle and lower upper part (Fig. 23) (7) *R. affine*

(7) *Racomitrium affine* (Schleich. ex Web. et Mohr) Lindb.
Fig. 23-24, 67A.

Trichostomum affine Schleich. ex Web. et Mohr, Bot. Taschenb. 127. 1807 (*T. affine* Schleich., Plant. Crypt. Helv. Exs., Cent. 3, no. 18. 1805 *nom. nud.*; *T. affine* Schleich. ex Schrad., Neues J. f. Bot. 1(2): 198. 1805 *nom. nud.*). - *Racomitrium heterostichum* var. **affine* (Schleich. ex Web. et Mohr) Lesq., Mem. Soc. Sc. Neuchatel 3(3): 28. 1846 *nom. illeg. incl. var. prior.* (var. *alopecurum* Hüb. 1833; var. *fasciculatum* Bruch et Schimp. in Moug. et Nestl. 1840). - *R. affine* (Schleich. ex Web. et Mohr) Lindb., Act. Soc. Sc. Fenn. 10: 552. 1875. - *Grimmia* **affinis* (Schleich. ex Web. et Mohr) Lindb., Musci Scand. 29. 1879 *hom. illeg. non* Hornsch., Flora 2: 85, 443. 1819. - *G. heterosticha* [subsp.] ✯*G. affinis* (Schleich. ex Web. et Mohr) Kindb., Bih. K. Svensk. Vet. Ak. Handl. 7(9): 114. 1883. - *Racomitrium heterostichum* [subsp.] *R.* II*affine* (Schleich. ex Web. et Mohr) Amann, Fl. Mouss. Suisse 2: 143. 1919. - Type: "Schleich.[er's Pl. Crypt. Helv. Exs.] Cent. 4 [err. pro 3!], n. 18." (Lectotype: Helvetia, Valais. In sylvis vallis Servan. Schleicher's Pl. Crypt. Helv. Exs., Cent. 3, no. 18. - LAU-Schleicher. Paralectotypes: BM, G, G-Hedw./Schwaegr., G-De Candolle, S-Swartz?, JE-Schliephacke?; Frisvoll 1984a: 302, Fig. 1).

Trichostomum **alopecurum* Schkuhr 1811 *nom illeg. incl. spec. prior.*, vid. *Racomitrium heterostichum* var. *alopecurum* Hüb. - Type: Homotypic with *T. affine* Schleich. ex Web. et Mohr.

Trichostomum fastigiatum (Hoffm.) ex Wallr., Fl. Crypt. Germ. 1: 175. 1831 (*Bryum* **fastigiatum* Hoffm., Deutschl. Flora 40. 1796 *nom. inval.*). - *Racomitrium* **fastigiatum* 'Wallr.' in Limpr., Laubm. Deutschl. 1: 802. 1889 *comb. inval. in synon.* - Type: "In pinetis infra Bructerum m. prope Schierke." (Neotype nov.: "*Racomitrium fastigiatum*" - GZU-Hoppe 3436).

Racomitrium heterostichum [var.] ß. *alopecurum* Hüb., Musc. Germ. 208. 1833 ('*Alopecurum*') (*Trichostomum* **alopecurum* Schkuhr, Deutschl. Krypt. Gew. 2(2): 77. *35.* 1811 *nom. illeg. incl. spec. prior.* [*T. affine* Web et Mohr, 1807]; *Racomitrium* **alopecurum* Brid., Mant. Musc. 79. 1819 *nom. illeg. incl. spec. prior.*). - *Grimmia heterosticha* [var.] ß. *alopecura* (Hüb.) C. Müll., Syn. 1: 808. 1849. - *Racomitrium heterostichum* f. b. *alopecurum* (Hüb.) Boul., Fl. crypt. Est, Musc. 642. 1872. - Type: "ß. in der Schweiz (Schleicher), im Schwarzwald (Braun), und am Brocken (Hübener)." (Hübener 1833). (Lectotype nov.: Same as for *Trichostomum affine* Schleich. ex Web. et Mohr.).

Trichostomum heterostichum var. *fasciculatum* Bruch et Schimp. in Moug. et Nestl., Stirp. Crypt. Vog. Rhen. fasc. 11: n. 1010. 1840 (*T. affine* Web. et Mohr, 1807). - Type: Homotypic with *Trichostomum affine* Schleich. ex Web. et Mohr.

Racomitrium heterostichum var. γ *gracilescens* Bruch et Schimp. in B., S. et G., Bryol. Eur. 3: 145. *266γ.* 1845 (fasc. 25-28 Mon. 9. *3γ*). - *Grimmia heterosticha* [var.] γ. *gracilescens* (Bruch et Schimp. in B., S. et G.) C. Müll., Syn. 1: 808. 1849. - *Racomitrium affine* var. ß. *gracilescens* (Bruch et Schimp. in B., S. et G.) Lindb., Act. Soc. Sc. Fenn. 10: 553. 1875. - *R. heterostichum* f. c. *gracilescens* (Bruch et Schimp. in B., S. et G.) Boul., Fl. crypt. Est, Musc. 643. 1872. - *Grimmia* **affinis* var. ß. *gracilescens* (Bruch et Schimp. in B., S. et G.) Braithw., Brit. Moss. Fl. 2: 42. 1888. - Type: "var. ß [*alopecurum*] locis humidis vel irroratis montium editiorum; var. γ locis similibus et hic illic promiscue cum var. ß." (Lectotype nov.: *Racomitrium heterostichum* var. γ. Bryol. Eur. [BRD] Donnersberg am gehauenen Stein. 31. Dec. 1839 Gumbel." - BM-Bruch/Schimp. Isolectotypes: BM-Bruch/Schimp., S).

Grimmia heterosticha [var.] ß. *elongata* T. Jens., Bryol. Dan. 145. 1856. - *Racomitrium heterostichum* var. *elongatum* (T. Jens.) Par., Ind. Bryol. ed. 2, 4: 152. 1905. - Type: "Afarterne ß og γ [*gracilescens*] forekomme paa Bornholm, ..." (Lectotype nov.: "*Rhacomitrium heterostichum* Brid. forma *elongata*. [Dania] Bornholm: Almindingen 1854 Th. Jensen." - S. Paralectotype?: "Bornholm: Almindingen 8/56 Th. Jensen." - C).

Racomitrium heterostichum f. **brevipilum* Zett., Rev. Grimm. Skand., Add. p. [3] et Grimm. et Andr. exs. No. 30a. 1861 *nom. nud.* - Orig.: Zetterstedt's Grimmieæ et Andreææ exsiccatæ No. 30a. [Suecia] "In saxis montis Tystingsbergen paroeciæ Wiby, Nericiæ. Jul. 1855. J.E. Zetterstedt." - RO, TRH, UPS, etc.

Racomitrium microcarpon var. *grimmiaceum* De Not., Atti Univ. Genova 1: 675. 1869. - Type: "Var. in Valle Formazza infra Andermatt, ad moles graniticas ipse

legi autumno 1859." (Holotype: "*Racomitrium*. [Italy] Ad moles graniticas in sylva ... Andermatt vallis Formatiæ, Legi ... 1859." - RO-De Notaris).

Racomitrium heterostichum var. *compactum* Röll, Deutsch. Bot. Monatsschr. 4: 104. 1886. - *R. heterostichum* subsp. **vulgare* f. *compactum* (Röll) Podp., Consp. 294. 1954. - Type: "auf Porphyrfelsen am Weissenstein cfr.!! und steril bei Schmiedefeld!! (am letzten Standort vielleich nur Jugendform)." (Lectotype nov.: "*Racomitrium heterostichum* Brid. var. *compactum* Rl. (in Nachtrag 1883). Weissenstein bei Schmerbach in Thüringen, Porphyrfelsen, 14/5 69." - WB-Röll).

Racomitrium heterostichum var. *micropoides* Kindb. in Röll, Hedwigia 35: 65. 1896. - *R. heterostichum* [subsp.] ✲*R. micropoides* (Kindb. in Röll) Kindb., Eur. N. Am. Bryin. 239. 1897. - Type: "Cascaden: Enumclaw, Wash. No. 350." (Holotype: "350. *Racomitrium heterostich.* Brid. ✲*micropoides* Kindb. Nord-Amer. Enumclaw, Wash. 7/7 88 Röll." - S-Kindberg).

Racomitrium heterostichum var. *limprichtii* Loeske, Laubm. Eur. 1: 184. 1913 ('*Limprichtii*'). - Type: "v. *alopecurum* (Schkuhr) Hüb. ex p. oder *Rh. affine* Lindberg apud Limpricht (I., p. 802)." Reference to Limpricht's (1890) localities of *R. affine*: Schlesien, Plagwitzer Steinbergs bei Löwenberg (Limpricht); Thüringen, bei Elgersberg und im Sieglitztal (Everken); Westfalen, Bruchhauser Steine (H. Müller); Tirol, bei Trient (Venturi); und die oberen Vogesen (Schimper); and new localities given by Loeske for var. *affine* (err. pro var. *limprichtii*): Bodetal des Harzes (Mönkemeyer, Loeske); Rotliegendem bei Eisenach (Loeske, Janzen, Krüger). (Lectotype nov.: "*Racomitrium affine* Lindb. Fl. Hercyn: Bodethal, an nassen Felsen, Juli 1900 Mönkemeyer" - JE-Schliephacke. Paralectotype: "*R. affine* (Schleich.) Lindb. Thüringen, Eisenach: Breitengescheid. Feuchte, besonnte Felsen. 340 m. Rotliegendes. 14.5.1912 Krüger." - JE).

Plants olivaceous in upper part, brownish or blackish in lower part, or brownish or blackish in all parts, usually not grayish, in loose, often wide mats or cushions. **Stem** up to 5 cm or more, from subpinnately branched to almost or quite unbranched. **Leaves** frequently secund along the whole shoot and especially at the stem apex, (1.7)2.5-3.4(4.0) x 0.5-0.8 mm. **Hair-point** erect-flexuose, from absent or very short to long, frequently about 0.5-1 mm (T: 0 - > 1 mm), yellowish rather than whitish, denticulate at the margin and sometimes spinulose at the dorsal side, usually not or slightly (nevertheless sometimes distinctly) decurrent down margin of lamina. **Margin** recurved on both sides towards the hyaline point, in upper part quite unistratose or with bistratose spots, rarely predominantly bistratose in one cell row. **Costa** strongly convex at the dorsal side and flat at the ventral side towards the base, in lower part 80-100(110) µm broad, in upper part 60-70 µm broad, reaching towards and sometimes slightly into the point, in basal part three- to four-stratose with large ventral and small dorsal cells (d. 11-18, c. 11-14, v. 5-7), in middle part three-stratose with cells homogeneous (d. 11-13, c. 5-7, v. 3-4), in upper part bi- to three-stratose (d. 5-8, c. 0-3, v. 2-3). **Lamina** unistratose, or very rarely with bistratose spots in upper part. Basal **laminal cells** elongate (T: 17-36 x 7-10 µm), middle and upper cells usually rectangular to isodiametric (T: 10-25 x 7-10 µm) but also

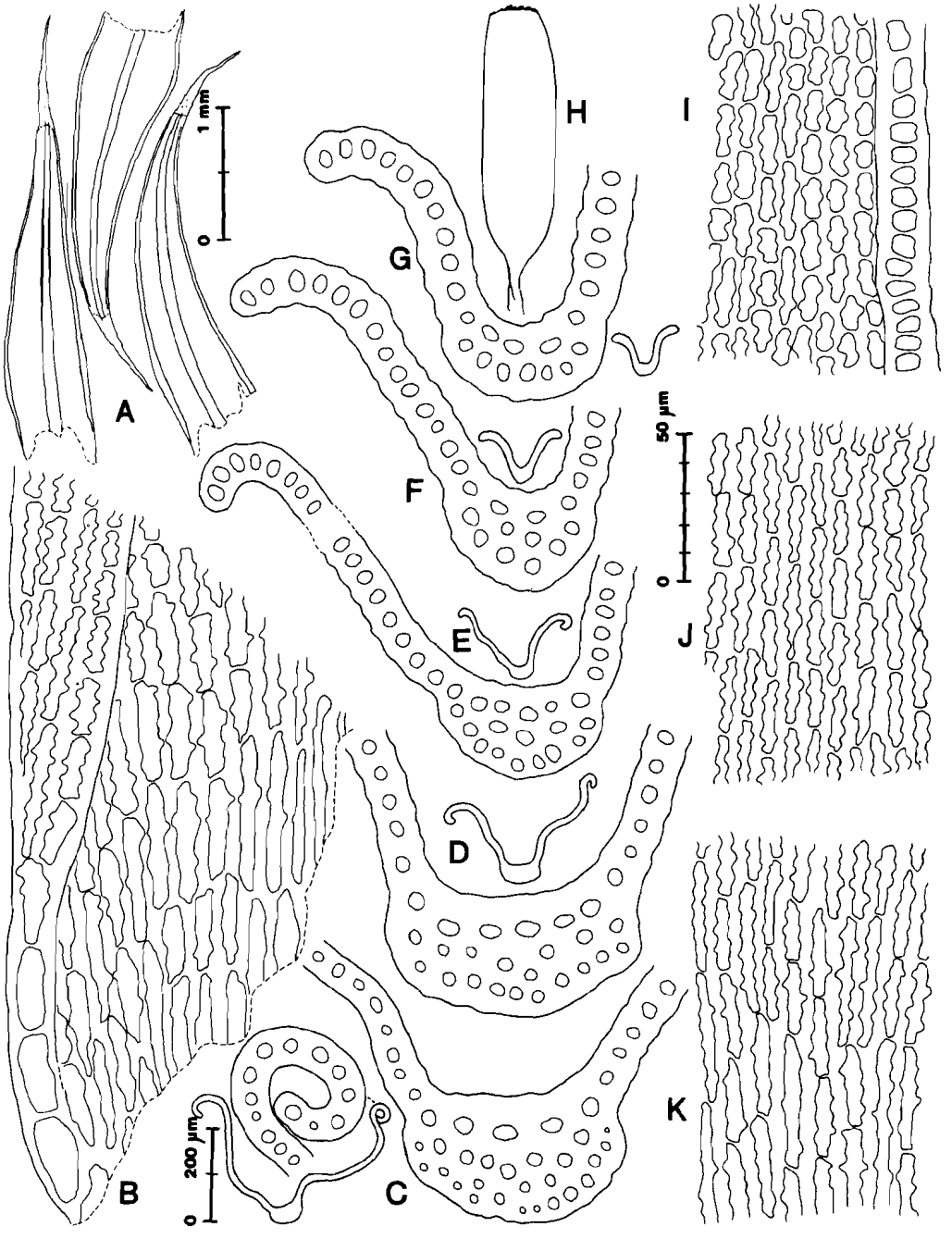

Fig. 23. *Racomitrium affine*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. (U.S.A.: Washington, Olympic Natl. Park, Ireland 6821 - CANM.)

predominantly isodiametric or elongate, upper marginal cells like the short upper cells (T: 7-15 x 5-12 µm) or sometimes transversely elongate, cell walls not or slightly bulging dorsally and ventrally. **Alar cells** usually yellowish and slightly differentiated, but sometimes forming a small group of wide cells, or rarely reddish and slightly auriculate, 1-5 esinuose cells in the marginal row.

Perichaetial leaves not squarrose when wet, the inner (3-6 or more) leaves epilose or rarely pilose, ± ovate, the innermost one(s) (almost) hyaline with crenulate margin, and the next with successively more chlorophyllous and eventually pilose apex, median (chlorophyllous) perichaetial leaves sometimes very broad-obtuse. **Seta** about 4-10 mm. **Urn** oblong-cylindrical or sometimes ovoid or slightly curved (1.5-3.2 x 0.6-0.8 mm), exothecial cells irregularly rectangular, 2-4 rows of small incrassate cells at the mouth. **Teeth** about 200-400 µm long, of two prongs with median line perforated rather than continuous, distinctly papillose, basal membrane present (about 30 µm). **Spores** 12-20 µm.

Diagnostic characters

(1) Plants olivaceous and often blackish. (2) Stem often elongate. (3) Leaf m. long and m. broad (2.5-3.4 x 0.5-0.8 mm). (4) Hair-point +/-, 0.5-1.0 mm, denticulate. (5) Margin recurved (long, long), uni/bi (1, in spots or throughout). (6) Costa m. broad below and broad above (80-100/60-70 µm), stratosity/ventral cells (3-4/5-7, 3/3-4, 2-3/2-3), ventrally flat near the base. (7) Lamina with rare bistratose spots in upper part. (8) Alar cells slightly differentiated. (9) Pl not squarrose, epilose, the innermost hyaline. (10) Seta long (4-10 mm). (11) Urn long (1.5-3.2 mm). (12) Basal membrane + (30 µm).

Variation

Racomitrium affine is very variable with regard to the colour and size of the cushions and plants, and the length of the hair-point and lamina cells. Brevipilose leaves usually have isodiametric cells far down the lamina, and the variation in the length of the leaf cells in one area seems to be environmentally induced. In some specimens, notably in many from western N. America, the cells are very elongate also in the upper part of the leaf. But as the cell size is one of the most variable characteristics within the species group concerned, I see no reason that these ill-defined populations should be recognized taxonomically. The margin is frequently unistratose, but may include bistratose spots or be largely bistratose for one cell row. Usually, the capsule is cylindrical, but shortly ovoid or ellipsoid capsules occur. Short capsules are present in a number of specimens from Idaho (U.S.A.), and in these the setae are also short (and the inner perichaetical leaves pilose); but otherwise short capsules occur here and there throughout the distribution area of the species. Also the peristome may be more or less developed. However, all these black and light, short and elongate, erect and decumbent, pilose, subepilose and epilose plants with long or short lamina cells, etc., are closely linked by a remarkable constancy

in the structure of their costa. Because of that I consider *R. affine* a well defined species. And all its modifications and supposed micro-genetically different ecads are usually easily recognized and placed in the species as circumscribed in this paper. Weak plants may have the costa three-stratose also at the base, with a forth stratum sometimes indicated by a single cell; and there may also be a similar indication of a fifth stratum; but these are exceptions.

The plant described as *R. heterostichum* var. *gracilescens* (Fig. 66) is a genetically fixed epilose state of *R. affine* (pilose *R. affine* is present in the lectotype specimen). This is a case parallel to that of *R. obtusum* f. *obtusum* (epilose) and its f. *trichophorum*. Var. *gracilescens* is a rare plant, but those who wish to have a name for it can use the available combination *R. affine* var. *gracilescens* (Bruch et Schimp. in B., S. et G.) Lindb.

Racomitrium affine was satisfactorily described for the first time when it was typified (Frisvoll 1984a). Usually, it has been said to possess a bistratose margin (e.g. by Limpricht 1890; Loeske 1913, 1930; Lawton 1972: 255); but because its margin is often predominantly or quite unistratose, it has been confused with most of the many *Laevifolia*-species with which it grows.

Comparison with other taxa

1. *Racomitrium sudeticum* (Fig. 15-17) has often been used as the name for black specimens of *R. affine* mod. *subepilosum-vel-brevipilum*. However, *R. sudeticum* differs from all ecads of *R. affine* in its narrower leaf apex and narrower and stouter hair-point. The alar cells of *R. sudeticum* are (usually) more numerous, and the costa is usually but three-stratose and not flat on the ventral side towards the base. The upper part of the costa of *R. sudeticum* is more dorsally convex than in *R. affine* (Frisvoll 1984a: 300). Some plants of *R. sudeticum* with an unusually long hair-point will be recognized by the form of the leaves and stratosity of the costa. The seta and urn of *R. sudeticum* are distinctly shorter than in *R. affine*, and the structure of their perichaetial leaves is different. There are no real problems in distinguishing between them.

2. Subpinnate plants of *R. affine* with elongate upper cells have been named *R. microcarpon* (Fig. 39), but that species is very different in, e.g., the *structure* of the cells (including the basal marginal border), costa, perichaetial leaves, and urn.

3. *Racomitrium obtusum* f. *trichophorum* (Fig. 31) may imitate *R. affine*; the two have much the same colour and general appearance. But the costa of *R. obtusum* is bistratose in its central part, and canaliculate and often broader, and this difference alone will always distinguish between the two. Also the epilose *R. obtusum* f. *obtusum* and *R. affine* 'var. *gracilescens*' are separated by the same characteristics. In some moss floras *R. obtusum* is treated as a subordinate taxon of *R. affine*, but the relationship of *R. obtusum* is with *R. heterostichum* and not with *R. affine*.

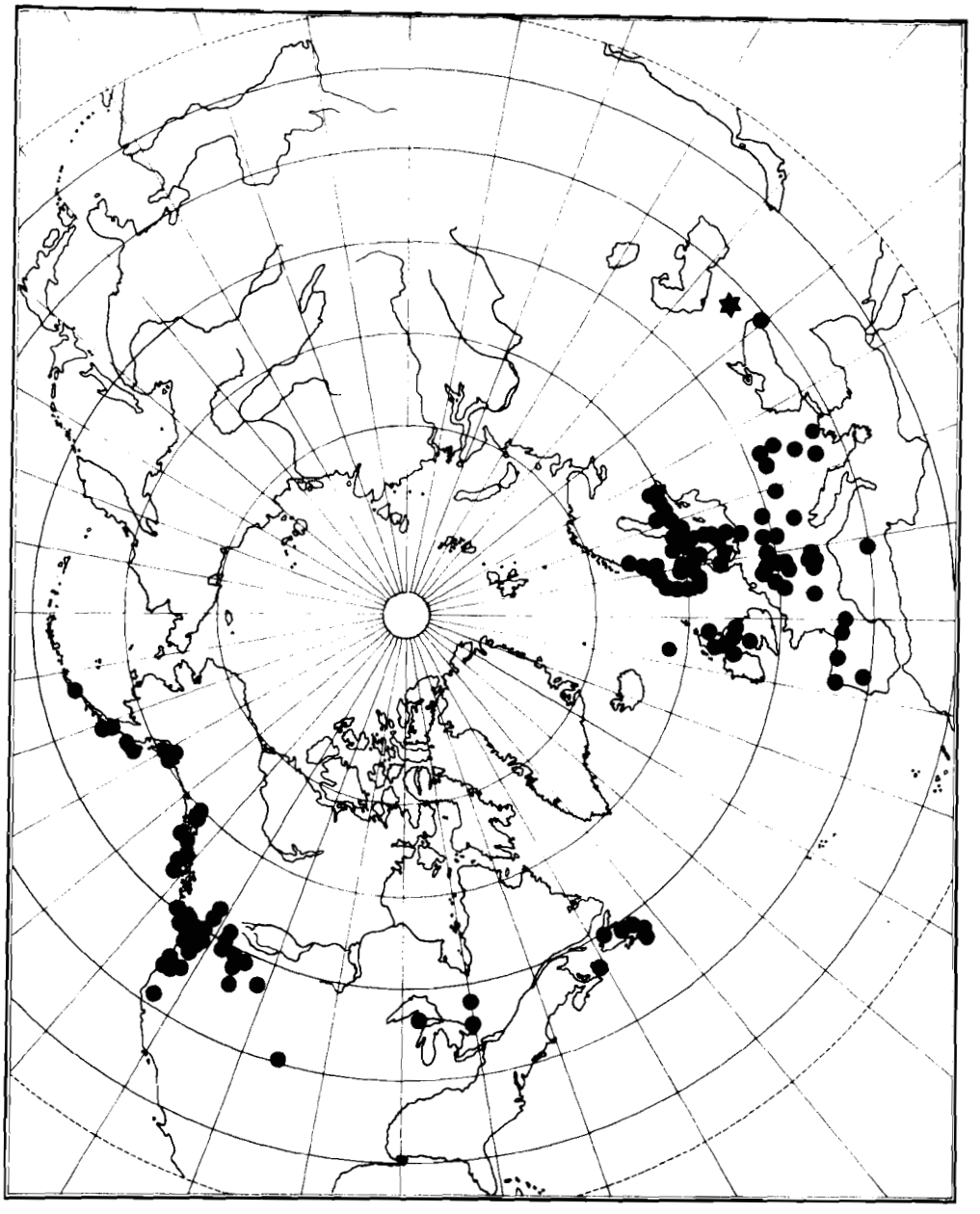

Fig. 24. Distribution of *Racomitrium affine*. ★ locality inexact.

4. Regarding the difference between *R. affine*, and *R. heterostichum*, *R. himalayanum*, *R. lawtonae*, *R. macounii*, *R. obesum*, *R. occidentale*, *R. pacificum*, and *R. venustum*, see these species.

Habitat

Racomitrium affine grows on rocks in moist or periodically moist localities. It co-occurs with many species in the section, both in western Europe and N. America, and appears to have wider ecological amplitudes than some of these other species. It is, e.g., frequently mixed with *R. heterostichum*, which, however, is unable to grow in many wet and/or shady localities where *R. affine* grows.

Distribution

Racomitrium affine is known from Europe, Asia (NE Turkey) and N. America (Fig. 24). In Europe it grows in the Caucasus; the mountains of central and (in part) south Europe, from Romania in the east to Portugal in the west; the British Isles; and the southern and western parts of Fennoscandia. In America it is known from Labrador and Nova Scotia; the Great Lakes Basin and vicinity; one isolated locality in Colorado (Rocky Mountain National Park); the Rocky Mountains of Idaho, Montana and British Columbia; and from northern California through Oregon, Washington and S. Alaska west to Unalaska Island.

(8) *Racomitrium depressum* Lesq.
Fig. 25-26.

Racomitrium depressum Lesq., Mem. California Ac. Sc. 1: 14. 1868. Type: "falls of the Yosemite Valley, Bol." (Isotype: "Ex herb. Leo Lesquereux purchased 1911. *Racomitrium depressum* Lesq. 'Falls of the Yosemite - Bolander' Mem. Cal. Acad 1: 14. - ? " - NY).

Plants large, olivaceous and sometimes blackishly tinged above, brown below, in loose or dense cushions or mats. **Stem** very robust, up to 4.5 cm in herbarium specimens, but sometimes much longer (13 cm according to Frye 1917), from simple to dichotomously and fastigiately branched, sometimes with a few branchlets. **Leaves** imbricate or distantly spaced, large and ventrally concave, erect or falcate, (2.6)3.0-4.0(4.5) x 0.95-1.5 mm, broad towards their apex, in old stem parts sometimes eroded and present only as costae. **Hair-point** absent; leaf apex acute or obtuse and without or with a few low marginal crenulations or teeth. **Margin** broadly recurved to 2/3-3/4 the leaf length on one side, and flat or more narrowly recurved to 1/2 the leaf length on the other side, unistratose. **Costa** usually flat and very broad, frequently biconvex in part, (80)105-150(180) µm broad at the base and 55-80(130) µm broad in upper part, reaching towards the apex, in basal part three- to four- (to five-)stratose (d. 13-24(32),

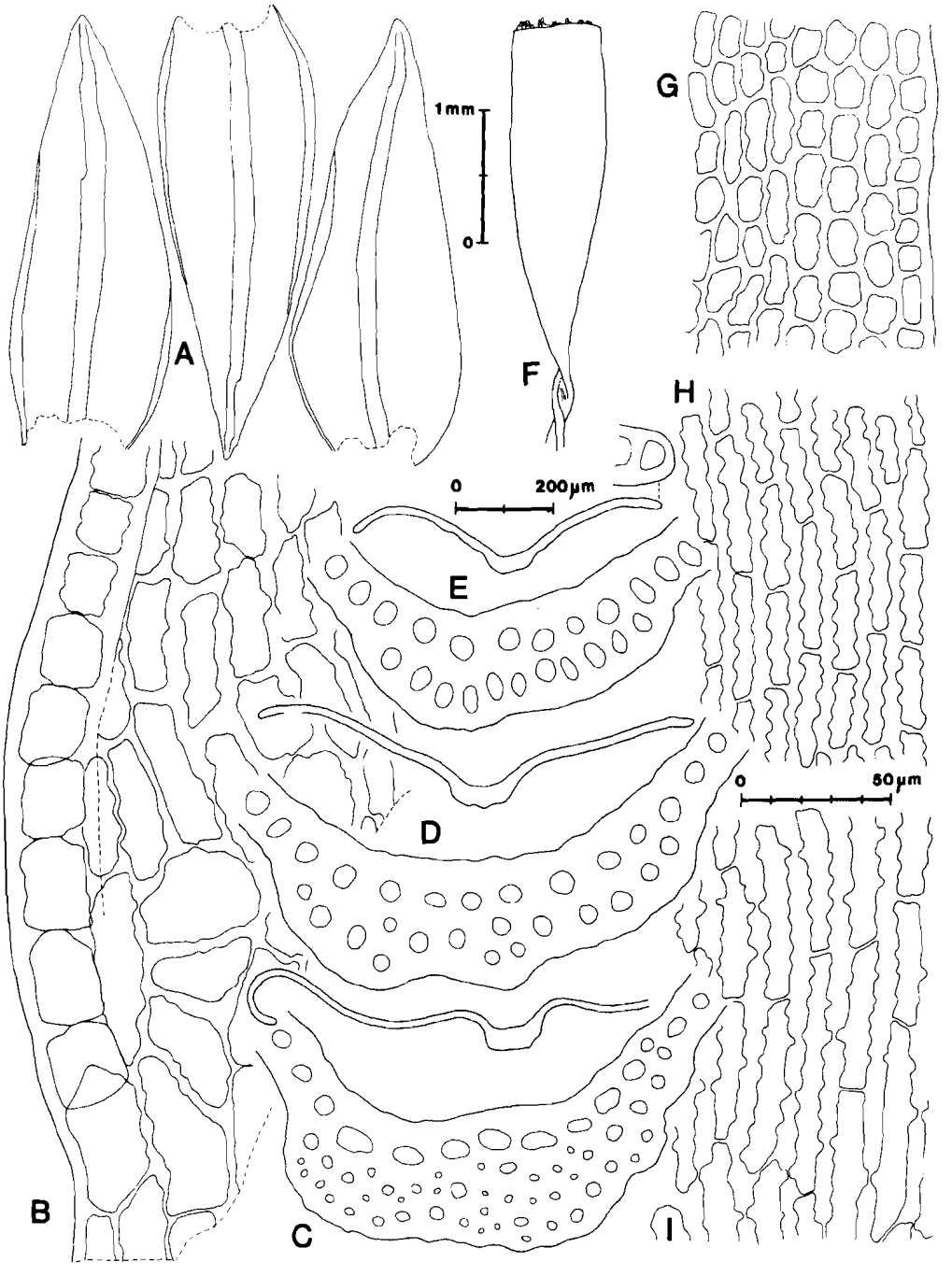

Fig. 25. *Racomitrium depressum*. a. Leaves. b. Alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (a-e, g-i. Isotype - NY. f. U.S.A.: California, Plumas Co., Leiberg 5414 - NY.)

c. (1)5-15(20), v. (5)7-11(15)), in central part bi- to four-stratose (d. 9-18(25), c. 0-10, v. (4)7-12), in upper part bi- to three-stratose (d. 6-11, c. 0-6, v. 4-7). **Lamina** unistratose. Basal **laminal cells** elongate (T: 37-100 x 14 µm), middle and upper cells quadrate to short-rectangular (T: 9-47 x 9-12 µm), upper marginal cells transversely elongate to short-rectangular (T: 9-16 x 10 µm), cells not or slightly pseudopapillose. **Alar cells** not differently coloured, usually large, thin-walled and elongate like the adjacent cells, hyaline or esinuose in one or rarely in more basal marginal rows, 2-8 such cells in the marginal row.

Perichaetial leaves not squarrose when wet, the innermost (1-2) leaves small and yellowish-hyaline, and the next leaves slightly differentiated and successively with more narrow hyaline margin. **Seta** about 6 mm. **Urn** reddish brown, oblong-cylindrical (1.9-2.7 x 0.7-0.9 mm), sometimes slightly curved, exothecial cells short to rectangular with thin walls and rounded corners, 1-4 rows of small cells at the mouth. **Teeth** (ca. 380 µm long,) reddish, of 2(-3) prongs which are separated by narrow slits or sometimes along their whole length, low-papillose above and almost epapillose below, basal membrane present (35-50 µm). Spores 12-16 µm.

Diagnostic characters

(1) Plants large. (2) Stem very robust, not or moderately branched. (3) Leaf long and broad (3.0-4.0 x 0.95-1.5 mm), concave. (4) Hair-point - ; apex broad, obtuse or acute, without or with minute crenulations. (5) Margin recurved (m. long, short/flat), uni. (6) Costa very broad below and broad above (105-150/55-80 µm), stratosity/ventral cells (3-4(5)/7-11, 2-4/7-12, 2-3/4-7), usually flat and frequently biconvex. (7) -. (8) Alar cells not or slightly differentiated. (9) Pl not squarrose, the innermost (1-2) small and hyaline. (10) Seta long (6 mm). (11) Urn m. long (1.9-2.7 mm). (12) Basal membrane + (35-50 µm).

Variation

The plants vary much in size, compactness and colour. They usually grow close to the water level of rivers and creeks, and it is evident that some specimens have been periodically inundated: they are muddy, and the lamina of the lower leaves eroded with only costa left. The costa is usually very broad, more than 100 µm at the base, and rather flat or frequently biconvex. One specimen (Showers 2437) differs from the other in having a canaliculate and narrower costa, 80-100 µm at the base, and consequently also fewer costal cells (t.s.). The plants of this specimen are strongly falcate and have not grown in or close to water; probably, this accounts for the difference in the structure of the costa (the costa of mosses growing in water are often broad and flat). The size and cell structure of the leaves of this aberrant specimen are as in the other specimens.

A few taxa in the mainly xerophilous family Grimmiaceae have adopted them-

selves to a life close to or in running water; and the life form of the taxa is the same. *Scouleria* and *Hydrogrimmia* are such genera, and in *Schistidium* we have *S. rivulare* (Brid.) Podp. and *S. agassizii* Sull. et Lesq. In *Racomitrium* there are a few subaquatic species in sect. *Papillosa*, notably *R. aciculare* (Hedw.) Brid. and *R. aquaticum* (Schrad.) Brid., and in sect. *Laevifolia* *R. depressum*. Jones (1933) placed *R. depressum* between *R. aciculare* and *R. aquaticum*, but the apparent similarity is of convergent and not taxonomic nature.

Comparison with other taxa

1. Regarding differences between *R. depressum* and *R. pacificum* (Fig. 33), see the latter.

2. The European *R. obtusum* (Fig. 31) has a strongly recurved or revolute margin and a much narrower leaf, 0.5-0.7 mm broad, and it grows in less wet habitats.

3. No other species in sect. *Laevifolia* is likely to be confused with *R. depressum*. It has been confused with *R. aciculare* and *R. aquaticum*, which have papillose leaves and belong to a different section (see Variation).

Habitat

The labels mention "dripping rock", "on rock at water level of small creek" and "falls" as habitats of *R. depressum*. One specimen is collected from "dry, south facing rocky cliffs", according to the label (this is the aberrant plant mentioned above).

Distribution

Racomitrium depressum is known from western N. America (Fig. 26). It has a limited distribution in the high mountains of California and adjacent Nevada (mainly in Sierra Nevada).

Specimens examined

U.S.A.: California, Off highway from General Grant Grove to Fresno, Sequoia Nat'l Park, MacFadden 21881 (WTU, 2 sp.); Yosemite Valley, 1870 Bolander 375 (WTU); falls of the Yosemite, VII.1870 Bolander (TRH); Bucks Ranch, Plumas Co., VII.1900 Leiberg (NY, 4 sp.; S); Lassen Volcanic Nat'l Park, Flatiron Ridge, Showers 2437 (WTU); headwaters of Oregon Creek N of Trinity Summit Guard Station, 41°05'N, 123°29'W, Norris & Creek 50170 (WTU). - Nevada, Lake Tahoe Basin, E side, 1 mi N of Sand Harbour, 1/2 mi up small creek from Rt 28, Lawin M-5720 (WTU).

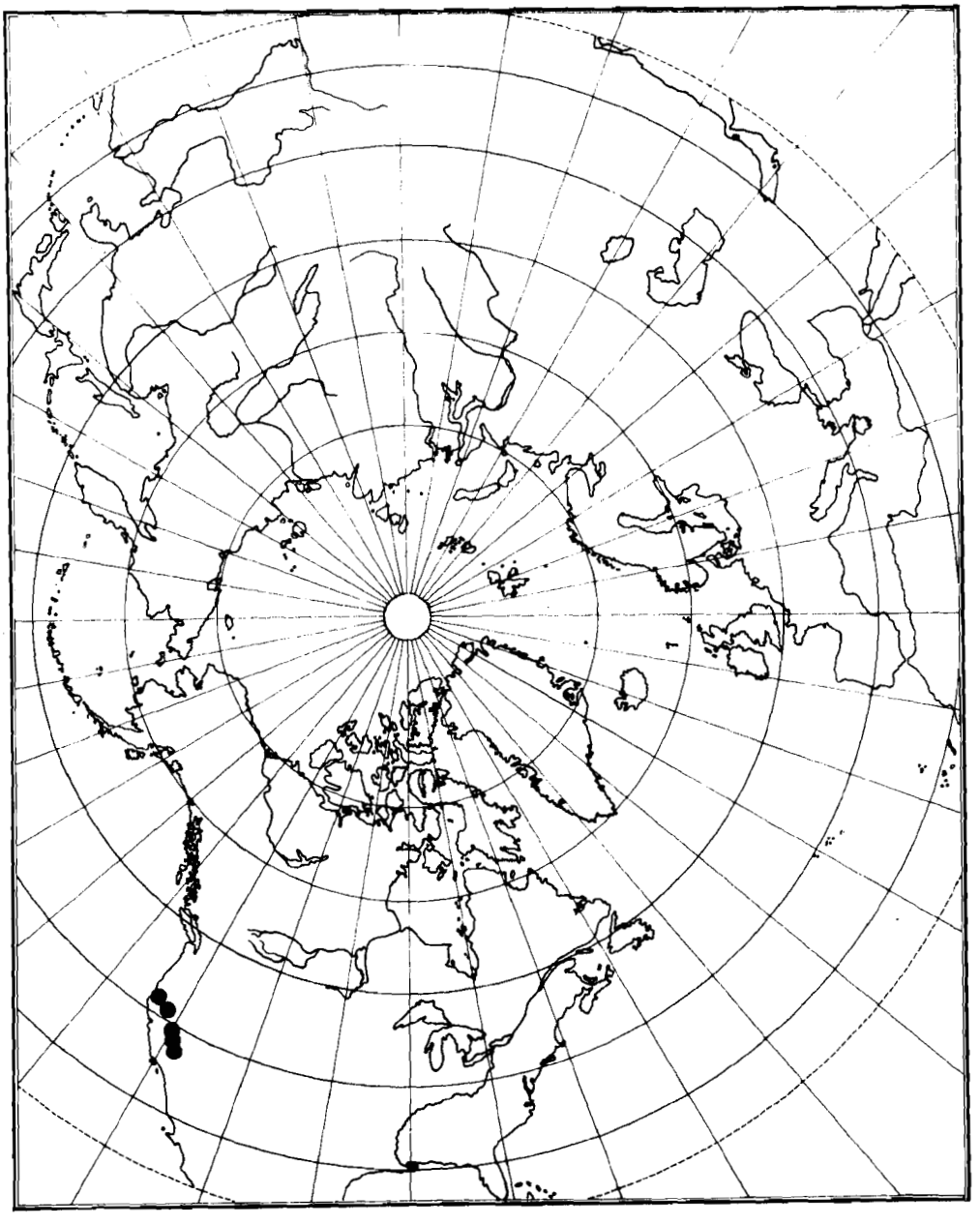

Fig. 26. Distribution of *Racomitrium depressum*.

(9) *Racomitrium heterostichum* (Hedw. ex Hedw.) Brid.
Fig. 1, 4B, 27-28, 67B.

Trichostomum heterostichum Hedw. ex Hedw., Sp. Musc. 109. 1801 (*T.* **heterostichum* Hedw. in Timm, Fl. Megap. prodr. 215. 1788 *nom. inval.*). - *Bryum heterostichum* (Hedw. ex Hedw.) Dicks., Pl. Crypt. Brit. fasc. 4: 14. 1801. - *Racomitrium heterostichum* (Hedw. ex Hedw.) Brid., Mant. Musc. 79. 1819. - *Grimmia heterosticha* (Hedw. ex Hedw.) C. Müll., Syn. 1: 807. 1849. - *Racomitrium heterostichum* f. a. **vulgare* Boul., Fl. crypt. Est, Musc. 642. 1872 *nom. illeg. incl. typ. spec.* - *R. heterostichum* f. **typicum* Chal., Grimm. Tatr. 98. 1882 *nom. illeg. incl. typ. spec.* (*'typica'*). - *R. heterostichum* var. **vulgare* Boul., Muscin. France 361. 1884 *nom. illeg. incl. typ. spec.* - *R. heterostichum* [var.] a. **eu-heterostichum* Mönkem., Laubm. Eur. 379. 1927 *nom. illeg. incl. typ. spec.* - *R. heterostichum* subsp. **vulgare* Loeske, Biblioth. Bot. 101: 207. 1930 *nom. illeg. incl. typ. spec.* - Type: "Locus saxosis, lapidosis, montanarum regionum Germaniae." (Lectotype: "*Trichostomum heterostichum* Hedw. Musc. fr. Voll. II. t. 25, E ducatu Megapolitano." - G-Hedw./Schwaegr. 732/14; Frisvoll 1984a: 305, Fig. 2).

Dryptodon carnosus (Dicks.) ex Brid., Bryol. Univ. 1: 206. 1826 (*Trichostomum* **carnosum* Dicks. ex Brid., Bryol. Univ. 1: 206. 1826 *nom. nud. in synon.*). - Type: "In Britanniâ habitat unde amicus Green misit." (Holotype: "*Dryptodon/Trichostomum carnosus* (Dicks.)" - B-Bridel).

Racomitrium heterostichum f. *incanum* Limpr., Laubm. Deutschl. 1: 806. 1889. - Type: "An den Basaltbergen Schlesiens ..." (not seen).

Racomitrium heterostichum var. *lanatum* Bauer, Deutschl. Bot. Monatsschr. 18: 180. 1900. - *R. heterostichum* subsp. **vulgare* f. *lanatum* (Bauer) Podp., Consp. 294. 1954. - Type: "Auf Schieferfelsen bei Rothau." (Isotype: "*Racomitrium heterostichum* var. *lanatum* mihi. Erzgebirge: Schieferfelsen beim Rothauer Kalkofen [= Mts. Krusné hory: opp. Kraslice, pag. Rotava], 6.6.1893, 500 m, E. Bauer." - OP).

Racomitrium heterostichum var. *amblyphyllum* Stirt., Ann. Scott. Nat. Hist. 1902(42): 112. 1902. - *R.* **amblyphyllum* (Stirt.) Stirt., Ann. Scott. Nat. Hist. 63: 179. 1907 *comb. inval. err. cit. pro R. heterostichum* var. *amblyphyllum* Stirt. - Type: "... turned up last year near Killin." (Lectotype: "Scotland, Killin, on railed dyke above the main road, 5. Sept. 1901." - BM-Dixon; Frisvoll 1985a: 381, Fig. 3g-k).

Racomitrium divergens Stirt., Ann. Scott. Nat. Hist. 1907(63): 179. 1907. Type: "This moss has been discovered in many places in the West of Scotland and Western Islands." (Lectotype: "Scotland, Arisaig, Aug. 1906." - GLAM, NHB-1927-8-2001. Syntypes: GLAM, NHB-1927-8-2002/2006/2009. Frisvoll 1985a: 382, Fig. 2g-l).

Racomitrium heterostichum f. *falcatum* Möll., Ark. Bot. 26A(2): 86. 1931 ('*falcata*'). - Type: Not indicated. (Lectotype nov.: "*Rhacomitrium heterostichum* f. *falcata*. Uppland, Fresta, Skällnora, 11.9.1927 R. Florin." - S).

Plants from light to dark brown and blackish below, and olivaceous and usually grayish above because of long hair-points, in loose or dense mats or cushions. **Stem** up to 10 cm or more, but usually 2-6 cm, from slightly to much branched, stems and elongated branches often with numerous short branchlets. **Leaves** erect or secund, 2.6-3.75(4.7) x 0.55-0.85 mm. **Hair-point** usually conspicuous, 0.5-1.5(3.0) mm, but sometimes short or very rarely absent, usually distinctly denticulate at the margin (one ecad almost edenticulate, see Variation), frequently spinulose at the dorsal side, often somewhat or distinctly decurrent down margin of lamina. **Margin** recurved on both sides towards the hyaline point, or usually less recurved on one side, in upper part unistratose or sometimes with bistratose spots. **Costa** reaching to or almost to the hyaline point, ventrally canaliculate throughout, in lower part (60)80-110(150) µm broad, in upper part (40)50-65(75) µm broad, in basal part three- or sometimes four-stratose (d. (9)15-20(25), c. 2-8(15), v. (4)5-9(11)), in middle part bi- to three-stratose (d. (6)9-15, c. 0-2(3), v. (3)4-8), in upper part bistratose (d. 3-10, c. 0, v. 2-4(5)). **Lamina** unistratose. Basal **laminal cells** elongate (T: 15-35 x 10 µm; but in other specimens up to 60 µm long), middle and upper cells quadrate to rectangular (T: 10-25 x 10 µm), upper marginal cells from transversely elongate to short-rectangular (T: 7-15 x 10 µm), cell walls from not to strongly bulging dorsally and ventrally. **Alar cells** not or yellowish coloured, usually slightly differentiated but sometimes made up of a small but distinct group of short, widened cells, about 3-10 differentiated, esinuose or slightly sinuose cells in the marginal row.

Perichaetial leaves not squarrose when wet, ovate, the innermost (1-4) leaves hyaline and epilose (or rarely pilose) with crenulate upper margin, and the next with successively longer hair-point and more chlorophyllous upper lamina. **Seta** about 4-8 mm. **Urn** oblong-cylindrical to narrowly oblong-cylindrical (1.5-3.0 x (0.3)0.5-0.8 mm), exothecial cells relatively wide, ranging from short-rectangular to quadrate, 1-3 rows of narrow rounded cells at the mouth. **Teeth** about 260-370 µm, of (1)2(3) prongs which usually are imperfectly split, distinctly papillose, basal membrane about 35-50 µm. Spores 14-16.5 µm.

Diagnostic characters

(1) Plants usually grayish (due to long hair-points). (2) Stem frequently much branched. (3) Leaf m. long/long and m. broad (2.6-3.75 x 0.55-0.85 mm). (4) Hair-point +, 0.5-1.5 mm, distinctly denticulate and frequently spinulose. (5) Margin recurved (long, m. long), uni/bi (1, in rare spots). (6) Costa broad below and m. broad above (80-110/50-65 µm), stratosity/ventral cells (3-4/5-9, 2-3/4-8, 2/2-4), canaliculate throughout. (7) -. (8) Alar cells slightly differentiated. (9) Pl not squarrose, the innermost (1-4) hyaline, epilose. (10) Seta long (4-8 mm). (11) Urn long (1.5-3.0 mm). (12) Basal membrane + (35-50 µm).

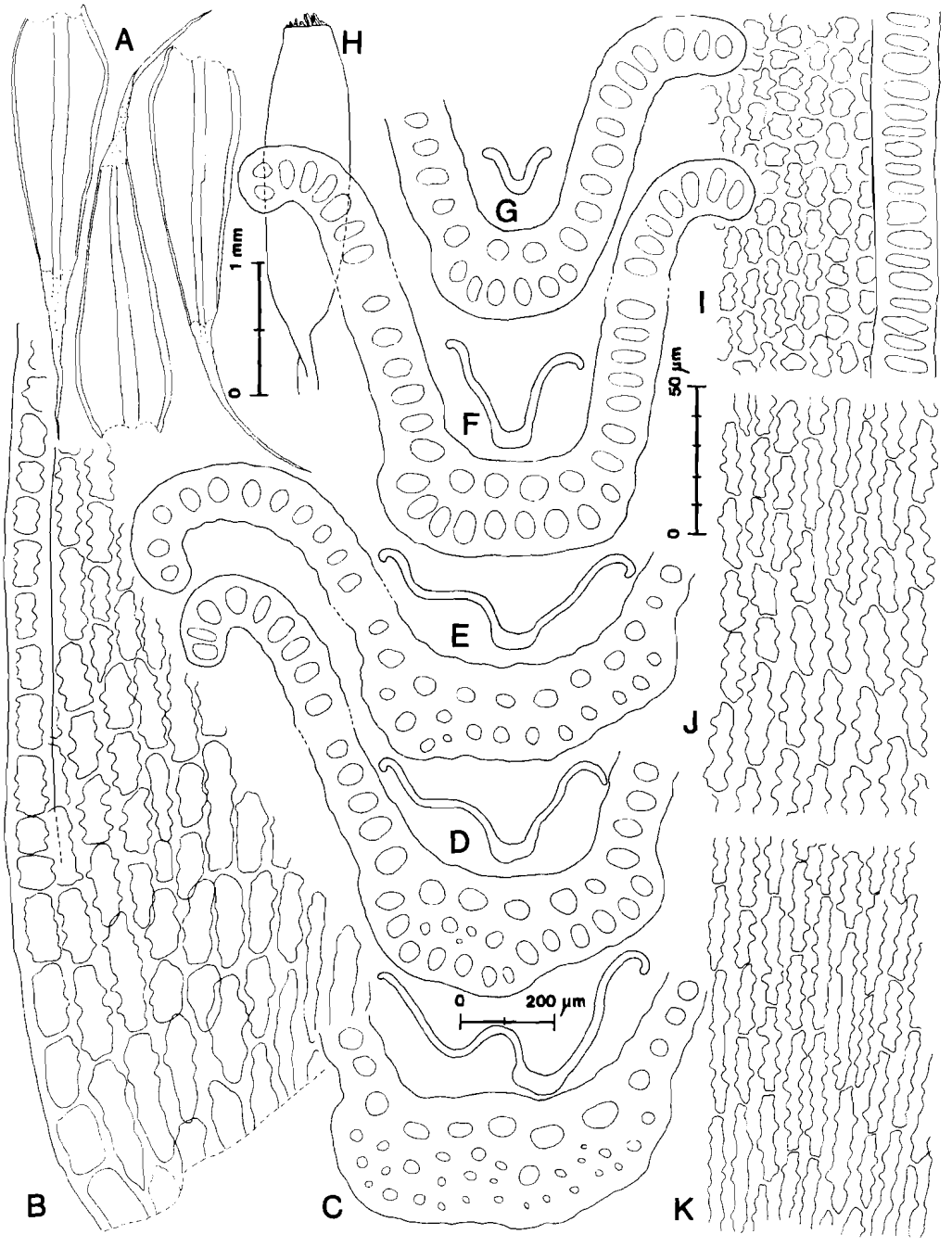

Fig. 27. *Racomitrium heterostichum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. (U.S.A.: Oregon, Lane Co., Henderson 17936 - NY.)

Variation

The majority of the specimens of *R. heterostichum* are easily recognized. Usually it consists of moderately robust plants with long hair-points so that the cushions are gray. But also subepilose greenish plants occur, and a probable epilose specimen is seen once (Europe, Hungary; H). Sometimes it is dense and pulvinate, with small leaves with narrow costa; this appears to be a modification from dry and warm, perhaps overhanging rocks. The margin is usually unistratose, but may rarely include bistratose spots and extremely rarely be more bistratose. All this standard variation of the species is easily recognized by the structure of the costa (the small pulvinate plants have very few costal cells in t.s., but the costa is typically bistratose in its upper half). The costa is frequently three-stratose at the base (Frisvoll 1984a: Fig. 2f), but sometimes it is four- to very rarely five-stratose and therefore more like the base of the costa of *R. affine* (Fig. 23). The ventral and central cells of such costae are usually narrow and stereid-like. Specimens of *R. heterostichum* with four-stratose base of costa are present throughout the distribution area of the species, and are considered to be part of its normal morphological variation; they are more numerous in western N. America (Fig. 27) than in Europe.

Specimens from the Canary Islands, Madeira and the Azores are yellowish and have a narrow costa with only (2)3-6(7) ventral cells in the basal and middle part. The middle and upper part of the costa is usually bistratose and shows cross-sections typical of *R. heterostichum*, but towards the base it is frequently four-stratose. Even in such a small area there is some variation in the structure of the costa, and in some specimens it is broader. Plants from the Azores have the narrowest costa: (In basal part three- to four-stratose: d. 9-14(19), c. 1-5(14), v. 4-6; in middle part bi- to three-stratose: d. 6-9, c. 0-1, v. 3-4; in upper part bistratose: d. 5-7, c. 0, v. 2).

Three specimens with duplicates from Humbolt Co., California (Duell 577/3, 1914/1, 1974/2 - B, H, NY) have a distinctly canaliculate costa which is three- to four-stratose in the lower and three-stratose (yet canaliculate) also in many transections from its middle part (cf. *R. affine*); the upper part is bistratose. Because of the canaliculate costa and its bistratose upper part the specimens are referred to *R. heterostichum*.

The Kodiak/Aleutian *R. heterostichum* consists of unusually gracile plants, with slightly denticulate hair-point. The base of the costa is often four-stratose with many (sometimes up to 20) central cells, but it is canaliculate throughout and typically bistratose (sometimes with 1-3 central cells) in the middle and upper part. Robust *R. affine* grows in the same area. In Unalaska, the two clearly grow together: In one specimen (Macoun 255 - S) both species are pasted to the same small sheet of paper as different pieces, and called *R. heterostichum* at first and then *R. affine*. And on the 1. May 1932 Hultén collected both *R. heterostichum* and *R. affine* in Unalaska (Hultén 5196 and 5199, respectively - S). The distribution and morphological constancy of the SW Alaskan plant should be better known before it eventually is given a subordinate name.

The SW Alaskan and NW African plants are isolated from the main American and European populations of *R. heterostichum*. They probably represent old genotypes.

Comparison with other taxa

1. *Racomitrium heterostichum* and *R. affine* (Fig. 23) are closely related. They grow together in large parts of Europe and western N. America, and maintain their morphological characteristics throughout this large area. A few specimens may appear to include characteristics from both (see Variation); the true nature of these plants is unknown. I am convinced that *R. heterostichum* and *R. affine* ought to be treated as different species. Usually, *R. heterostichum* is grayish green and *R. affine* more yellowish green, and the bulk of the specimens may be known by their gross morphology. But the colour and general appearance of the two are so inconstant, that it is frequently necessary to cross-section the leaf. Then *R. heterostichum* is recognized by the canaliculate costa which is bistratose in its middle and lower upper part, and *R. affine* by having the same portion of the costa three-stratose and more dorsally convex. If the costa of a difficult specimen is canaliculate, and predominantly bistratose in its middle and lower upper part (sometimes including 1-2 or more narrow central cells), and especially if some unquestionable *heterostichum* transections occur, the relationship of the specimen is with *R. heterostichum*; and conversely, if the costa is not canaliculate, and predominantly three-stratose in its middle and lower upper part, the relationship of the specimen is with *R. affine* (the uppermost part of the costa is bistratose in both). If the above "key" is employed, there are very few, if any, specimens of the two which cannot be meaningfully named. But such a technical identification is rarely needed. *Racomitrium affine* is less variable than *R. heterostichum*.

2. *Racomitrium sudeticum* (Fig. 15) is recognized from *R. heterostichum* by the shorter capsule, the narrower leaf with shorter hair-point, and by the structure of the costa. The two are quite different and need never be mixed up. I think the existence of *R. affine* has caused the bryologists to doubt the specific status of *R. sudeticum*.

3. *Racomitrium heterostichum* has been used as the name of many Asiatic species, but since it does not appear to grow in Asia the problem is minimal. *Racomitrium subsecundum* (Fig. 60-61) has, above all, a reddish leaf-base with (usually) inflated alar cells, and it has a different leaf form, a shortly recurved leaf margin, and a more flexuose and less denticulate hair-point than *R. heterostichum*.

4. *Racomitrium himalayanum* (Fig. 54) grows in Scotland and may be mixed with all Scottish representatives of sect. *Laevifolia*. There it has, e.g., short flexuose hair-points and elongate upper leaf-cells. It has been confused with *R. microcarpon* and *R. obtusum*, and rarely with *R. heterostichum*.

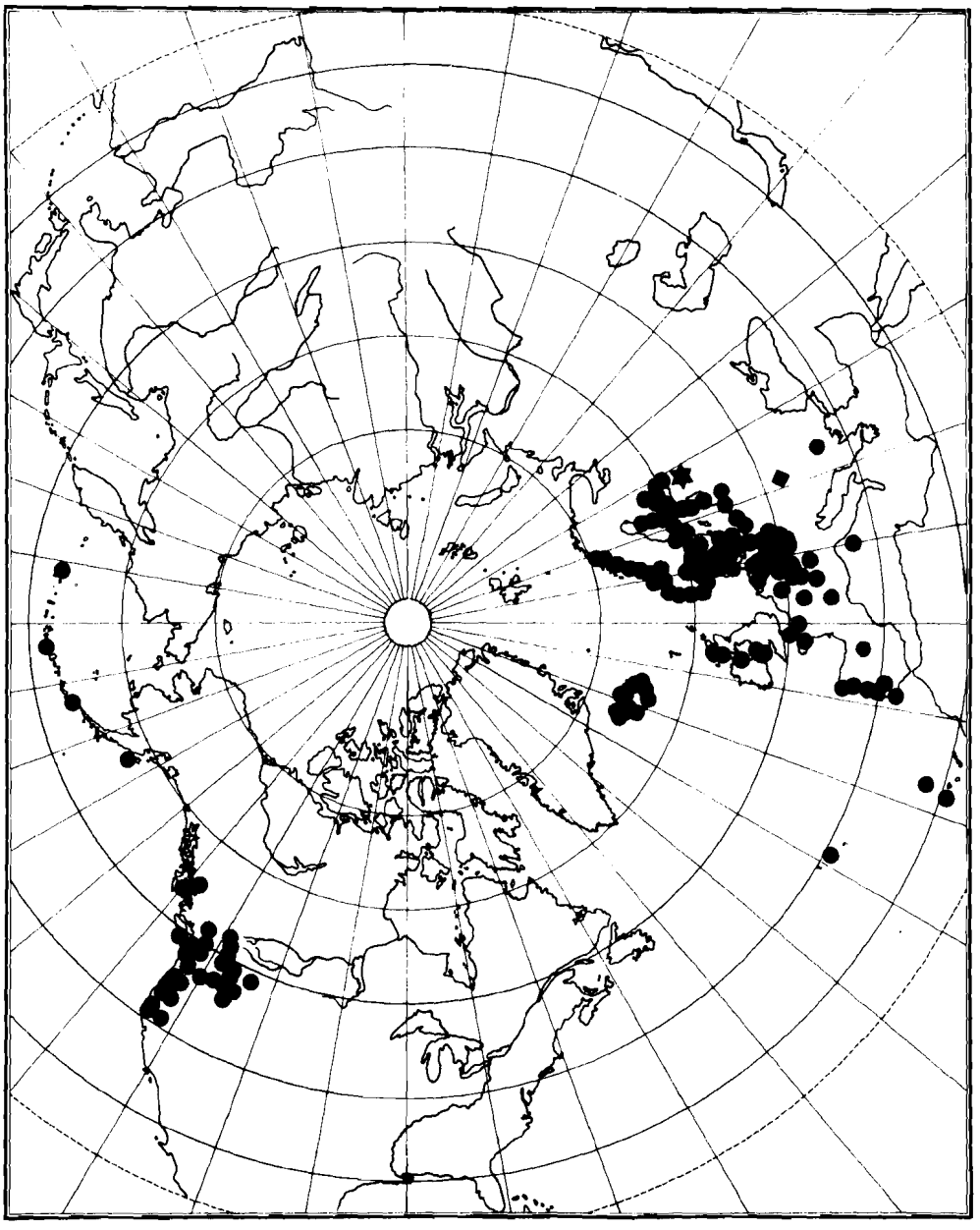

Fig. 28. Distribution of *Racomitrium heterostichum*. ★ locality inexact. ◆ epilose plant (Ungarn: Comit. Abauj-Torna, montes Sátorhegység, 14.VII.1957 Vajda - H).

5. For differences between *R. heterostichum*, and *R. brevipes*, *R. laetum*, *R. lawtonae*, *R. microcarpon*, *R. obesum*, *R. obtusum*, *R. occidentale*, *R. pacificum*, and *R. venustum*, see these species.

Habitat

Racomitrium heterostichum almost always grows on rocks, and the rock appears to be invariably acid (gneisses, basalts, sandstones, etc.). It may grow on flat or steep rock faces, including stones and boulders. Under special circumstances it seems to be able to grow on sand: Topotypes of *R. sudeticum* f. *subepilosum* (q.v.) are a mixture of *R. sudeticum* and a depauperate plant which has been identified as *R. heterostichum*. But such a habitat must be exceptional. However, when soil accumulates on flat dry rock faces, *R. heterostichum* may not always die, and then the label may read "on soil over boulder". It is a plant of the low mountains and lowland.

Distribution

Racomitrium heterostichum is known from the western parts of Europe, N. Africa and N. America (Fig. 28). In Europe it is mainly known from the areas north and west of the Alps (except for three localities, in Bulgaria, Ungarn and Italy: Corsica). It is fairly commonly distributed throughout this area, from Portugal in the south to the Baltic coast and Finland in the northeast, and Norway and Iceland in the north and northwest. In Africa it grows in the Canary Islands (only La Palma), Madeira and the Azores. In America it is known from the Rocky Mountains of Montana, Idaho and British Columbia; from northern California to northernmost coastal British Columbia; and from SE Alaska (Kodiak Island and scattered localities throughout the Aleutian archipelago). - The distribution patterns of *R. heterostichum* and *R. affine* (Fig. 24) includes similarities and dissimilarities. The most striking European differences include the higher frequency of *R. affine* in the mountains of eastern Europe, its presence in Caucasus/Turkey, and its absence from Iceland. Contrary to *R. heterostichum* it is known in some high mountain areas of western Europe (such as the French Alps and the Pyrenees), whereas it is unknown or very rare in the lowland of Germany, Poland and the Baltic coast. *Racomitrium affine* is not known from N. Africa, whereas *R. heterostichum* is absent from the eastern and central part of N. America.

(10) *Racomitrium obesum* Frisvoll *sp. nov.*
Fig. 29-30

Caulis robustus, leniter ramosus; margo folii in parte superiori bistratus.

Holotype: "Bryophytes coll. by R. & I. Duell. Exs. n. 369 - USA 1981. *Racomitrium heterostichum* (Hedw.) Brid. "f. breviseta": c. spg. California: Trinity Co.

40°27' n.b. / 123°26' w.l. *Pseudotsuga* mountain forest between Forest Glen and Mad River near Norse Butte. Primitive rocks, about 1340 m, shady, sometimes wet rocks. 638./4g. - lg. DUELL 27.4.1981." - NY. Isotype: B.

Plants large, greenish or olivaceous above and brown below, sometimes faintly grayish due to hyaline hair-points. **Stem** comparatively robust, up to 9 cm long or longer but usually 3-4 cm, from unbranched to dichotomously branched or sometimes with more branches or a few branchlets. **Leaves** large, erect or slightly recurved, 3.2-4.0 x 0.75-1.0 mm. **Hair-point** short but usually present, up to 1.0 mm, slightly or more distinctly denticulate and spinulose, not decurrent down margin of lamina, not flexuose, stiff. **Margin** broadly recurved or in part revolute towards the hyaline point, in upper part bistratose for one to two (or three) cell rows, with variously frequent uni- and three-stratose spots, in lower part unistratose with infrequent bistratose spots, more or less uneven. **Costa** broad and robust, in lower part 85-120 µm broad, in upper part 55-75(80) µm broad, reaching to the hyaline point, in basal part three- to four- (and rarely five-)stratose (d. 12-20, c. (1)5-10(16), v. 4-9), in middle part bi- to three-stratose (d. 7-13, c. 0-4, v. 4-6(8)), in upper part bi- or rarely three-stratose (d. 7-11, c. 0-1, v. 3-4(6)), somewhat irregular and asymmetrical in outline (t.s.). **Lamina** unistratose or with rare bistratose spots in its upper part, strongly contracted at the connection with the hair-point. Basal **laminal cells** elongate (T: 21-70 x 9 µm), middle and upper cells short (T: 5-25 x 9 µm), upper marginal cells transversely elongate to short-rectangular (T: 5-16 x 10 µm), distinctly but lowly pseudopapillose. **Alar cells** not or yellowish coloured, slightly differentiated with a few, sometimes inflated, wider cells in two to three rows, 0-8 esinuose basal cells in the marginal row.

Perichaetial leaves not squarrose when wet, the (2-4) innermost leaves hyaline with crenulate margin, ovate with short apex, the next 1-2 leaves pilose with (largely) hyaline lamina, and the following leaves like vegetative ones. **Seta** about 3-4.5 mm. **Urn** narrowly oblong-cylindrical (1.5-2.5 x 0.45-0.5 mm), exothecial cells rectangular, 2-3 rows of rounded incrassate cells at the mouth. **Teeth** about 400-470 µm long, of 1-2 prongs which are irregularly split, densely papillose, basal membrane present (about 25 µm). Spores 12-16.5 µm.

Diagnostic characters

(1) Plants large, greenish or olivaceous above. (2) Stem robust, slightly branched. (3) Leaf long and broad (3.2-4.0 x 0.75-1.0 mm). (4) Hair-point +/((-)), 0.1-1.0 mm, stiff (not flexuose), denticulate and spinulose. (5) Margin broadly recurved/revolute (long, long), bi (1-2, in upper part)/uni - three (in spots). (6) Costa broad (85-120/55-75 µm), stratosity/ventral cells (3-4(5)/4-9, 2-3/4-6, 2(-3)/3-4). (7) Lamina with rare bistratose spots in upper part, contracted at the connection with the point. (8) Alar cells not or slightly differentiated. (9) Pl not squarrose, the innermost (2-4) epilose, hyaline. (10) Seta short (3-4.5 mm). (11) Urn m. long (1.5-2.5 mm). (12) Basal membrane + (25 µm).

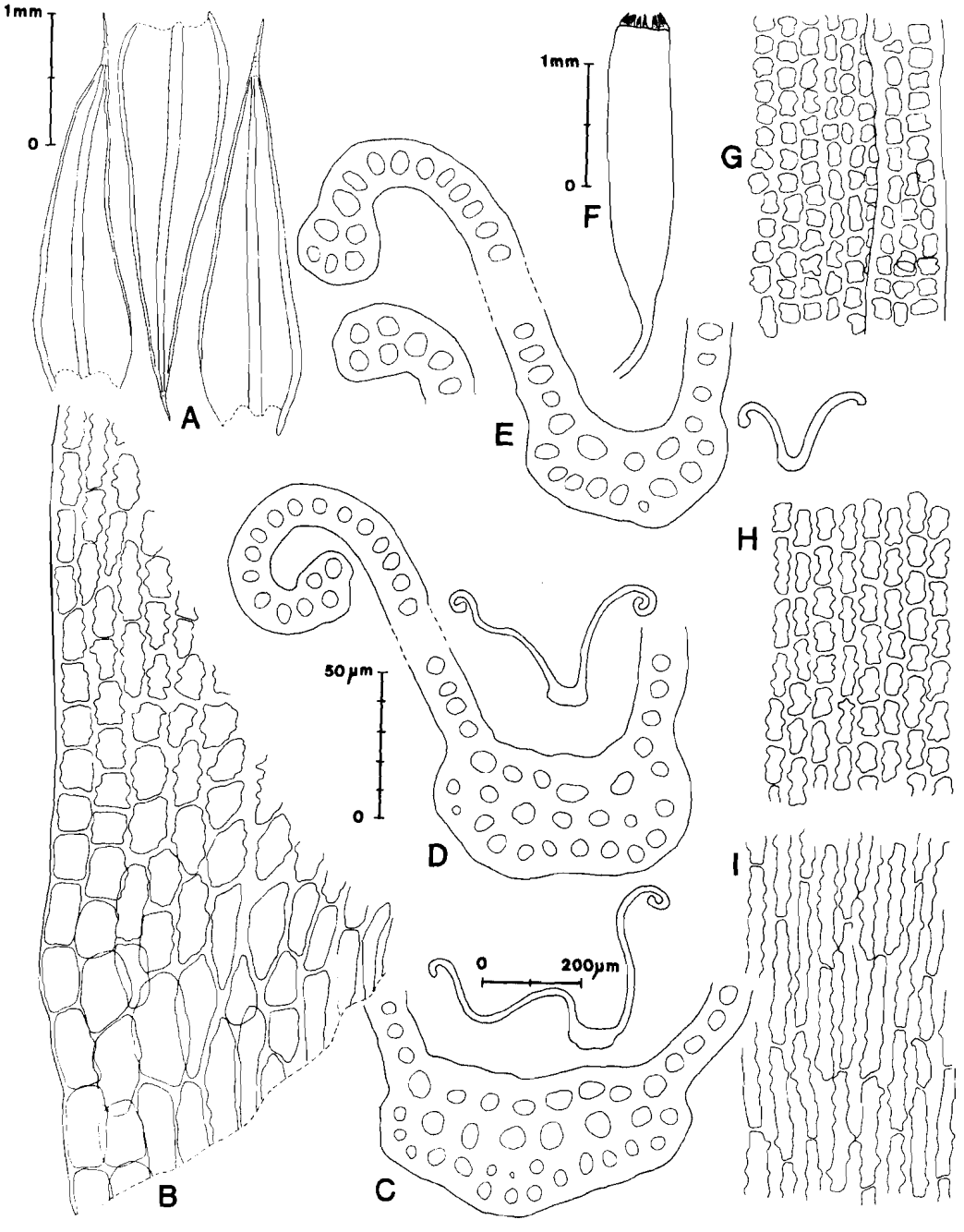

Fig. 29. *Racomitrium obesum*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. - Holotype (NY).

Variation

The species varies as usual in some characteristics of no taxonomic importance, like the colour of the cushions, the height and ramification of the stems, and the length of the hair-point. It is the most robust species in the section, and when growing with e.g. *R. affine* and *R. heterostichum* it is twice as coarse. The dorsal side of the costa is variable in transection; it is frequently lower (thinner) on one shoulder, and often faintly furrowed. Sometimes it may split off thin, short branchlets. The ventral side of the costa is from concave to plane or not infrequently convex. The hair-point is long or short, but is invariably stiff and not much flexuose. The leaf laminae of the species in sect. *Laevifolia* are often somewhat contracted at the junction with the hair-point, but in *R. obesum* this is especially pronounced. It is a well defined species which is unlikely to be confused with other taxa in the section or area.

Comparison with other taxa

1. *Racomitrium heterostichum* (Fig. 27) is strikingly less robust than *R. obesum*, and is usually more ramified and has a longer hair-point which is broad and flat at the connection with the lamina. The margin of *R. heterostichum* is entirely or predominantly unistratose in upper part. The seta is often shorter in *R. obesum* than in *R. heterostichum*. The two are easily differentiated by studying the leaf apex (including the hair-point and the upper part of the leaf margins) of reversed leaves in a high-powered microscope.

2. *Racomitrium affine* (Fig. 23) differs from *R. obesum* in much the same characteristics as *R. heterostichum*. *Racomitrium affine* has a narrower costa which is more often three-stratose in upper part.

3. *Racomitrium occidentale* (Fig. 13) may be distantly related to *R. obesum*; both has a stiff, not or slightly flexuose hair-point, and a bistratose uneven margin. But they are different in a number of important characteristics, and are not likely to be confused. The leaf of *R. obesum* is broader than that of *R. occidentale*; and its leaf margin is broadly recurved towards the hair-point, while in *R. occidentale* it is narrowly recurved to 2/3-3/4 the leaf length. The innermost perichaetial leaves of *R. obesum* are strongly differentiated, but slightly differentiated and pilose in *R. occidentale*. Otherwise there are many quantitative and qualitative differences in the structure of their costa (see Descriptions and Figures).

Habitat

Racomitrium obesum is collected from rocks, boulders, cliff ledges, and soil over cliff; one label identifies the rock as dry limestone, which, indeed, is an unusual substrate for species in the section. It is collected between 900 and 1800 m a.s.l., according to the labels.

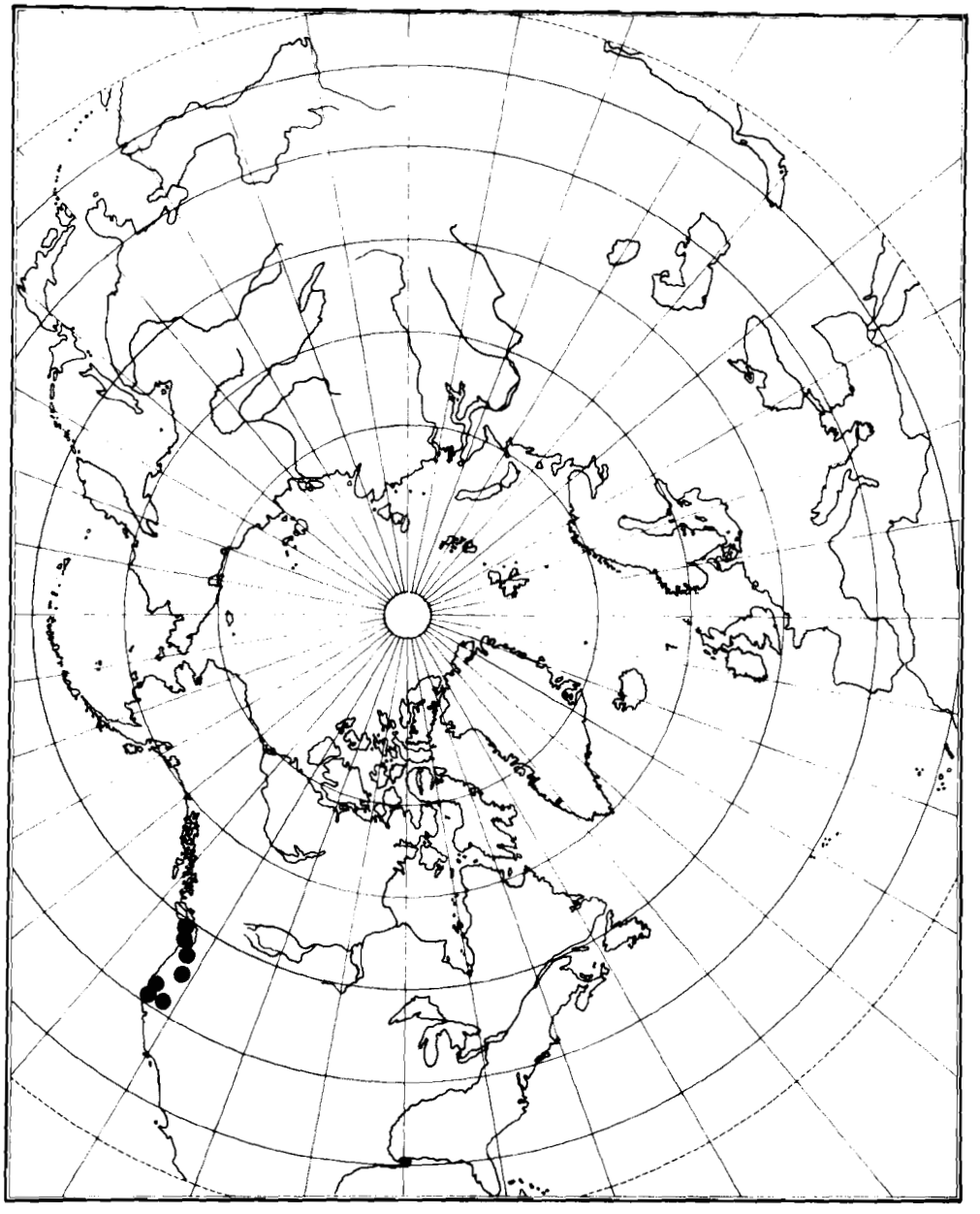

Fig. 30. Distribution of *Racomitrium obesum*.

Distribution

Racomitrium obesum is known from western N. America (Fig. 30). It grows in northern California, Oregon, Washington and southermost British Columbia.

Specimens examined

CANADA: British Columbia, Vancouver Island, Nanaimo Lakes, Becking 5309P1655 (WTU). USA: Washington, Port Angeles, 27.VIII.1927 Frye (WTU); Clallam Co., Mount Angeles, Svihla 1044 (WTU); Jefferson Co., Olympic National Park, along road to Lake Constance, Ireland 6460 (CANM); Pierce Co., along road to Sunrise on west slope of Mt. Rainier Nat'l Park, Ireland 3788 (CANM), 5788 (NY); Mt. Rainier National Park, near South Tahoma Creek, 4.VIII.1934 Frye (WTU); Mason Co., Mt. Ellinor, Foster 2165 (WTU). - Oregon, Wasco Co., U.S. Highway 26, ab. 3.5 mi south of northern boundary of Warm Springs Indian Reservation, Young 157 (CANM); Oregon Caves, 25.III.1931 Frye (WTU); Multnomah Co., Larch Mountain near summit, Flowers 9015 (NY); Clackamas Co., Clackes, IX.1889 Elmer (NY). - California, Butte Co., West Branch Campground, Kowalski 10/10/67 (CANM); Santa Clara Co., Little Butano Creek, Schofield 5739 (NY, S); Siskiyou Co., ab. one mile east of Copper Butte, Sec. 10, R11W T47N, 41°56'N, 123°06'W, Norris 50208 (NY); region of Upper Sacramento, Shasta Springs, Howe 111 (NY).

(11a) *Racomitrium obtusum* (Brid.) Brid. (f. *obtusum*)
Fig. 6B, 31-32, 69A.

Trichostomum obtusum (Retz.) ex Brid., J. f. Bot. (Schrader) 1800(2): 290. 1801 (*Bryum hypnoides* var. **obtusum* Retz., Fl. Scand. prodr. Ed. 1(2): 214. n. 1234. 1779 *nom. inval.*). - *Racomitrium obtusum* ((Retz.) ex Brid.) Brid., Mant. Musc. 79. 1819. - *R. microcarpon* [var.] b. *obtusum* ((Retz.) ex Brid.) Rabenh., Deutschl. Krypt. Fl. 2: 158. 1848. - *Grimmia* **obtusa* ((Retz.) ex Brid.) Lindb., Musc. Scand. 29. 1879 *hom. illeg. non* Brid., J. f. Bot. 1800(2): 276. 1801 [= *G. plagiopodia* Hedw.] *nec* Schwaegr., Spec. Musc. Suppl. 1(1): 88. *25.* 1811 [= *G. donniana* Sm.]. - *Racomitrium heterostichum* f. *obtusum* ((Retz.) ex Brid.) Bolay, Musc. France 1: 361. 1884. - *R. heterostichum* var. *obtusum* ((Retz. ex Brid.) Delogn., Ann. Soc. Belg. Micr. 9: 179. 1885. - *R. affine* var. ß *obtusum* ((Retz.) ex Brid.) Limpr., Laubm. Deutschl. 1: 803. 1889. - *R. affine* [subsp.] ☆*R. obtusum* ((Retz.) ex Brid.) Kindb., Eur. N. Am. Bryin. 2: 239. 1897. - Type: Not indicated. (Lectotype: OXF-Dill., herb. fol. 118, No. 30 p.p. *Bryum hypnoides alpinum, operculis obtusis* Dill.; Frisvoll 1984a: 312, Fig. 4c, 5).

Dicranum aciculare [var.] δ. *pumilum* Turn., Musc. Hib. 67. 1804. - *Racomitrium aciculare* [var.] γ. *pumilum* (Turn.) Brid., Bryol. Univ. 1: 221. 1826. - *Racomitrium heterostichum* var. *pumilum* (Turn.) Moore, Proc. R. Irish Ac. Sc. 1: 361. 1873. - Type: "et δ., quam, prope Derry, D. Brown legit." (Holotype: "91. *Bryum*

curtum. From a large stone beside a Muting house about 1/2 way between Strabane and Derry, Mr. Brown", also marked "*δ*". - BM-Turner).

Trichostomum microcarpon [var.] ß, *oblongum* Tayl. in Mackay, Fl. Hib., part 2. 20. 1836. - *Racomitrium sudeticum* var. **oblongum* 'Tayl.' in Wijk et al., Regn. veg. 48: 275. 1967 *nom. inval. err. cit. pro Trichostomum microcarpon* var. *oblongum* Tayl. in Mackay. - Type: "On Secawn mountain, near Dublin." (Holotype: "Secawn 29 April 1816." - FH-Taylor; Frisvoll 1984b: 292).

Trichostomum saxatile Tayl., Ann. Mag. Nat. Hist. 11: 208. 1843. - Type: "Comitatus Kerriensis, Hiberniæ ... This plant, in the 'Flora Hibernica', has been referred to a variety of *Trichostomum fasciculare*, Schrader, growing on stones at Carig Mountain." (Lectotype: "Ballygriffin, near Kenmare, 5. April 1841." - FH-Taylor. Paralectotypes: FH-Taylor, BM-Wilson. Frisvoll 1984b: 291).

Racomitrium obtusum var. ß. *subsimplex* Lindb., Act. Soc. Sc. Fenn. 10: 543. 1875. - *Grimmia* **obtusa* var. ß. *subsimplex* (Lindb.) Braithw., Brit. Moss Fl. 2: 41. 1888. - *R. heterostichum* subsp. *affine* var. *obtusum* f. *subsimplex* (Lindb.) Podp., Consp. 295. 1954. - Type: "Hibernia, Glendough, loco verisimillime valde humido (c. fr., 1870, Dr. Orr, sub nomine *Rh. lanuginosi* ab eo communicata)." (Holotype: "*Racomitrium lanuginosum*, Glendough, Dav. Orr 1870" - H-SOL).

Racomitrium heterostichum var. *affine* f. *epilosum* Corb., Mem. Soc. Sc. Nat. Cherbourg 26: 259. 1889. - Type: "f. *epilosum* mihi in herb.; - *R. heterostichum* var. *gracilescens* Schimp. Syn. p. 277 (p.p.); Husn. Musci G. no. 74." (Syntype: "Husnot, Musci Galliæ. 74. *Rhacomitrium heterostichum* var. *gracilescens* Sch. Rochers siliceux. - Le Châtellier (Orne). Mars." - S).

Racomitrium heterostichum var. **alpestre* Schimp. ex Limpr., Laubm. Deutschl. 1: 804. 1889 *nom. nud. in synon. p.p.* - Orig: "Aus den oberen Vogesen vertheilte Schimper beide Formen [*R. affine* and its var. *obtusum*] in demselben Convolut als *R. heterostichum* var. *alpestre*; ..." (Orig. spec.: "*Racomitr. heterostich.* v. *alpestre*. ... Vogesen, com. W. Ph. Schimper." - BP-Limpricht 37181) [= *R. obtusum f. obtusum* and f. *trichophorum*].

Plants olivaceous green with darker base, quite blackish or blackish brown with lighter apices, or more yellowish, rarely green. **Stem** up to 6 cm or more but often shorter, from slightly to much branched. **Leaves** usually not but sometimes secund, (2.0)2.25-3.0(3.4) x (0.4)0.5-0.7 mm. **Hair-point** absent (in f. *obtusum*), or (in f. *trichophorum*) short (usually 0.1-0.5 mm, but sometimes up to about 1 mm), erect or erect-spreading when dry and not or slightly flexuose, slightly or usually distinctly denticulate along the margin, and from not to distinctly spinulose at the dorsal side, decurrent down margin of lamina in long points. **Margin** revolute or distinctly recurved on both sides from base towards the apex or hair-point, in gracile specimens sometimes less recurved, in upper part unistratose without or with bistratose spots in one or two cell rows, or sometimes predominantly bistratose, in lower part unistratose without or with bistratose spots. **Costa** broad, canaliculate and moderately dorsally convex

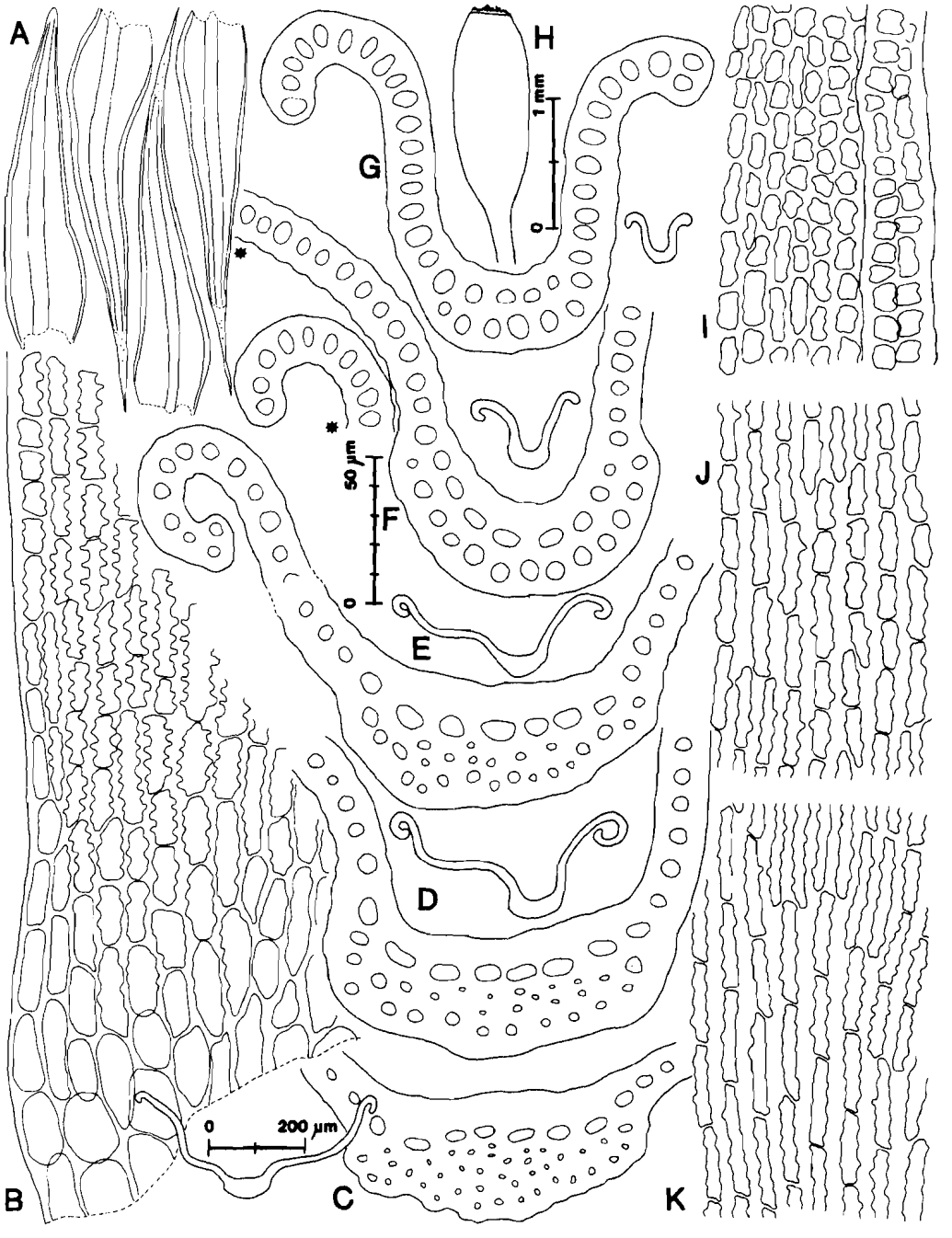

Fig. 31. *Racomitrium obtusum* s.l. a (left leaf). forma *obtusum*; the rest of a. and b-k. forma *trichophorum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. - Holotype specimen of *R. obtusum* f. *trichophorum* (TRH).

throughout, in lower part (75)85-115 µm broad, in upper part (45)50-70(90) µm broad, reaching to the hyaline point or ending shortly before the apex, in basal part (three- to) four-stratose (d. 12-20(27), c. (2)4-12(20), v. (4)5-8(11)), in middle part bi- to three-stratose (d. 9-15(20), c. 0-4, v. 4-7(10)), in upper part bistratose (d. 5-11, c.0(-1), v. 2-4(7)). **Lamina** unistratose, sometimes with rare bistratose spots. Basal **laminal cells** elongate (T: 15-40 x 10 µm), middle and upper cells quadrate to rectangular (T: 5-17 x 10 µm), upper marginal cells from transversely elongate to short-rectangular (T: 5-17 x 12 µm), not or slightly pseudopapillose. **Alar cells** sometimes yellowish, with 2-9 esinuose cells in the basal marginal row, frequently not but sometimes differentiated into a small group of short and widened, not or subauriculate cells.

Perichaetial leaves not squarrose when wet, the innermost (3-4) leaves hyaline and ovate with short apex, and the next more like vegetative leaves. **Seta** thick and rigid, about 3.2-6.5 mm. **Urn** ellipsoid, obovate or more rarely oblong-cylindrical (1.3-2.2 x 0.75-0.8 mm), exothecial cells short and rounded throughout, ± thick-walled, 3-5 rows of narrow cells at the mouth. **Teeth** (ca. 200-270 µm,) of 2-3 prongs which are irregularly cribrose below and split above, basal membrane often high (up to 60-75 µm). Spores 14-19 µm.

Diagnostic characters

(1) Plants frequently dark-olivaceous. (2) -. (3) Leaf short/m. long and m. broad (2.25-3.0 x 0.5-0.7 mm). (4) Hair-point -/+, 0-0.5 mm, slightly or not flexuose. (5) Margin broadly recurved/revolute (long/long), uni/bi (1, in spots or rarely throughout). (6) Costa broad (85-115/50-70 µm), stratosity/ventral cells ((3-)4/5-8, 2-3/4-7, 2/2-4), canaliculate. (7) Lamina sometimes with bistratose spots. (8) Alar cells usually slightly differentiated. (9) Pl not squarrose, the innermost (3-4) hyaline. (10) Seta m. long (3.2-6.5 mm). (11) Urn short to m. long (1.3-2.2 mm). (12) Basal membrane + (60-75 µm).

Variation

The olivaceous colour of the upper part of the shoots is characteristic of this species. The olivaceous leaves are often spotted or speckled with brown, and when this has been realized it is a good distinguishing feature. But the colour varies much, from quite black to green or yellowish. In exposed sites the cushions may be low and blackish, 0.5-1 cm, whereas in shady, less extreme habitats the plants are gracile and usually less branched and of a light colour. This last modification is the so-called var. *subsimplex* Lindb. The margin may be from almost or quite unistratose to bistratose. The long-revolute margin is one of the best characteristics of the species. Sometimes, however, it is less strongly revolute. One Spanish specimen including duplicates (H), has a very robust and broad costa, with numerous central cells in its lower part. But the really critical characteristic of *R. obtusum* is that of the apex of its leaves. From Lindberg (1875) onwards the name has been used about plants with obtuse, i.e. epi-

lose leaves. (However, the epithet *obtusum* refers to the operculum; and Dillenius (1741), Bridel (1798) and others allowed the taxon to be hairy, but they had most certainly not a good concept of what they described, see Frisvoll 1984a). However, during this study it soon became clear, that *R. obtusum* either had to be abandoned as a proper species, or it had to include both epilose and pilose specimens. The detailed study of a large amount of material collected by myself (Norway, Sør-Trøndelag: Frøya, 1982) and H. Blom (Norway, Hordaland: Sund, Fjell, Bergen, Os; Rogaland: Gjesdal, Forsand, 1985) clarified the situation. This material is taken from mixed stands between all possible constellations of *R. affine*, *R. heterostichum* and *R. obtusum*, from strongly to slightly exposed habitats. *Racomitrium affine* and *R. heterostichum* vary as usual, i.e. they have long hair-points in exposed and shorter in less exposed habitats, and *R. obtusum* is present as epilose, subepilose and pilose specimens. But the case is not quite simple, because there are also many specimens which include mixed epilose and pilose plants of *R. obtusum* as defined here. The presence or absence of a hair-point is the only important difference between these plants. Similar mixed specimens of pilose and epilose plants have been seen of *R. affine*, *R. microcarpon*, *R. sudeticum* and *R. subsecundum*. The taxonomic significance of this mixing is discussed separately (see chapter 4.2). It is likely that some epilose specimens of *R. obtusum* are modifications of genotype(s), which in other habitats would have had a hair-point, and vice versa. The type of *R. obtusum* includes only epilose leaves (Frisvoll 1984a). Because both epilose and pilose plants are frequent in this species; because these common pilose and epilose plants are (usually) not modifications of exactly the same genotype; and because within the treated pilose species of sect. *Laevifolia* this is the only taxon whose type is epilose, I have introduced a new taxon. The pilose and epilose plants seem to have about the same distribution, and are separated as forms.

(11b) *Racomitrium obtusum* f. *trichophorum* Frisvoll *f. nov.*
Fig. 31-32.

Racomitrium heterostichum var. **alpestre* Schimp. ex Limpr., Laubm. Deutschl. 1: 804. 1889 *nom. nud. in synon. p.p.* - Orig.: See *R. obtusum* f. *obtusum*, synonyms.

A typo *Racomitrio obtusi* differt foliis piliferis.

Holotype: "Norvegia. Hordaland: Bergen, Hop. kbl. 1115 I (M 711), UTM 984 932, ca. 80 m. Hovdenveien, v. veien. *hab.* avsats (sva) i steil bergvegg, sigevannspåvirket, halvskyggehabitat. 7.VII.1985 Hans H. Blom" (TRH, mixed with f. *obtusum*, both forms with sporophytes). Isotype: BG (includes f. *obtusum* and *R. affine*).

Comparison with other taxa

1. *Racomitrium heterostichum* (Fig. 27) and *R. obtusum* f. *trichophorum* may easily be confused. They may be separated as follows: **Plants** (*obt*: usually olivaceous green; *het*: green but rarely with an olivaceous or yellow tinge), **hair-point** (*obt*: often short and broadly-acute, and when more elongate slightly flexuose; *het*: rarely short, usually elongate and somewhat flexuose. The point of f. *trichophorum* may be as long as or longer than in *heterostichum*, but in mixed stands the point of f. *trichophorum* in always shorter), **margin** (*obt*: revolute from base towards the hair-point, usually with bistratose spots; *het*: less recurved for about the same length or frequently more flat in the upper part, rarely with bistratose spots), **costa** (*obt*: usually four-stratose in the basal part, but sometimes (predominantly) three-stratose; *het*: usually three-stratose, but sometimes four-stratose), **capsule** (*obt*: often ellipsoid or obovate, with short cribrose teeth with high basal membrane; *het*: often oblong-cylindrical, with longer, not cribrose teeth and lower basal membrane). Some experience with *R. obtusum* f. *trichophorum* is needed to separate it from *R. heterostichum*. The plentiful and widely distributed material from Sandefjord in Vestfold, southern Norway (collected by Jørgensen in 1891), is a mixture of *R. obtusum* f. *obtusum* and f. *trichophorum*, and not of *R. obtusum* and *R. heterostichum* as stated by Loeske (1913: 186). Single, atypical specimens from areas outside the main range of *R. obtusum* may need to be recollected and restudied. An epilose Hungarian specimen (H) imitating *R. obtusum*, is thought to be the only known epilose specimen of *R. heterostichum*; it has a weakly recurved and unistratose leaf margin, and a three- to mainly bistratose costa. A few aberrant pilose plants of *R. heterostichum* s.l. with a more bistratose leaf margin have also been seen. As they come from outside the main range of *R. obtusum*, they are not thought to belong to that species. Fertile material may solve the problem. One American specimen of *R. obtusum* is certainly wrongly labelled and of European origin.

2. *Racomitrium sudeticum* (Fig. 15-17) has sometimes been used as the name of gracile plants of *R. obtusum*. Cross sections of leaves will always distinguish between them. They are very different.

3. Scottish plants of *R. himalayanum* (cf. Fig. 54) have been named *R. obtusum*; both have a wide costa. The hair-point of *R. himalayanum* is flexuose and edenticulate with narrow base; its leaf cell walls are usually (but not always) more pseudopapillose; and its upper leaf cells are usually more elongate. The inner perichaetial leaves are hyaline in *R. obtusum* but not so in *R. himalayanum*.

4. Since *R. microcarpon* (Fig. 39) is absent (or extremely rare) in Scotland, specimens of *R. obtusum* with long upper leaf cells have been thought to be that species (e.g. by Stirton). The structure of the costa, and the basal marginal border of *R. microcarpon* separates it at once from *R. obtusum*.

5. Regarding the differences between *R. obtusum*, and *R. affine*, *R. depressum*, and *R. pacificum*, see the latter species.

Habitat

Racomitrium obtusum grows in the same habitats as *R. affine* (q.v.), viz. on ± moist acid rocks. It is frequent on slopes of naked rock on the SW coast of Norway.

Distribution

Racomitrium obtusum is known from western Europe (Fig. 32). It is usually found near or not far from the Atlantic or Baltic coast. The innermost localities are in Vosges (France), Karl-Marx-Stadt (DDR) and southwesternmost Poland. It reaches Bornholm (Denmark) and Blekinge (S. Sweden) in the Baltic area, and is known from Närke (Sweden).

Specimens examined

SPAIN: Galicia, prov. Pontevedra, prope oppid. Pontevedra, via valle flum. Lerez, 10.VIII.1930 Buch (H); in Monte de la Francha, 27.VII. and 27.VIII.1930 Buch (H). FRANCE: Finistere, Roc Trevezel NW of Huelgoat, 21.VI.1954 Størmer (O); Chaos de St. Herbot SW of Huelgoat, 21.VI.1954 Størmer (O); Roch Trevezel, 16.VI.1947 Cuynet (S); Falaise (Calvados), De Brebisson, Husnot's Musci Galliæ 75 (S); Chemirè, VIII.1895 Monguillon (H, S); La Chatellier (Orne), Husnot's Musci Galliæ 74 (FH, S); Cherbourg, 14.III., 25.III., and 15.IV.1886 Lorbiere (TRH), 10.XI.1867 herb. Jolis (O); Vogesi, 1845 Schimper (S). BELGIUM: Louette-Saint-Pierre (Namur), I.1869 and X.1872 Gravet (S); Gedinne (Namur), VIII.1875 Gravet (S). BRD: Westfalen, Bruchauser Steine, Schmidt s.a. (JE); Wuppergebiet, Schmidt s.a. (JE); Tecklenburg, IV.1882 Winter (JE); Hessen, Laubach, Gaulskops, 2.IX.1896 Roth (S); Schleswig-Holstein, Elmenhorst, Mechmershausen 543 (H). DDR: Sachsen, Rautenkranz, VII.1906 Stolle (S). POLAND: Schlesien, Bunzlau, Looswitz, 18.IV.1867 Limpricht (S). IRELAND: Co. Wicklow, 9.VII.1873 Lindberg (S); Luggielaw, IX.1873 Lindberg (H, S), s.a. Moore (H, PC); Lough Bray, 9.VII.1873 Lindberg (GLAM, H); Dublin Mts., 1855 and 1872 Orr (H); Kerry, Brandon Mt., 21.VIII.1935 Dixon (BM). GREAT BRITAIN: England, by the Lyn [?], N. Devon, W.B. s.n. (MANCH); Wales, Crymmych, VII.1906 s.leg. (FH); above Aber, Collins 4035 (FH); Llanberis, Dolbadarn Castle, 1865 Hunt (H); Llanbedr [?], North Wales, 1850 Wilson (S); Trellech, Monmouthshire, VIII.1903 Armitage (GLAM); Scotland, Killin, IX.1902 Stirton (GLAM); Glen Lochay, Pertshire, IX.1902 Stirton (GLAM); Caithness, Borgue Hill, Dunbeath, 8.VI.1899 Lille (BM); Isl. of Lewis, nr. Carloway, VIII.1901 Braithwaite & Stirton (BM), VIII.1901 Stirton (GLAM); Tarbert, Harris, Stirton s.n. (BM), VI.1900 and 1902 Stirton (GLAM); Arisaig, VI. and IX.1906 Stirton (GLAM). DENMARK: Bornholm, at Allinge, Hesselbo, Bry. Dan. Exs. 189 (BG, O, S, TRH); Sjælland, Mortenstrups Overdrev, III.1882 Jensen (O, S). SWEDEN: Bohuslän, Göteborg, Örgryte, Torp 7.VI.1930 Stenholm (FH); Orust (near Göteborg), Rossö, 18.VI.1892 and 18.VII.1892 Arnell (FH, S, TRH), VI.1892 Arnell (BG, O, PC, S, TRH), 28.VI.1892 Arnell (S); Rörvik, 16.VIII.1892 Arnell (S); Marstrand, Koön, 11.VI.1926 Larsson

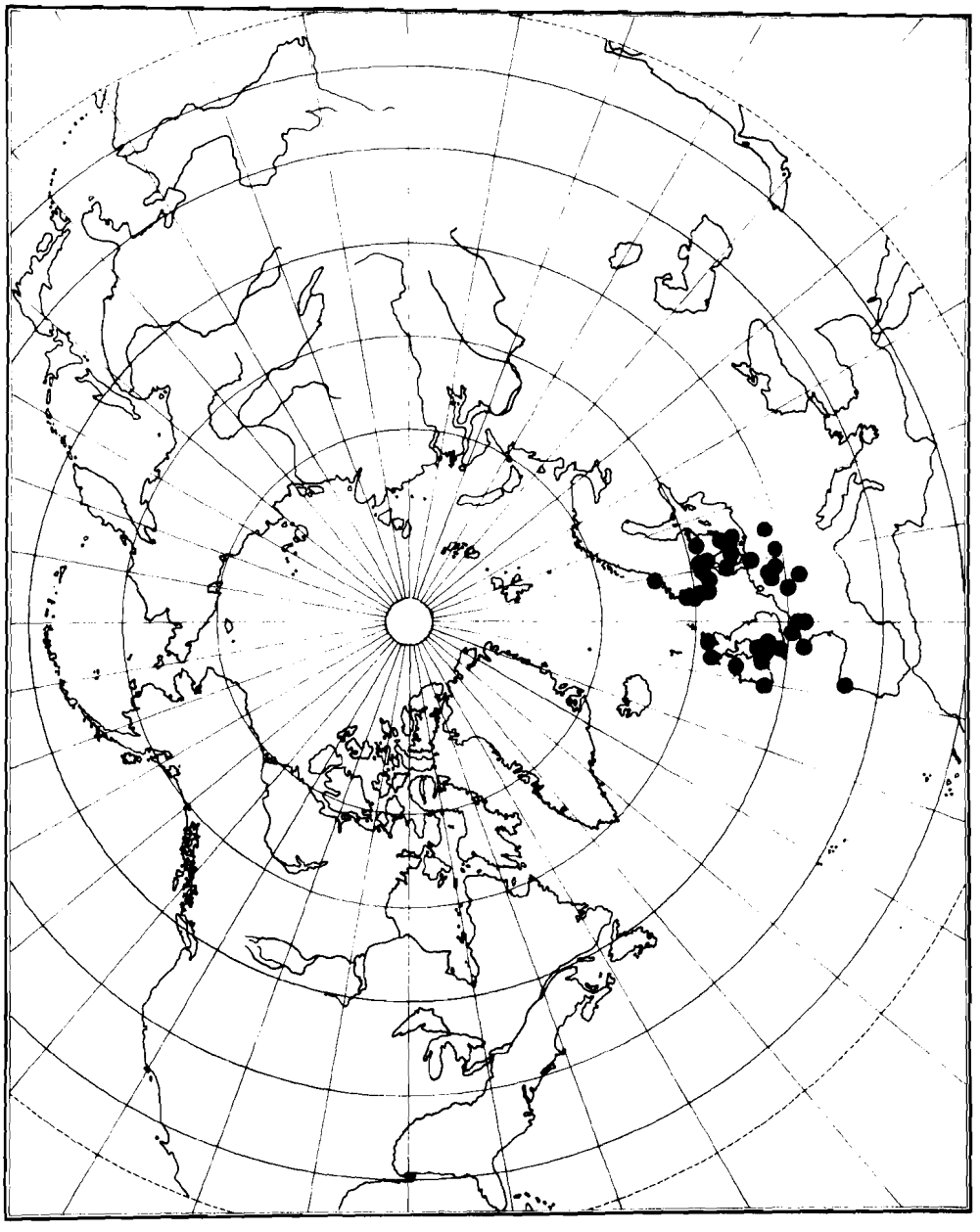

Fig. 32. Distribution of *Racomitrium obtusum* s.l.

(S); Solberga sn., Brattan, 2.VI.1933 Hülphers (S); Fiskebäckskil, 29.VII.1911 Möller (S); Fjällbacka, Dyngö, 17.VII.1922 Möller (H); Jörlanda, Sävelycke, 19.VI.1926 Stenholm (TRH); Halland, Enslöv sn., Sperlingdalens Wald, IX.1920 Hülphers (ALTA); Skåne, Kullaberg, 16.VII.1880 Lindberg (GLAM, H, O); Kullen, Flinck s.n. (H); Skäralid, 4. and 7.VII.1875 Lindberg (H, O, TRH); Blekinge, Mjällby sn., Hörvik, Getberget, 19.IV.1922 Medelius (H, S); Sternö, 21.XI.1917 Medelius (TRH); Närke, Viby, Fagerlidshatt, 14.VIII.1905 Adlerz (S). NORWAY: Many localities along the coast from Østfold to Sogn og Fjordane, and Sør-Trøndelag (Fig. 69A - BG, O, TRH).

(12) *Racomitrium pacificum* Irel. et Spence
Fig. 33-34.

Racomitrium pacificum Irel. et Spence, Can. J. Bot. 65: 859. *1-10.* 1987. - Holotype: "Canada. British Columbia: Vancouver Island, Victoria, Mt. Tolmie, on shaded cliff, 29 March 1964, Schofield & Boas 22668." (UBC, not seen). Isotypes (S, seen; CANM 101533 fide protologue). Numerous paratypes; seen the following isoparatypes: British Columbia, Macoun's Canad. Musci 620 (WTU), Schofield 22631 (S), Schofield & Chuang 35854, 35858 (S), Schofield & Boas 17654 (S); Washington, Ireland 5912, 5937, 5958 (WTU); Oregon, Frye's Moss Exsicc. 20 (WTU).

Plants olivaceous or brownish green above, and usually darker brown or blackish below. **Stem** 1-4 cm, irregularly branched but usually with few branchlets. **Leaves** rigid, erect or slightly secund, 2.25-3.0 x 0.7-0.95 mm. **Hair-point** absent; leaf apex obtuse or acute, usually with some small marginal teeth or crenulations made up of protruding cell ends, or in acute apices sometimes a few dorsal spinulae. **Margin** broadly recurved to 2/3-3/4 the leaf length on one side, more narrowly recurved to 1/2 the leaf length or plane on the other side, unistratose. **Costa** strongly dorsally convex and ventrally canaliculate, in lower part (70)80-120(160) µm broad, in upper part 50-65 µm broad, reaching almost to the apex, in basal part (bi- to) three- to four-stratose (d. 13-20, c. (0)3-15, v. 4-8), in middle part bi- to three-stratose (d. 10-15, c. 0-5, v. 3-6), in upper part usually bistratose (d. 7-12, c. 0-1, v. 2-4). **Lamina** unistratose. Basal **laminal cells** elongate (T: 37-65 x 9 µm), middle and upper cells from rounded quadrate to rectangular (T: 9-23 x 9 µm), upper marginal cells transversely elongate to short-rectangular (T: 7-14 x 10 µm), cells from not to distinctly pseudopapillose. **Alar cells** yellowish or orange, short wide and porose for 3-5 rows, sometimes constituting an auriculate group, basal marginal cells usually thick-walled, of 4-10 differentiated, not or somewhat sinuose cells.

Perichaetial leaves not squarrose when wet, the innermost (2-3) leaves hyaline and ovoid with short apex, the next with successively fewer hyaline basal and more chlorophyllous upper cells. **Seta** about 5.5-8.2 mm. **Urn** oblong-cylindrical to narrowly oblong-cylindrical, ± gradually tapering into the seta (2.2-3.7 x 0.45-0.7 mm), exothecial cells rectangular, 1-3 slightly differentiated cell rows

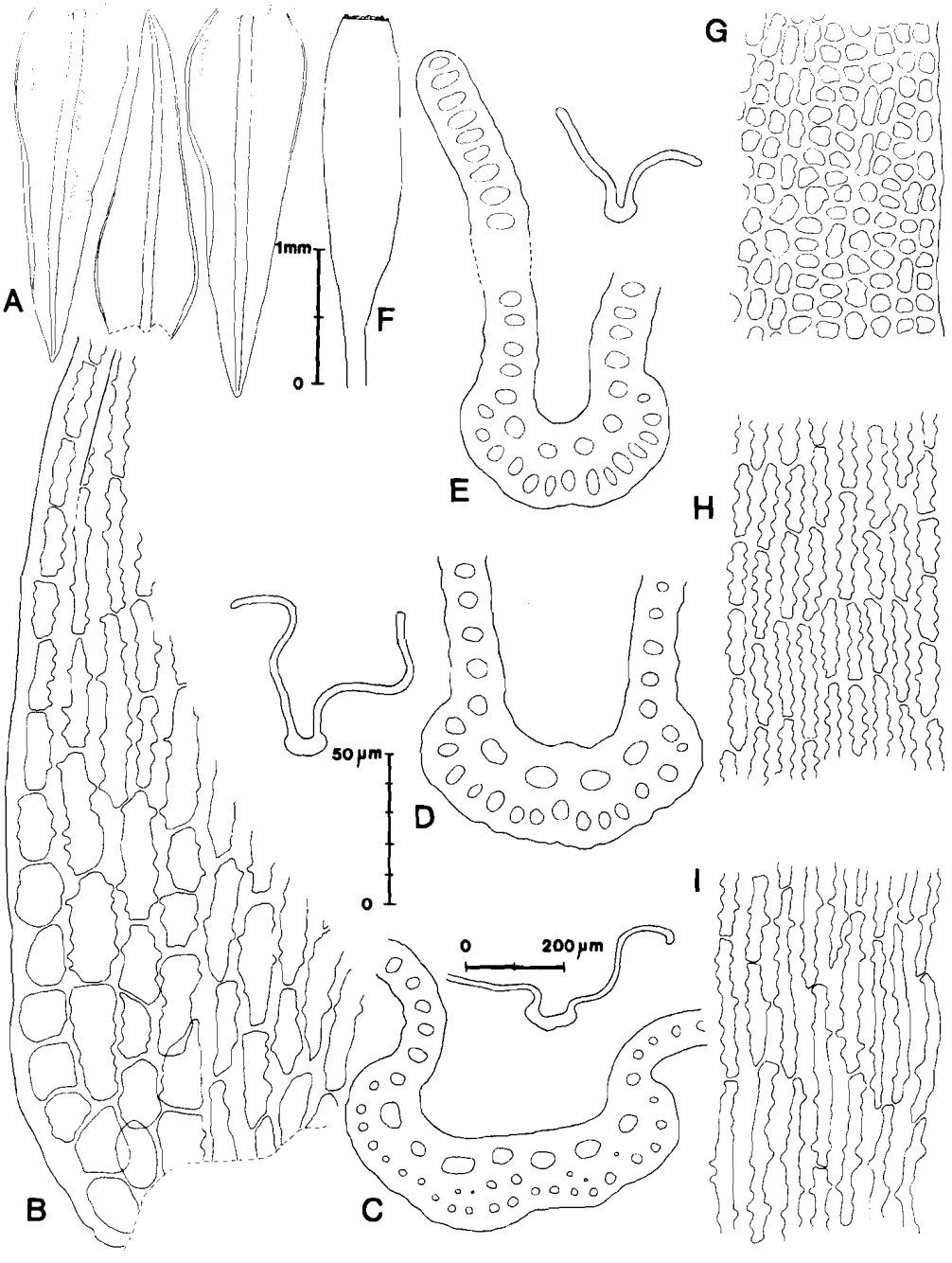

Fig. 33. *Racomitrium pacificum*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. - (U.S.A.: Washington, Skagit Co., Fidalgo Isl., W of Anacortes, Lawton 3644 - WTU.)

at the mouth. **Teeth** (broken,) basal membrane present (40-50 µm). Spores 14-21 µm.

Diagnostic characters

(1) Plants olivaceous or brownish green. (2) Stem irregularly branched with few branchlets. (3) Leaf short/m. long and broad (2.25-3.0 x 0.7-0.95 mm). (4) Hair-point -; leaf apex rounded or acute, usually with minute teeth. (5) Margin recurved (m. long, short/flat), uni. (6) Costa broad below and m. broad above (80-120/50-65 µm), stratosity/ventral cells ((2)3-4/4-8, 2-3/3-6, 2/2-4), canaliculate. (7) -. (8) Alar cells yellowish (or orange), short, wide and porose for 3-5 rows. (9) Pl not squarrose, the innermost (2-3) hyaline. (10) Seta long (5.5-8 mm). (11) Urn long (2.2-3.7 mm). (12) Basal membrane + (40-50 µm).

Variation

Usually, the plants are dark or light olive brown but may rarely be blackish. The leaf apex is sometimes acute with small apical (and lateral) teeth and dorsal spinulae; sometimes acutely obtuse and more or less crenulate; and sometimes broadly obtuse with distinct crenulations or teeth. The teeth and spinulae consists of protruding cell halves or cell ends. The width of the costa varies much; it may be broad in most leaves and very broad in some, or relatively narrow in most leaves. The structure of the costa is fairly constant, but it is sometimes less thick towards the base (2-3 versus usually 3-4 stratose). The alar cells are thick-walled when mature, and wide and porose. Sometimes they constitute small reddish auricles as in some plants of *R. subsecundum*.

Comparison with other taxa

1. *Racomitrium pacificum* is epilose like *R. depressum* (Fig. 25), and the two have been confused in the past (e.g. by Frye 1917). *Racomitrium pacificum* is a lowland coastal plant of Oregon, Washington and southernmost British Columbia, whereas *R. depressum* is a Californian mountain plant. *Racomitrium pacificum* grows on dry rocks, whereas *R. depressum* grows on frequently inundated or wetted rocks close to mountain streams and creeks. Usually, they are easily separated, but large plants of *R. pacificum* and small plants of *R. depressum* may be similar. The two species probably never grow together. They are separated by the following characteristics: **Leaf** (*pac*: closely set, rigid, and moderately large, most leaves smaller than 3.0 x 1.0 mm; *dep*: not closely set, and often soft and flaccid, many or all leaves larger than 3.0 x 1.0 mm), **margin** (less recurved in *R. depressum* - frequently flat on one side - than in *R. pacificum*), **costa** (usually much broader and not canaliculate and sometimes biconvex in *R. depressum*; but genetically different plants or modifications have a narrow canaliculate costa approaching that of *R. pacificum*), **alar cells** (*pac*: short, thick-walled and porose, in mature leaves constituting a more or less

well-defined group, usually coloured; *dep*: elongate, thin-walled and not or slightly different from the adjacent cells, or made up of a group of thin-walled, decurrent hyaline cells; it is important to check a number of leaves to ascertain the structure of the alar cells). The two species are probably closely related (Lawton 1972: 258). The form and structure of the leaves (including the apex) of *R. pacificum*, are more like that of *R. depressum* than of any other epilose taxon in the section.

2. *Racomitrium obtusum* (Fig. 31) is a European moss. It has, e.g., a strongly and longly recurved or revolute, frequently bistratose margin; no crenulations at the leaf apex; and a less deeply canaliculate costa. The two may appear to be very closely related, but I doubt that they are.

3. *Racomitrium heterostichum* (Fig. 27) has always pilose or predominantly pilose leaves with, inter alia, a more longly recurved margin. And *if* epilose plants of this species should occur in the area, they could be separated from *R. pacificum* by the structure of their costa (inter alia less keeled in upper part) and, presumably, by their colour, leaf form, and cell structure.

4. The alar cells of *R. pacificum* sometimes resemble those of *R. subsecundum* (Fig. 60-61), but otherwise the two taxa have not much in common. Usually, *R. subsecundum* possesses a hair-point, and if epilose it possesses no apical crenulations.

5. *Racomitrium affine* (Fig. 23) can be distinguished from *R. pacificum* by similar characteristics as *R. heterostichum.*

6. *Racomitrium pacificum* has been confused with *R. aquaticum* and *R. aciculare.* The last two species have papillose leaf cells and belong to sect. *Papillosa.*

Habitat

The species has been collected from rocks ("serpentine rocks; bluff overlooking water; cliff top; edge of creek") and from soil over boulders beside a river. The last habitat is certainly also primarily epilithic and not epigeic. The localities are all from the lowland, but altitude is not indicated on the labels.

Distribution

Racomitrium pacificum is known from western N. America (Fig. 34). It grows in northern California, Oregon, Washington and southern British Columbia.

Specimens examined

U.S.A.: California. Del Norte Co., Smith River, Eastwood 407 (S). - Oregon.

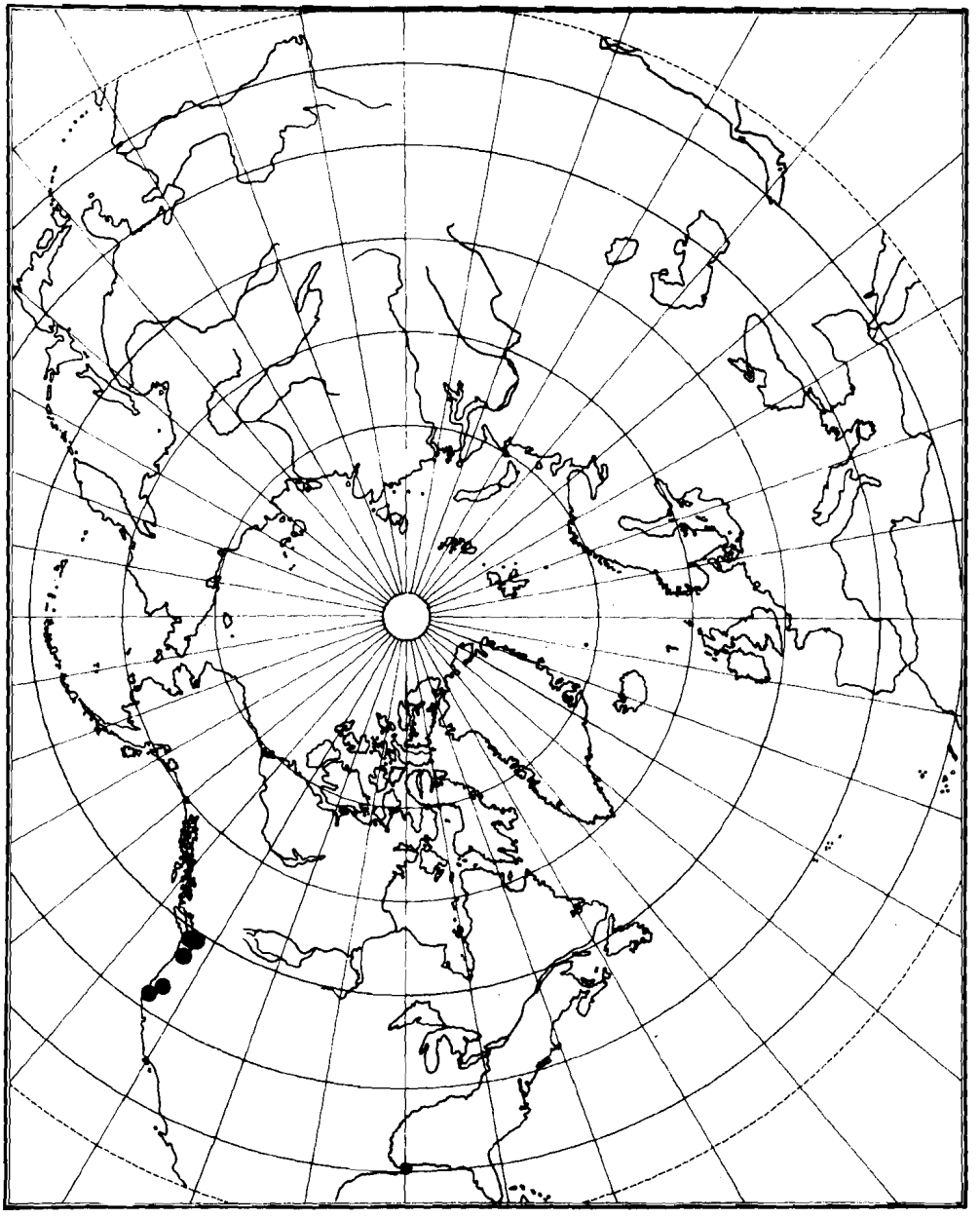

Fig. 34. Distribution of *Racomitrium pacificum*.

Curry Co., McGribble Forest Camp, Young 401 (WTU); Dillard, Frye 20 (WTU). - Washington. Skagit Co., near Hamilton, along south Fork of Nooksack River, Ireland 5912 (WTU); Fidalgo Point, ab. 4 mi SW of Anacortes, Ireland 5958 (WTU); Thurston Co., 5 mi W of Rainier, along Deschutes River in Deschutes River Park, Ireland 5737 (WTU); Friday Harbour, Trout Lake, 10.VII.1925 Frye (WTU). CANADA: British Columbia. Victoria, V.I., Macoun 1.VI.1908, Canad. Moss. 98a vel s.n. (CANM, FH, NY, S); along the Colquitz River, Canad. Moss. 457 (NY), 458 (FH); Colquitz River, 10.VI.1908 Macoun (S); Colquitz River, Burnside Road, Victoria Isl., Canad. Musci 620 (or 281) (WTU, 2 sp.); Vancouver Isl., Goldstream, Schofield 22631 (S); Langford, Schofield & Chuang 35858 (S); Saanich Pen., Schofield & Chuang 35854 (S); Mt. Tolmie, Victoria, Schofield & Boas 22668 (S); Mill Creek, New Denver, MacFadden 151 = Holzinger's Musc. Acroc. Bor.-Am. et Eur. 620 (NY, S); Maine Isl., Head of Campbell Bay, S Strait of Georgia, Schofield 17654 (WTU); Gambier Isl., Herve Sound, 6.VI.1963 Schofield (TRH).

(13) *Racomitrium venustum* Frisvoll *sp. nov.*
Fig. 35-36.

Caulis valde ramosus; pilus foliorum spinuloso-denticulatus; margo folii in parte superiori bistratus.

Holotype: "Plants of Ontario. Lakehead University, Thunder Bay, Ontario. *Rhacomitrium heterostichum* (Hedw.) Brid. *County* Thunder Bay Dist. *N.* 48°02' *W.* 89°29'. *Habitat* On drier vertical shaded rock faces of basaltic cliff along lakeshore. *Locality* SE. corner of Pine Bay in Lot 9H, Crooks Twp. *Date.* 10 July 1979. *Collector & No.* C.E. Garton 18879. *Det. By* C.E.G. *No. of Replicates* 10. Ver. R.R. Ireland, 1981." - CANM. Isotype: H.

Plants not robust, greenish, olivaceous or brownish above, and darker brown or blackish below, usually not grayish, in loose or (usually) dense mats or cushions. **Stem** 1.0-4.5 cm, from slightly to usually subpinnately branched. **Leaves** from erect to slightly or (rarely) strongly secund (1.5)1.7-2.4(2.6) x 0.5-0.7 mm. **Hair-point** stout, erect or erect-squarrose, up to 0.5 mm or sometimes longer, but often missing in all or the greater part of the leaves, sharply denticulate and spinulose, the long points somewhat decurrent down margin of lamina. **Margin** uneven, broadly recurved towards the hair-point or apex, in upper part bistratose for one to three (to four) cell rows, or sometimes largely unistratose or with frequent three-stratose spots, in lower part unistratose with bistratose spots for one (to two) cell rows or sometimes predominantly bistratose. **Costa** strongly dorsally convex, in lower part 50-80 µm broad, in upper part 35-45 µm broad, reaching to the hyaline point or apex, in basal part three (rarely four-)stratose (d. 8-15, c. (0)2-9, v. 3-5), in middle part bi- to three-stratose (d. 8-11, c. 0-3, v. 2-4), in upper part bistratose (d. 4-8, c. 0(-1), v. 2-3). **Lamina** unistratose. Basal **laminal cells** quadrate to elongate (T: 16-45 x 8 µm), middle and upper cells quadrate to rectangular (T: 9-28 x 8 µm), upper marginal cells quadrate to rectangular (T: 9-18 x 9 µm), cell walls from mode-

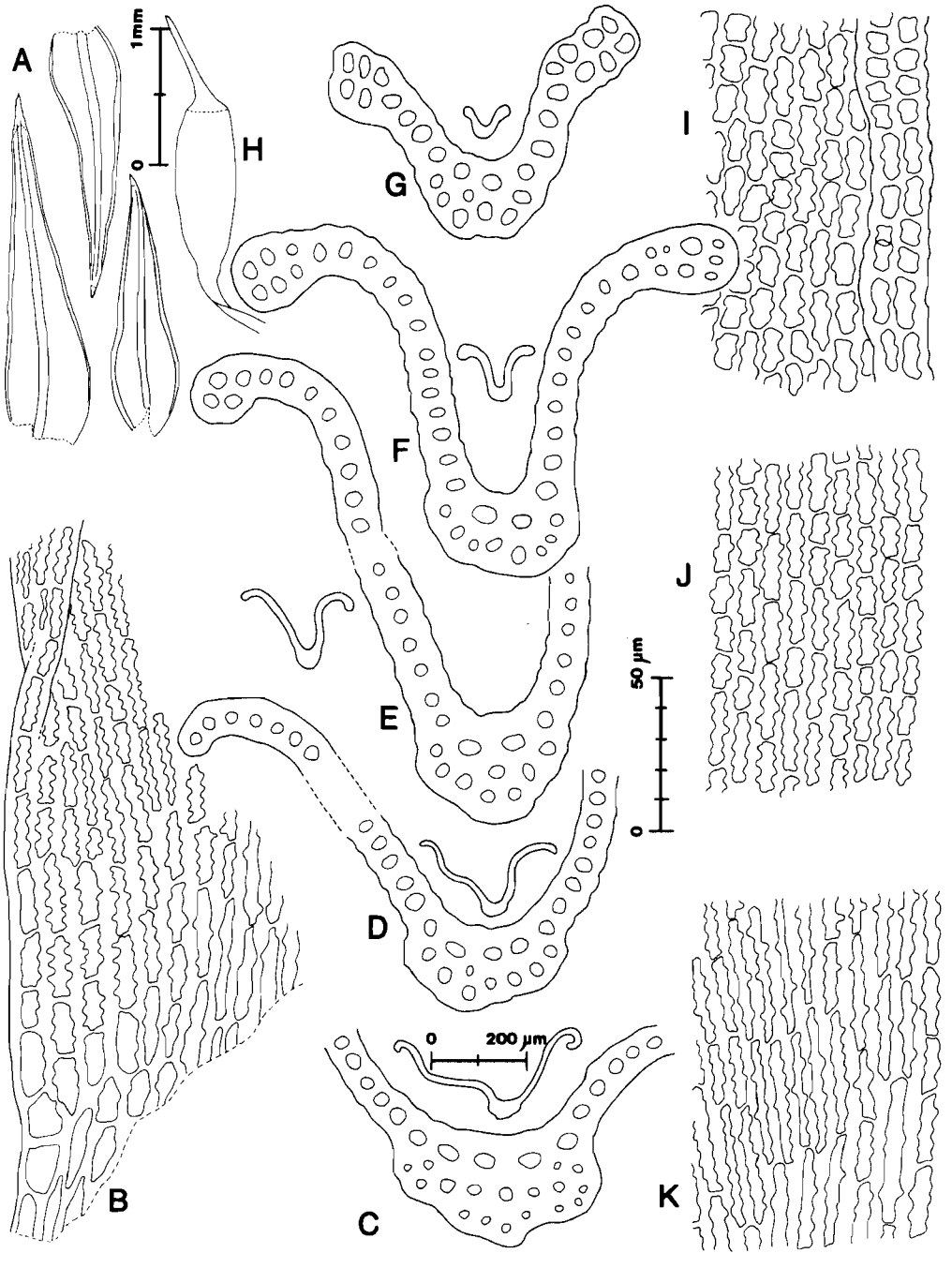

Fig. 35. *Racomitrium venustum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. - Holotype (CANM).

rately to distinctly bulging dorsally and ventrally. **Alar cells** usually yellowish and slightly differentiated, but a few basal cells in one to three marginal rows shorter and more porose, and 2-8 marginal cells not or slightly sinuose and somewhat thick-walled.

Perichaetial leaves not squarrose when wet, epilose, the innermost (two) leaves hyaline, the next with successively less hyaline basal and more chlorophyllous and sinuose upper cells. **Seta** about 6-7.5 mm. **Urn** ovoid (1.2-2.0 x 0.4-0.6 mm), exothecial cells relatively short, more or less rounded, 3-4 rows of incrassate cells at the mouth. **Teeth** (ca. 190 µm long,) of 2-3 somewhat irregular prongs which may possess distinct cross-bars (especially in the lower half), basal membrane present (35-50 µm). Spores 12-19 µm.

Diagnostic characters

(1) Plants in dense mats or cushions. (2) Stem not robust, usually much branched. (3) Leaf short and narrow/m. broad (1.7-2.4 x 0.5-0.7 mm). (4) Hair-point +/-, 0-0.5 mm, stout and spinulose-denticulate. (5) Margin broadly recurved (long/long), bi (1-3, in upper part)/uni - three (1, in spots), uneven. (6) Costa narrow (50-80/35-45 µm), stratosity/ventral cells (3(-4)/3-5, 2-3/2-4, 2/2-3). (7) -. (8) Alar cells slightly differentiated. (9) Pl not squarrose, epilose, the innermost (two) hyaline. (10) Seta long (6-7.5 mm). (11) Urn short (1.2-2.0 mm). (12) Basal membrane + (35-50 µm).

Variation

Taxonomically, *Racomitrium venustum* is one of the least variable species in the section. It varies, however, as usual in modifiable characteristics like the size, colour and branching of plants and stems. It is never large, and in dry sites it may be very small. The hair-point is frequently absent but sometimes rather long; it is always stout and denticulate-spinulose, and short points are frequently quite spinulose. This main structure of the point is always the same. The leaf margin is uneven, and strongly recurved throughout. The upper part of the margin (below the point or apex) is therefore dorsally erect, and its structure is easily studied in the microscope on reversed flattened leaves. This part of the margin is usually bistratose with unistratose spots, but may also be predominantly unistratose or include three-stratose spots. The lower part of the margin accords with the upper part, in that it is more bistratose when the upper margin is strongly thickened. The alar cells are slightly differentiated, but I have seen sub-auriculate alar groups in a few leaves.

Comparison with other taxa

Specimens of *R. venustum* have been named *R. heterostichum*, *R. affine*, *R. microcarpon* and *R. sudeticum*. The three last-mentioned species grow in the same

area as *R. venustum*, whereas *R. heterostichum* has not been found in eastern N. America.

1. *Racomitrium affine* (Fig. 23) is a larger species with larger leaves including a longer hair-point (usually); and it can for the most part be readily separated from *R. venustum*. But difficult modifications of the two may be problematic to distinguish *ex habitus*, and then there are some reliable microscopical differences which can be checked: **Hair-point** (*ven*: absent or short, stout and strongly spinulose-denticulate; *aff*: usually present, longer and not so stout, often narrow and capillaceous above and flat below, denticulate and not or moderately spinulose), **margin** (*ven*: uneven, usually bistratose above, often for two cell rows - but see Variation; *aff*: not or less uneven, in the area predominantly unistratose, without or with bistratose spots for one cell row), **costa** (*ven*: weaker, made up of fewer cells, see Diagnostic characters, predominantly three-stratose in the basal part, and frequently with some or all central cells as wide as the ventral ones; *aff*: stronger, made up of more cells, see Diagnostic characters, predominantly four-stratose in the basal part, and only the ventral layer made up of wide cells; this differences are relative and not always clear-cut, and must be checked on many transections), **perichaetical leaves** (*ven*: epilose; *aff*: the innermost epilose and the outer pilose in pilose specimens, see Diagnostic characters), **urn** (shorter in *R. venustum* than in *R. affine*, see Diagnostic characters). *Racomitrium venustum* and *R. affine* can always be distinguished by characteristics seen on the upper part of the reversed leaf, including the apex/hair-point and the erect margins. They are perhaps closely related, but I have only met with specimens that could be placed at once.

2. *Racomitrium sudeticum* (Fig. 15-17) is usually less branched than *R. venustum* and its leaves are more strongly keeled. It has a narrow leaf apex with a more dorsally convex costa running into the apex or hair-point. The costa of *R. sudeticum* is made up of homogeneous cells (except at the base), and not of wide ventral and narrow dorsal cells as in *R. venustum*. The hair-point of *R. sudeticum* is usually narrow and less (yet sometimes quite) spinulose. The margin of *R. sudeticum* is smooth and flat towards the apex of the leaf, and not uneven and recurved as in *R. venustum*. The perichaetial leaves of *R. sudeticum* are slightly differentiated. There are lots of differences between the two, and they are referred to different subgroups within the section. But they are sometimes so similar that a microscopical check is needed before a specimen can be named. Depauperate, blackish and epilose plants are most difficult, and *R. venustum* can be as small as *R. sudeticum*.

3. *Racomitrium heterostichum* (Fig. 27) is unknown from the area of *R. venustum*; it has a broader and flatter costa, and a long hair-point. The two are but distantly related.

4. *Racomitrium microcarpon* (Fig. 39) has a unistratose margin and a long hyaline basal marginal border, as well as a quite different costa (t.s.). The length of the lamina cells is not a reliable distinguishing characteristic, but

the structure of the cells is different: the cells of *R. venustum* are less thick-walled and more sinuose towards the base of the leaf.

Habitat

Racomitrium venustum is collected from rocks ("boulder, rock outcrop, cliff face, bluff") in dry ("sunny cliff"), shaded ("deeply shaded cliff") or wet ("in dripping water, very wet rock cliff") sites, in woods, in creeks and along rivers, lakes and roads. The rock is granite, gneiss, sandstone or basalt, according to the labels. It is known from the lowland, and extends up to 1940 m a.s.l. in North Carolina.

Distribution

Racomitrium venustum is known from eastern N. America (Fig. 36). It grows throughout the Appalachian Mountain Range, and is otherwise known from the Canadian provinces Newfoundland, Nova Scotia, New Brunswick, Quebec, and Ontario; and from single localities in Ohio, Michigan and Minnesota, U.S.A.

Representative specimens examined

U.S.A.: Georgia, White Co., Yonah Mountain, Small 9160 (S), 9660 (NY); Tallulah Falls, VIII.1893 Small (FH, NY, S). South Carolina, Pickens Co., Table Rock Mt., Anderson 22.284 (S). North Carolina, Swain Co., Fork Ridge, below Mt. Collins, Great Smoky Mts. Nat. Park, Anderson 10.627 (NY); Yancey Co., (E slope of) Mt. Mitchell, Anderson 22.396 (FH, NY), Vitt 22.450 (ALTA); Roan Mt., Williams 115 (NY), Hermann 15199 (CANM, FH). Tennessee, Sevier Co., Mt. Le Conte, 13.V.1934 Sharp (NY); Monroe Co., Sycamore Creek, Sharp 54157 (NY). Virginia, Botetourt Co., Peaks of Otter, Patterson 2903 (NY); Nelson Co., near Montebello, at Crabtree Falls, Patterson 1061 (NY). Ohio, Jacksons Co., cliff along Big Run, Bartley & Pontious 459 (NY); Pike Co., head of Clyce Hollow, Bartley & Pontious 462 (NY). Pennsylvania, Carbon Co., Stony Creek, Rau 66/55/380 (FH). New Yersey, Closter, Austin s.n. (NY). Connecticut, Bear Mt., Salisbury, 24.IX.1910 Nichols (NY). Massachusetts, Saugus, Kingman 1808, 1811 (FH); Cohasset, Kennedy 721 (FH). New York, Warren Co., Crane Mountain, Smith & Ellett 40008 (B, S); Essex Co., Chilson Lake, 13.VIII.1900. E.G.B. (FH). New Hampshire, Grafton Co., Brighthollow, Grafton, Hutchinson 266, 360 (NY); Crawford Notch, 13.VIII.1897 F... (NY). Maine, Oxford Co., N. Hartford, Williams 12965 (NY); Piscataquis Co., along trail to Basin Ponds, E slope of Mt. Katahdin, Hermann 19230 (NY), 19237 (S). Michigan, Marquette Co., Sugar Loaf Mountain, ab. 5 mi NW of Marquette, Ireland 4588 (CANM). Minnesota, T62N, R11W, SE 1/4 Sec 28, near where Minn. hwy 1 crosses the S branch of the Kawishiwi River, Olson 576 (FH). CANADA: Newfoundland, Avalon Pen., 7 km NE of Long Harbour, Placentia Bay, Brassard 9127 (S); Gander Lake near Gander Airport, Gander Falls, 48°52'N, 54°40'W, Tuomikoski 6059 (H). Nova Scotia, Hants Co.,

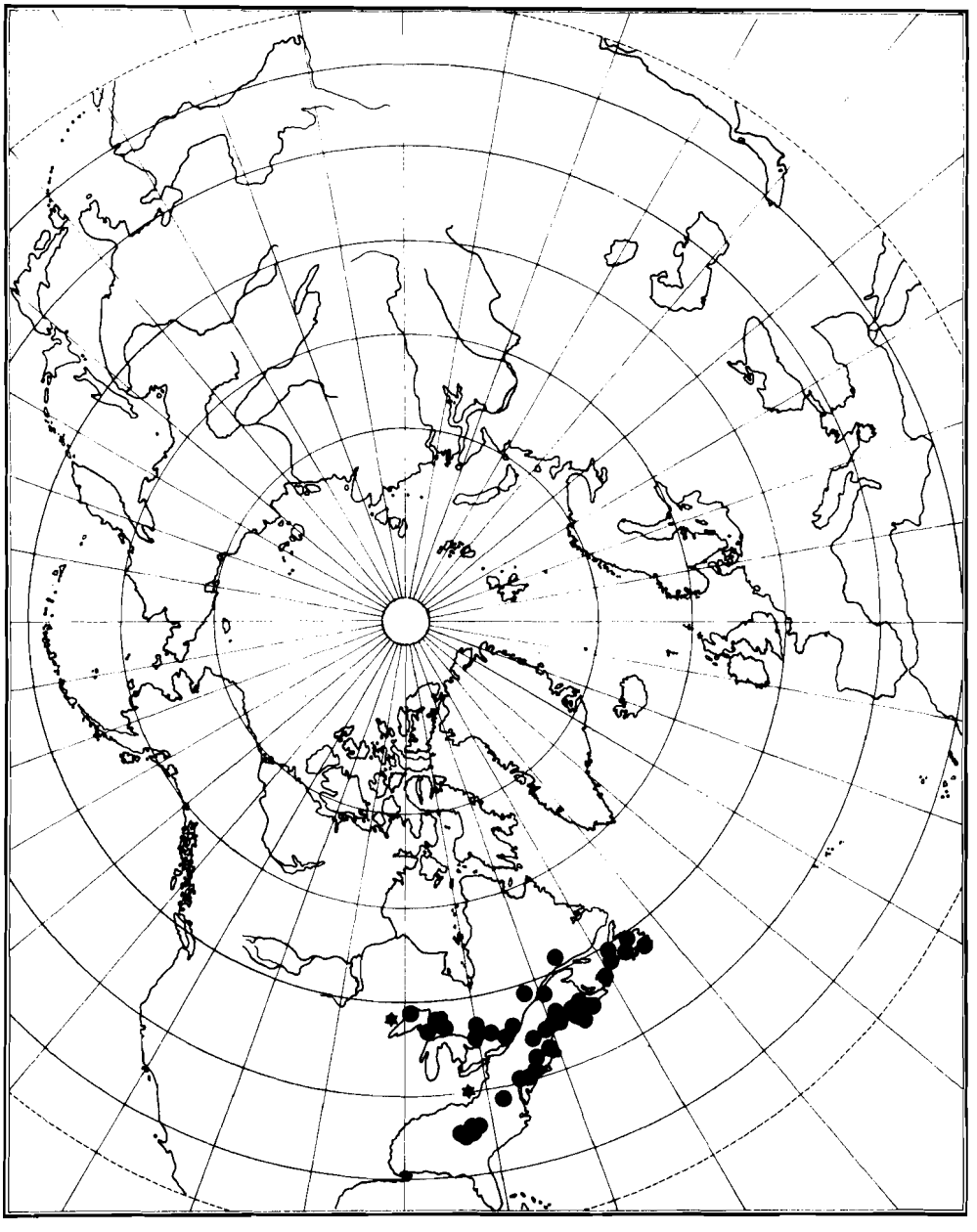

Fig. 36. Distribution of *Racomitrium venustum*. ★ locality inexact.

near Uniacke Lake, Fernald, Bartram & Long 793, 798, 809 (FH); Halifax Co., Armdale (Dutch Village), Fernald, Bartram & Long 815 (FH); Cape Breton, vicinity of Barrasois River, VIII.1909 Nichols (FH). New Brunswick, Albert Co., Fundy National Park, ca. 1/2 mi E of Point Wolfe Campground, ca. 45°33'N, 65°01'W, Ireland 11395 (NY). Quebec, Terrebonne Co., St. Jovite and vicinity, Crum 9892 (CANM); Luskville Falls, NE of Luskville, 45°32'N, 76°00'W, Ireland & Ley 9987 (CANM). Ontario, Algoma Distr., Lake Superior Provincial Park, near Indian Pictographs N of Agawa Point, 47°32'N, 84°40'W, Ireland 14962 (ALTA, CANM, FH, H, NY, S, WTU); Parry Sound Distr., near Carling, 45°24'N, 80°10'W, Ireland 20670 (ALTA, NY).

5.6 THE *MICROCARPON* SUBGROUP

Innermost bracts strongly modified, hyaline below but not above, epilose (except in western N. American *R. microcarpon*); outer bracts not squarrose when wet. Stem often strongly, pinnately or intricately branched; hair-point strongly flexuose; costa bi- to three-stratose below; lamina cells thick-walled, esinuose and strongly porose below and tending to be elongate in the upper part of the leaf; basal marginal border long.

Four species: *R. crispipilum*, *R. microcarpon*, *R. verrucosum*, *R. vulcanicola*. - *Racomitrium microcarpon* and *R. vulcanicola* are closely related. The tropical *R. crispipilum* possesses characteristics which place it near to *R. microcarpon*. The bistratose margin and lamina of *R. verrucosum* may indicate a less close relationship to the above species, but the structure of its leaf cells and basal marginal border is essentially as in these.

5.6.1 Key to the taxa in the *microcarpon* subgroup

1	Leaf margin 2-stratose	2
1	Leaf margin 1-stratose	3
2	Leaf lamina with frequent 2-stratose areas or cells rows; hair-point usually absent; upper lamina cells short	(16a) *R. verrucosum* var. *verrucosum*
2	Leaf lamina 1-stratose or with scattered 2-stratose spots; hair-point usually present; upper lamina cells elongate	(16b) *R. verrucosum* var. *emodense*
3	Plant robust; leaves long and broad (≥ 3.0 x 0.7 mm); urn 2.0-2.5 mm; southern (Fig. 37)	(14) *R. crispipilum*
3	Plant less robust; leaves smaller (≤ 3.0 x 0.7 mm); urn 1.3-2.0 mm; northern.	4
4	Gemmae present in leaf axils and perichaetia (Fig. 45)	(17) *R. vulcanicola*
4	Gemmae absent. *R. microcarpon* s.l.	5
5	Cells of the basal marginal border usually short, wide and hyaline (rarely some cells slightly sinuose) (Fig. 39)	(15a) *R. microcarpon* f. *microcarpon*
5	Basal marginal cells usually elongate, narrow and more or less sinuose and/or thick-walled (Fig. 40)	(15b) *R. microcarpon* f. *afoninae*

(14) *Racomitrium crispipilum* (Tayl.) Jaeg.
Fig. 37-38.

Trichostomum crispipilum Tayl., London J. Bot. 5: 47. 1846. - *Grimmia crispipila* (Tayl.) C. Müll., Syn. 1: 808. 1849. - *Racomitrium crispipilum* (Tayl.) Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 96. 1874 (Ad. 1: 374). - Type: "Summit of the Quitinian Andes, Prof. William Jameson, 1845." (Holotype: "*Trichostomum crispipilum* Tayl. [Equador] Summit of the Quitenian Andes, D. William Jameson, 1845." - FH-Taylor. Isotype: "*Trichostomum crispipilum* Tayl! in L. J. Bot. v. 5. p. 47 (Dr. T's spm.) Quitenian Andes (Jameson)" - BM. Acc. to Lawton 1973, also NY).

Grimmia (Racomitrium) contermina C. Müll., Syn. 2: 655. 1851. - *Racomitrium conterminum* (C. Müll.) Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 98. 1874 (Ad. 1: 376). - Type: "America centralis, Costa-Rica, alt. inter 5000-8000', Febr. lg. A.S. Oersted." (Lectotype nov.: "Museum botanicum Hauniense. Plantae centro-americanae Ørsted. 1845-48. 8434 *Grimmia (Rhacomitrium) contermina* n. sp. determ: C. Müller. Costa Rica 5-8000'" - C. Isolectotypes: NY, TRH - Fig. 37).

Plants robust, brownish below and olivaceous green to more yellowish green in their uppermost part, frequently whitish or grayish due to long hair-points. **Stem** up to 12 cm, pinnately or subpinnately branched or more rarely with fewer branchlets. **Leaves** often slightly or distinctly falcate, 3-4(6.5) x 0.7-1.0 mm. **Hair-point** strongly flexuose, from absent to usually long or very long, mostly about 0.5-1 mm (T: 0.5-0.75 mm; in other specimens to 3-4 mm), edenticulate or obtusely low-denticulate and not or slightly decurrent down margin of lamina. **Margin** broadly recurved on one side to some distance below the hair-point, and more narrowly and usually shortly recurved or quite flat on the other side, unistratose. **Costa** thin and narrow, convex at the dorsal side in upper part and rather flat on both sides below, in lower part 70-90 µm broad, in upper part 30-50 µm broad, reaching to or ending shortly before the hyaline point, in basal part bistratose, sometimes with a trace of a third stratum (d. 8-16(22), c. 0-1, v. 3-4), in central part bistratose (d. 7-16(20), c. 0, v. 2(-3)), in upper part bistratose (d. 5-10, c. 0, v. 2). **Lamina** unistratose. Basal **laminal cells** elongate (T: 38-60 x 9 µm), middle and upper cells also usually elongate (T: 15-35 x 7.5 µm), upper marginal cells quadrate to rectangular (T: 7-14 x 10 µm), cell walls from not or slightly to sometimes distinctly bulging dorsally and ventrally, in lower part about two times as broad as the cell lumen. **Alar cells** not or slightly yellowish or sometimes orange, one row of 10-25(30) differentiated, pellucid and usually thin-walled and esinuose (but sometimes more thick-walled and slightly sinuose) cells extending as a border up along the margin.

Perichaetial leaves not squarrose when wet, inner (4-5) leaves epilose, with ovate base (with pellucid ± sinuose cells) and acute to acuminate apex (with chlorophyllous sinuose cells). **Seta** about 6.0-8.5 mm. **Urn** narrowly oblong-cylindrical (2.0-2.5 x 0.5 mm), exothecial cells narrow and elongate with thick walls, 4-6 rows of incrassate, small and rounded cells at the month. **Teeth** (ca.

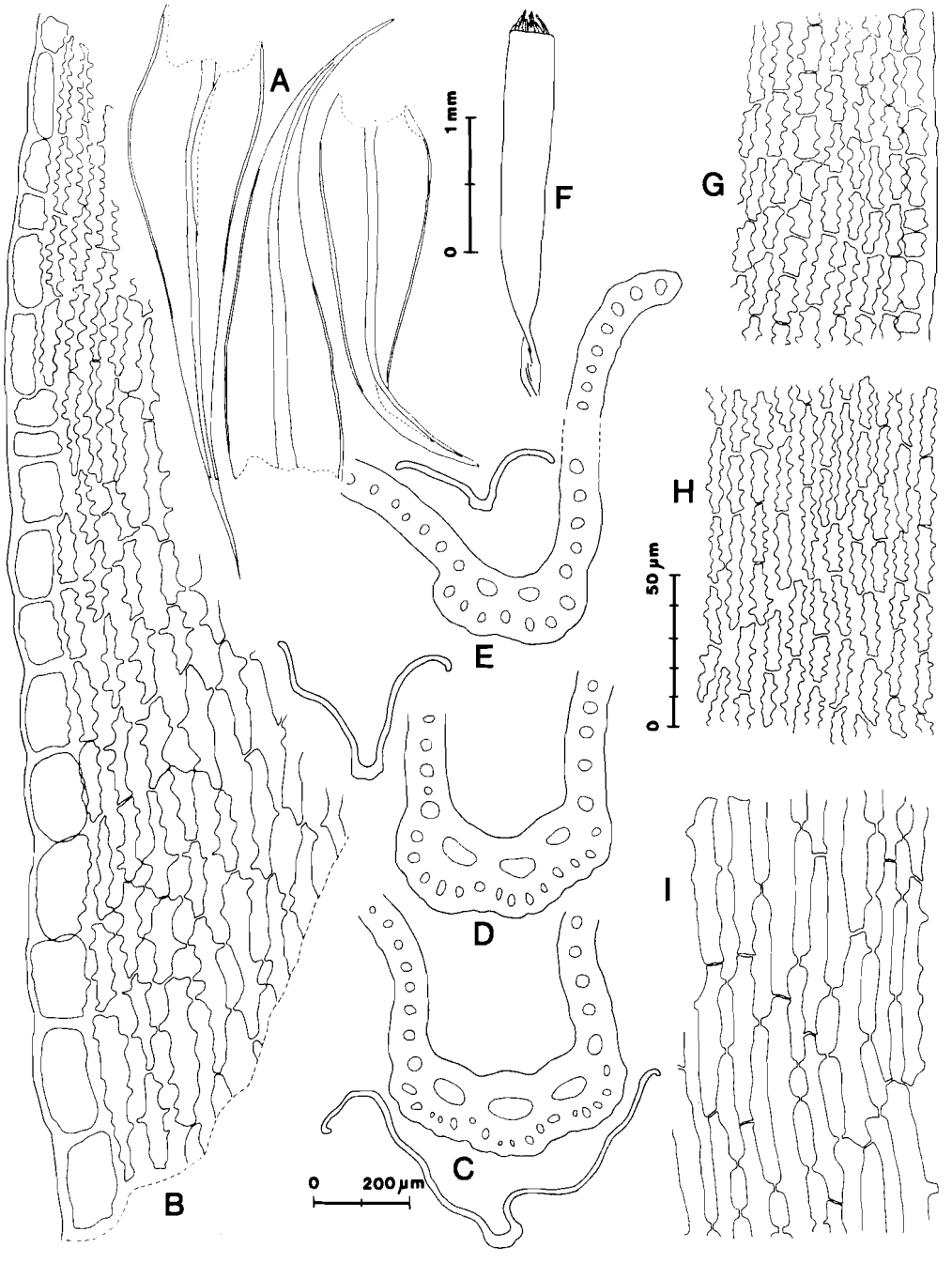

Fig. 37. *Racomitrium crispipilum.* a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (a-e, g-i. Isolectotype of *R. conterminum* - TRH. f. Costa Rica: San José, Standley 43878 - NY.)

280 µm long,) of 2 prongs with median line perforated, coarsely papillose, no basal membrane. Spores 12-14 µm. (1 fertile specimen.)

Diagnostic characters

(1) Plants large, frequently grayish (due to long hair-points). (2) Stem robust, elongate and usually pinnately or subpinnately branched. (3) Leaf long and broad (3-4 x 0.7-1.0 mm). (4) Hair-point +/((-)), 0.5-1(3) mm, edenticulate. (5) Margin recurved (m. long, short/flat), uni. (6) Costa m. broad below and narrow above (70-90/30-50 µm), stratosity/ventral cells (2(-3)/3-4, 2/2(-3), 2/2), reaching to or ending shortly before the point. (7) Lamina cells elongate. (8) Bmb of 10-25 wide and pellucid, usually esinuose and thin-walled but sometimes slightly sinuose, more thick-walled cells. (9) Pl not squarrose, epilose, not hyaline. (10) Seta long (6.0-8.5 mm). (11) Urn m. long (2.0-2.5 mm). (12) Basal membrane

Variation

Racomitrium crispipilum is easily recognized by a combination of the above characteristics, and is not variable in the area. Its type specimen possesses somewhat thick-walled basal marginal cells, but they are differentiated in the same way as the usually more thin-walled cells of the C. American material. And a few C. American specimens are like the type material also in this respect. Otherwise, the hair-point of the uppermost leaves is extremely long in some specimens (e.g. hair-point 4 mm and chlorophyllous part of lamina 2.6 mm), but the structure of the costa and basal marginal cells in such specimens is as in more short-haired ones. This is one of the largest species in sect. *Laevifolia*.

Comparison with other taxa

1. The only other species of sect. *Laevifolia* known from C. America is *R. subsecundum* (Fig. 60-61). Like *R. crispipilum* it is a large species made up of much branched plants; and both have large leaves with flexuose, almost or quite edenticulate hair-point. *Racomitrium subsecundum* is different in having a (much) broader costa including more ventral cells, especially in the central part of the leaf (5-8 versus 3-4 cells). The structure of the costa is the best distinguishing characteristic between them. *Racomitrium subsecundum* also as a rule has an auriculate, orange-red alar region and only a few or no differentiated pellucid basal marginal cells above that. Some specimens of *R. subsecundum* have weakly developed or no auricles; and some have more esinuose marginal cells above the alar regions. Usually, the two are easily separated.

2. The Himalayan *R. capillifolium* (Fig. 47-48) has a narrower leaf with a broader costa, and is clearly different from *R. crispipilum*. However, some of

the *R. crispipilum* specimens with very long hair-points imitate *R. capillifolium*. In spite of this they are not considered to be closely related.

3. Specimens of *R. crispipilum* were named *R. heterostichum* (Fig. 27), but that species has a very different costa and no differentiated basal marginal border. The two do not grow in the same areas.

4. Regarding the difference between *R. crispipilum* and *R. emersum*, see the latter.

Habitat

The labels indicate the following substrate for the species: moist and wet rocks; bluff of old lava; rock ledges; and noncalcareous boulder. One specimen comes from exposed rocks, but usually it seems to grow in less exposed sites, as: mountain cloud forest; in partial shade; and in crevices. The studied specimens are collected from between 2600 and 4500 m a.s.l; at 3400-3500 m in Costa Rica it is stated to be the most common moss on rock ledges and among rocks. *Racomitrium crispipilum* is a large species, which certainly has a great ability to compete with other plants growing on rocks. It probably grows in extensive cushions or mats.

Distribution

Racomitrium crispipilum is known from C. America (Fig. 38) (as well as from some places outside the treated area). It grows in the high mountains of southern Mexico, Guatemala and Costa Rica.

Specimens examined

MEXICO: SW end of Ixtaccihuatl, Delgadillo 1308 (TENN); Popocatepetl, Sharp 4758 (TENN); Nevado de Toluca, at summit of NE side of mountain, 19°14'N, 99°45'W, Horton 7887, 7894, Vitt 17917 (TENN). COSTA RICA: Prov. San Jose. Cerro de las Vueltas, Standley (& Valerio) 43878 (NY, 2 sp.); Paramo of Cerro Chirripo-Massif ab. 15 km NE of Canaan, Bowers 858-D, 859-D (TENN); along Interamerican Highway ab. 10 km NW of summit La Ascension, 9°37'N, 83°48'W, M. & C. Crosby 5723 (GRO, TENN), 5730 (TENN). - Prov. Cartago. Along the Interamerican Highway ab. 73 km S of Cartago, Bowers 723-A (TENN); Paramo Buena Vista ab. 3 km off the Interamerican Highway ab. 90 km S of Cartago, Bowers 618 (TENN); behind Hotel La Georgina on Interamerican Highway ab 97 km S of Cartago, Bowers 308-C, 822-B, and Griffin III, Canessa & Eakin 019981 (GRO, TENN); Pan American Highway, 5 km above Millsville (ab. 8 km above Nivel), Cordillera de Talamanca, Holm & Iltis 1065 (TENN). GUATEMALA: Near summit of Tajumulco, San Marcos, Sharp 5425 (TENN).

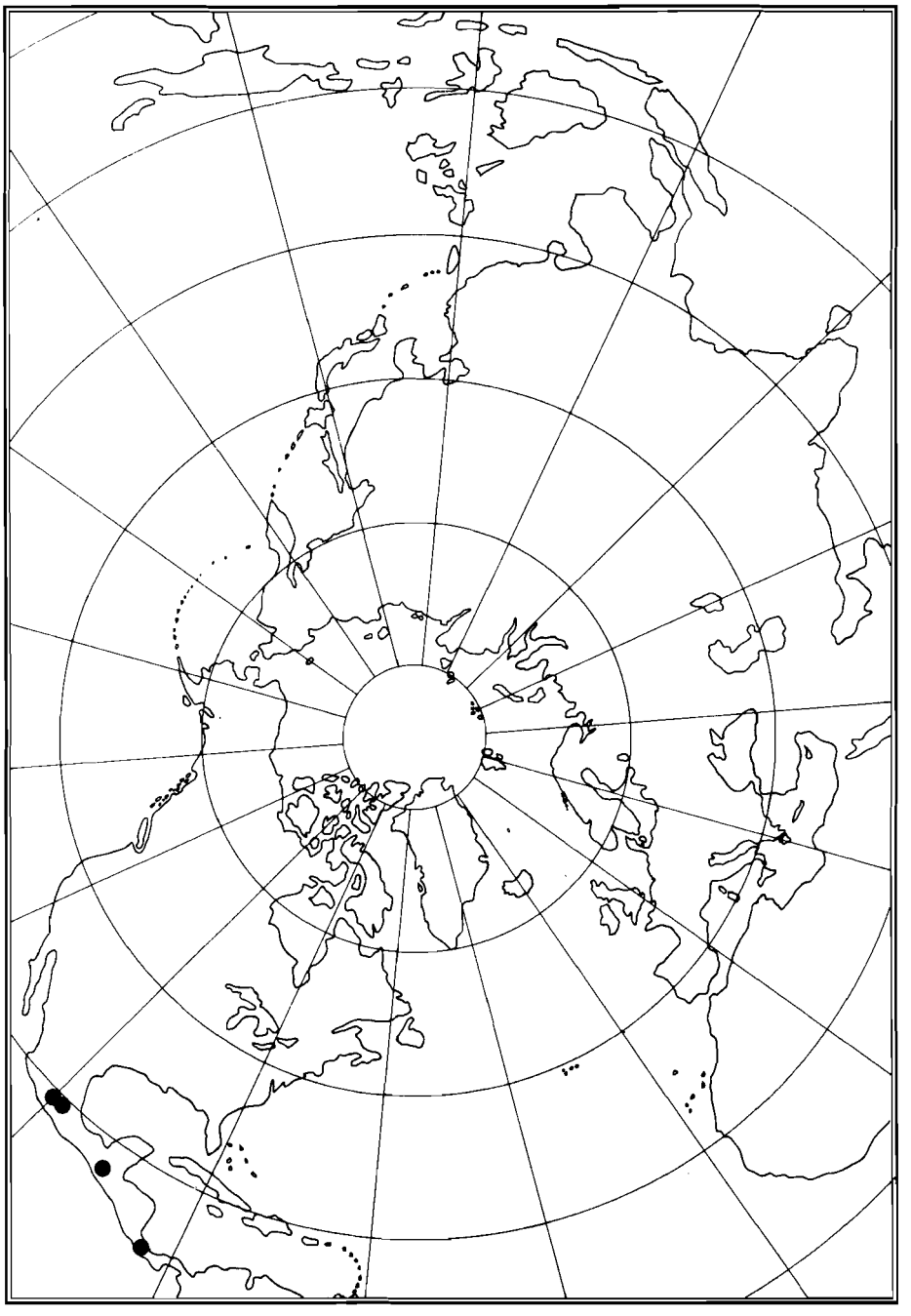

Fig. 38. Distribution of *Racomitrium crispipilum* in the treated area.

(15a) *Racomitrium microcarpon* (Hedw.) Brid. f. *microcarpon*
Fig. 5A, 39, 41, 68B.

Trichostomum microcarpon Hedw., Sp. Musc. 112. *23 f. 8-12.* 1801. - *Bryum microcarpon* (Hedw.) Funck, Krypt. Gew. Fichtelgeb. fasc. 2: 3, n. 40. 1801. - *Racomitrium microcarpon* (Hedw.) Brid., Mant. Musc. 79. 1819. - *Trichostomum heterostichum* var. *microcarpon* (Hedw.) Wahlenb., Fl. Suec. 2: 751. 1826. - *Grimmia microcarpa* (Hedw.) C. Müll., Syn. 1: 804. 1849. - *Racomitrium heterostichum* [var.] γ. *microcarpon* (Hedw.) Boul., Muscin. France 1: 360. 1884. - Type: "Locus alpestris, praesertim in fissuris rupium Angliae, Helvetiae, Sudetum auf der Schneekoppe (Austriae, Clagenfurthi, in granite Bructeri et Franconiae montis piniferi. S.)." (Lectotype: "e Sudetum Schnekuppe, infra fissuris rupium Ludwig hortus." - G-Hedw./Schwaegr. 732/33 p.p.; Frisvoll 1984a: 308, Fig. 3, 4a).

Trichostomum canadense Michx., Fl. Bor. Am. 2: 296. 1803. - *Racomitrium canadense* (Michx.) Brid., Mant. Musc. 80. 1819. - Type: "in pinetis Canadæ." (Isotypes: "*Trichostomum canadense* Mx." - G-Hedw./Schwaegr.; BM-Hookerianum ex Reichard, ex P. de Beauvois).

Grimmia ericoides Pyl. ex Brid., Bryol. Univ. 1: 768. 1826 *non* (Brid.) Lindb., Musci Scand. 29. 1879 *hom. illeg.* [≡ *Racomitrium ericoides* (Brid.) Brid.]. - Type: "In calcareis insulae Terre Neuve caespitibus densis amorphis habitat. Clar. La Pylaie detexit nosque illâ donavit; at fructu carent omnia specimina." (Lectotype nov.: "*Grimmia ericoides*. Terre Neuve, La Pylaie 1825." - B-Bridel).

Racomitrium ramulosum Lindb., Act. Soc. Sc. Fenn. 10: 550. 1875. - *Grimmia ramulosa* (Lindb.) Lindb., Musci Scand. 29. 1879. - *R. heterostichum* [var.] δ. *ramulosum* (Lindb.) Corb., Mem. Soc. Sc. Nat. Cherbourg 26: 260. 1889. - *R. heterostichum* [subsp.] ☆*R. ramulosum* (Lindb.) Dix. in Dix. et Jameson, Stud. Handb. Brit. Moss. ed. 2: 167. 1904. - *R. sudeticum* subsp. *ramulosum* 'Dix.' in Podp., Consp. 296. 1954 *nom. inval. in synon. err. pro R. heterostichum* subsp. *ramulosum* (Lindb.) Dix. - Type: Eight main references, including "*Bryum microcarpon* Funck. Crypt. Gew. Ficht. fasc. 2, p. 3, n. 40 (1801)." (Lectotype nov.: "40. *Bryum microcarpon* H. Auf dem Schneeberg und Ochsenkopf an Granit. Gesammelt im Iun." (Funck 1801) - H-SOL. Isolectotype: TRH).

Racomitrium microcarpon var. *compactum* Röll, Deutsch. Bot. Monatsschr. 4: 104. 1886. - *R. fasciculare* f. *compactum* (Röll) Podp., Consp. 297. 1954. - *R. fasciculare* var. **compactum* 'Röll' in Podp., Consp. 297. 1954 *nom. inval. in synon. err. pro R. microcarpon* var. *compactum.* - Type: "auf der sonnigen Porphyrkuppe des grossen Finsterbergs!!" (Holotype: "*Racomitrium microcarpon* v. *compactum.* gr. Finsterberg, Porphyrfelsen, 2900', 21/7 80." - WB-Röll).

Racomitrium microcarpon var. *ericoides* Röll, Deutsch. Bot. Monatsschr. 4: 104. 1886. - Type: "auf Porphyr am Beerberg!!" (Lectotype nov.: "*Racomitr. microcarpon* c. fr. v. *ericoides*! Porphyrblöcken am Beerberg, 3/9 72." - WB-Röll).

Racomitrium microcarpon var. *gracilescens* Röll, Deutsch. Bot. Monatsschr. 4: 104. 1886. - Type: "auf Porphyr an der Ausspanne bei Oberhof!! auf Granit an der Hirschbalz zwischen Winterstein und Steinbach (R.)!" (Lectotype nov.: "*Racomitrium microcarpon* v. *gracile* Beerberg, Porphyrblöcken b. v. Ausspanne, 31/7 69." - WB-Röll).

Grimmia ramulosa f. *crassior* Sæl. in Broth. et Sæl., Ark. Soc. F. Fl. Fenn. 6(4): 79. 1890. - Type: "Ex alpe Hibinä (F. Nylander)." (Holotype: "*Grimmia ramulosa* (Lindb.) Broth. Im, Kipinä 1843, leg. Fr. Nylander." (outside label) "*Racomitrium ~~canescens Brid.~~ microcarpon* f. In alpe Kipinä, Lapp. rossica, Fr. Nylander 1843." (inside label) - H-BR).

Racomitrium ramulosum var. *terrestre* Hag., K. Norsk. Vid. Selsk. Skrift. 1909 (5): 86. 1909. - *R. microcarpon* var. *terrestre* (Hag.) C. Jens., Skand. Bladmfl. 247. 1939. - Type: "Hist og her på jord på de højeste fjelde, overalt st." [p. 86]. "... den går op på de højere fjelde, selv på toppene, (Gausta 1810 m., Dyrhaugtinden ca. 2000 m., Galdhøen op til 1880 m., Tronfjeldet og Knutshøen til 1700 m.)" [p. 85]. (Lectotype nov.: "*Racomitrium ramulosum* Lindb. st. Norvegia. Hedemarkens amt, Lille-Elvedal, Tronfjeldet, varden, 1740 m, 29.VII.1908 Borgen." - TRH. Paralectotypes: Borgen s.a. (TRH), Hagen 11.VIII.1887 (O, TRH), ? Ex herb. Kiaer 5.VIII.1890 (TRH), 11.VIII.1866 (O), see chapter 8.0).

Racomitrium microcarpon f. *nigricans* H. Wint., Hedwigia 49: 296. 1910. - Type: "Ulefoss, Hotel Borte (Thelemarken) c. fr., Hoitind am Svartisen, 1200 m." (Lectotype nov.: "Flora von Norwegen. *Racomitrium microcarpum nigricans.* Thelemarken, umgebung von Hotel Borte, Juli 1903 leg. H. Winter." - JE).

Racomitrium microcarpon f. *fastigiatum* Loeske, Laubm. Eur. 1: 188. 1913 ('*fastigiata*'). - *R. ramulosum* var. *fastigiatum* (Loeske) Med., Ark. Bot. 20A(10): 36. 1926. - *R. microcarpon* var. *fastigiatum* (Loeske) C. Jens., Skand. Bladmfl. 247. 1939. - Type: "Eine abweichende f. *fastigiata* beobachtete ich am Arlberg auf feuchtem Silikatgestein des 'Wirts' bei 2300 m, steril." (Lectotype nov.: "ex Herbario bryologicum L. Loeske, von Original. *Rhacomitrium microcarpon* sensu Limpr. v. *fastigiata.* Tirol, Arlberg, am „Wirt" an feuchtem Silikatfelsen, 2300 m, 2.7.1907 Loeske." - S).

Racomitrium tatrense Vilh., Preslia 2: 145, 147. 1922 *pro hybr.* - Type: "mezi Matliary a Kezmarskymi zleby u Tatranské Lomnice (1919), ..." Holotype: "*Racomitrium microcarpon* ♀ x *heterostichum* ♂ (*tatrense* Vilh.) Slovacia centr., mts. Vysoké Tatry, in piceeto inter pagum Tatranské Matliare et Kezmarskí zleby, 24.VIII.1919 J. Vilhelm." - PRC).

Racomitrium sudeticum f. *brevirostellatum* Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 25. 1925 ('*brevirostellata*'). - Type: "Habitat in saxis montium Corconticorum in Bohemia (Certova zahrádka, Kotel, Vilh.)." (Lectotype nov.: "*Racomitrium sudeticum* ? cfr. Bohemia septentr.-or., mts. Krkonose, convexum Obri dul, loc. Certova zahrádka, 30.VIII.1919 J. Vilhelm." - PRC).

Racomitrium microcarpon f. *repens* L.I. Savicz in L.I. et V.P. Savicz, Bryoth. Ross. n. 36. 1928. - Type: "Rossia arctica. Lapponia tulomensis, litus murmanicum in vicin. Stationis Biologicae prope Alexandrovsk, in lapidibus magnis humidis ad ripam rivuli. Anno 1927-VIII-19 leg. et determ. L.I. Savicz." (Lectotype nov.: LE. Isolectotype: S, etc.).

Racomitrium heterostichum f. *subepilosum* Möll., Ark. Bot. 24A(2): 86. 1931 ('*subepilosa*'). - Type: "Värmland, Färnebo 1927 G. Åberg; Gästrikland, Torsåker 1912 M.; Västerbotten, Umeå 1912 M." [in loc. list p. 92, 93]. (Lectotype nov.: "*Rhacomitrium heterostichum* (L.) Lindb. f. *subepilosa*. Gästrikland, Torsåker, Hofors bruk, 21/10 1912 Leg. Hj. Möller." - S. Paralectotypes: 17.VI.1912 Möller; 30.IX.1927 Åberg. - S).

Racomitrium ramulosum f. *atrum* Möll., Ark. Bot. 24A(2): 113. 1931 ('*atra*'). - Type: "Uppland, Västland 1918 Florin; Dalarna, Idre 1893 G. Hellsing; Hälsingland, Undersvik 1920 A. Liljedahl; Västerbotten, Jörn 1912 M." [in loc. list p. 116, 117, 118]. (Lectotype nov.: "*Rhacomitrium ramulosum* Lindb. f. *atra*. Västerbotten, Jörn, 19/6 1912 Leg. Hj. Möller." - S. Paralectotypes: 21.VIII.1918 Florin; ? 1920 Liljedahl. - S).

Racomitrium ramulosum f. **gracile* Möll., Ark. Bot. 24A(2): 113. 1931 *nom. nud.* ('*gracilis*'). - Orig.: "Västerbotten, Vännäs 1874 C.P. Lästadius." [p. 118]. (Orig. spec.: "*Rh. heterostichum*. WB. Mell. Fällfors och Stärkesmark, Wännäs, 4/7 74 C.P. Læstadius." - S).

Racomitrium ramulosum f. **propaguliferum* Möll., Ark. Bot. 24A(2): 118. 1931 *nom. nud.* ('*propagulifera*'). - Orig.: "Härjedalen, Storsjö 1841 J. Ångström, 1926 G. Åberg." (Orig. spec.: "3292 *Rhacomitrium ramulosum* Lindb. f. *propagulifera*. Hrjd. Storsjö kap., Björnsjöberget. Underlag: torr klippa. Höjd: c. 600 m. Cl. 16/7 1926 Gerhard Åberg." - S).

Racomitrium ramulosum f. *repens* Möll., Ark. Bot. 24A(2): 113. 1931. - Type: "Ångermanland, Örnsköldsvik 1901 M." [p. 118]. (Holotype: "*Rhacomitrium ramulosum* Lindb. f. *repens*. Ång. Örnsköldsvik, Bussjöholen, Aug. 1901 Leg. Hilda Möller." - S).

Racomitrium ramulosum f. *subepilosum* Möll., Ark. Bot. 24A(2): 113. 1931 ('*subepilosa*'). - Type: Not indicated. (Lectotype nov.: "*Rhacomitrium ramulosum* f. *subepilosum*. Torne Lappmark, Karesuando, 20/7 1912 Leg. Hj. Möller." - S. Paralectotypes: 23.VIII.1896 s. leg.; 27.VII.1918 Möller; 27.VII.1897 s. leg. - S).

Plants black or brown below, yellowish, olivaceous green or green above, usually not but sometimes grayish due to long hair-points, in dense, often large mats or cushions. **Stem** (0.5)2-4(6) cm, often intricately ramified, all main stems and elongated branches usually with subpinnately arranged branchlets. **Leaves** frequently secund, (1.5)1.9-2.8(3.2) x (0.4)0.5-0.75(0.8) mm. **Hair-point** usually present, capillaceous, usually flexuose, to 1 mm or longer but frequently about 0.3-0.7 mm, from distinctly acute-denticulate to more obtusely denticulate, not

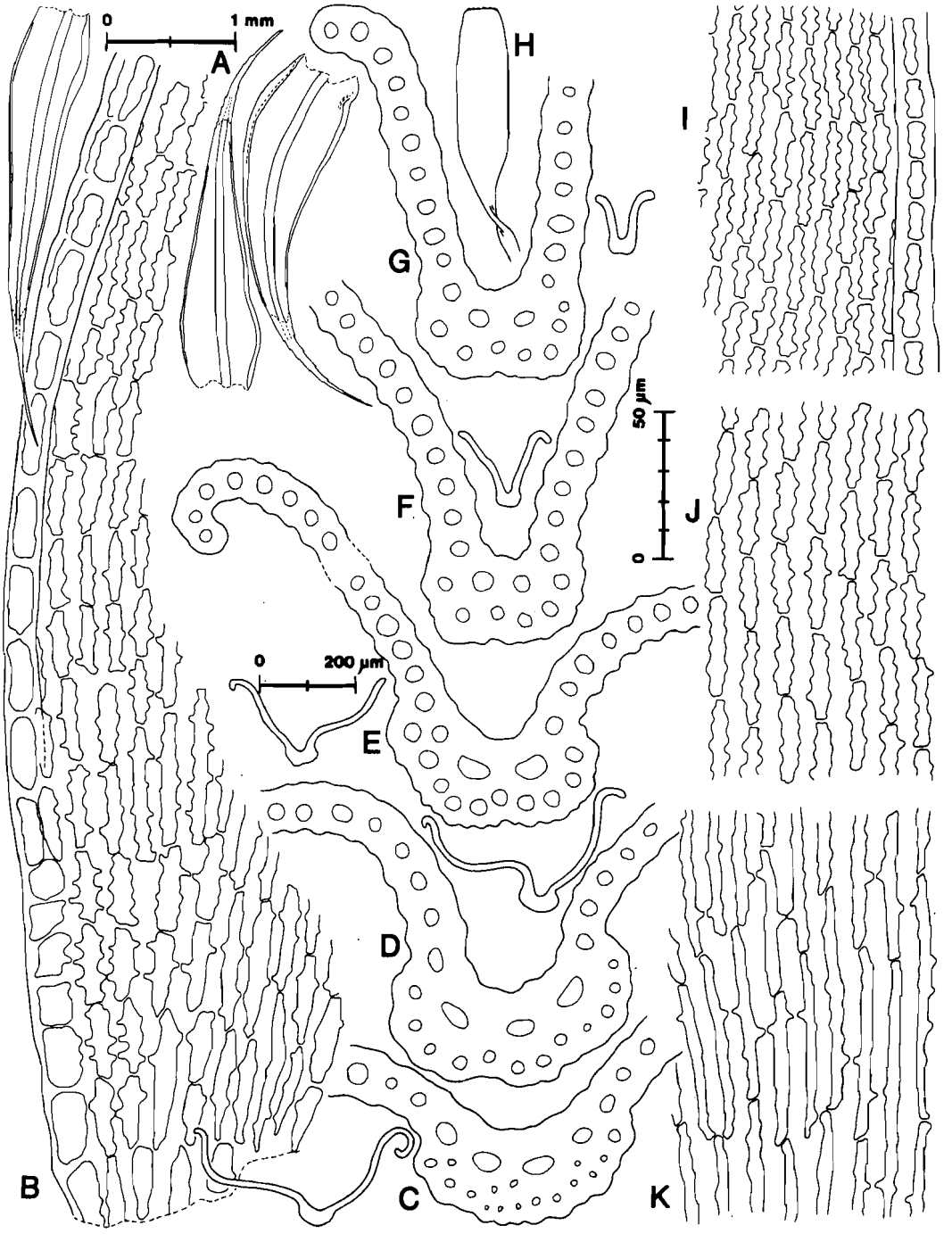

Fig. 39. *Racomitrium microcarpon* f. *microcarpon*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. (a-g, i-k. Canada: B.C., Wells Gray Prov. Park, L. & T. Ahti 7316 - CANM. h. U.S.A.: Montana, Lake Co., Schofield 11777 - CANM.)

or slightly decurrent down margin of lamina. **Margin** broadly recurved to the hair-point or more frequently to 3/4 the leaf length on one side, and more narrowly and usually shortly recurved to rarely flat on the other side, unistratose throughout or very rarely with bistratose spots. **Costa** strongly convex at the dorsal side, in lower part (50)60-80(100) µm broad, in upper part (35)40-55 µm broad, reaching to or almost to the hyaline point, in basal part bi- to three-stratose (d. 10-17, c. 0-4(9), v. (2)3-4(5)), in central part bi- or more rarely three-stratose (d. 6-10(12), c. 0-2, v. 2-3(4)), in upper part bistratose (d. 4-9, c. 0(-1), v. (1)2(3)). **Lamina** unistratose. Basal **laminal cells** thick-walled, porose and not sinuose, elongate (T: 25-50 x 9 µm), middle and upper cells strongly sinuose, rectangular (T: 24-30 x 10 µm), upper marginal cells quadrate to rectangular (T: 10-25 x 12 µm) or sometimes transversely elongate, walls from slightly or not to strongly bulging dorsally and ventrally, the marginal wall thick. **Alar cells** of the same colour as the lamina, one to two hyaline basal marginal cell rows extending as a border up the margin, (5)10-20(28) cells in the marginal and 0-10 cells in the second (frequently sinuose cell) row.

Perichaetial leaves not squarrose when wet, the inner (4-6) leaves epilose or sometimes all with hair-point, ovate with acuminate apex, not hyaline except at the base of the innermost leaves. **Seta** about 4.5-8 mm. **Urn** oblong-cylindrical or elongate-ovate, (1.3)1.5-2.0 x 0.3-0.6 mm, exothecial cells rectangular, 4-5 rows of narrow (in part transversely elongate) cells at the mouth. **Teeth** about 315-340 µm, lowly papillose, of 2 prongs which are split down to the base, basal membrane low or absent. Spores 12-14 µm.

Diagnostic characters

(1) Plants in dense cushions or mats. (2) Stem frequently (sub)pinnately branched, usually not robust. (3) Leaf short/m. long and m. broad (1.9-2.8 x 0.5-0.75 mm), frequently secund. (4) Hair-point +, 0.3-0.7 mm, denticulate, flexuose. (5) Margin recurved (m. long/long, m. long/flat), uni. (6) Costa narrow (60-80/40-55 µm), stratosity/ventral cells (2-3/3-4, 2(-3)/2-3, 2/2(-3)). (7) Lamina cells towards the leaf base thick-walled, porose and esinuose. (8) Bmb of 10-20 hyaline cells and sometimes a second row of fewer somewhat sinuose cells. (9) Pl not squarrose, the inner (4-6) epilose or all with hair-point, not hyaline. (10) Seta long (4.5-8.0 mm). (11) Urn short (1.3-2.0 mm). (12) Basal membrane ± (10 µm).

Variation

Racomitrium microcarpon is usually easy to recognize. Depauperate, high-alpine plants may by almost epilose, but the basal marginal border and the characteristic costa (t.s.) are as usual also in these specimens. Such plants have short upper leaf cells and may possess bistratose marginal spots. Very rarely, the hair-point is wanting due to a genetical aberrance, and such epilose plants may be mixed with pilose plants. The cushions are sometimes grayish due to long

hair-points, but this is not the rule. The costa is entirely or almost bistratose; a third stratum may be indicated or is sometimes more developed. There are some regional differences with regard to the occurrence of a distinctly developed third stratum in the costa. It was not seen in the few leaves of the lectotype which were sectioned by Frisvoll (1984a: Fig. 3); but the type is made up of small, gracile plants, and such plants usually have a bistratose costa. Robust plants from the type area may have a three-stratose costa, and this potential in robust specimens seems to be the usual condition in the species. The number of cells in the basal marginal border vary much. Most often the border is long, but sometimes it is made up of fairly few cells, and they may even be slightly sinuose. Plants with this kind of border are frequently rigid, and may have short upper leaf-cells and short hair-points. The leaf cross sections, and the structure of the basal lamina cells and the hair-point place these plants in *R. microcarpon*. The leaf cells are from not to strongly pseudopapillose.

The western N. American ecad has always strongly pseudopapillose cells. It is also robust when not depauperate, and have distinctly secund large leaves (e.g. 2.6-3.2 mm long) with a long hair-point (to more than 1 mm); because of the long hair-points the cushions may appear grayish. The specimens may also possess comparatively many central costal cells. Some specimens from *eastern* N. America approach the western N. American specimens in robustness, but are less pseudopapillose. Similar robust plants have not been seen from Europe and Asia (but see f. *afoninae*). Pseudopapillae occur in many areas; they are rarely as high as in the western N. American ecad, but may sometimes be pronounced - even in small specimens. The western N. American plant might have been described as an infraspecific taxon; but because it is not always well separated morphologically, I have chosen not to do so. Lawton (1972: Table 2, Fig. 23-24) called the pseudopapillose western N. American specimens "plant E", and she correctly identified them as *R. microcarpon*. More comments on the variation of *R. microcarpon* are given below.

Comparison with other taxa

1. *Racomitrium vulcanicola* (Fig. 45) is the Japanese counterpart of *R. microcarpon*; for differences between the two, see the former.

2. *Racomitrium sudeticum* (Fig. 15-17) grows together with *R. microcarpon* throughout much of its distribution area, and the separation of the two has troubled bryologists from pre-Hedwigian times and till now. Actually, the lectotype specimen of *Trichostomum microcarpon* includes two plants of *R. microcarpon* and two of *R. sudeticum* (Frisvoll 1984a: Fig. 4a). This mixing on the type sheet appears to be symbolic, because no flora can help distinguish well between them, and the herbarium material is really a mixture of the two. And yet they do not appear to be very closely related, and mixed stands are frequent and do not include intermediates. Because they have been so much confused, a very thorough comparison is needed: **Stem** (*mic*: much, usually intricately and subpinnately branched; *sud*: less branched, and frequently almost

or quite unbranched), **leaves** (*mic*: usually secund; *sud*: frequently not, yet sometimes distinctly secund), **hair-point** [*mic*: sometimes broad at the base but invariably capillaceous towards the apex, with all or the majority of the end cell of the points long and very narrow like an acute needle, the majority of the points secund - but sometimes erect-flexuose - and not distinctly recurved at the connection with the lamina when dry, from distinctly acute-denticulate to obtusely denticulate at the margin and sometimes slightly spinulose dorsally; *sud*: usually not broad at the base, more stout and not capillaceous, with all or the majority of the end cell of the points shorter and less acute, (usually) not flexuose, the majority of the points distinctly recurved at the connection with the lamina when dry, (usually) denticulate at the margin and spinulose dorsally], **margin** (*mic*: unistratose with rare bistratose spots in some modifications or ecotypes; *sud*: usually bistratose or with frequent bistratose spots, sometimes largely or entirely unistratose), **costa** (*mic*: principally bistratose, with a third stratum frequently indicated towards the base, the central cells are stereid-like as are the basal dorsal cells; *sud*: principally three-stratose, but sometimes largely bistratose with a third stratum typical of *R. sudeticum* always present in the most robust part of the costa, the central and dorsal cells are less stereid-like), **lamina cells** (*mic*: basal lamina cells elongate, with thick *esinuose* and porose walls, central and upper cells strongly sinuose and porose and frequently long-rectangular, but short to quadrate cells are frequently mixed with the long cells, and sometimes all upper cells are from quadrate to short-rectangular; the upper *marginal* cells are usually quadrate to short-rectangular, but may be elongate and also predominantly transversely elongate and quadrate; *sud*: basal laminal cells elongate with *sinuose* walls, central and upper cells less porose and frequently short-rectangular and quadrate, but sometimes the majority of the upper cells are longly rectangular; the upper marginal cells are shorter but vary according to the length of the upper laminal cells), **alar cells** (*mic*: a hyaline basal marginal leaf border present, of various length - see Variation; *sud*: the basal marginal cells differentiated, of somewhat thick-walled esinuose, or slightly sinuose cells, very rarely with a longer hyaline basal marginal border approaching that of *R. microcarpon*; note that in subperichaetial leaves the same cells may be more hyaline). The perichaetial leaves and sporophytes of the two are also different (see Descriptions). - In the literature, *R. microcarpon* is said to have long and *R. sudeticum* short upper leaf cells. Sometimes, alpine specimens of *R. microcarpon* have been allowed to possess "shortly-rectangular to quadrate cells towards the apex of the leaf" (Mårtensson 1956), but *R. sudeticum* has rarely if ever been allowed to possess elongate upper leaf cells. The length of the leaf cells is of no importance in distinguishing between the two, but the structure of the cells in various parts of the leaf is of significance as outlined above. Difficult specimens can always be identified by combining characteristics of the hair-point, costa and basal laminal and marginal cells. The most variable species is *R. sudeticum*.

3. Specimens of *R. heterostichum* (Fig. 27) with elongate upper leaf cells have been called *R. microcarpon* by competent bryologists (see e.g. Frisvoll 1985a: 382). The two are different in all important structures, including, e.g., the average size and structure of the sporophyte and perichaetial leaves, and the struc-

ture of hair-point, costa and basal margin leaf cells. The length of the upper lamina cells is as unimportant in this context, as it is when distinguishing between other species in the section.

4. For differences between *R. microcarpon*, and *R. affine*, *R. himalayanum*, *R. nitidulum*, *R. obtusum*, *R. venustum* and *R. verrucosum*, see these species. For differences between f. *microcarpon* and f. *afoninae*, see the latter.

Habitat

Racomitrium microcarpon grows in two kinds of habitats. In sub-alpine areas sensu lato it grows on acid boulders and rocks. Here it may occupy extensive patches as almost pure mats. In alpine areas it still grows on rocks, but is also common on soil and gravel. The terrestrial specimens make up its so-called var. *terrestre*. It is the absence of a tree layer and the reduced competition from the field layer, that enables this and other 'epilithic' mosses to grow on soil in the alpine region. The growth habit of epigeic plants is naturally different from epilithic plants. Another parallel seems to be *R. fasciculare* and it so-called var. *rivulare* (Zett.) Möll.

Distribution

Racomitrium microcarpon f. *microcarpon* is known from Europe, N. America and Asia, and appears to have an almost completely northern circumboreal distribution (Fig. 41). In Europe it is common in Fennoscandia (except for the western parts of Norway, Fig. 68B), whereas it is known only from the high mountains of central Europe (the Carpathians, Tatry, Krkonose, from Harz and south to the Alps, Vosges); in the European USSR it is known in scattered localities from the Baltic coast to the Ural Mountains; it is present but very rare in Iceland (two specimens seen). In America it occurs in southern Greenland; in eastern Canada and U.S.A. from Newfoundland to the western part of Ontario; and in the west it occurs in the Rocky Mountains from Montana to Yukon, and in a few localities nearer to the coast. In Asia it is known from scattered localities in the mountains of southern Siberia, and in Gory Putorana farther to the north. (There is one British specimen including some duplicates: "The only claim to its being considered a native of Britain rests upon a specimen in Hooker's Herbarium, labelled ['Highlands']." (Dixon & Jameson 1896: 152). To my knowledge this is still true, and I consider *R. microcarpon* should be recollected before it is definitely regarded as British. This badly labelled Hooker specimen is glued to the same sheet as two specimens of *R. microcarpon* from Scandinavia - leg. Sommerfelt, and a mislabelling or misunderstanding might have taken place. See also Distribution maps of bryophytes in Britain - 56/6 *Rhacomitrium microcarpon*; J. Bryol. 7: 448. 1973.)

(15b) *Racomitrium microcarpon* f. *afoninae* Frisvoll. *f. nov.*
Fig. 40-41.

A typo *R. microcarpontis* differt margine basalis foliorum e cellulis crasseparietinibus habet.

Holotype: "USSR, Chukotka. Inchoun Village, stony tundra near snow patch, 6.VIII.1975 O. Afonina" - LE. Isotypes: ALTA, TRH.

Plants quite blackish or brownish below and olivaceous green above. **Stem** much branched. **Leaves** secund or not, (1.9)2.6-3.4(3.75) x (0.35)0.5-0.7 mm. **Hair-point** strongly flexuose, up to 1.0 mm, not or obtusely denticulate, not decurrent. **Margin** broadly recurved to 1/2 or 3/4 the leaf length on one side, more narrowly recurved to rarely plane on the other side, usually unistratose or with rare bistratose spots. **Costa** 55-85 µm broad below and 45-60 µm broad above, reaching to the point, often irregular in outline (t.s.), in basal part bi- to three-stratose (d. (6)8-14, c.0-3(6), v. 2-3(4)), in central part bi- to three-stratose (d. 7-12, c. 0-1(4), v. 2-3), in upper part bi- or rarely three-stratose (d. 5-8(10), c. 0-1(3), v. 2(-3)). Basal **laminal cells** elongate (T: 40-95 x 12 µm), middle and upper cells elongate or rectangular (T: 20-47 x 12 µm), upper marginal cells quadrate to rectangular (T: 14-28 x 14 µm), all cells very thick-walled and porose, and moderately pseudopapillose. **Alar cells** not especially coloured, one row of basal marginal cells differentiated, made up of elongated, thick-walled, ± sinuose and not or slightly hyaline cells, 7-15(20) cells in the marginal row.

Sterile.

Diagnostic characters

(3) Leaf m. long and m. broad (2.6-3.4 x 0.5-0.7 mm). (4) Hair-point not or obtusely denticulate, strongly flexuose. (6) Costa slightly more robust in the upper part (45-60 µm), often asymmetrical in transection. (8) The cells of bmb usually not hyaline, but thick-walled and often with (slightly) sinuose walls.

Variation

The colour of the plants are usually quite blackish, and the lighter specimens are supposed to have grown in less exposed microhabitats. Normally, the form seems to be made up of large and coarse plants; but more gracile plants are also seen, and all material from the type area is considered to belong to the same taxon. Sometimes the costa includes many central cells, but the central layer may also be almost lacking. The cells of the basal marginal leaf border are usually thick-walled. This cannot be a mere modification of the type of f. *microcarpon*, because high-alpine specimens from other areas possess typically developed, hyaline border cells. F. *afoninae* is likely to occur in (sub)arctic adjacent parts of N. America, and also to have a larger distribution in Siberia.

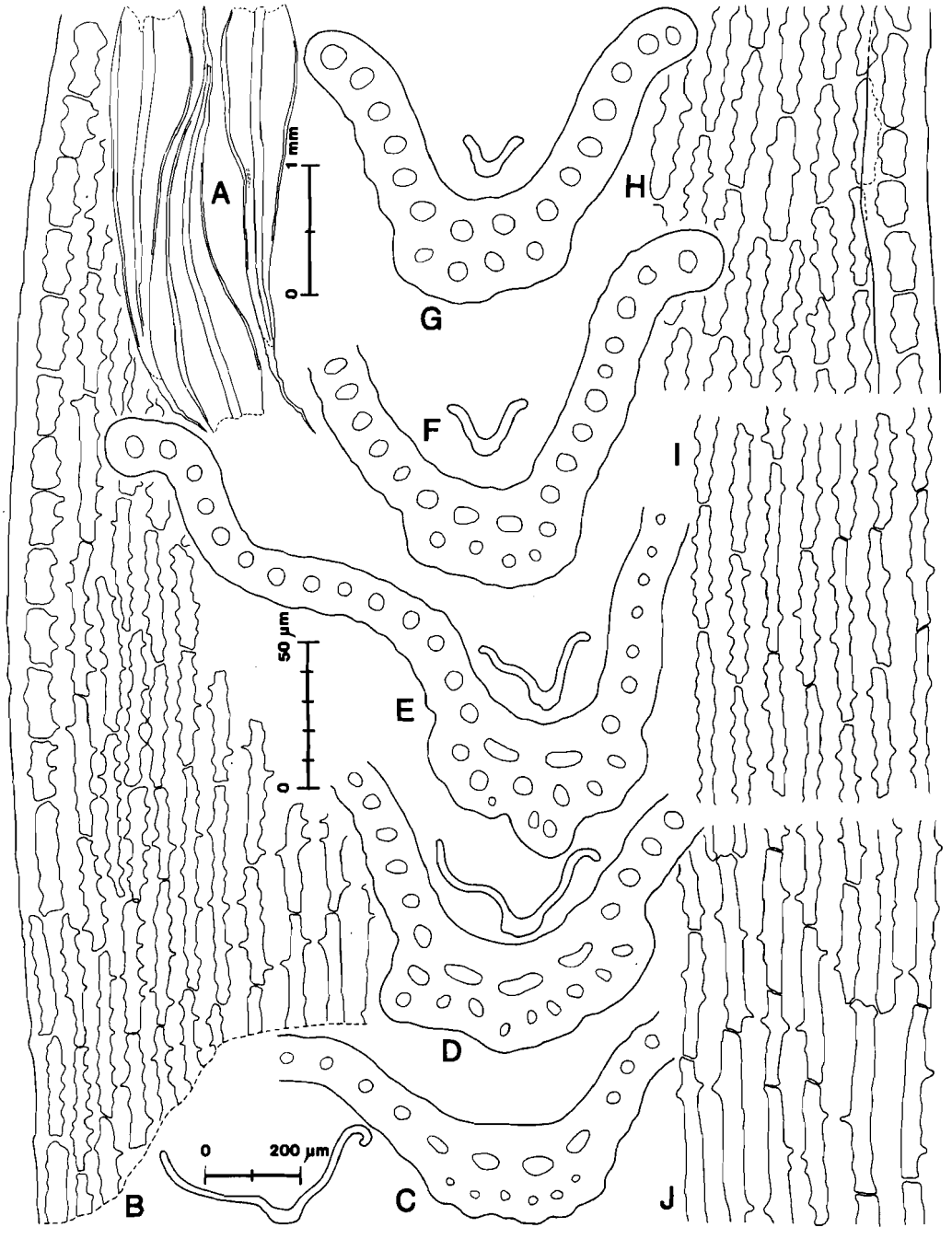

Fig. 40. *Racomitrium microcarpon* f. *afoninae*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h-j. Cells from the upper, lower middle and basal part of the leaf. - Holotype (LE).

And material from these areas will throw more light on the variation of the taxon. The few known American specimens are well in accord with the Asiatic material.

Comparison with other taxa

1. *Racomitrium microcarpon* f. *microcarpon* (Fig. 39) possesses a thin-walled hyaline basal marginal border. The border of f. *afoninae* is not hyaline and its cells more or less thick-walled. The border cells of f. *afoninae* are often long and narrow, whereas in f. *microcarpon* they are short and wide. The lamina cells of f. *afoninae* are very thick-walled and porose. Its costa is robust and asymmetric in the upper part of the leaf, see Description; f. *microcarpon* has a less robust, symmetric costa.

2. Several specimens of f. *afoninae* are mixed with a large, often yellowish plant of *R. sudeticum* f. *terricola* (Fig. 17). The latter is slightly or not branched and have, inter alia, a shorter hair-point than f. *afoninae*; less thick-walled and less porose cells which are sinuose also towards the base of the leaf; less differentiated basal marginal cells; frequent bistratose marginal spots; and (at least in spots) a typical three-stratose *sudeticum*-costa. Some specimens have quite elongate cells also in the upper part of the leaf, with a weaker, frequently bistratose costa and a frequently unistratose margin. Because f. *afoninae* sometimes has some central costal cells, the two may be confused.

Habitat

The labels indicate the following habitats: "stony moss tundra; stony tundra near snow patch; stony slope on rocks and soil; boulders of talus on tundra." It seems to be a lowland plant in Chukotka, whereas it is known from 800 m a.s.l. in Canada.

Distribution

USSR: Siberia, Chukotka. U.S.A.: S. Alaska. CANADA: British Columbia.

Specimens examined

USSR: Chukotka. Inchoun Village, 29.VII. and 6.VIII. (3 sp.) 1975 Afonina (LE); Nunligran Village, 26.VI.1970 Afonina (LE); Gilmimli hot springs, SW Chukotka, 22.VII.1977 Afonina (LE); Yetljanen River, 3.VIII.1976 Afonina (LE). - CANADA: British Columbia. Along Haines Highway, 58 miles WNW Haines (Alaska), Hermann 21827 (WTU). U.S.A.: Alaska. Valdez Quadrangle, Along Richardson Highway, Worthington Glacier View, ca. 30 miles E Valdez, Hermann 21600 (S).

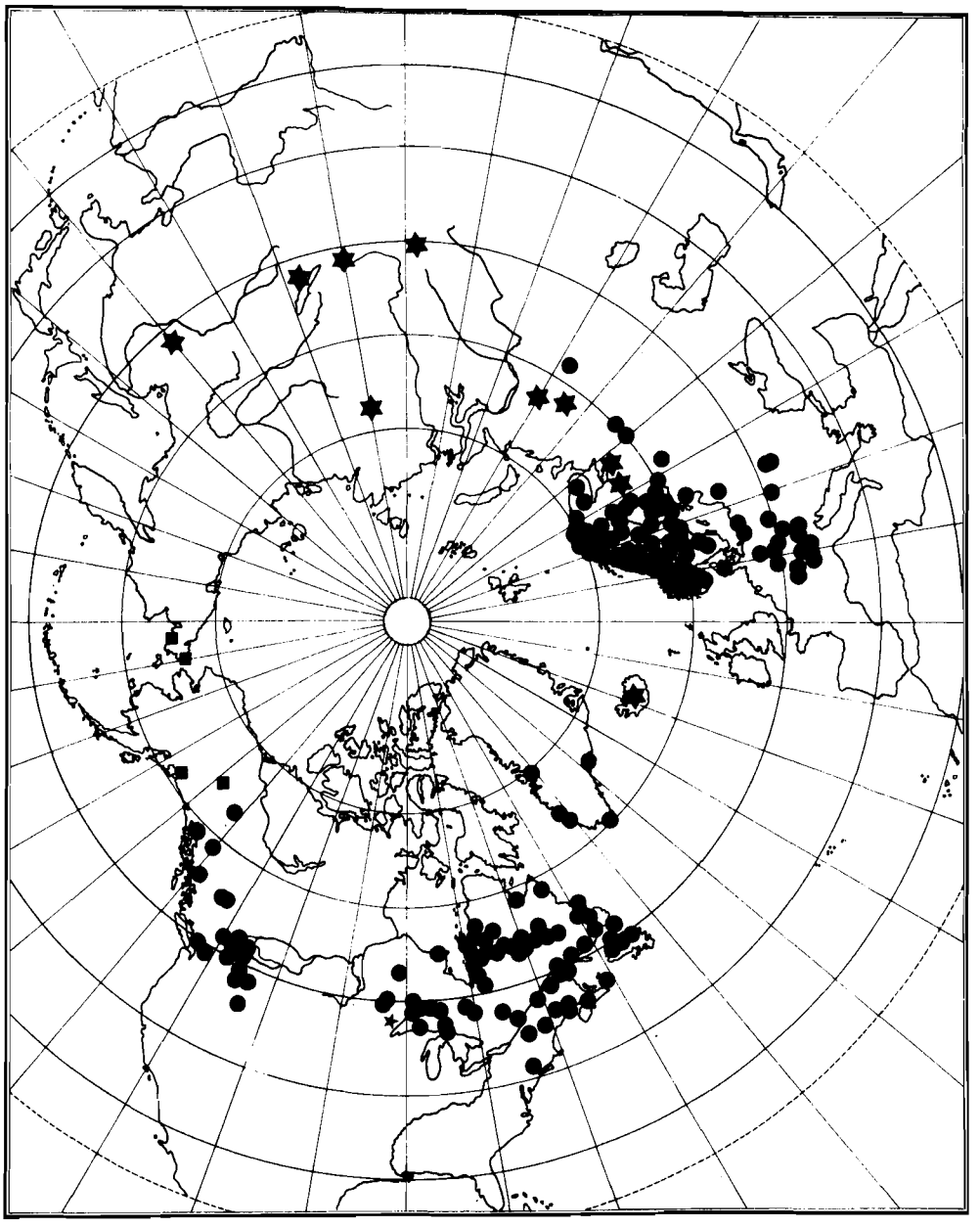

Fig. 41. Distribution of *Racomitrium microcarpon* s.l. ● f. *microcarpon*. ★ locality inexact. ■ f. *afoninae*.

(16a) *Racomitrium verrucosum* Frisvoll *sp. nov.* var. *verrucosum*
Fig. 42, 44.

Margo foliorum late recurvatus, bistratus; cellulae foliorum valde porosae, in areis maculiformibus bistratae.

Holotype: "Nepal. Between Thang La (pass) and Thudam. On rock, 4550 m alt. June 21, 1972. The 5th. Bot. Exped. to E. Himalaya by Univ. of Tokyo. Coll. Z. Iwatsuki, no. 1459." - NICH. Isotypes: H, L.

Plants comparatively small, usually quite brownish or blackish with lighter apices, in dense interwoven cushions. **Stem** up to 3.5 cm, not robust, strongly, irregularly or pinnately branched. **Leaves** 1.9-2.25(2.4) x (0.4)0.5-0.65 mm. **Hair-point** usually absent, or very short (to 170 µm). **Margin** usually recurved towards the apex on both sides, but sometimes to 3/4 the leaf length on one and more shortly and narrowly recurved on the other side, in upper part bistratose for 1-5(8) cell rows (but where the margin borders on a bistratose lamina there may be more continuous bistratose cell rows), sometimes in spots three-stratose, in lower part bistratose for 1-2 and sometimes for more cell rows, rarely with unistratose spots. **Costa** variable but usually broad, reaching into and sometimes filling up the apex, dorsally convex, in lower part (75)80-110(120) µm broad, in upper part 50-70 µm broad, in basal part (bi- to) three-stratose (d. (12)18-21, c. (0)3-12, v. (4)5-9), in middle part bi- to three-stratose (d. (9)13-17, c. (0)1-3, v. 4-7), in upper part bi- (to three-)stratose (d. 8-12, c. 0-2, v. 3-5). **Lamina** from apex and towards the base with bistratose areas or cell rows, sometimes less thickened and almost unistratose. Basal **laminal cells** elongate (T: 25-50 x 9 µm), with thick esinuose walls, middle and upper cells shorter (T: 9-25 x 9 µm) or in some leaves or specimens very short (6-11 x 9 µm), upper marginal cells short (T: 5-15 x 12 µm), cell walls usually strongly porose throughout the leaf (sometimes less porose in its upper part), areolation frequently opaque because of the bistratose lamina and the dark-coloured and usually distinctly bulging cell walls. **Alar cells** with the same colour as the lamina, one row of hyaline, thin-walled (but see Variation) and esinuose cells extending as a border up long the margin, (12)16-22(25) cells in the marginal row.

Perichaetial leaves not squarrose when wet, epilose, not hyaline, ovate with acuminate point. **Seta** about 4.5 mm. **Urn** ovoid (1.3 x 0.5 mm), exothecial cells relatively short and wide, 2-3 incrassate rounded cell rows at the mouth. **Teeth** (broken, probably of 2 prongs which are imperfectly split below,) basal membrane present (25 µm). Spores 12-16.5 µm. (2 fertile specimens.)

Diagnostic characters

(1) Plants comparatively small and cushions dense, dark-coloured except at the top. (2) Stem not robust, strongly branched. (3) Leaf short and narrow (1.9-2.25 x 0.5-0.65 mm). (4) Hair-point -/(+), 0-0.15 mm. (5) Margin broadly recurved

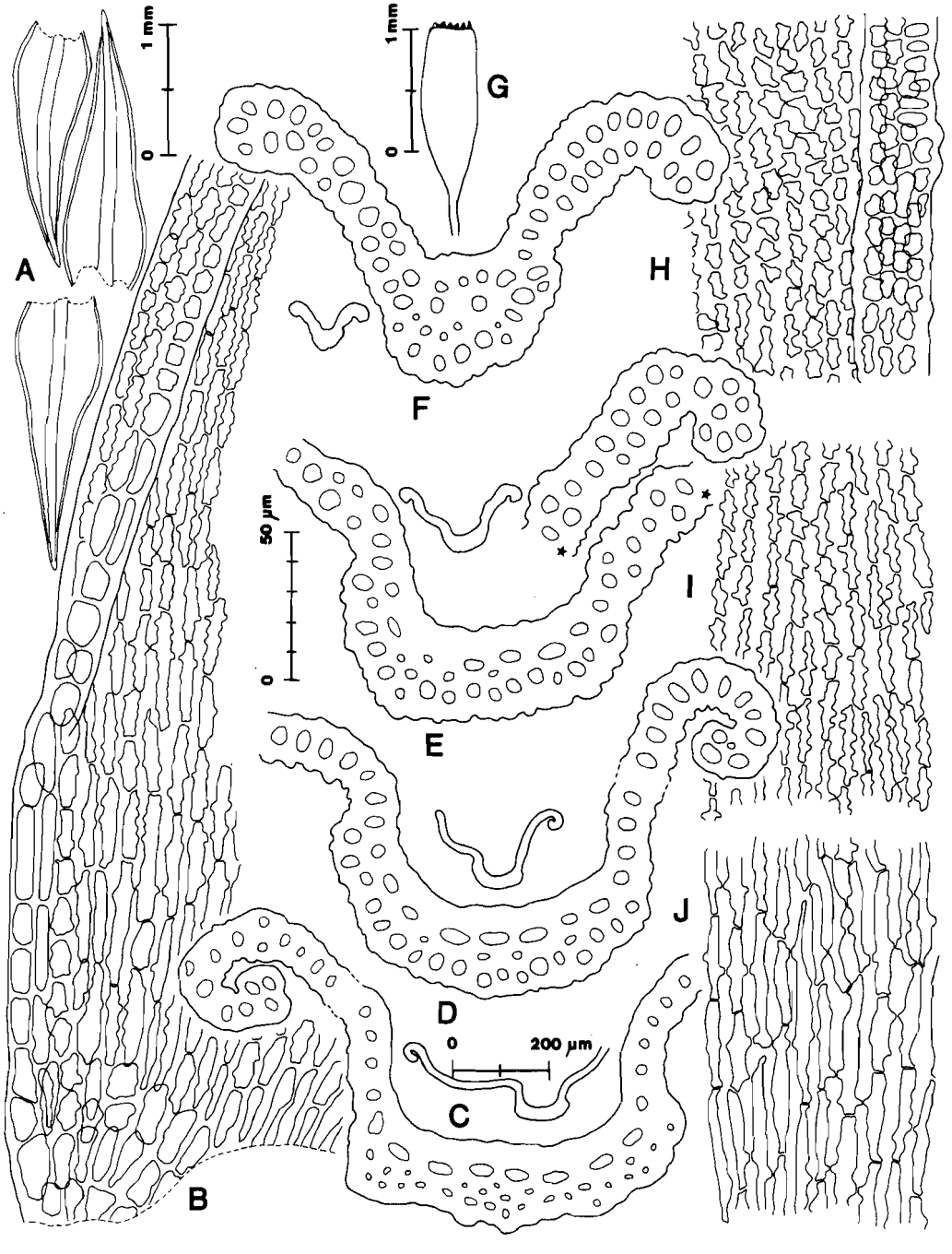

Fig. 42. *Racomitrium verrucosum* var. *verrucosum* a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g. Capsule. h-j. Cells from the upper, lower middle and basal part of the leaf. (a-f, h-j. Holotype - NICH. g. China: NW Yunnan, Handel-Mazzetti 9976 - S.)

(long, long/m. long), bi (1-5)/three (in spots). (6) Costa broad (80-110/50-70 µm), stratosity/ventral cells ((2-)3/5-9, 2-3/4-7, 2(-3)/3-5), reaching into or almost or quite filling up the apex. (7) Lamina with bistratose areas or spots, cells strongly pspp and strongly porose. (8) Bmb of 16-22 hyaline, esinuose cells. (9) Pl not squarrose, epilose, not hyaline. (10) Seta short (4.5 mm). (11) Urn short (1.3 mm). (12) Basal membrane + (25 µm).

Variation

There is some variation in the microscopical characteristics of the taxon. The form of the leaves varies from rather broad-triangular to more narrow. The cells in the upper part of the lamina are usually strongly porose and irregular (the short cells being stellate), but sometimes they are less irregular and less porose. In the middle and lower part of the leaf the cells are thick-walled, with esinuose and porose walls, and this seems to be constant. The leaf lamina is sometimes less thickened, with scattered bistratose cell rows in its upper part. The hyaline basal marginal leaf border is present in all the above ecads. The single Yunnan specimen differs in the following characteristics: The leaves are narrow (0.4-0.5 mm) at their broadest part; the upper half of the leaf is elongate and narrow; the costa is percurrent or almost excurrent, and occupies most of the apex; the basal marginal border is made up of somewhat thick-walled and rounded cells (but the number is the same); the costa is narrow (about 75 µm) and has more central cells, especially in the middle and upper part (5-9 and 3-6 cells, respectively). The structure of the lamina (in t.s.) and laminal cells is as in the Himalayan material.

Four Chinese specimens may represent a separate taxon: **Plants** variously but often much branched, to 2.5 cm long, yellowish above and darker below. **Leaves** small, 1.3-1.75 x (0.3)0.35-0.5 mm, epilose. **Margin** longly recurved on both sides, and bistratose for (0)1-3(6) cell rows above and uni- or bistratose for one cell row below. **Costa** reaching to or filling up the apex, 65-80 µm broad below and 55-70 µm broad above, in basal part three-stratose (d. 13-18, c. 2-6, v. 4-5), in middle part three-stratose (d. 14-15, c. 1-4, v. 3-4), in upper part bi- or three-stratose (d. 9-12, c. 0-1, v. 3-4). **Lamina** with frequent bistratose spots or areas. **Laminal cells** *not* porose, in basal part 15-50 x 9 µm, in middle and upper part 7-15 x 9 µm, upper marginal cells 5-9 x 11 µm, cell walls not or slightly bulging. **Alar cells** not or slightly yellowish coloured, basal marginal cells from moderately thick-walled and slightly sinuose to hyaline, 5-15 differentiated cells in the marginal row. Sterile. - One specimen has a thinner costa (fewer central cells in the different positions), a less bistratose margin and lamina, and longer upper leaf cells (± 15 µm). Another specimen and its duplicate include closely intermingled shoots of *R. verrucosum* var. *emodense*. There is a striking difference in the porosity of their cell walls. The above Chinese specimens may therefore not belong to the *microcarpon* subgroup. More (and preferably also fertile) specimens are needed before the systematic position and status of the specimens can be settled. Localities: China: Shensi Prov., Taipai

Mountain, 3600 m, on soil, Wei 5114 (TRH ex KUN); Tibet, Lang 671, 672 (PE), Ni 72 (PE).

(16b) *Racomitrium verrucosum* var. *emodense* Frisvoll *var. nov.*
Fig. 43-44.

A typo *R. verrucosi* differt lamina foliorum minus bistrata atque cellulae superioris foliorum magis elongatae.

Holotype: "Expédition scientifique Genevoise au Népal 1952. *No.* 293. *Date* 19 Avril. *Rhacomitrium crispulum* Hook. f. et Wils. *Loc.* rochers de la Chouk Pula. *Alt* 5000 m. *Leg.* A. Zimmermann. *Det.* A. Nog." - BM. Isotype: NICH.

Plants and **stem** as in var. *verrucosum*. **Leaves** longer and narrower, 2.1-2.8 x 0.4-0.5(0.8) mm. **Hair-point** present, up to 0.65 mm, capillaceous and slightly denticulate. **Margin** narrowly recurved to 1/2-3/4 the leaf length on one side, and more narrowly and shortly recurved or flat on the other side, in upper part bistratose for (1)2(4) cell rows, in lower part bistratose for one cell row or rarely unistratose. **Costa** narrow, reaching to the hyaline point, in lower part 65-85(100) µm broad and in upper part 45-55 µm, in basal part bi- to three-stratose (d. 11-15, c. 0-2, v. 4), in central part bi- or three-stratose (different specimens) (d. 11-15, c. 0-2, v. 4), in upper part bi- or three-stratose (different specimens) (d. 9-12, c. 0-2, v. (2)3-4). **Lamina** unistratose. **Laminal cells** elongate in the whole leaf (at the base 30-60 x 9 µm, in upper part 15-35 x 9 µm, upper marginal cells 7-20 x 9-12 µm), with thick (6 µm), strongly porose walls and narrow lumen (3 µm), walls distinctly bulging dorsally and ventrally. **Alar cells** yellowish like the base of the leaf, one row of hyaline or slightly thick-walled and sometimes sinuose cells extending as a border up along the margin, (5)8-14(16) cells in the marginal row.

Sterile.

Diagnostic characters

(4) Hair-point +/(-), to 0.65 mm. (5) Margin narrowly recurved (m. long, short/flat), bi (1-3). (6) Costa narrow (65-85/45-55 µm), stratosity/ventral cells (2-3/4, 2-3/4, 2-3/3-4). (7) Lamina unistratose, upper cells elongate.

Variation

Var. *emodense* is not particularly variable, but some specimens include more bistratose laminal spots. They seem to bridge the difference with regard to var. *verrucosum*.

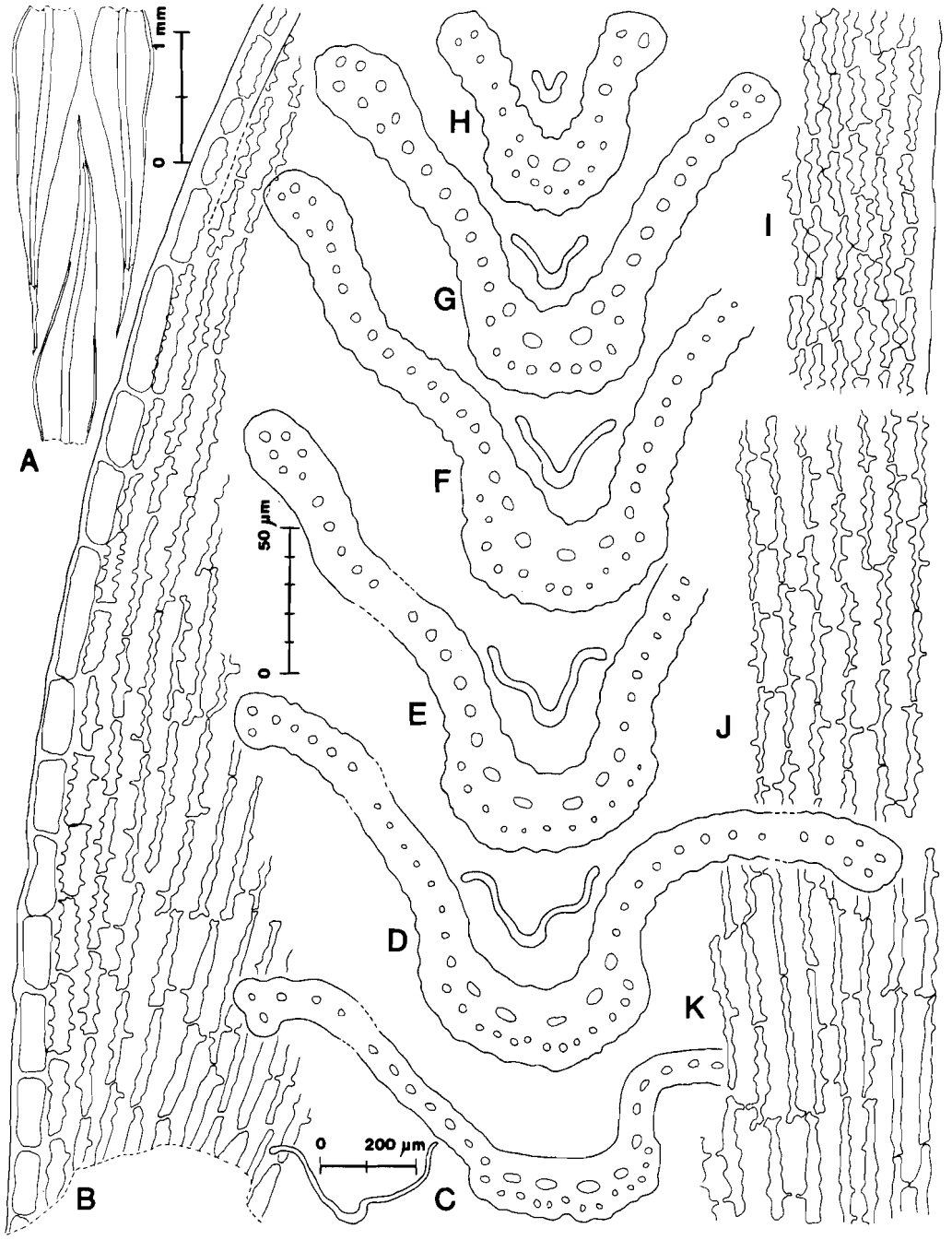

Fig. 43. *Racomitrium verrucosum* var. *emodense*. a. Leaves. b. Alar and supra-alar cells. c-h. Leaf cross sections. i-k. Cells from the upper, lower middle and basal part of the leaf. (Bhutan: Tsampo; Ludlow, Sherriff & Hicks 19424a - BM.)

Comparison with other taxa

1. Var. *emodense* differs, inter alia, from var. *verrucosum* (Fig. 42) in (usually) having a hair-point; in its narrower leaves with narrower costa; in its (usually) unistratose lamina; and in its cells being elongate also in the upper part of the leaf. A few specimens seem to be difficult to place.

2. *Racomitrium himalayanum* (Fig. 54) is usually easily separated from *R. verrucosum*: Most plants of the former have larger pilose leaves with less porose cells; a shorter and usually more thick-walled basal marginal border (of 4-12(16) cells); and their margin and lamina are unistratose. However, epilose *R. himalayanum* from wet habitats has shorter leaves, whose upper part may possess bistratose marginal and laminal spots (cf. the lectotype, Deguchi 1980: Fig. 4). Such plants are separated from *R. verrucosum* by the structure of their laminal cells (less porose, especially in the lower central part of the leaf), and basal marginal border (shorter and less hyaline). The perichaetial leaves of *R. himalayanum* is squarrose; the two fertile specimens of *R. verrucosum* possess non-squarrose perichaetial leaves.

3. The type material of *R. cucullatulum* (Fig. 50) has, like *R. verrucosum*, a leaf margin which is bistratose for many cell rows, and a lamina which includes bistratose spots. But that taxon has a reddish leaf base, and its lamina cells are sinuose and less porose towards the base. Its marginal leaf border is also shorter and more thick-walled. The two are not considered to be closely related.

4. *Racomitrium sudeticum* (Fig. 15) has, e.g., no comparable basal marginal leaf border, and a different structure of the lamina cells and costa. The two are not closely related, and do not grow in the same area. Some specimens of *R. verrucosum* were named *R. sudeticum*.

5. *Racomitrium microcarpon* (Fig. 39) has, like *R. verrucosum*, a hyaline leaf border; but its margin is almost always unistratose throughout. Var. *emodense* resembles *R. microcarpon* in its cell structure.

6. *Racomitrium subsecundum* (Fig. 60-61) is a much larger species; moreover, it has no hyaline basal marginal border but a group of strongly reddish alar cells. The two are not likely to be confused.

7. *Racomitrium fuscescens* (Fig. 52) has often a warm brownish colour, and possesses a unistratose or much less thickened margin, and also much less porose and pseudopapillose laminal cells.

8. *Racomitrium crispulum* (Frisvoll 1984c: Fig. 1) has, e.g., a similar bistratose margin; a lamina with frequent bistratose spots; and a hyaline basal marginal border. However, it has a broader leaf and a different areolation (less porose cells throughout the leaf, with more distinctly sinuose cells in the basal part).

It has less pseudopapillose leaves, and a different point, etc. (for further details, see Frisvoll 1984c). The two are not considered to be closely related.

9. Regarding differences between *R. verrucosum*, and *R. brevipes* and *R. joseph-hookeri*, see these species.

Habitat

The species has been collected from boulders, and dry and moist rocks (according to the information on four labels). It is known to occur between ca. 4200 and 6150 m a.s.l. (Polunin M226a).

Distribution

Racomitrium verrucosum s.l. is known from Himalaya and Yunnan (Fig. 44). It grows in Punjab (India), Nepal, Sikkim, Bhutan, and Tibet and Yunnan (China).

Specimens examined (specimens which do not clearly belong to var. *emodense* are placed in var. *verrucosum*)

Var. *verrucosum*. NEPAL: Iwatsuki 1459 (NICH, holotype; H,L, isotypes); around Kipuphu, Iwatsuki 1677 (NICH); Arun Tamur watershed, Thagla Bhanjgang, N of Topke Gola, Stainton No. 1927 (BM); Tamur valley, Mewa Khola, Topke Gola, Stainton No. 1907 (BM); Phakurji Lekh, south of Jumla, Polunin, Sykes & Williams 4796c (BM); above Sauwoila Khola, Stainton, Sykes & Williams 3001c, 4406c (BM); on Gangja La Pass, Polunin M226a (BM). SIKKIM: Lachoong, Hooker 314 (BM, L, NY); Lachen, Hooker 298 (NY). - INDIA: Kulu Distr., Punjab, Schelpe 3301a (BM); s.loc., Hooker s.n. (BM, NY). CHINA: NW-Yünnan, am Osthang des Si-la sw. Landsang-djiang u. Lu-djiang, 28°, Handel-Mazzetti 9976 (S, syntype of *R. cucullatulum*).

Var *emodense*. NEPAL: Around Kipuphu, Iwatsuki (1678) (NICH); between Kipuphu and Phujeng La (pass), Iwatsuki 1719 (NICH); around Banduke Pokhari (Duo Tulo Pokhari), Iwatsuki 1104 (NICH); between Ghopte (Tal Pokhari) and Gosa (near Kobche), Iwatsuki 989 (NICH); Camp de Base - Sommet Ouest, Zimmermann 315 (BM, NICH), 309, 315a (NICH); debut de la vallee du Yeti, Zimmermann 540c, 544b (NICH); vers le camp I, etc., Zimmermann 327b (NICH); entre le camp de base etc., Zimmermann 312 (NICH). BHUTAN: Tsampo Marhing, Ludlow, Sherriff & Hicks 19424 (BM). Himalaya: Hooker & Thomson 1300 (H-BR). CHINA: Tibet, E side of Mt. Everest, Wang 11 (PE); some unlocalized specimens from Tibet (PE).

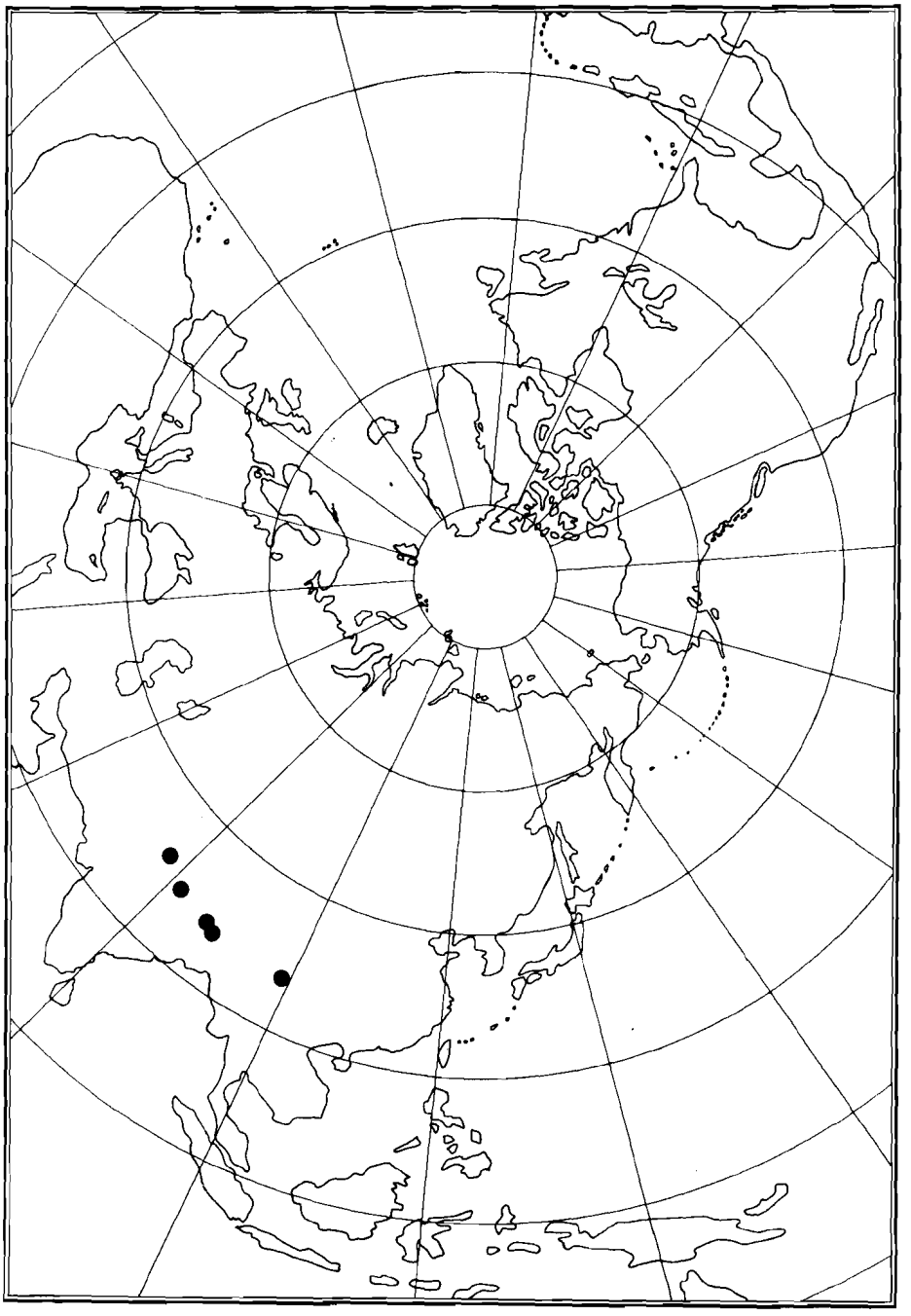

Fig. 44. Distribution of *Racomitrium verrucosum* s.l.

(17) *Racomitrium vulcanicola* Frisvoll et Deguchi *sp. nov.*
Fig. 45-46.

Margo foliorum basalis 15-25 cellulis hyalinis instructus; gemmae adsunt.

Holotype: "Japan. Hokkaido, Prov. Kamikawa: Sorachi-gun, Kamifurano-cho, Mt. Furano, 1600 m alt. On rock. Aug. 5, 1973 H. Deguchi 12339." - TRH. Isotypes: H, KOCH.

Plants small, brownish throughout or usually yellowish or olivaceous for the uppermost 1-4 mm, in dense cushions or tufts. **Stem** up to 4 cm, usually intricately branched, the primary and secondary stems with numerous short branchlets. **Leaves** sometimes secund at the shoot apices, slightly or not contorted when dry, (1.5)1.7-2.25(2.35) x (0.3)0.4-0.6 mm. **Hair-point** usually present, capillaceous and erect-flexuose, about 0.3-0.7 mm, from edenticulate to distinctly low-denticulate, not or moderately decurrent down margin of lamina. **Margin** broadly recurved to 3/4 the leaf length on one side, and more narrowly and usually shortly recurved or sometimes flat on the other side, unistratose or sometimes with rare bistratose spots in the upper part. **Costa** strongly dorsally convex throughout, in lower part 45-75 µm broad, in upper part 35-45 µm broad, reaching to or ending shortly or some distance below the hyaline point or apex, in basal part bi- (to three-)stratose (d. 9-13(16), c. 0(-2), v. (2)3-4), in middle part bistratose (d. 6-9, c. 0, v. 2-3), in upper part bistratose (d. 4-7, c. 0, v. 2). **Lamina** unistratose. Basal **laminal cells** elongate (T: 21-52 x 10 µm), middle and upper cells quadrate to rectangular (T: 12-30 x 10 µm), upper marginal cells quadrate to rectangular (T: 9-21 x 12 µm), cell walls usually distinctly bulging dorsally and ventrally. **Alar cells** not differently coloured, one to two rows of esinuose and hyaline basal cells extending as a border up the margin, about (10)15-25(30) cells in the marginal row and (0)5-10 cells in the second row. **Gemmae** spherical or broad-elliptical, 30-35 µm in diameter, when mature brownish with darker brown cross-walls, formed in abundance on branched filamentous hairs produced from the dorsal surface of the basal part of the costa and from epidermal cells of the stem, or rarely occurring in perichaetia, the gemmae are moniliformly arranged on a single hair, intercalated by very thin-walled, transparent sterile cells.

Sterile.

Diagnostic characters

(0) Gemmae present, formed on branched filamentous hairs. (1) Plants in dense mats or tufts, brownish with yellowish or olivaceous apices. (2) Stem intricately branched, not robust. (3) Leaf short and narrow (1.7-2.25 x 0.4-0.6 mm). (4) Hair-point +/((-)), 0.3-0.7 mm, strongly flexuose. (5) Margin recurved (m. long, short/flat), uni. (6) Costa narrow (45-75/35-45 µm), stratosity/ventral cells (2(-3)/3-4, 2/2-3, 2/2). (7) Lamina cells pseudopapillose. (8) Bmb in one or two cell rows, 15-25 cells in the marginal and 5-10 cells in the second row.

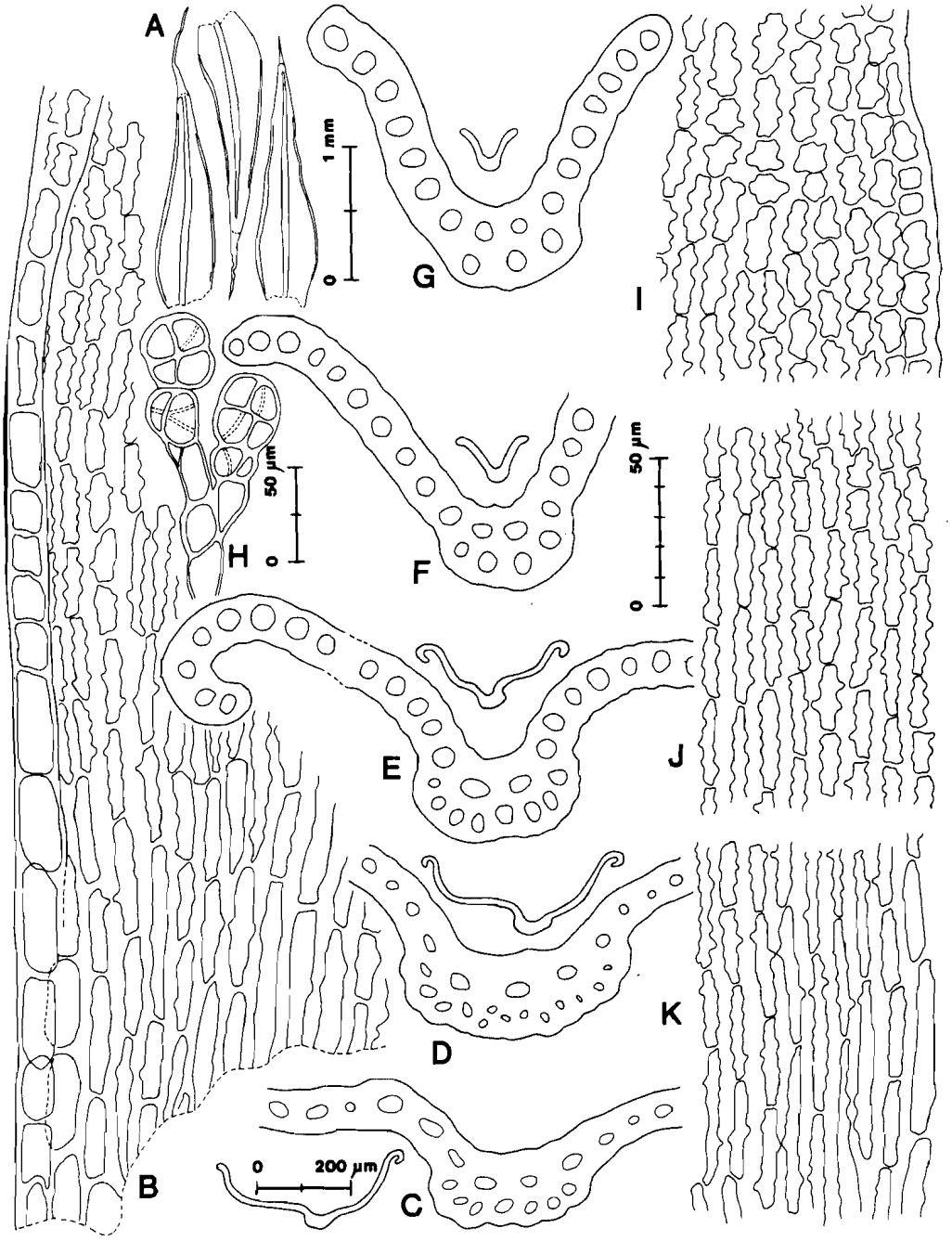

Fig. 45. *Racomitrium vulcanicola.* a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Gemmae. i-k. Cells from the upper, lower middle and basal part of the leaf. - Holotype (TRH).

Variation

The known specimens of *R. vulcanicola* are not variable. The differences which have been observed, such as in the length and flexuosity of the hairpoint, the recurvance of the margin, the pseudopapillosity of the leaves, and the number of cells in the basal marginal border, are of no taxonomic importance. The most outstanding feature of the species is its gemmae. They were described and illustrated for the first time by Deguchi (1977), and briefly commented on by Crum and Anderson (1981: 433) and Churchill (1981). The discovery of a gemmiferous *Racomitrium* species was unexpected and sensational. Within Grimmiaceae, gemmae are otherwise only known in the subfamily Grimmioideae, and are mostly confined to the informal taxon "*Rhabdogrimmia*" within *Grimmia* s.l. (sensu Churchill 1981); *Racomitrium* belongs to the subfamily Ptychomitrioideae. The gemmae of *R. vulcanicola* have a close resemblance to those of *Grimmia trichophylla* Grev.

Comparison with other taxa

1. The gametophyte of *R. vulcanicola* approaches that of *R. microcarpon* (Fig. 39). The two have in common, e.g., a strongly branched stem; small leaves with capillaceous and flexuose hair-point; a narrow, mainly bistratose costa with 3-4 ventral cells in the lower and 2 in the upper part; strongly sinuose, thick-walled lamina cells in the upper part of the leaf and less sinuose cells towards the leaf base; and a long basal marginal border of hyaline cells. There are some differences in the size and colour of the two: The plants of *R. microcarpon* are often larger and less yellowish coloured than those of *R. vulcanicola.* The basal marginal border is usually made up of more cells in *R. vulcanicola* than in similar *small* plants of *R. microcarpon.* The basal leaf cells of *R. microcarpon* are frequently more thick-walled than in *R. vulcanicola.* But more fundamental morphological differences between them have not been found. However, gemmae are present in all Japanese specimens referred to *R. vulcanicola*; and gemmae have not been observed in *R. microcarpon.* This difference seems so important in the genus, that we consider it sensible to separate the two as different species. If non-gemmiferous Japanese populations matching *R. vulcanicola* or gemmiferous populations of *R. microcarpon* are found, the status of the former has to be reconsidered.

2. *Racomitrium laetum* (Fig. 19) is not or sparsely branched (*vul*: intricately branched); its hairpoint is non-flexuose and often erect-squarrose or squarrose; its margin is shortly recurved, and bistratose for one cell row in a number of plants; the cells of its basal marginal border is yellowish and not quite hyaline; and *R. laetum* lacks gemmae. The two are not likely to be confused.

3. *Racomitrium sudeticum* (Fig. 15) has a stouter and more denticulate hairpoint; a three- to four-stratose costa in the lower part of the leaf; a usually bistratose margin; and no comparable basal marginal border.

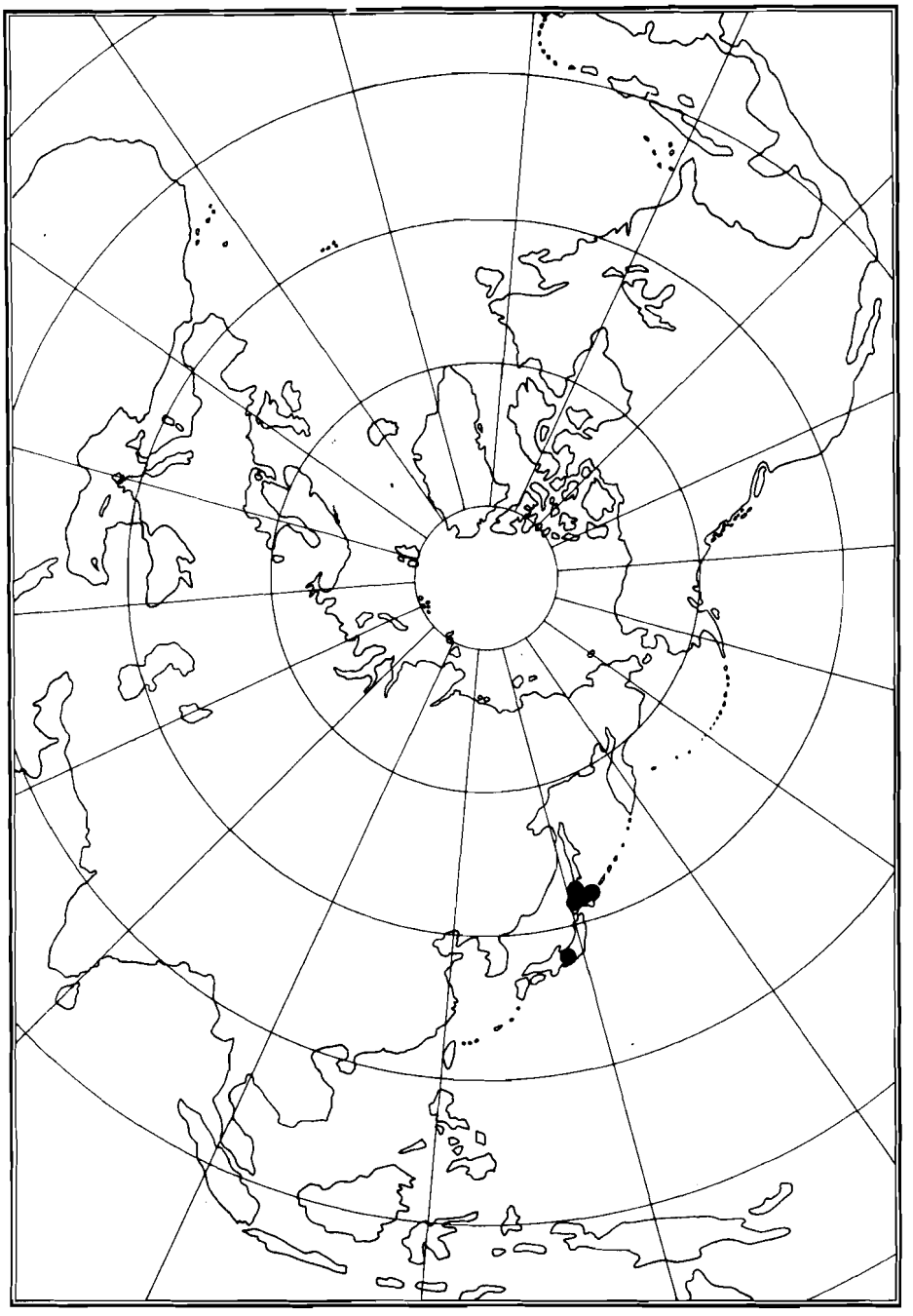

Fig. 46. Distribution of *Racomitrium vulcanicola*.

4. Regarding differences between *R. vulcanicola* and *R. nitidulum*, see the latter.

Habitat

Racomitrium vulcanicola is collected from sunny exposed, dry volcanic boulders of high mountains.

Distribution

Japan (Fig. 46); oroboreal vegetation zone (Hämet-Ahti et al. 1974) of Hokkaido and Honshu.

Specimens examined

JAPAN: Hokkaido, Rishiri I., Mt. Rishiri, Ochi 333 (KANA); Mt. Rausu, 1500 m, Deguchi 12581 (KOCH, TRH); Mt. Kurodake - Mt. Hokkai, 1950 m, Deguchi 12215 (KOCH, TRH); Mt. Haku-un, 2050 m, Deguchi 12243 (KOCH, TRH); Mt. Tomuraushi, ca. 1900 m, Kanda 611 (NIPR); Mt. Furano, 1600 m, Deguchi 12339 (KOCH, TRH); Mt. Nipesotsu, 1780 m, Deguchi 12447 (KOCH, TRH); Mt. Yotei, 1800 m, Deguchi 12615, 12649 (KOCH, TRH). Honshu, Yamanashi-ken, Mt. Kitadake, 2920 m, Deguchi 13242 (KOCH, TRH); Nagano-ken, Mt. Okuhijiri, 2900 m, Ito 570 (N. Takaki's private herbarium, No. 39777); Shizuoka-ken, Mt. Fuji, 3400-3776 m, Kawai 3586, 3588, 3595, 3598, 3600 (KANA).

5.7 THE *SUBSECUNDUM* SUBGROUP

Innermost bracts strongly modified, pellucid below but not above, epilose; outer bracts squarrose when wet. Hair-point slightly or not denticulate; costa bi- to three-stratose; cells tending to be elongate in the upper part of the leaf lamina.

Seven species: *R. capillifolium*, *R. cucullatulum*, *R. fuscescens*, *R. himalayanum*, *R. joseph-hookeri*, *R. nitidulum*, *R. subsecundum*. - *Racomitrium subsecundum* is the common S. Asiatic species of sect. *Laevifolia*. And, taxonomically, it occupies a central position in a complex of closely related taxa. The most isolated species in the subgroup seems to be *R. fuscescens*.

5.7.1 Key to the taxa in the *subsecundum* subgroup

1 Basal marginal leaf border distinct, of 10-20 or more differentiated, usually hyaline and thin-walled but sometimes more thick-walled pellucid or slightly sinuose cells (many leaves!) 2

1 Basal marginal leaf border absent or indistinct or at most made up of 7-

10 usually (moderately) thick-walled cells 6

2 Hair-point of the upper leaves extremely long and capillaceous, up to 4(-6) mm, not flexuose when dry; basal marginal border long, of 20-30(40) thin-walled cells (many leaves!) (Fig. 47) (18a) *R. capillifolium* var. *capillifolium*

2 Hair-point less capillaceous and usually more flexuose and shorter; basal marginal leaf border usually shorter, rarely of more than 20 cells 3

3 Leaf margin recurved towards the hyaline point or apex on both sides; marginal border short, of 4-12(16) cells (Fig. 54) (21) *R. himalayanum*

3 Leaf margin recurved to about 1/2 the chlorophyllous part of the leaf or shorter on one side, and more shortly recurved or often flat on the other side 4

4 Hair-point short (0-0.5 mm) in the upper leaves; basal marginal border long, of 12-20 or more hyaline cells (20) *R. fuscescens*

4 Hair-point long (0.5-3 mm) in the upper leaves; basal marginal border relatively short, of (5)7-12(16) usually moderately thick-walled and often rounded cells 5

5 Leaf cells strongly bulging dorsally and ventrally; margin 2-stratose for 1-3(4) cell rows from apex and almost to the base (Fig. 56) (22) *R. joseph-hookeri*

5 Leaf cells not or slightly bulging; margin 1-stratose with frequent 2-stratose spots especially in the lower part (Fig. 48) (18b) *R. capillifolium* var. *lorifolium*

6 Leaf margin recurved towards the hyaline point or apex on both sides or somewhat shorter on one side (many leaves!) 7

6 Leaf margin recurved to about 1/2 the chlorophyllous part of the leaf on one side and more shortly recurved or often flat on the other side 8

7 Many or some alar cells inflated and thin-walled (± auriculate) or the alar group made up of strongly nodulose and porose (stellate) cells; costa broad below and rapidly narrower (35-50 μm) at the apex; leaf cells not or slightly pseudopapillose; stem cortex reddish (Fig. 60-61) (24) *R. subsecundum*

7 No or exceptional alar cells inflated and thin-walled; costa broad below and also broad (50-70 μm) above; leaf cells distinctly pseudopapillose; stem cortex orange (Fig. 54) (21) *R. himalayanum*

8 A moderately long basal marginal leaf border present, of (5)7-12(16) usually moderately thick-walled and often rounded cells 9

8 No distinct basal marginal border present 10

9 Leaf cells strongly bulging dorsally and ventrally; margin 2-stratose for 1-3(4) cell rows from apex towards the base (Fig. 56) (22) *R. joseph-hookeri*

9 Leaf cells not or slightly bulging; margin 1-stratose with frequent 2-stratose spots especially in the lower part (Fig. 48) (18b) *R. capillifolium* var. *lorifolium*

10 Leaf margin 2-stratose for 2-4 or more cell rows in the upper part (sometimes with 3-stratose spots) and in lower part usually 2-stratose for 1-2 cell rows, the thickened margin club-shaped; lamina not infrequently with 2-stratose spots (Fig. 50) (19) *R. cucullatulum*

10 Leaf margin 1-stratose or at most 2-stratose for 1-2(3) cell rows, the thickened margin more spherical; lamina 1-stratose 11

11 Costa broad (80-110 µm) below and there flat and with 5-8 ventral cells; alar cells frequently enlarged, thin-walled and auriculate or made up of strongly nodulose and porose (stellate) cells; hair-point (when present) not stout or capillaceous; a robust species (Fig. 60-61) (24) *R. subsecundum*

11 Costa narrower (55-85 µm) below and there dorsally convex with 3-5 ventral cells; alar cells less differentiated, without or with a small group of inflated cells; hair-point short, stout or capillaceous; species not robust 12

12 Stem with numerous (very) short branchlets; hair-point frequently short and stout (when present); olivaceous plant in dense cushions (23) *R. nitidulum*

12 Stem less branched; hair-point short and capillaceous (when present); (dark) brownish plant in less dense cushions (19) *R. cucullatulum*

(18a) *Racomitrium capillifolium* Frisvoll *sp. nov.* var. *capillifolium*
Fig. 47, 49.

Pilus foliorum (apicalis) longissimus usque ad 4(-6) mm longus, capillaceus, rectus; margo basalis 20-30 cellulis pellucidis vel hyalinis instructus.

Holotype: "Bhutan. Thimphu district: above Pajoding monasteries; Thimphu. 27° 29' N, 89°34' E. *Juniper/Rhododendron* scrub on hillside; on boulder, 3750 m, 16 April 1982 D.G. Long No. 10884." - E. Isotypes: KUN, NICH, NY, TRH.

Plants in lower part dark brown, with yellowish or olivaceous green apices, grayish and woolly due to long hair-points. **Stem** 2-5 cm, from sparsely to irregularly and subpinnately branched, the branches often elongate and becoming new stems. **Leaves** 0.5-0.8 mm broad, with comparatively narrow base, either epilose and then about 2.25 mm long, or usually with very or extremely long hair-point and then reaching to about 3-6(8) mm with chlorophyllous part about 2.2-3.0 mm, epilose and pilose leaves sometimes alternating down the stem. **Hair-point** erect, not spirally twisted when dry, not or moderately flexuose, not or slightly recurved at the connection with the lamina, and not or slightly decurrent down margin of lamina, (0)1.5-4(6) mm, distantly and obtusely denticulate or almost edenticulate, very delicate and capillaceous in upper half. **Margin** recurved to the hyaline point (in longipilose leaves) or to 3/4 the leaf length, more narrowly and usually shortly recurved on one side, unistratose or with frequent bistratose spots in one cell row especially in the basal part. **Costa** convex in its upper part and less convex or flat towards the base, reaching to the apex of epilose leaves and into the point of pilose leaves (where it is chlorophyllous for some distance, and hyaline for the rest and therefore difficult to follow), in lower part 75-100 µm broad but somewhat narrower (about 75 µm broad) close to the base, in upper part 45-55 µm broad, in basal part bi- to three-stratose (d. 12-17(21), c. 0-3, v. (3)4-6(8)), in central part bistratose or rarely three-stratose (d. 9-15, c. 0-2, v. 3-5(6)), in upper part bistratose (d. 8-11(14), c. 0, v. 2-4). **Lamina** unistratose. Basal **laminal cells** elongate (T: 25-65(75) x 9 µm) with thick walls and narrow lumen (T: walls 6 µm, lumen 3 µm), middle and upper cells also elongate, especially in longipilose leaves (T: 20-45 x 7.5 µm), upper marginal cells shorter (T: 10-35 x 10 µm),

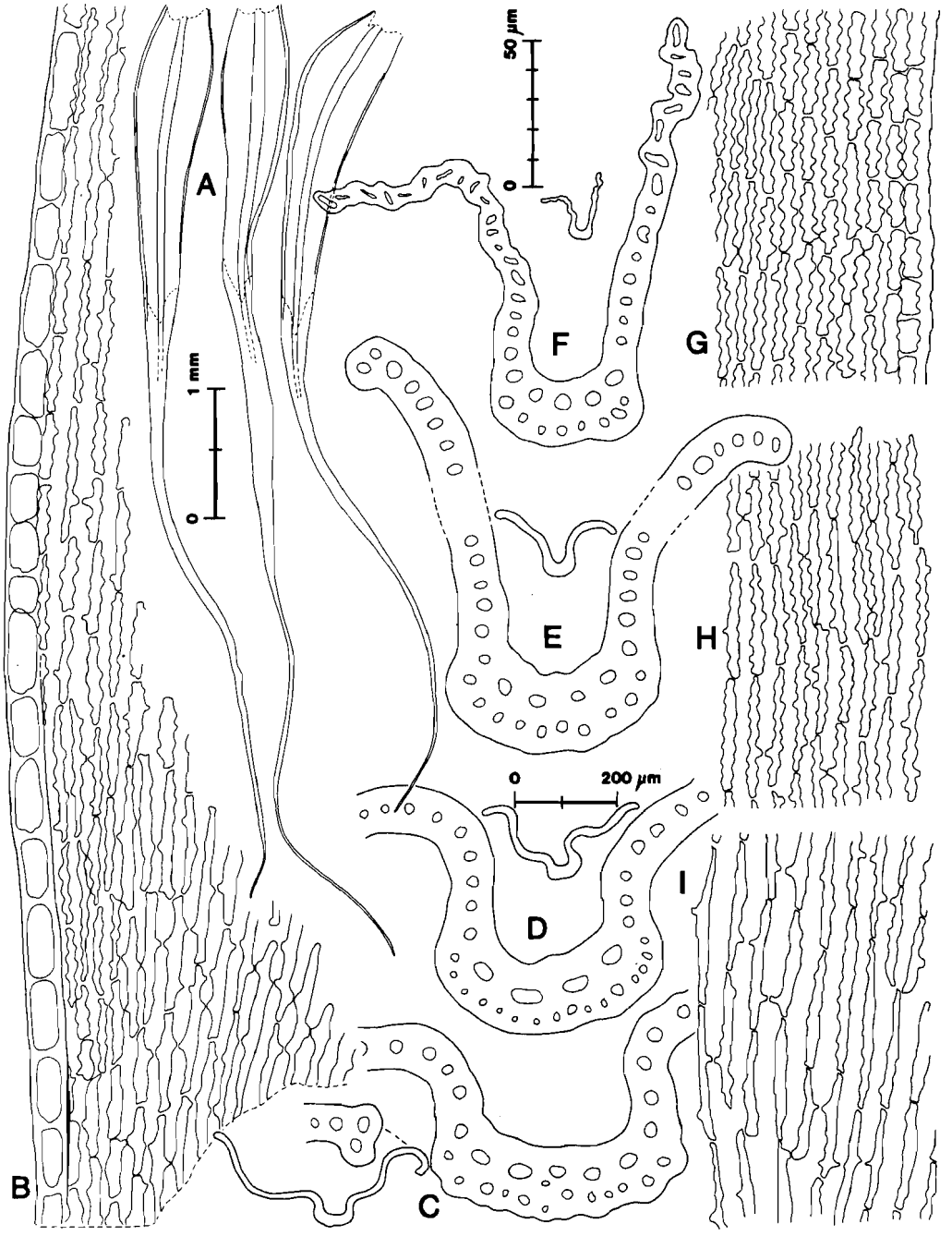

Fig. 47. *Racomitrium capillifolium* var. *capillifolium*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g-i. Cells from the upper, lower middle and basal part of the leaf. - Holotype (E).

cell walls usually not bulging, usually distinctly porose throughout. **Alar cells** decurrent but not inflated or auriculate, yellowish, one row of thin-walled and esinuose, pellucid or hyaline, rectangular or quadrate cells (or usually a mixture) extending as a border up along the margin, from 20-30(40) differentiated cells in the marginal row.

Sterile (but see var. *lorifolium*).

Diagnostic characters

(1) Plants grayish and woolly (due to long hair-points). (2) Stem often much branched. (3) Leaf long and m. broad (3-6 x 0.5-0.8 mm). (4) Hair-point + (1.5-4 mm), very capillaceous above, erect and not or slightly flexuose, from obtusely denticulate to almost edenticulate. (5) Margin recurved (long, m long), uni/bi (1, spots in lower part). (6) Costa broad below and narrow above (75-100/45-55 µm), stratosity/ventral cells (2-3/4-6, 2(-3)/3-5, 2/2-4), running into the hyaline point. (7) Lamina cells usually not pspp, cells elongate. (8) Bmb of 20-30(40) pellucid or hyaline, esinuose cells.

Variation

The most outstanding feature of the taxon is its impressively long hair-point. But the number of known specimens are small, and the variation of the taxon therefore poorely known. The point may be shorter in less exposed habitats. The basal marginal border is considered to be one of its most important characteristics. The known specimens indicate that the variation of the taxon is slight.

Comparison with other taxa

1. For differences between var. *capillifolium* and var. *lorifolium* (Fig. 48), see the latter.

2. *Racomitrium fuscescens* (Fig. 52) has a basal marginal border (of 12-17(25) cells) similar to that of *R. capillifolium* var. *capillifolium*, and the rapidly narrowing leaf base is not unlike in the two. The structure of the costa is also largely the same, and the two are considered to be related. But whereas var. *capillifolium* has the longest hair-points in the section (to 4 mm or more) the points of *R. fuscescens* are frequently lacking, or very short (0-0.5 mm). One of the isolectotypes of *R. fuscescens* (BM-Hookerianum) is critical in this context. Here, typical epilose or subepilose *R. fuscescens* is mixed with 3-4 shoots of a longipilose plant. The colour of the two is similar, as is the main form of their leaves. However, the leaves of *R. fuscescens* have slightly sinuose and almost aporose cells in their central and upper part, whereas the longipilose plant has strongly sinuose and porose cells there. *Racomitrium capillifolium*

usually has porose cells in the upper part of its leaves. The (BM) specimen is a mixture of the two, but with the appearance of the *R. capillifolium* element more similar to *R. fuscescens* than generally seen. The difference in cell structure is very striking in the mixed specimen, but does not seem to be quite constant. See also var. *lorifolium*.

3. For differences between *R. capillifolium*, and *R. crispipilum* and *R. josephhookeri*, see these species. For differences between *R. capillifolium*, and *R. himalayanum* and *R. subsecundum*, see var. *lorifolium*.

Habitat

The known specimens are collected between 3300 and 4660 m a.s.l. The sparse habitat information on the labels include *Juniper/Rhododendron* scrub on hillside; rocky cliff; and large boulder on north facing hillside.

Distribution

Racomitrium capillifolium var. *capillifolium* is known from the Himalayas (Fig. 49). It grows in Nepal, Sikkim, Darjeling (India) and Bhutan.

Specimens examined

NEPAL: Between Phujeng La and Topke Gola, Iwatsuki 1779 (H, NICH); above Langtang village, Polunin M42 (BM, with var. *lorifolium*); de Namche Bazaz à Khumjung, Zimmermann 1698 (BM, NICH; with var. *lorifolium*); between Banduke Pokhari (Duo Tulo Pokhari) and Saju Pokhari, Iwatsuki 1125 (C, NICH); Selap - Zongi - Walunchung Gola, Kanai, Murata & Togashi 236362 (NICH). SIKKIM: Jongri, Hooker 304 (BM, with *R. fuscescens*), Togashi 201599, 201614 (NICH). INDIA: Darjeling, Phalut, Togashi 201483, 201536 (NICH). BHUTAN: Sanah, s. leg., herb. Griffith (NY); Long 10884 (E, holotype).

(18b) *Racomitrium capillifolium* var. *lorifolium* (Hampe) ex Frisvoll *var. nov.*
Fig. 48-49.

Racomitrium **lorifolium* Hampe ex Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 98. 1874 (Ad. 1: 376) *nom. nud.* Orig.: "Asia; Sikkim - Himalaya (S. Kurz Nr. 2097)."

Pilus foliorum (apicalis) longus usque ad 3.0(-3.4) mm, plus minusve flexuosus; margo basalis 10-20 cellulis crasseparietinibus munitus.

Holotype: "2097 *Rhacomitrium lorifolium* Hpe. Sikkim, Fragloo top. S. Kurz." - BM-Hampe. Isotype: BM-Hampe.

Plants and **stem** as in var. *capillifolium*, but not woolly or appearing as gray as plants of that variety. **Leaves** 2.25-5.1 mm. **Hair-point** 0-3.0(3.4) mm, spirally twisted when dry, from erect and not or slightly flexuose to erect-flexuose, not or sometimes recurved at the connection with the lamina, almost edenticulate or sometimes slightly denticulate. **Margin** recurved to 3/4 the leaf length or less on one side, and more narrowly and shortly recurved on the other side, with bistratose spots as in var. *capillifolium*. **Costa** and **lamina** as in var. *capillifolium*. **Lamina cells** as in var. *capillifolium* (T: basal cells 25-50 µm long; middle and upper cells (10)15-40 µm; upper marginal cells 7-15 x 9 µm), but less porose. **Alar cells** yellowish or yellowish-red, one or a few basal cells in one or two (to three) marginal rows frequently slightly enlarged, thick walled, rounded, and sometimes subauriculate, one row of esinuose, pellucid and usually short or (typically) rounded thick-walled cells extending as a border up along the margin, from (5)10-20 differentiated cells in the marginal row.

Perichaetial leaves squarrose when wet, inner (6 or more) leaves epilose with broadly ovate base (with pellucid somewhat thick-walled porose inner and more thin-walled marginal and submarginal cells) and acute to acuminate apex (with chlorophyllous, sinuose cells). **Seta** about 6.5-7 mm. **Urn** oblong-cylindrical (1.3-1.7 x 0.5 mm), exothecial cells irregular but usually elongate, 4-5 rows of narrow cells at the mouth. **Teeth** (ca. 400 µm long,) strongly papillose, of 2 prongs which are separated to the base, no (or a very low) basal membrane. Spores 12-14 µm. (1 fertile specimen.)

Diagnostic characters

(1) Plants not woolly. (4) Hair-point +/((-)), less capillaceous (than in var. *capillifolium*) above, usually spirally twisted and erect or erect-flexuose when dry. (8) Bmb of 10-20 esinuose, usually short and rounded, thick-walled cells, one or a few basal cells frequently slightly enlarged, yellowish red. (9) Pl squarrose, epilose, not hyaline. (10) Seta long (6.5-7.0 mm). (11) Urn short (1.3-1.7 mm). (12) Basal membrane -.

Variation

The taxon varies somewhat, in the appearance of the hair-point and the structure of the alar cells (see Description and below).

Comparison with other taxa

1. The main differences between var. *capillifolium* (Fig. 47) and var. *lorifolium*, are found in the structure of their dry hair-point and especially in the structure of their alar cells and basal marginal border. The hair-point of var. *capillifolium* is not flexuose, and extremely long and capillaceous; the point of var. *lorifolium* is from slightly to distinctly spirally twisted and flexuose, and less

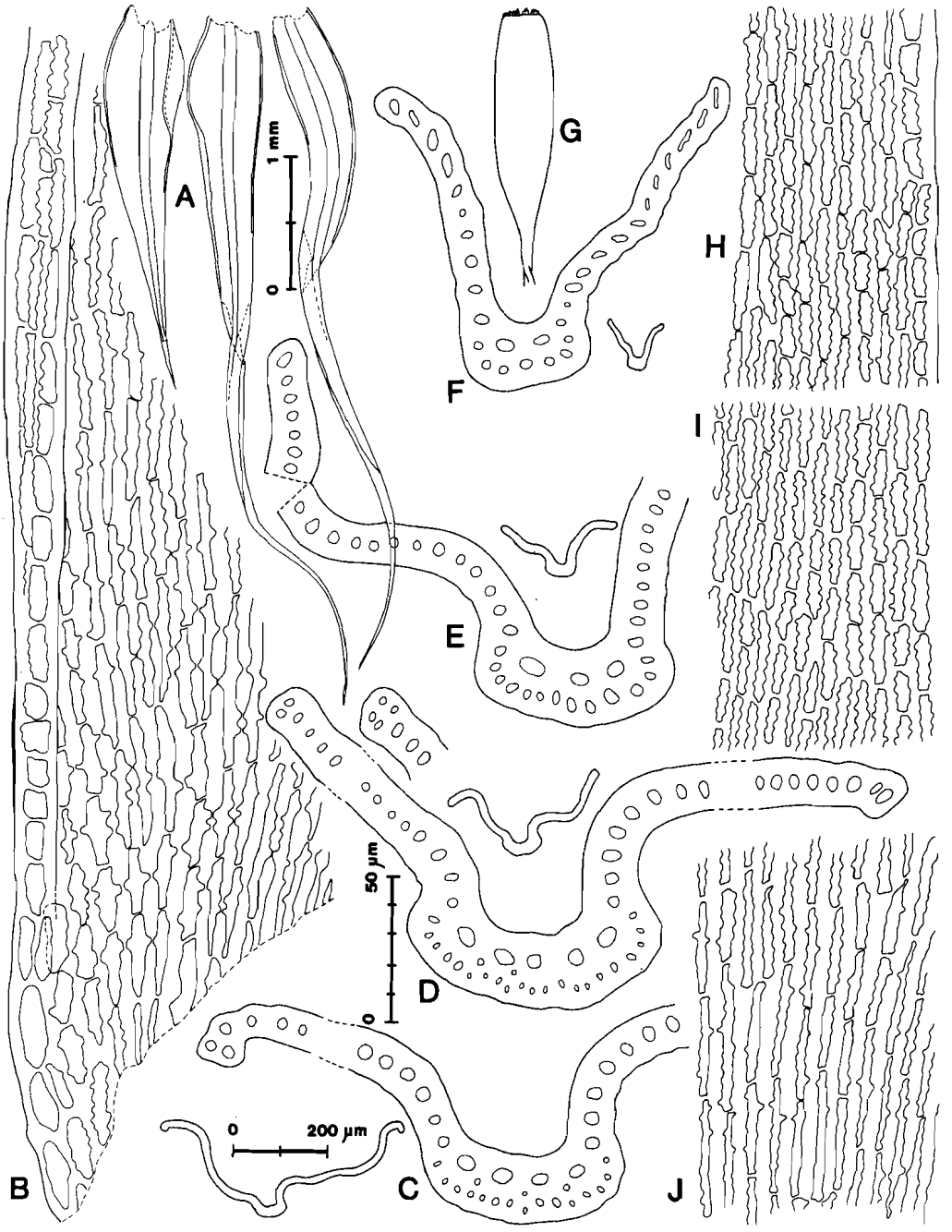

Fig. 48. *Racomitrium capillifolium* var. *lorifolium*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g. Capsule. h-j. Cells from the upper, lower middle and basal part of the leaf. (a-f, h-j. Holotype - BM. g. India: Darjeling, Ribu 13 - BM.)

elongate and less capillaceous. The alar cells of var. *capillifolium* are not enlarged or sub-auriculate, and the border is hyaline and very long (of 20-30 cells); the alar cells of var. *lorifolium* are slightly enlarged and sometimes subauriculate, and the border is thick-walled and shorter (of 10-20 cells). Both taxa are present in two specimens (see list of specimens studied), but because the stems are loose and not intermingled it is uncertain whether they grew in true mixed stands. The difference between them seems to be constant in the above specimens, and all known specimens can be referred to one of the varieties. However, they are undoubtedly very closely related, and too little material is known to treat them as different species. They also seem to have about the same distribution.

2. Var. *lorifolium* is more like *R. subsecundum* (Fig. 60) than is var. *capillifolium*. Only *R. subsecundum* with narrow leaves and long hair-points can be mistaken for var. *lorifolium*. The two have been found in the same specimens, and one of these seems to be a true mixed stand. Typically, *R. subsecundum* possesses a strongly inflated and usually auriculate group of alar cells, and no trace of a border of differentiated cells above the auricles. When, as it happens, *R. subsecundum* occurs as less auriculate ecads, it still lacks a basal marginal border. The hair-point is frequently missing or short in *R. subsecundum*, and when long it is less erect and more strongly flexuose. One specimen from Java imitates var. *lorifolium* in its general appearance; but it has a very incrassate reddish group of alar cells and no border, and is clearly a part of the variation of *R. subsecundum* in that area (see *R. subsecundum*, Variation and Fig. 61a-e).

3. *Racomitrium himalayanum* (Fig. 54) sometimes possesses a long hair-point which, however, is more strongly flexuose than in var. *lorifolium*. In addition it has, e.g., more longly recurved leaf margins; a broader costa in the upper part of the leaf; a different basal marginal leaf border (see Description); and usually more strongly bulging cell walls.

4. For differences with regard to *R. joseph-hookeri* and *R. crispipilum*, see these.

Habitat

Habitat information is lacking on the labels; but from the mixed collections with var. *capillifolium* it appears that the ecology of the two is largely the same. Var. *lorifolium* is collected between 3650 and 4580 m a.s.l.

Distribution

Racomitrium capillifolium var. *lorifolium* is known from the Himalayas (Fig. 49). It grows in Nepal, Sikkim, Darjeling (India), and Bhutan.

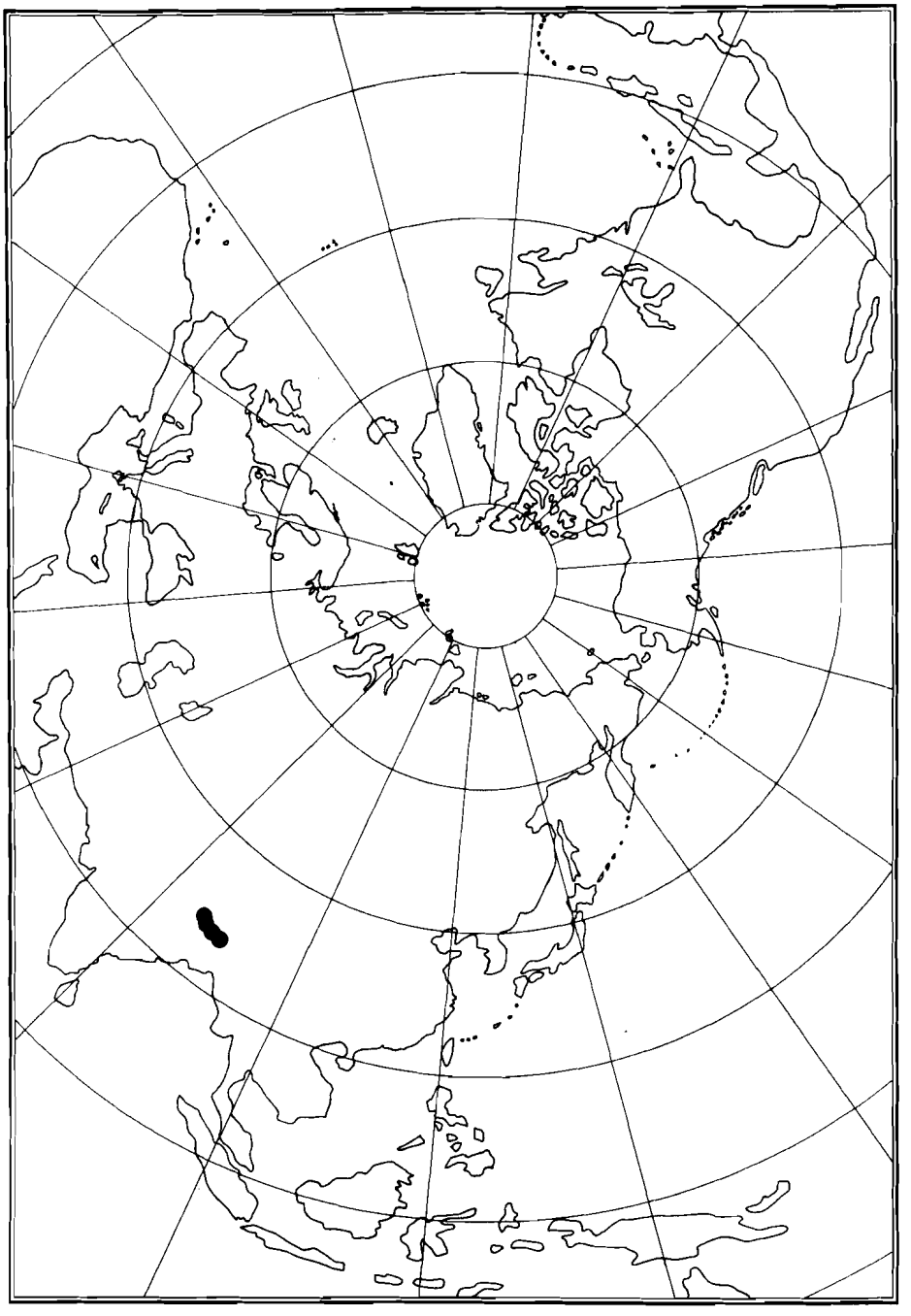

Fig. 49. **Distribution of *Racomitrium capillifolium* s.l.**

Specimens examined

NEPAL: Between Hile Chok and Ghopte (Tal Pokhari), Iwatsuki 874 (NICH); Selap - Zongi - Walunchung Gola, Kanai, Murata & Togashi 236363 (NICH). SIKKIM: Jongri, Hooker 302 (NY, BM), Togashi 201601, 201618 (NICH), H.H., H.K., G.M., M.T. & T.T. 53d, 69b (NICH); Kurz 2097 (BM, holotype); s. loc., Hooker s.n. (H-SOL). INDIA: Darjeling, Onglak Chang, 12.X.1908 Ribu (BM); Phalut, Togashi 201528, 201530 (NICH). BHUTAN: Chamsa - Kohina - Yabu Thang, Tanaka 287075 (NICH). Regarding mixed specimens with var. *capillifolium*, see that.

(19) *Racomitrium cucullatulum* Broth. in Hand.-Mazz.
Fig. 50-51.

Racomitrium cucullatulum Broth. in Hand.-Mazz., Symb. Sin. 4: 47. 1929. - Type: "NW-Y.[unnan]: Glimmerschieferfelsen der Hg. St. im birm. Mons. am Osthange des Si-la zwischen Landsang-djiang (Mekong) und Lu-djiang (Salwin), 28°, 4200-4375 m, c. sp. 27.VIII.1916 (9976). S.[etschwan]: Diabasfelsen der tp. St. des Lungdschu-schan bei Huili, 3550-3675 m, c. sp. 26.III.1914 (951)." (Lectotype nov.: "Handel-Mazzetti, Iter Sinense 1914-1918. Nr. 951. *Rhacomitrium* [unpubl. epithet derived from the name of the province] Broth. n. sp. = *Rh. cucullatulum* Broth. [China] Prov. Setschwan austro-occid.: In montis Lungdschu-shan prope urbem Huili regione temperata ad rupes. alt. s. m. ca. 3600-3730 m. Leg. 26.III.1914 Dr. Heinr. Frh. v. Handel-Mazzetti. (Diar. Nr. 238)." - H-BR. Isolectotypes: S, WU).

Plants brownish (chestnut), rather small. **Stem** up to 3(-5) cm, not robust, slightly to irregularly or subpinnately branched. **Leaves** small, 1.7-2.3(2.6) x 0.5-0.6 mm. **Hair-point** usually absent, or present in the upper leaves, up to 0.25 mm, edenticulate and not decurrent, capillaceous (with narrow base). **Margin** broadly recurved to 3/4 the leaf length on one side, and more narrowly recurved to 1/2 the leaf length or plane on the other side, the type material with upper part bistratose for (1)2-4(7) cell rows (sometimes with three- or even four-stratose spots) and lower part unistratose or usually bistratose for 1-2(4) cell rows, but other material has much less bistratose and sometimes nearly unistratose margin. **Costa** strongly dorsally convex in upper part and more flat below, reaching to the hyaline point or in epilose leaves near to the apex, comparatively strong, in lower part 65-85 (in one specimen 85-100) µm broad, in upper part (30)40-60 µm broad, in basal part bi- or more rarely three-stratose (d. 15-20, c. 0-5, v. 4-5(7)), in central part bi- or sometimes three-stratose (d. 13-18, c. 0-2, v. 3-6), in upper part bi- or three-stratose (d. 8-12(14), c. 0-3(6), v. 2-4). **Lamina** of type material with bistratose spots in upper and middle (and sometimes in lower) part, but other material possesses unistratose lamina. Basal **laminal cells** elongate (T: 25-40 x 7.5 µm), middle and upper cells also usually elongate but sometimes shorter (T: 12-28 x 7.5 µm), upper marginal cells short (T: 7-12 x 6 µm), cell walls not or slightly to rarely distinctly bulging dorsally and ventrally. **Alar cells** yellowish or reddish yellow, constitut-

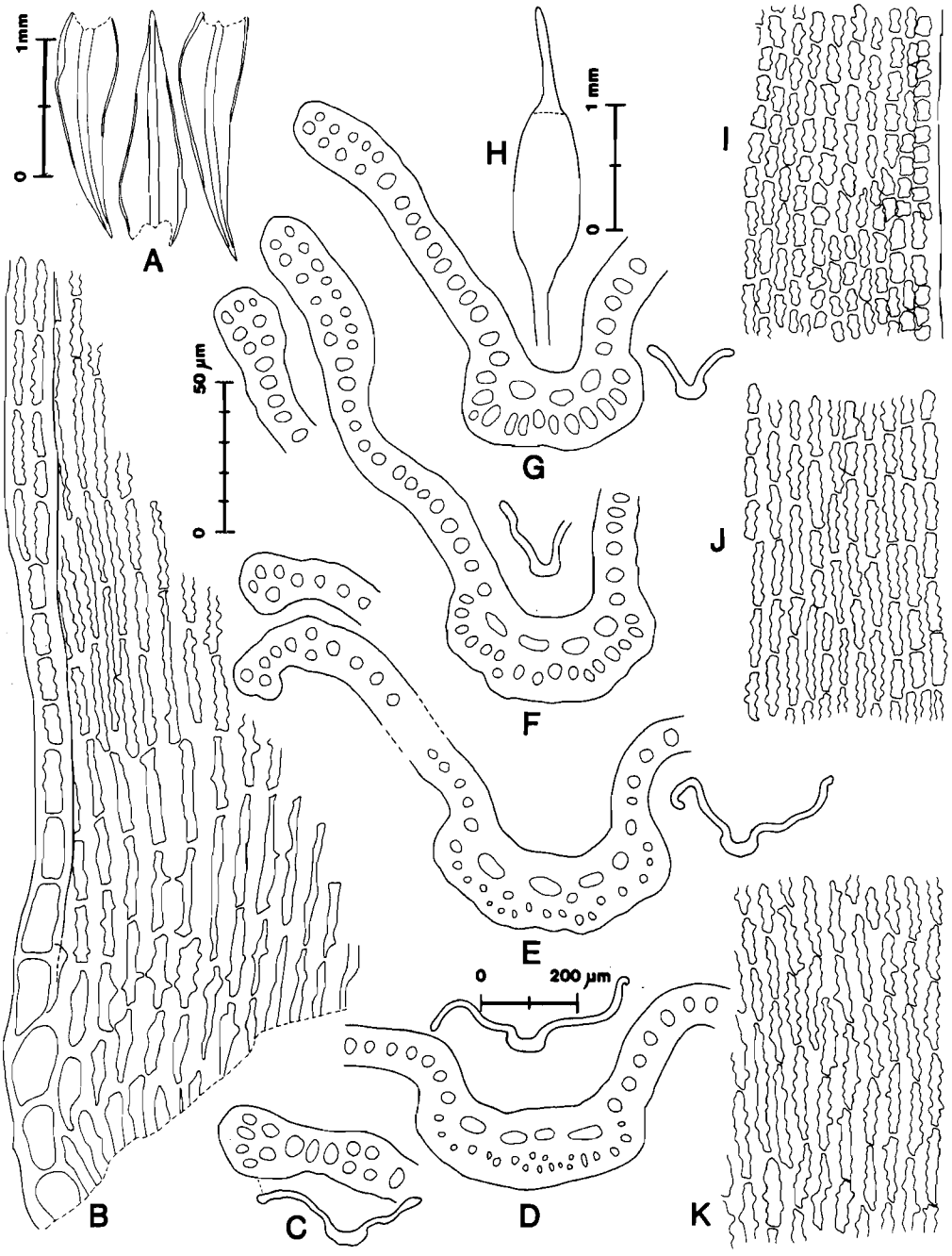

Fig. 50. *Racomitrium cucullatulum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. - Lectotype (H-BR).

ing a small group of thin-walled but not hyaline and usually not inflated cells, 6-12(15) esinuose cells in the marginal row.

Perichaetial leaves squarrose when wet, the inner (6 or more) leaves epilose with broadly ovate base (with ± thick-walled, porose cells) and acuminate apex (with chlorophyllous, sinuose cells). **Seta** about 3.0-5.5 mm. **Urn** oblong-cylindrical (1.6-1.8 x 0.5 mm), exothecial cells short, wide and thin-walled, with 6-7 rows of thick-walled and rounded cells at the mouth. **Teeth** (ca. 360 µm long,) strongly papillose, of 2(-3) prongs which are split down to the base, no basal membrane. Spores about 12 µm. (1 fertile specimen.)

Diagnostic characters

(1) Plants rather small, brownish. (2) Stem not robust. (3) Leaf short and narrow (1.7-2.3 x 0.5-0.6 mm). (4) Hair-point -/(+), 0-0.25 mm, edenticulate. (5) Margin recurved (m. long, short/flat), bi (2-4)/three (in spots) or sometimes almost uni. (6) Costa m. broad to narrow (65-85/40-60 µm), stratosity/ventral cells (2-3/4-5, 2(-3)/3-6, 2-3/2-4), comparatively strong in upper part. (7) Lamina with or without bistratose spots. (8) Alar cells not or slightly inflated. (9) Pl squarrose, epilose, not hyaline. (10) Seta short (3.0-5.5 mm). (11) Urn short (1.6-1.8 mm). (12) Basal membrane -.

Variation

The description is drawn up from the lectotype and its many duplicates, and a few other specimens. One of the specimens has a broader costa than the other, but otherwise it is not very different. The variation of the taxon is less well known (see also below).

Comparison with other taxa

The taxonomic status of *R. cucullatulum* is not finally settled, because it is known from relatively few localities. It is especially the warm brown colour and small size of the plants, in combination with the capillaceous hair-point and lack of auricles or a hyaline basal marginal border, that set it apart from the other taxa in the area.

1. *Racomitrium cucullatulum* is related to *R. subsecundum* (Fig. 60-61), and its status is critical with regard to ecads of this widely distributed and strongly variable taxon. Usually, *R. subsecundum* is made up of much coarser plants with much longer and broader leaves, whose costa is broad in lower part and weak towards the point. But sometimes it may be quite gracile. The bulk of the gracile plants are regarded as nothing but modifications of coarser plants, as they exhibit all characteristics of typical *R. subsecundum* - including the strongly inflated and frequently auriculate group of alar cells. The problem of

keeping *R. cucullatulum* as distinct from *R. subsecundum* involves two sets of variations: (a) Typical *large* plants of *R. subsecundum* normally possess leaves with bistratose margin for one cell row. Rarely, plants, which for other reasons (size of leaves, structure of costa and alar cells, etc.) have to be considered as part of the variation of typical *R. subsecundum*, possess a margin which in spots is bistratose for two cell rows and even sometimes for more cell rows. Usually, the thickened margin of *R. subsecundum* is more spherical than the club shaped margin of the type of *R. cucullatulum* (t.s.). (b) The *gracile* plants of *R. subsecundum* usually have a unistratose leaf margin. But some small plants without or with a weakly thickened margin may have less inflated alar cells approaching the alar group of *R. cucullatulum*. The large variation in the stratosity of the leaf margin is confusing; but for the present I place all (preferably) chestnut brown plants without inflated alar cells and without or with short filiform hair-point in *R. cucullatulum*. This seems to result in a meaningful sorting of the material, but some specimens are difficult. I have seen one mixed stand between *R. subsecundum* and *R. cucullatulum*-like plants with weakly thickened margin. The taxa should be studied in the field.

2. *Racomitrium himalayanum* (Fig. 54) is different in having a more strongly and longly recurved leaf margin, a broader costa, and more strongly bulging leaf cell walls.

3. *Racomitrium cucullatulum* sensu its type material resembles the southern hemisphere *R. crispulum* (see Frisvoll 1984c: Fig. 1). Both have a leaf margin which is bistratose for many cell rows, as well as bistratose spots in their lamina. *Racomitrium crispulum* is different from *R. cucullatulum* in having larger leaves with a broader and thicker costa; a differently shaped hair-point; and a longer basal marginal border made up of about 20 thin-walled hyaline cells, etc. The two are not supposed to be closely related.

4. Regarding the differences between *R. cucullatulum*, and *R. fuscescens*, *R. verrucosum* and *R. joseph-hookeri*, see these species.

Habitat

The type was collected from Diabasfelsen (Brotherus 1929). None of the specimens include adequate information about the habitat.

Distribution

Racomitrium cucullatulum is known from Sikkim and Yunnan (Fig. 51).

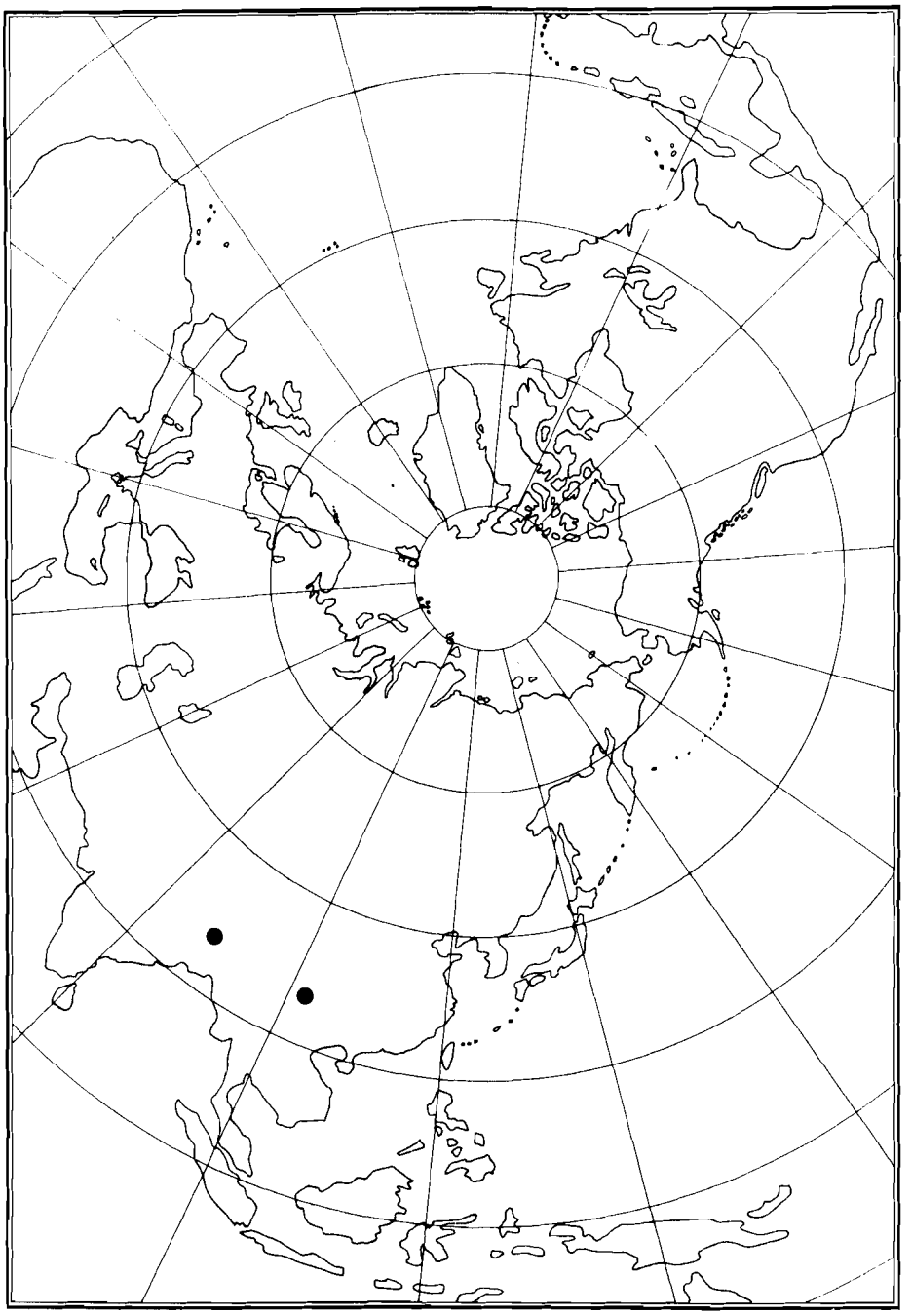

Fig. 51. Distribution of *Racomitrium cucullatulum*.

Specimens examined

SIKKIM: Lachen, 11000 ped., Hooker 318 (NY); Phalloot, [Kurz] 2126 (S, 3 sp.); Migothang, Togashi 201712, 201716 (NICH); Jongri, H.H., H.K., G.M., M.T. & T.T. 200197 (NICH), Togashi 201615 (NICH). CHINA: Yunnan (type of *R. cucullatulum*).

(20) *Racomitrium fuscescens* Wils. in Mitt. et Wils.
Fig. 52-53.

Racomitrium fuscescens Wils. in Mitt. et Wils., Kew J. Bot. 9: 324. 1857. - *Grimmia fuscescens* (Wils. in Mitt. et Wils.) Mitt., J. Linn. Soc. Bot. Suppl. 1: 44. 1859. - Type: "304. *Racomitrium fuscescens*, Wils. MSS. Hab. Sikkim - Himalaya alpina; Jongri, alt. 13.000 ped., J.D.H." (Lectotype nov.: "304. Herb. Ind. Or. Hook. fil. & Thomson. *Grimmia fuscescens* Mitt. *Hab.* Jongri. *Regio* alp. Sikkim - Himalaya. *Alt.* 13000 ped. *Coll.* J.D.H."; also separately labelled "304 *Racomitrium fuscescens* Wils. MSS." - BM-Hookerianum. Isolectotypes: BM-Hookerianum, BM-Wilson, BM-Bescherelle, L, S (3 sp.); NY (according to Deguchi 1980)).

Plants glistening dark brown (chestnut in the type) or lighter yellowish brown. **Stem** not robust, up to 4 cm, from strongly and irregularly branched to slightly branched. **Leaves** small, with more or less well-marked shoulders, ovate-triangular with narrow base, 1.7-2.4(2.8) x 0.4-0.6(0.75) mm. **Hair-point** usually absent, or present in the upper leaves, to 0.5(-0.7) mm, edenticulate and not decurrent, capillaceous, not flexuose. **Margin** narrowly recurved to 1/2-3/4 the leaf length on one side, and more shortly recurved on the other side, unistratose or rarely with bistratose spots in lower part. **Costa** stout, reaching to the point or apex, dorsally convex in upper part and flatter below, in lower part 70-90(100) µm broad, in upper part (30)40-50 µm broad, in basal part bi- to three-stratose (d. 13-18, c. 0-7, v. 4(-5)), in central part bi- to three-stratose (d. 13-15, c. 0-2, v. 4(-5, as in the type)), in upper part bistratose (d. 7-13, c. 0(-1), v. (2)3-4). **Lamina** unistratose, in transection often variously thick in different parts, and usually less thick at the margin. Basal **laminal cells** elongate with thick walls (T: 30-50 x 9 µm; walls 6 µm and lumen 3 µm), in central and upper part also usually elongate but sometimes shorter (T: 12-30 x 9 µm), upper marginal cells isodiametric or usually short-rectangular (T: 7-14(25) x 12 µm including the 7 µm thick marginal wall), walls not or slightly pseudopapillose. **Alar cells** yellowish or yellowish red, a few cells sometimes slightly enlarged or inflated, one row of thin-walled, esinuose, elongate or rounded cells extending as a border up along the margin, 10-17(25) cells in the marginal row, sometimes a second row of few cells similarly differentiated.

Perichaetial leaves (moderately) squarrose when wet, epilose, ovate with short apex, the innermost with yellowish-hyaline basal cells and sinuose and porose upper cells, and the next leaves with successively less thin-walled basal cells. **Seta** about 5-8 mm. **Urn** ± ovate (1.9 x 0.75 mm), exothecial cells short or long,

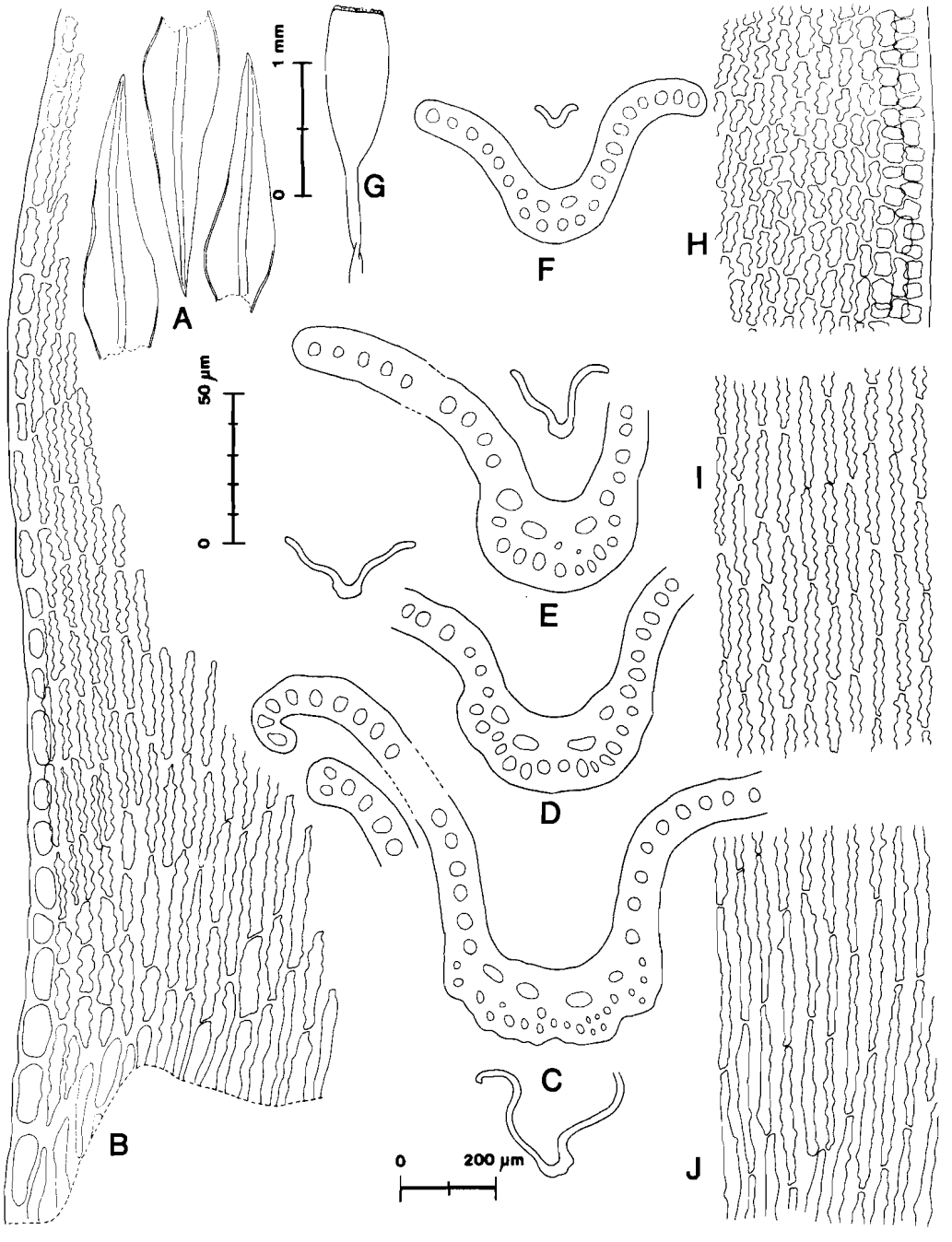

Fig. 52. *Racomitrium fuscescens*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g. Capsule. h-j. Cells from the upper, lower middle and basal part of the leaf. (a-f, h-j. Nepal: Wallanchoon, J.D. Hooker 323 - BM. g. Isolectotype - BM.)

3-4 rows of rounded incrassate cells at the mouth. **Teeth** (ca. 150 µm long,) of 2 prongs which are split down to the base, strongly papillose, basal membrane present (about 50 µm). Spores 12-14 µm. (1 fertile specimen, isolectotype.)

Diagnostic characters

(1) Plants comparatively small, often glistening brown. (2) Stem not robust. (3) Leaf short and narrow (1.7-2.4 x 0.4-0.6 mm), with faintly marked shoulders and narrow base. (4) Hair-point -/(+), 0-0.5 mm, not flexuose, edenticulate. (5) Margin recurved (m. long/short, short), uni/bi (1, spots in lower part). (6) Costa m. broad below and narrow above (70-90/40-50 µm), stratosity/ventral cells (2-3/4(-5), 2-3/4, 2/3-4). (7) Lamina cells with thick walls and narrow lumen. (8) Bmb of 10-17 esinuose cells. (9) Pl squarrose, epilose, not hyaline. (10) Seta long (4-8 mm). (11) Urn short (1.9 mm). (12) Basal membrane + (50 µm).

Variation

The type material of *R. fuscescens* is plentiful and distinctive. Most specimens have a slightly narrower costa than the type (65-75 versus 70-95 µm broad in the basal part); more numerous central costal cells (2-7 versus 0-2 in the basal part); less incrassate leaf cells; and some rounded cells in the basal marginal border as opposed to the solely rectangular or quadrate ones in the type. The type and most other specimens are gracile. A more robust specimen grew intermingled with large plants of *R. himalayanum* (Polunin M143 - BM). The leaves of this specimen are up to 2.8 x 0.75 mm (with costa up to 100 µm broad at the base and there with up to 6 ventral and 24 dorsal cells), and the margin is frequently bistratose for one to two cell rows below and possesses even three-stratose spots. Most characteristics, including the colour and form of the leaves, the recurvance of the margin, the cell structure, and the hyaline basal marginal border are a perfect match for the rest of the material. The above differences will certainly be bridged when more material becomes available.

Comparison with other taxa

1. The plants of *R. cucullatulum* (Fig. 50) have the same chestnut brown colour as *R. fuscescens*, and leaves without or with very short hair-point. But the leaf margin of the former is more broadly recurved on one side (as in *R. subsecundum*); its alar cells are more reddish; and at the basal margin there is a border of up to 10(-14) thick-walled and rounded pellucid cells. *Racomitrium fuscescens* possesses a thin-walled hyaline basal marginal border of 10-17 or more cells. It is important to be aware of the similarities between the two.

2. *Racomitrium subsecundum* (Fig. 60-61) is a larger species in all respects. The coloured and inflated/incrassate alar group of the leaves of *R. subsecundum* is absent in *R. fuscescens*, whereas the hyaline basal marginal border of *R.*

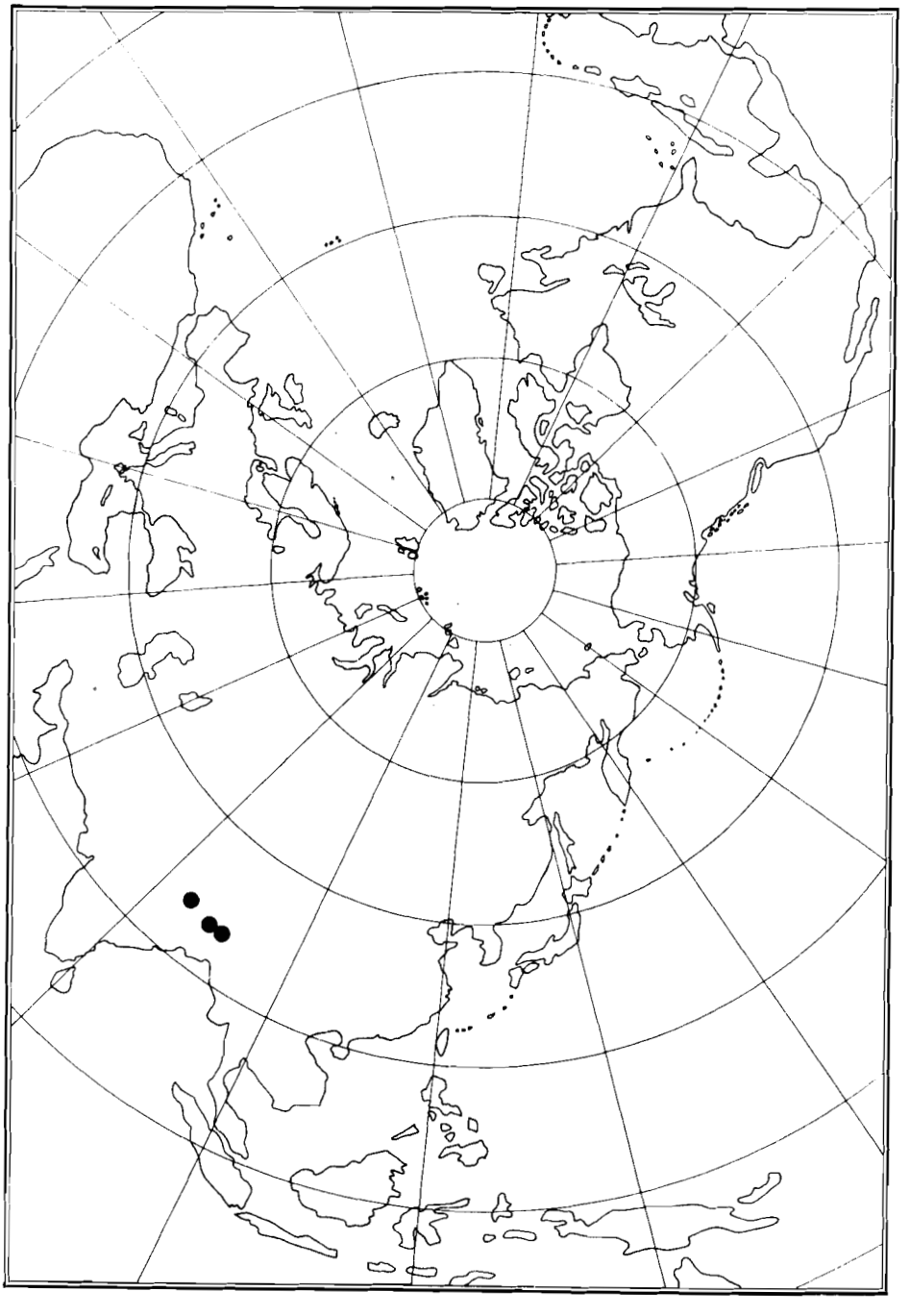

Fig. 53. Distribution of *Racomitrium fuscescens*.

fuscescens is lacking in *R. subsecundum*. The two are quite different and are not likely to be confused.

3. Regarding the differences between *R. fuscescens*, and *R. capillifolium*, *R. emersum* and *R. verrucosum*, see these species.

Habitat

Nothing is known about the habitat of *R. fuscescens*.

Distribution

Racomitrium fuscescens is known from the Himalayas (Fig. 53). It grows in Nepal, Sikkim and Bhutan.

Specimens examined

NEPAL: Chiline Khola, Polunin M143 (BM); S of Gurjakhani, Stainton, Sykes & Williams 3915b (BM); above Sauwoila Khola, Stainton, Sykes & Williams 4406b (BM); Taghing S of Tuhuchi, Kali Gandaki, Stainton, Sykes & Williams 1818a (BM); Wallanchoon, J.D.H. 322 (BM), J.D.H. 323 (BM, Fig. 52; L). SIKKIM: Migothang, Togashi 201717 (NICH); Jongri, Togashi 201598 (NICH), H.H., H.K., G.M., M.T. & T.T. 200217, 200221, 200222, 200226, 200229 (NICH). BHUTAN: Laum Thang - Singke La - Chawa Gassar, Hara et. al 287120 (NICH). (Country?): Patria Singalila, Mt. Singalila, Hara, Kurosawa & Ohashi (NICH).

(21) *Racomitrium himalayanum* (Mitt.) Jaeg.
Fig. 54-55.

Racomitrium **pumilum* Wils. in Mitt. et Wils., Kew J. Bot. 9: 324. 1857 *nom. nud.* - *R.* **pusillum* 'Wils. p.p.' in Par., Ind. Bryol. 1075. 1898 *nom. inval. in synon. err. pro R.* **pumilum* Wils. in Mitt. et Wils. - Orig.: "298, 326. *Racomitrium pumilum*, Wils. MSS. (allied to the last). - Hab. Sikkim-Himalaya temperata; Lachen, alt. 4-8.000 ped., J.D.H." (Orig. coll.: "326 *Racomitrium pumilum* Wils. MSS", also labelled "298 *Grimmia Himalayana* Mitt. Sikkim Himalaya, 5-8000 ped., J.D.H." and marked "W[ilson No.] 139" as is also another specimen of 326. - BM-Hookerianum. Duplicates: NY-Mitten).

Racomitrium fasciculare var. **minor* Mitt. et Wils., Kew. J. Bot. 9: 324. 1857 *nom. nud.* - *R. fasciculare* var. **minus* 'Wils.' in Wijk et al., Regn. veg. 48: 267. 1967 *nom. inval. err. cit. pro R. fasciculare* var. **minor* Mitt. et Wils. - Orig.: "321. *Racomitrium fasciculare* Brid. var. *minor*. - HAB. Sikkim-Himalaya alpina; Lachen, alt 13.000 ped., J.D.H." (Orig. coll.: "321 *Grimmia himalayana* Mitt.

Lachen, Sikkim Himalaya, 12000 ped., J.D.H." - BM-Hookerianum. Duplicates: NY-Mitten).

Grimmia himalayana Mitt., J. Linn. Soc. Bot. Suppl. 1: 45. 1859. - *Racomitrium himalayanum* (Mitt.) Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 97. 1874 (Ad. 1: 375). - Type: "In Himalayæ centralis et orient. reg. temp. et alp., Sikkim, J. D. Hooker (No. 298, 301, 305, 321, 326). Nepal, Wallich!" (Regarding localities, see Mitten & Wilson 1857). (Lectotype: "326. Lachen 4-7000" - NY-Mitten, selected by Deguchi 1980. Isolectotypes: BM-Hookerianum (2 sp). Paralectotypes: Hooker 301, 321 - NY-Mitten, BM-Hookerianum.)

Racomitrium dicarpum Broth. in Hand.-Mazz., Symb. Sin. 4: 47. 1929. - Type: "NW-Y[unnan]: Schieferfelsen der Hg. St. im birm. Mons. unter dem Doker-la in der Mekong-Salwin-Scheidekette, 28°15', 4225 m, c. sp. 17.IX.1915 (8067)." (Lectotype nov.: "Handel-Mazzetti, Iter Sinense 1914-1918. Nr. 8067 *Rhacomitrium dicarpum* Broth. n. sp. Prov. Yünnan bor.-occid.: Ad confines Tibeticas sub jugo Doker-la, 28°15', in regionis alpinae rupibus. *Substr.* schistaceo. *alt. s. m.* ca. 4225 m. Leg. 17.IX.1915 Dr. Heinr. Frh. v. Handel-Mazzetti. (Diar. Nr. 1499)." - H-BR. Isolectotypes: BM, E, S (2 sp.)).

Plants brownish or blackish except for the uppermost 2-5(20) mm which are lighter brown or usually olivaceous, in dense or loose tufts. **Stem** up to 7.5 cm but usually 1-4 cm, much, irregularly or frequently subpinnately branched, epidermis orange. **Leaves** erect, usually not falcate, in small specimens about 2 mm long (T: 1.7-2.1 x 0.4-0.5 mm), in robust specimens much larger (from 2.6-3.4 x 0.55-0.7 mm up to 3.4-4.5 x 0.75-0.9 mm in large pilose specimens). **Hair-point** variable, rarely quite absent (as in the lectotype), frequently moderately long (0.3-1.0 mm) or seldom longer (up to 1.9 mm), erect-flexuose and strongly crispate, usually slightly or not denticulate but sometimes with sharp low marginal teeth in long points, in brevipilose leaves not decurrent, in longipilose leaves distinctly decurrent down margin of lamina. **Margin** broadly recurved from base to the hyaline point or to 3/4-4/5 the leaf length, almost always unistratose, in epilose specimens sometimes bistratose for one to three cell rows in the upper part (as in the lectotype). **Costa** broad throughout, reaching into the hair-point or to the apex, dorsally convex, or flatter towards the base, in lower part (75)90-120(160) µm broad, in upper part 50-70 µm broad, in basal part three- (to four-)stratose (d. 16-24, c. 1-10(15), v. 6-8(12)), in middle part bi- to three-stratose (d. 12-20, c. 0-3(6), v. (4)5-8(9)), in upper part bistratose (d. 7-12(15), c. 0(-1), v. (2)3-6). **Lamina** unistratose, or exceptionally with bistratose spots in the upper part (as in the lectotype). Basal **laminal cells** elongate (T: 15-47 x 9 µm, in other specimens often about 25-65 µm long), middle and upper cells rectangular to elongate (T: 7-25 x 7.5 µm), upper marginal cells from transversely elongate to rectangular (T: 5-12 x 12 µm), cell walls from strongly to moderately bulging, rarely almost or quite plane. **Alar cells** not or slightly differentiated, sometimes orange-coloured or often like the adjacent laminal cells, not (or rarely one or a few cells slightly) enlarged, a basal marginal border usually present, of 4-12(16) thin-walled and pellucid (but usually not quite hyaline) esinuose cells, rarely cells more thick-walled.

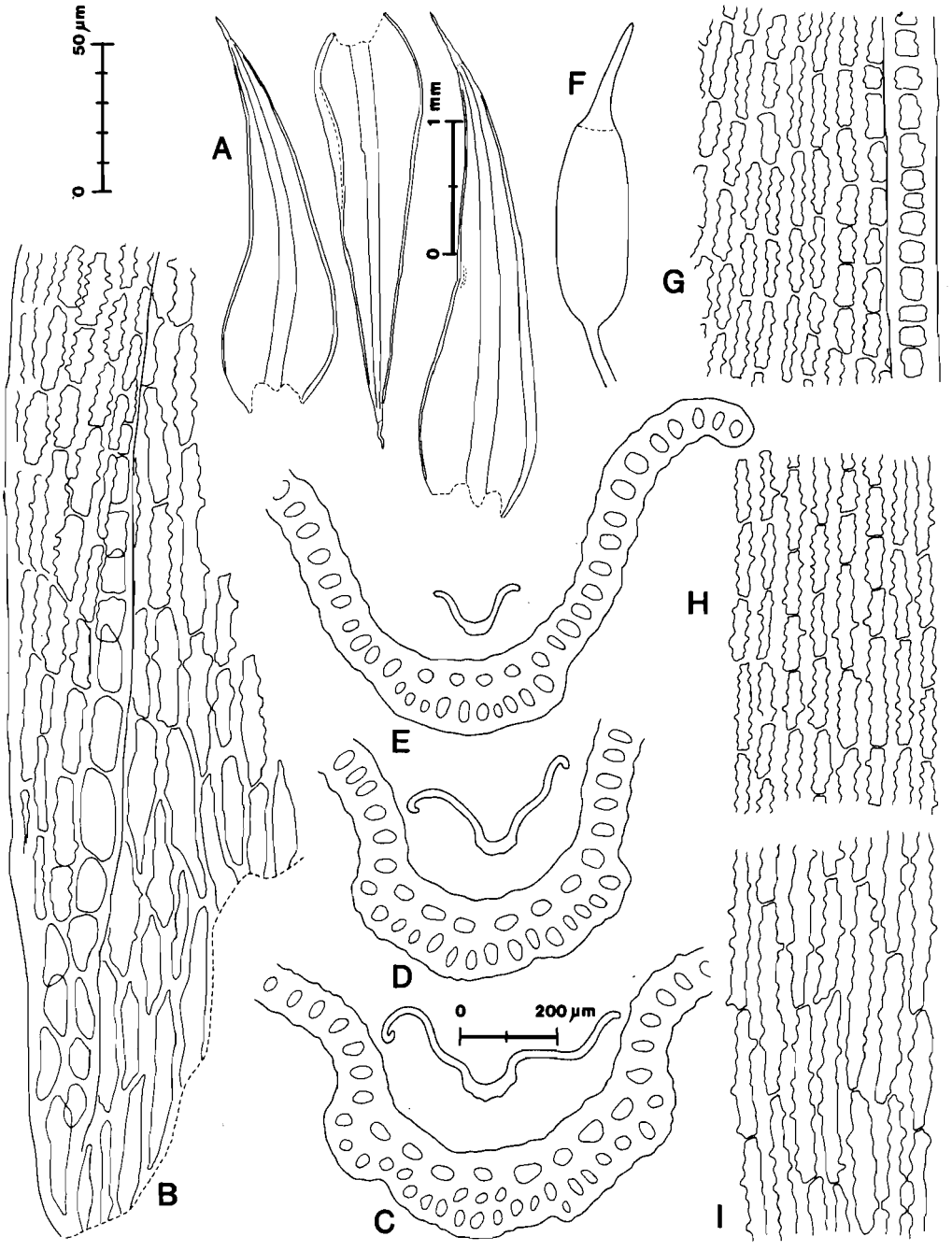

Fig. 54. *Racomitrium himalayanum*. a. Leaves. b. Alar and supra-alar cells. c-e. Leaf cross sections. f. Capsule. g-i. Cells from the upper, lower middle and basal part of the leaf. (Nepal: Kambachen, J.D. Hooker 301 - BM.)

Perichaetial leaves squarrose when wet, epilose, ovate with ± acuminate apex, the innermost (1-2) leaves with yellowish-hyaline base and chlorophyllous and sinuose cells in the upper part, the other leaves with successively more thick-walled cells at the base. **Seta** about 4-10 mm. **Urn** oblong-cylindrical (1.5-2.2 x 0.5-0.6 mm), exothecial cells rather elongate and narrow, 2-6 rows of rounded incrassate cells at the mouth. **Teeth** 400 µm long (1 capsule), of 2 prongs which are regularly split, papillose, basal membrane present but low (10-35 µm). Spores 12-16 µm.

Diagnostic characters

(1) Plants brownish or blackish with olivaceous apex. (2) Stem strongly (often subpinnately) branched, epidermis orange. (3) Leaf m. long and m. broad (normally 2.6-3.4 x 0.55-0.7 mm). (4) Hair-point +/(-), 0.3-1.0 mm, erect and strongly flexuose, usually almost or quite edenticulate. (5) Margin broadly recurved (long, long), uni/bi (1-3, in rare epilose specimens). (6) Costa broad (90-120/50-70 µm), stratosity/ventral cells (3(-4)/6-8, 2-3/5-8, 2/3-6). (7) Lamina very rarely with bistratose spots in upper part, cells usually distinctly pspp. (8) Alar cells uncoloured or orange, not (or almost not) inflated or auriculate, bmb of 4-12 pellucid (but not hyaline and sometimes even thick-walled) esinuose cells. (9) Pl squarrose, epilose, not hyaline. (10) Seta long (4-10 mm). (11) Urn short to m. long (1.5-2.2 mm). (12) Basal membrane + (10-35 µm).

Variation

The Asiatic specimens are variable in a number of quantitative characteristics. The lectotype is unrepresentative for the bulk of the specimens, and is considered to represent the smallest epilose extremity (see chapter 8.0). The hair-point of the leaves is usually present but not long; such moderately long points are not or not much decurrent, but long points are distinctly decurrent down margin of lamina. Long points are also more denticulate than short points. The leaf margin is usually broadly recurved to the uppermost part of the leaf, but sometimes it is slightly more shortly and narrowly recurved. The alar group is usually slightly differentiated, but sometimes there are a few inflated cells, in specimens which must be named *R. himalayanum* on the basis of their other characteristics. The alar group may be colourless or (more rarely) orange. Inflated cells are frequently coloured (see Comparison with other taxa, 1). Usually, the cell walls are distinctly bulging dorsally and ventrally, but sometimes they are faintly pseudopapillose or quite smooth. Some coarse specimens have a very broad, bistratose canaliculate costa in the middle part of their leaves, and quite dorsally flat costa basally. The Scottish population is small and seems to be macroscopically homogeneous, but nevertheless it is variable in some microscopical characteristics: The leaves are sometimes distinctly pseudopapillose, but often the cell walls are slightly or not bulging. The alar cells are from not or moderately differentiated to slightly inflated and orange (in different specimens from the same locality). The margin is from broadly and longly

to more narrowly recurved, and the costa is usually broad in the upper part or sometimes more narrow. The Scottish specimens appear to have more central costal cells in the middle part of their leaves than the Asiatic specimens (about 1-6 versus 0-3). Coarse, strongly pseudopapillose specimens are frequent in Asia but lacking in Scotland. Some Scottish specimens are quite similar to moderately robust Asiatic specimens (as, e.g., the lectotype of *R. dicarpum*).

Comparison with other taxa

1. *Racomitrium himalayanum* is usually easily recognized, but some specimens resemble *R. subsecundum* (Fig. 60-61) and may be confused with it. A thorough comparison between the two is therefore necessary: **Stem** epidermis (*him*: orange; *sub*: more reddish orange), **leaves** (*him*: not secund; *sub*: usually secund or at least secund at some shoot apices), **hair-point** (*him*: strongly crispate-flexuose to its extreme apex; *sub*: less strongly crispate-flexuose in its upper part), **margin** (*him*: broadly and longly recurved, unistratose; *sub*: broadly recurved and often folded on one side, and shorter and more narrowly recurved on the other side, unistratose or frequently bistratose far down the lamina), **costa** (*him*: broad below and comparatively broad also in the upper part; *sub*: broad below and rapidly narrowing in upper part), **cell walls** (*him*: distinctly bulging, rarely slightly or not; *sub*: not, rarely slightly bulging), **alar cells** (*him*: colourless or orange, usually not but sometimes slightly inflated and auriculate; *sub*: reddish or orange, usually distinctly inflated and auriculate), **basal marginal border** (*him*: of 4-12 pellucid, esinuose cells; *sub*: no or almost no thin-walled esinuose cells above the differentiated alar group). Especially some specimens from very high mountains (up to more than 5000 m a.s.l.) may be difficult to place. They may have from less to not pseudopapillose cells and sometimes slightly inflated alar cells. An orange-coloured stem; strongly crispate-flexuose hair-points; a broadly and longly recurved margin; the lack og a (large) inflated alar group; and the presence of a short basal marginal leaf border, indicate that a difficult specimen belongs to *R. himalayanum*. I have seen one instructive specimen of intermingled *R. himalayanum* and *R. subsecundum*.

2. In Scotland, *R. himalayanum* grows with *R. sudeticum* (Fig. 15), which, however, has a less recurved leaf margin; a stouter spinulose hair-point; a narrower costa; shorter upper leaf cells; and only slightly differentiated perichaetial leaves.

3. Many Scottish specimens of *R. himalayanum* have been called *R. microcarpon* (Fig. 39). The two are not closely related, and easy to separate. The most obvious differences are found in their hair-point (denticulate and less crispate in *R. microcarpon*), lamina cells (more porose and less sinuose towards the base of the leaf in *R. microcarpon*), and basal marginal border (long and made up of wide, hyaline cells in *R. microcarpon*; shorter and made up of less differentiated cells in *R. himalayanum*). Other important differences exist in the structure of the costa (see Descriptions).

4. *Racomitrium affine* (Fig. 23) differs from the Scottish *R. himalayanum* in having a broader leaf with a longer, denticulate and not (very) flexuose hair-point (if not epilose or brevipilose); a ventrally flat, four-stratose costa towards the base of the leaf; shorter upper lamina cells; and hyaline innermost perichaetial leaves.

5. For differences between *R. himalayanum*, and *R. brevipes*, *R. capillifolium*, *R. cucullatulum*. *R. fuscescens*, *R. heterostichum*, *R. joseph-hookeri*, *R. obtusum*, and *R. verrucosum*, see these species.

Habitat

According to the labels, the species grows on rocks ("rocks, damp rocks, rock slope"), boulders, or earthy scree, and among stones on exposed ridges. The specimens are collected from 3300 m a.s.l. in western Himalaya and from between 4100 and 5730 m in Nepal and Tibet.

Distribution

Racomitrium himalayanum is known from a large Asiatic and a small European area (Fig. 55). In Asia it grows in India (Tehri-Garhwal), Nepal, Sikkim, Bhutan and China (Tibet, Yunnan, Shensi). In Europe it is known from central Scotland.

Specimens examined

INDIA: Tehri-Garhwal, Kidarkanta, X.1879 Duthie (BM). NEPAL: Namdo (N of Mustang), Stainton, Sykes & Williams [shortened S., S. & W.] 2345h, 2350b (BM); above Sauwoila Khola, S., S. & W. 3001c, 3590a, 4406b, c (BM); Lamjung Himal, S., S. & W. 6311a (BM); Rambrong, Lamjung Himal, S., S. & W. 6232a (BM); Annapurna Himal, Seti Khola, S., S. & W. 6616 + 6617 (BM); E of Chalike Pahar, S., S. & W. 4522a (BM); near Chalike Pahar, S., S. & W. 4601a (BM); Gauzisankaz, camp du Lac en face du Menlungtse, Zimmermann 1575 (BM, NICH); Col de Hadengi-La, Zimmermann 1457 (BM, NICH); au debut de la vallee de Yeti, Zimmermann 539, 539b (NICH); Tanga - Luzebon, Zimmermann 815a (NICH); Chaine de Taseche, Zimmermann 603e (NICH); Chouk Pula, Zimmermann 292 (BM); Tamur Valley, Mewa Khola, Topke Gola, Stainton 967, 1907 (BM); Khola Karka (Chiline Khola), Polunin M93, M143 (BM); Lantang area, Polunin M241 (BM); Langshisha Kharka, Polunin 197 (BM); Gangja La, Polunin M217 (BM); Phakurji Lekh, S of Jumla, Polunin, Sykes & Williams 4796c (BM); Jangla Bhanjyang, Polunin, Sykes & Williams 2354c (BM); Kambachen, J.D.H. 301 (BM, NY); between Thang La (pass) and Thudam, Iwatsuki 1494 (NICH); between Ghopte (Tal Pokhari) and Gosa (near Kobche), Iwatsuki 1004 (NICH). SIKKIM: Lachen, J.D.H. 321, 326 (BM, NY); Jongri, J.D.H. 302 p.p. (BM), Togashi 201573, 201578, 201581, 201582, 201583, 201592, 201604, 201625 (NICH), H.H., H.K., G.M., M.T. & T.T. 200010, 200199, 200202, 200219, 200230 (NICH); Migothang, Togashi

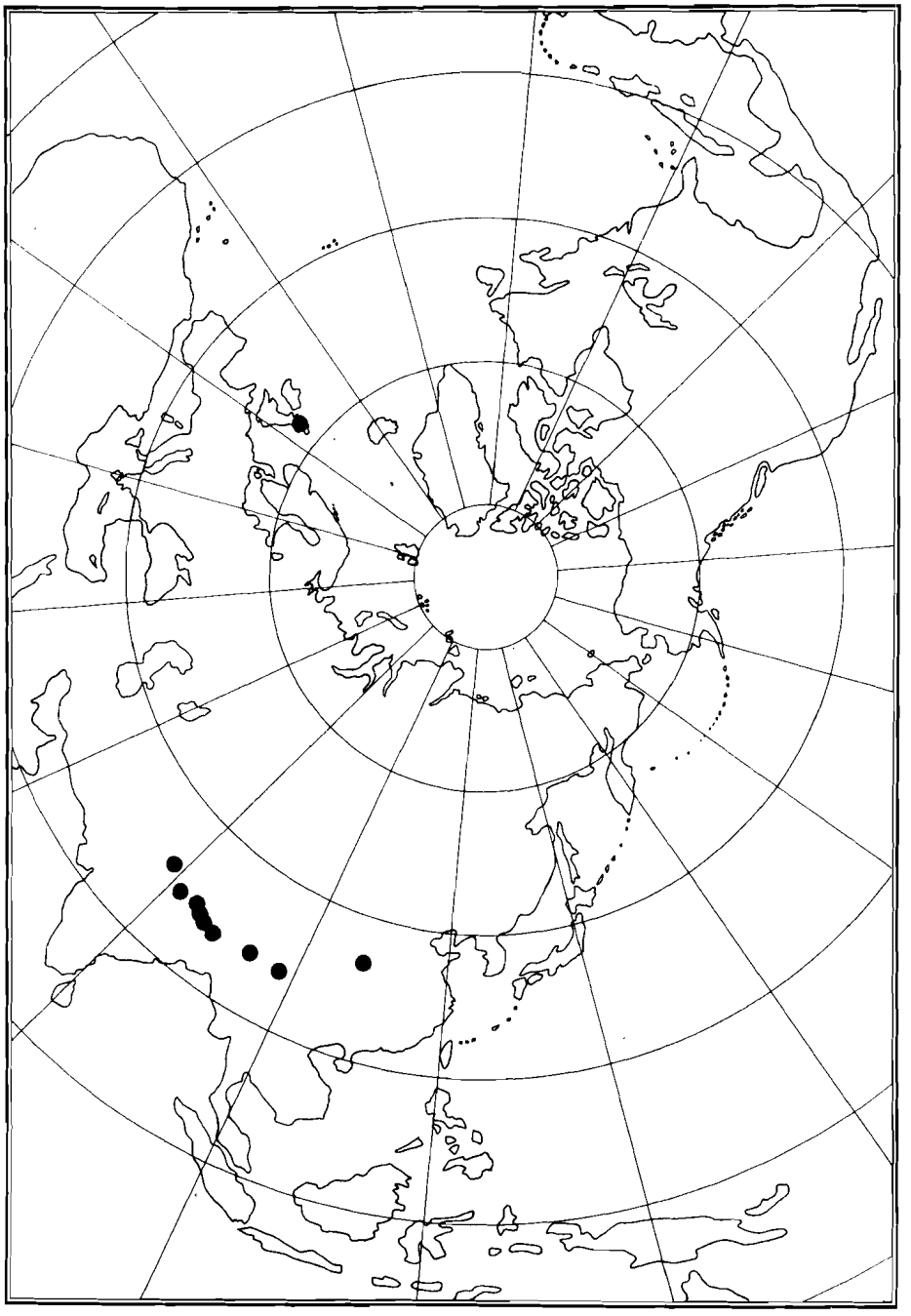

Fig. 55. Distribution of *Racomitrium himalayanum*.

201665 (NICH); Jongri - Preig Chu - Olothang, Togashi 201633 (NICH). BHUTAN: Laum Thang - Lingke La - Chawa Gassar, Hara et al. 286687, 286692, 286698, 286700 (NICH); Gasa - Pari La - Chamsa, Tanaka 287068 (NICH); Chawa Gassar - Tharizaj Thang - Jari La - Seanchu Passa, Hara et al. 287128 (NICH); Lingshi - Yale La - Shodu, Hara et al. 287151 (NICH). CHINA: Tibet. Lang La, 28°51'N, 93°53'E, Ludlow, Sherriff & Taylor [shortened L., S. & T.] 6258a (BM); Chitzchar, Isari Chu, L., S. & T. 6394 (BM); Sobhe La, Pome, Yigrona Range, Ludlow, Sherriff & Elliott 12048b (BM); Redonbu, Zang 5158 (TRH ex KUN); Motou, Su 862 (TRH ex KUN); Bu Mi, Su 918 (TRH ex KUN); Shensi, Taipai Mountain, Liu 1037 (TRH ex KUN). GREAT BRITAIN: Scotland, Ben Lawers, VIII.1902 Jones (BM), VIII.1902 Jones, Cleminshaw & Duncan (BM, E, FH, GLAM), VIII.1907 Duncan & Knight (BM, E, GLAM, S), 14.VIII.1907 Duncan & Knight (S), I.IX.1913 Duncan (BM, E, GLAM), VII.1927 Duncan (BM), VII.1929 O'Longhlin (BM), IX.1940 U. Duncan (E, GLAM); Cam Craig, Killin, VII.1909 Duncan, Knight & Jones (BM); VIII.1909 Jones (BM, E, GLAM); Meall nan Iarmachan, Killin, VIII.1902 Cleminshaw (BM, E, GLAM); Ben Douran, 30.VII.1908 Knight (E, GLAM), VIII.1912 Duncan, Watson & Jones (BM), VII.1913 D.A./mes. (BM), VIII.1913 Jones & Duncan (BM, E, GLAM), VIII.1913 Duncan, Watson & Jones (BM), VIII.1929 Duncan (E, GLAM); Craig Mohr, VII.1898 Young (BM, E, GLAM), VII.1906 Young (BM); s. loc., s. coll. (BM).

(22) *Racomitrium joseph-hookeri* Frisvoll *sp. nov.*
Fig. 56-57.

Folia margine bistratis; cellulae laminaribus parietibus valde protuberantibus.

Holotype: "322. Herb. Ind. Or. Hook. fil. & Thomson. *Grimmia subsecunda* m. *Hab.* Wallanchoon. *Regia* alp. Sikkim Himalaya. *Alt.* 13 000 ped. *Coll.* J.D.H." - BM-Hookerianum. Isotypes: BM, L (2 sp.), S (2 sp.).

Plants blackish or brownish in lower part, lighter brown at the apex, slightly grayish due to long hair-points, in loose mats. **Stem** creeping or ascending, up to 4 cm long, from slightly to subpinnately branched. **Leaves** (2.6)3.0-4.0 x (0.5)0.6-0.7 mm. **Hair-point** (0)0.9-2.0 mm, not or usually moderately flexuose and from erect to usually squarrose, edenticulate, usually distinctly decurrent down margin of lamina. **Margin** broadly recurved to 1/2 the leaf length or towards and sometimes into the hyaline point on one side, more narrowly and shortly recurved on the other side, bistratose in 1-2(4) cell rows from apex and almost to the base, rarely with three-stratose spots. **Costa** reaching to the apex or running into the hyaline point (and there chlorophyllous for some distance), dorsally convex in upper part and more flat below, in lower part 90-130 µm broad, in upper part 50-60 µm broad, in basal part bi- to three-stratose (d. 17-20, c. 0-3, v. 5-8), in middle part three-stratose (d. 13-20, c. 1-4(6), v. 5-7), in upper part bi- to three-stratose (d. 9-14, c. 0-2, v. (2)3-4). **Lamina** unistratose. Basal **laminal cells** elongate (T: 25-50 x 9 µm, with walls 6 µm and lumen 3 µm), middle and upper cells shorter (T: (7)10-25 x 7.5 µm), upper marginal cells short (T: 9-18 x 9 µm), all cells porose and strongly pseudopa-

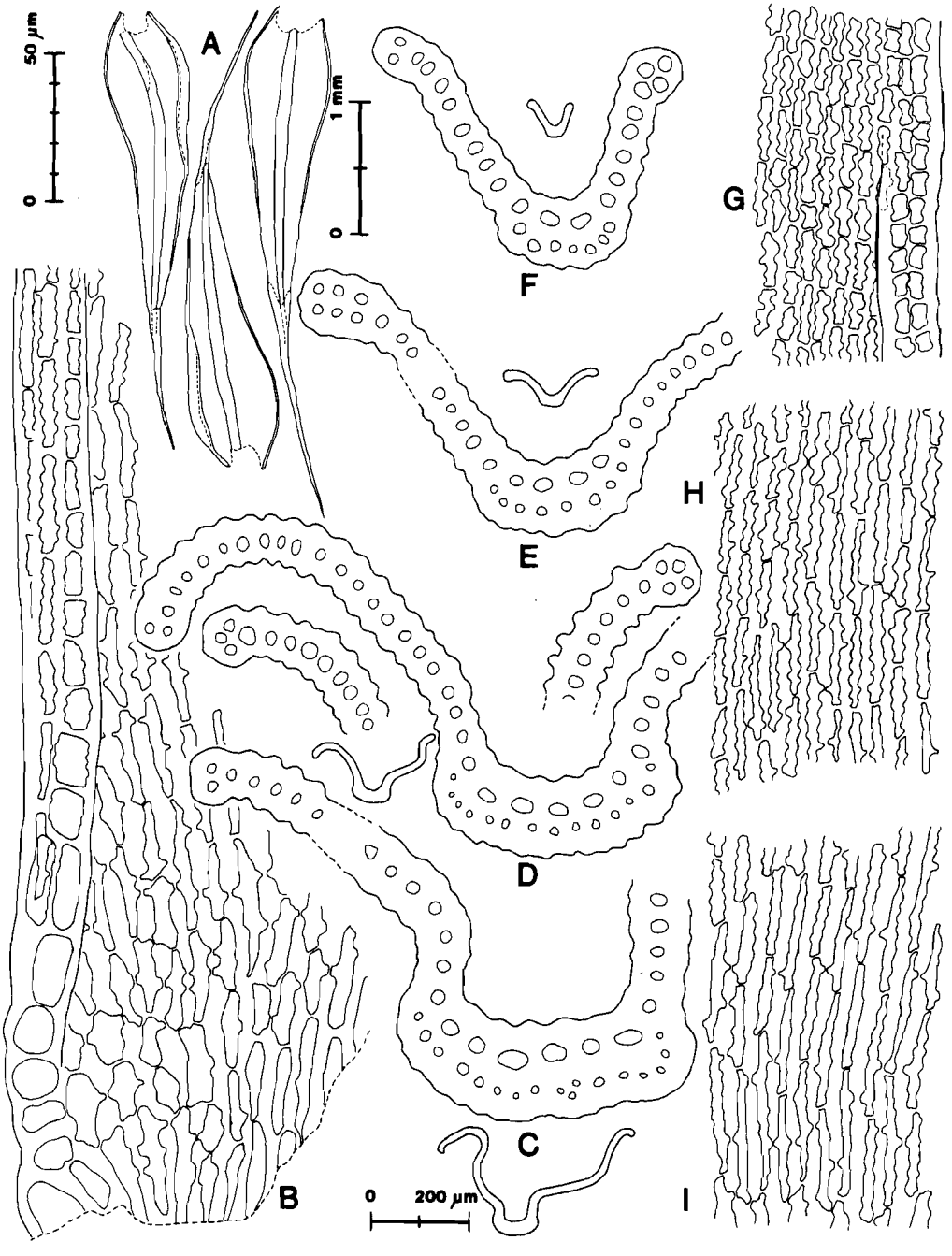

Fig. 56. *Racomitrium joseph-hookeri*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g-i. Cells from the upper, lower middle and basal part of the leaf. - Holotype (BM).

pillose. **Alar cells** not or slightly coloured, decurrent, not or slightly enlarged or inflated and not or very slightly sub-auriculate, one row of pellucid, usually rounded and moderately thick-walled cells extending as a short border up along the margin, 7-12(16) cells in the marginal row.

Sterile.

Diagnostic characters

(1) Plants brownish. (2) -. (3) Leaf long and m. broad (3.0-4.0 x 0.6-0.7 mm). (4) Hair-point +/((-)), 0.9-2.0 mm, edenticulate and distinctly decurrent. (5) Margin recurved (m. long, m. long/short), bi (1-3)/three (1, rare spots). (6) Costa broad above and m. broad below (90-130/50-60 µm), stratosity/ventral cells (2-3/5-8, 3/5-7, 2-3/3-4), reaching into the hyaline point. (7) Lamina cells strongly pspp. (8) Alar cells not enlarged or auriculate, bmb of 7-12(16) rounded, pellucid and slightly thick-walled cells.

Variation

The few known specimens vary only a little (but see below). There is a slight variation in the number of differentiated cells in the basal marginal border: The holotype has less than or about 10 cells, whereas another specimen has from 10 to 16 cells. The structure of the alar cells and border is similar, as is the pronounced pseudopapillosity of the leaves, the bistratosity of the leaf margin, the stout costa, and the long squarrose hair-point. The species is only known from four localities, and all specimens except one were collected by J.D. Hooker in 1848 (see Specimens examined). The recently collected Bhutan specimen matches the older specimens completely.

Three specimens (duplicates) from Yunnan [labelled "Prope fines Tibeto-Birmanicas inter fluvios Lu-djiang (Salween) et Djiou-djiang (Irrawadi or. sup.), in jugi Tschiangschel, 27°52', 3800-4050 m, Handel-Mazzetti 9329 (S, 2 sp.; WU)] perhaps belong here. They may be described as follows:

Plants dark brown or jet-black with a few lighter (immature) top leaves. **Leaves** up to 2.6 x 0.75(0.85) mm. **Hair-point** up to 0.6 mm. **Margin** broadly recurved to 4/5 the leaf length on one side and more narrowly and shortly recurved on the other side, bistratose in 2-3 cells rows from apex and far down the lamina, rarely with three-stratose spots. **Costa** reaching to the hair-point, dorsally convex in upper part and more flat towards the base, in lower part 100-115 µm broad, in upper part 45-60 µm broad, in basal part three-stratose (d. 18-25, c. 1-4, v. 5-8), in middle part three-stratose (d. 14-17, c. 1-3, v. 5-7), in upper part bistratose (d. 5-10, c. 0, v. 3-5). **Lamina** unistratose. **Laminal cells** elongate and thick-walled (at the base 18-40 x 9 µm with walls 5 µm thick; in upper part 12-30 x 12 µm; upper marginal cells 9-25 x 10 µm), walls very strongly bulging on both sides, and areolation opaque and difficult or frequently impossible to

study. **Alar cells** decurrent, yellowish, one row of pellucid, rounded cells making up a short basal marginal border, 7-13 cells in the marginal row. Sterile.

The plant differs particularly from *R. joseph-hookeri* in its slightly broader leaves, its lack of a long hair-point, and its opaque areolation. The structure of the costa and margin is essentially the same. It is tentatively placed here; but more material is needed before the status of the Yunnan plant can be established.

Comparison with other taxa

The known material of *R. joseph-hookeri* cannot, without reservation, be referred to any of the below Himalayan species, or be treated as an infraspecific taxon of one of these. It is therefore described as new.

1. *Racomitrium cucullatulum* (Fig. 50) may have from one to three rows of bistratose marginal leaf cells like *R. joseph-hookeri*. However, the known specimens of the former taxon have small leaves (to 2.3 mm long) with very short (to 0.25 mm) or usually no hair-point, and smooth or slightly bulging cell walls. The structure of the alar cells and costa is not unlike in the two. They are hardly closely related.

2. *Racomitrium capillifolium* var. *lorifolium* (Fig. 48) has a unistratose leaf margin with frequent bistratose spots for one cell row; not or very slightly bulging cell walls; and usually more (10-20) cells in the bordering marginal cell row. Var *lorifolium* may be the closest relative of *R. joseph-hookeri*. Var. *capillifolium* (Fig. 47) has a much longer hair-point and still more (20-30(40)) cells in its marginal border, and is unlikely to be confused with *R. joseph-hookeri*.

3. *Racomitrium subsecundum* (Fig. 60-61) has distinctly enlarged and frequently auriculate alar cells; no differentiated marginal border; not or less bulging cell walls; and usually a less thickened leaf margin. The known material of *R. joseph-hookeri* is not likely to be confused with *R. subsecundum*.

4. *Racomitrium himalayanum* (Fig. 54) has distinctly but usually less strongly bulging leaf cell walls than *R. joseph-hookeri*. The leaf margin of *R. himalayanum* is more strongly recurved, and is unistratose as opposed to the bistratose margin of *R. joseph-hookeri*. The point of *R. himalayanum* is usually short, and when long it is still crispate-flexuose; *R. joseph-hookeri* has a long, straight or less flexuose point. The basal marginal leaf border is much the same in the two.

5. *Racomitrium verrucosum* (Fig. 42-43) is a smaller taxon, which has no or short hair-points; possesses bistratose spots in its lamina (only var. *verrucosum*); and has a longer, quite hyaline basal marginal leaf border. It resembles *R. joseph-hookeri* in its bistratose leaf margin and the pronounced pseudopapillosity

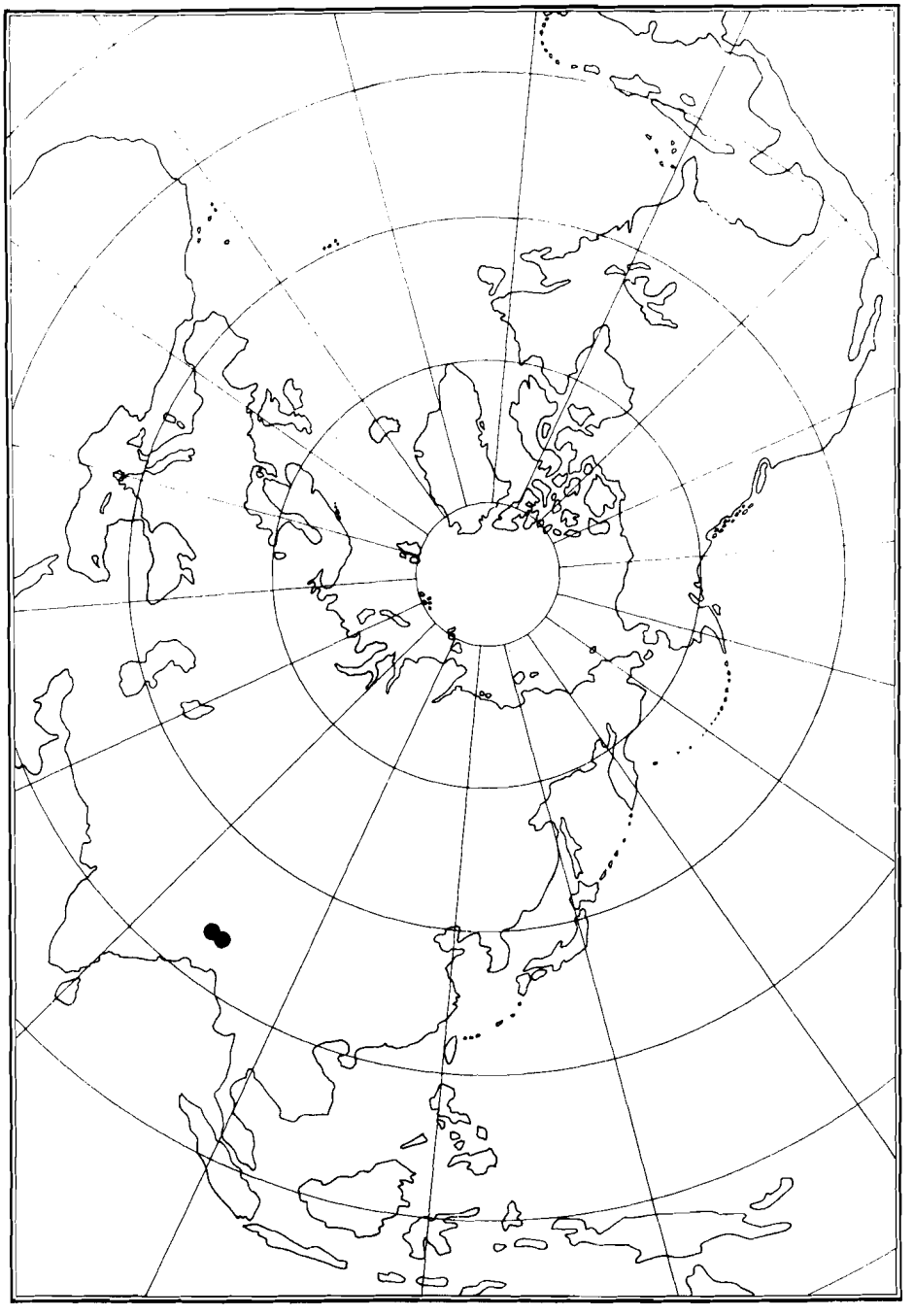

Fig. 57. Distribution of *Racomitrium joseph-hookeri*.

of its leaves, but the areolation of the two is different (see Descriptions and Figures).

6. The western N. American *R. brevipes* (Fig. 7) is strongly pseudopapillose like *R. joseph-hookeri*, but has, e.g., a different form of the leaves and a stout, strongly denticulate and spinulose hair-point. The two are not closely related.

Habitat

No information about the habitat is given on the labels or in Mitten and Wilson (1857). It has been collected between 2300 and 4300 m a.s.l.

Distribution

Racomitrium joseph-hookeri is known from eastern Nepal and Bhutan.

Specimens examined

NEPAL (fide map in Hooker 1854, cf. also Mitten & Wilson 1857; Sikkim fide label): Wallanchoon, 12000 ped., Hooker 313 (BM, 3 sp; NY); Wallanchoon, 13000 ped., Hooker 322 [BM (2 sp. incl. holotype), S (2 sp.), L (2 sp.)]; s. loc. (= Wallanchoon, 13000 ped., fide Mitten & Wilson 1857), Hooker 323 (L) [according to J.D. Hooker (1854(1): 220-226) the above specimens must have been collected on a trip from Wallanchoon Village to Wallanchoon Pass, 25-27.XI.1848]; Tambur River, 7000 ped., Hooker s.n. (312, fide Mitten & Wilson 1857) (NY). BHUTAN: Laum Thang (3900) - Singka La (4950) - Ghawa Gassar (4000), Hara et al. 286695, The third botanical expedition to Eastern Himalaya 1967 (NICH).

(23) *Racomitrium nitidulum* Card.
Fig. 58-59.

Racomitrium nitidulum Card., Bull. Herb. Boiss. ser. 2, 8: 335. 1908. - *R. heterostichum* var. *nitidulum* (Card.) Nog., Misc. Bryol. Lich. 1(15): 2. 1958. - Type: "Japon: Fusiyama (n. 338). Corée: île Quelpaert, à 2000 m. (n. 627)." (Lectotype nov.: "Herb. J. Cardot. *Rhacomitrium nitidulum* Card. sp. nova. Japon: Fusiyama. Leg. Faurie, 1898, no. 338." - PC. Isolectotypes: H-BR, KYO (3 sp.), S).

Racomitrium sudeticum var. **robustum* Broth. ex Ihs., Classif. Moss. Japan 93. 1932 *hom. illeg. non* Lindb. ex Vent., Muscin. Trent. 44. 1899 [= *R. macounii* subsp. *macounii*]. - Type: "Mt. Yatsu, Nagano Pref." (? Holotype: "No. 737. *Rhacomitrium sudeticum* f. *robusta*. *Hab.* Mt. Yatsugatake, Shinano. *Date* 26/7 1908. *Coll.* E. Uematsu. Japan." - H-BR).

Plants brownish in lower part and olivaceous for the upper 2-4 mm, in dense cushions. **Stem** up to 6 cm but usually 2-3 cm, strongly and irregularly branched, or the main stems seemingly unbranched but with numerous very short branchlets, not robust. **Leaves** 1.7-2.3(2.6) x 0.4-0.6(0.7) mm. **Hair-point** frequently absent, or short (up to 0.5 mm), rather stout, not denticulate. **Margin** narrowly recurved to 1/2-3/4 the leaf length on one side, and flat or very narrowly recurved in the broadest part of the leaf on the other side, usually unistratose or with rare bistratose spots, seldom with more bistratose spots. **Costa** dorsally convex from base to apex, in lower part 55-80(85) µm broad, and in upper part 35-50 µm broad, reaching to the apex or hyaline point, in basal part bi- (to three-)stratose (d. 11-15(18), c. 0-2, v. 3-5(6)), in middle part bi- (or exceptionally three-)stratose (d.10-15, c.0(-2), v. 3-5), in upper part bistratose (d. 5-9, c. 0, v. 2(-3)). **Lamina** unistratose. Basal **laminal cells** elongate (T: 23-45 x 9 µm), middle and upper cells rectangular to elongate (T: 9-25 x 7.5 µm) or more rarely short to very short (5-19 µm), upper marginal cells rectangular or quadrate (T: 7-14 x 9 µm), cell walls usually distinctly bulging dorsally and ventrally, or rarely not bulging. **Alar cells** usually reddish, often enlarged and inflated for about three cell rows in a small, well delimited (sub)auriculate group, or rarely less or not inflated or auriculate, about 5-10(14) esinuose cells in the marginal row.

Perichaetial leaves squarrose when wet, epilose, not hyaline, ovate with acuminate apex. **Seta** about 4.5-7 mm. **Urn** oblong-cylindrical (1.4-2.2 x 0.6 mm), exothecial cells short or elongate, 4-6 rows of narrow rounded cells at the mouth. **Teeth** (broken,) papillose at the base. Spores 14-19 µm.

Diagnostic characters

(1) Plants small, dark-coloured with olivaceous apex. (2) Stem strongly and irregularly branched, not robust. (3) Leaf short and narrow (1.7-2.3 x 0.4-0.6 mm). (4) Hair-point -/+, 0-0.5 mm, rather stout, edenticulate. (5) Margin narrowly recurved (m. long, short/flat), uni/bi (1, in rare sports). (6) Costa narrow (55-80/35-50 µm), stratosity/ventral cells (2(-3)/3-5, 2(-3)/3-5, 2/2). (7) Lamina cells usually distinctly pspp. (8) Alar cells reddish and frequently enlarged and (sub)auriculate. (9) Pl squarrose, epilose, not hyaline. (10) Seta long (4.5-7 mm). (11) Urn short to m. long (1.4-2.2 mm). (12) Basal membrane ?.

Variation

The taxon seems to be stenotypic. Usually, the cells are elongate throughout the lamina, but some epilose specimens have shorter upper leaf cells. The alar group is usually distinct but sometimes less clearly differentiated; however, some auriculate leaves are found also in such specimens. Usually the stems are short, but when growing in less exposed habitats they may be elongate. The two Chinese specimens fit the Japanese material well. They have a less auriculate alar group, but possess typically enlarged and inflated basal marginal cells.

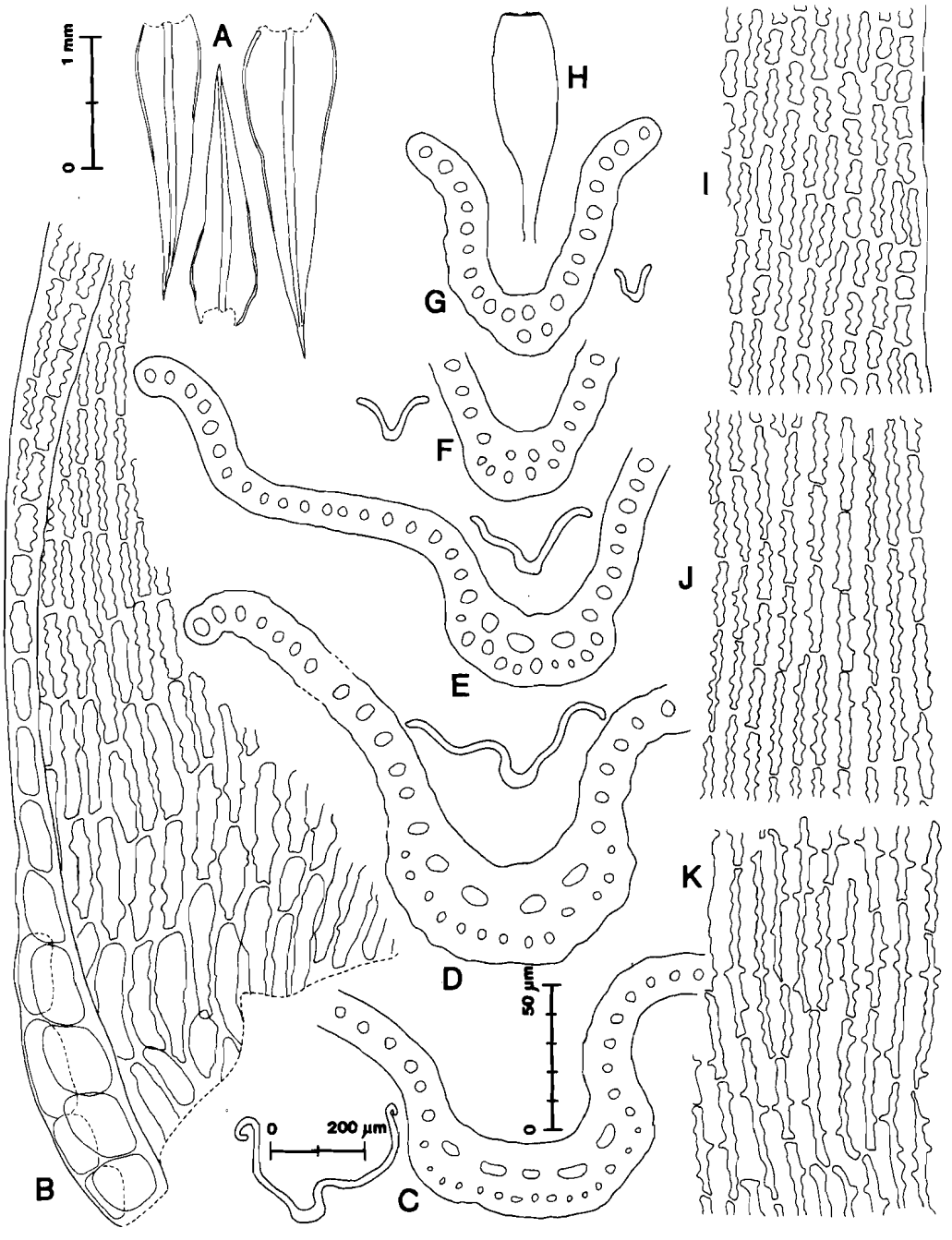

Fig. 58. *Racomitrium nitidulum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h. Capsule. i-k. Cells from the upper, lower middle and basal part of the leaf. - Isolectotype (H-BR).

Comparison with other taxa

1. *Racomitrium nitidulum* is thought to be related to the more southern *R. subsecundum* (Fig. 60-61) (whose nearest known locality is Taiwan). The two have in common a reddish leaf-base with more or less inflated alar cells, and squarrose non-hyaline perichaetial leaves. *Racomitrium subsecundum* is a larger plant in all respects. The costa of *R. nitidulum* is dorsally convex and ventrally canaliculate throughout, and not flat towards the base as in *R. subsecundum*. No plants approaching *R. nitidulum* have been seen from the distribution area of *R. subsecundum*.

2. The plants of *R. laetum* (Fig. 19) are yellowish coloured and not or slightly branched. Their leaves possess a yellowish-hyaline basal marginal border and no reddish leaf base or inflated alar cells; more irregular lamina cells; uneven margin; and a distinct hair-point. Modifications of *R. laetum* may have short hair-points, but the other leaf characteristics will easily distinguish such plants from *R. nitidulum*. The two are not closely related.

3. Japanese plants of *R. sudeticum* (Fig. 15) have a predominantly three- to four-stratose costa, no reddish leaf base with inflated alar cells, and a usually more bistratose leaf margin. Specimens of *R. sudeticum* with unistratose leaf margin are known by the characteristics of the costa and leaf base. When sporophytes are present, the different perichaetial leaves (squarrose and epilose in *R. nitidulum*, pilose and slightly differentiated in *R. sudeticum*) are an easily observed differential characteristic.

4. *Racomitrium nitidulum* was treated as a synonym of *R. microcarpon* (Fig. 39) by Noguchi (1974, as *R. heterostichum* var. *ramulosum*). The hair-point, areolation, costa structure, and alar cells including basal marginal cells, are very different in the two, and they are but distantly related.

5. *Racomitrium vulcanicola* (Fig. 45) differs from *R. nitidulum* by the same characteristics as *R. microcarpon*, and in addition it possesses the unique gemmae.

Habitat

Racomitrium nitidulum is collected from rocks, according to the labels, and one label identifies the rock as granite. It is collected between 1450 and 2000 m a.s.l.

Distribution

Racomitrium nitidulum is known from Japan (Honshu and Yaku-shima) and China (Kirin prov.) (Fig. 59).

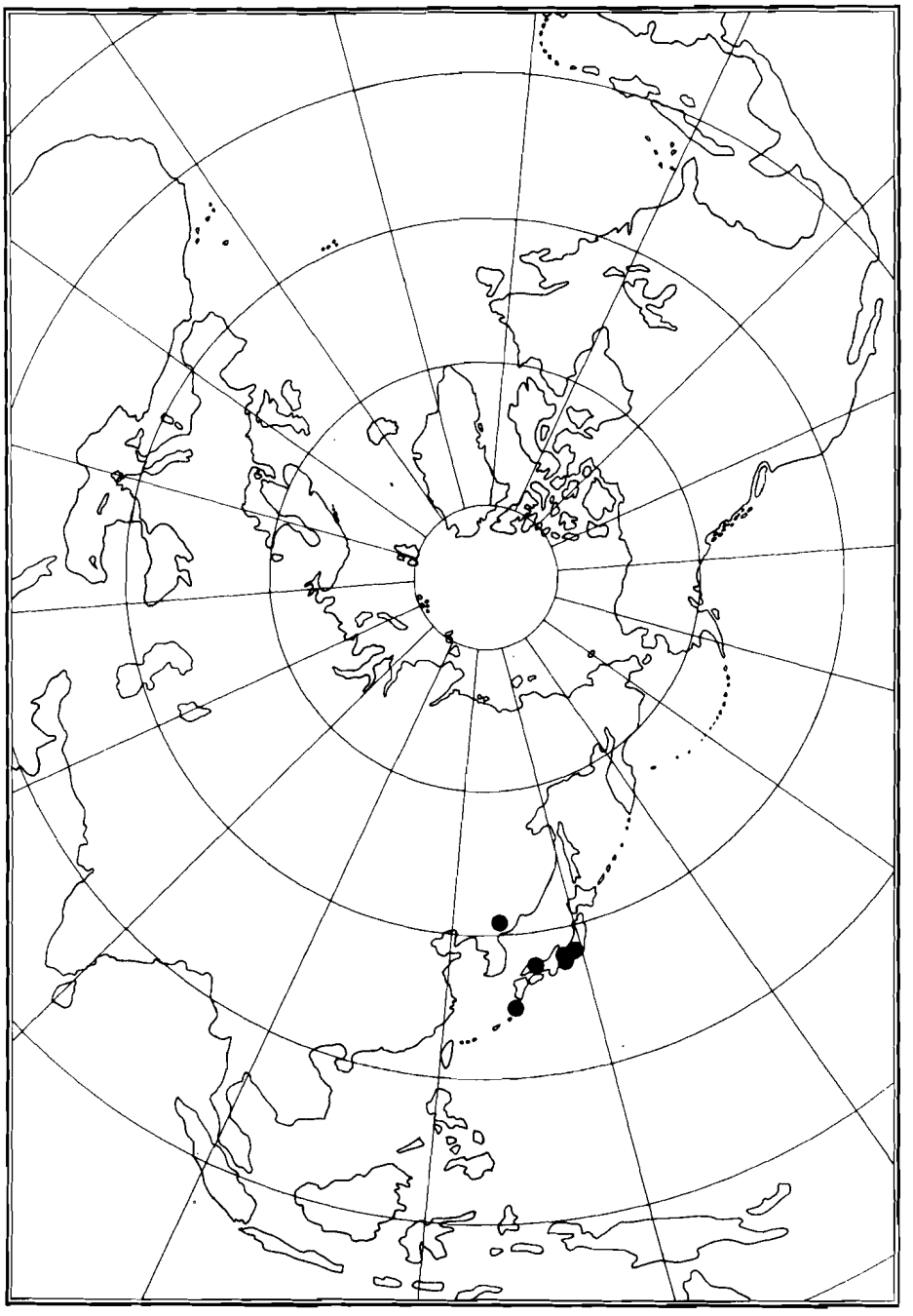

Fig. 59. Distribution of *Racomitrium nitidulum*.

Specimens examined

JAPAN: Honshu, Nagano Pref., Suwa-gun, Mt. Aka-dake, Miyawaki 3391 (NICH); Mt. Yuatsugatake, alpine zone of Akadake, Iwatsuki 3166 (NICH); type of *R. sudeticum* var. *robustum* (H-BR); Kagoshima Pref., Isl. Yakushima, Mt. Miyanouradake, 12.VII.1952 Shimizu (NICH); Yamanashi Pref., Mt. Fuji, Ando 29308 (TRH); do., Fujiyoshida-shi, Deguchi 20994 (TRH); type of *R. nitidulum* (PC, H-BR, KYO, S); Tottori Pref., Saihaku-gun, Mt. Daisen, Umezu 272 (NICH); Shimotsuke Prov., Nikko, Sakurai 669 (MAK). CHINA: Jilin [= Kirin] prov., Mt. Chang-pai Shan, Gao 22279 (ALTA, NY).

(24) *Racomitrium subsecundum* (Hook. et Grev. in Hook.) Mitt. et Wils.
Fig. 5B, 60-62.

Trichostomum subsecundum Hook. et Grev. in Hook., Icon. Pl. Rar. 1: *17. f. 5.* 1836. - *Racomitrium subsecundum* (Hook. et Grev. in Hook.) Mitt. et Wils., Kew. J. Bot. 9: 324. 1857. - *Grimmia subsecunda* (Hook. et Grev. in Hook.) Mitt., J. Linn. Soc. Bot. Suppl. 1: 45. 1859. - Type: Not indicated. (Lectotype nov.: "H. 2716 *Trichostomum subsecundum*" - BM-Hookerianum. Isolectotypes: "H. 2716 dup. *Trich. subsecundum*, Wallich." - BM-Hookerianum, BM (3 small sp.), BM-Hookerianum in hb. Giffith, NY-Mitten).

Racomitrium javanicum Doz. et Molk. in Zoll., Syst. Verz. 32. 1855 (*'javaanicum'*). - Type: "Habit. insulam Javae ubi primus ditissime fructificans legit Teysmann. - (?) Ibidem sine loco et numero Zoll." (Lectotype nov.: "*Rhacomitrium Javanicum* Dz. et Mb. Java. Teysmann legit. Communic. Dr. v.d. Sande Lacoste Br. jav. auct." - L. Isolectotypes: L).

Racomitrium **carnosum* Wils. in Mitt. et Wils., Kew. J. Bot. 9: 324. 1857 *nom. nud. in synon.* - Orig.: "303. *Racomitrium subsecundum* (*Trichostomum subsecundum*, Hook. et Grev.); var. fol. piliferis (*R. carnosum*, Wils. MSS). - Hab. Sikkim-Himalaya temperata; Tonglo, 8-9.000 ped., J.D.H." (Orig. spec.: "303. W. 142. *R. subsecundum* var. Wils. p. 324. Tonglo. Coll. J.D.H." - BM, NY (diff. loc.)).

Racomitrium cylindricum Schimp. in Besch., Mem. Soc. Nat. Cherbourg 16: 184. 1872 (*Grimmia* **cylindrica* (Schimp.) ex C. Müll., Syn. 1: 805. 1849 *hom. illeg. non* Nees et Hornsch., Bryol. Germ. 2(1): 161. 1827 [= *Grimmia ovalis* (Hedw.) Lindb.]. - *Racomitrium* **cylindricum* Schimp. ex C. Müll., Syn. 1. 805. 1849 *nom. nud. in synon.*). - Type: "Mexico, Pico de Orizaba: Liebmann" (Müller l.c.) (Lectotype nov.: "*Racomitrium microcarpon/cylindricum* nob. Pic d'Orizaba, Liebmann leg." - BM-Schimper. Paralectotypes: Liebmann No. 65 and 108 - BM-Schimper; Liebmann s.n. - S).

Racomitrium **subheterostichum* C. Müll. ex Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 95. 1874 (Ad. 1: 373) *nom. nud.* - Orig.: "Asia, Sikkim-Himalaya 9-10.000' (S. Kurz Nr. 2263)." (Orig. spec.: "2263 *Rhacomitrium subheterostichum*

C. M. Sikkim, Phalloot, 9-10.000 ft. S. Kurz" - BM-Hampe (3 sp.), H-BR, L, NY (2 sp.)).

Racomitrium fragile Ren. et Card., Rev. Bryol. 36: 106. 1909. Type: "Guatemala: Pico de Fuego (leg. R. Guérin; herb. F. Renauld)." (Isotype: "Herb. J. Cardot. *Rhacomitrium fragile* Ren. et Card. Guatemala: Pico de Fuego, 4000 m. Leg. R. Guérin. Ex hb. Renauld." - S).

Racomitrium javanicum var. *molle* Broth. ex Herz., Hedwigia 50: 127. 1910. - Type: "An den Gipfelfelsen des Pidurutalagala, ca. 2530 m." (? Holotype: "123 *Rhacomitrium javanicum* D. & M. v. *mollis* Broth. n. var. Ceylon. An den Gipfelfelsen des Pidurutalagala, ca. 2530 m, Januar, 06 Th. Herzog." - H-BR. Isotype: S).

Racomitrium javanicum var **muticum* Broth. ex Herz., Hedwigia 50: 127. 1910 *nom. nud.* - Orig.: "An den Gipfelfelsen des Kirigalpota, ca. 2450 m; an Felsblöcken unter dem Wasserfall bei Nuwara Eliya, ca. 2000 m, Jan. 06; - immer steril." (Orig. spec.: "124 *Rhacomitrium javanicum* Dz. Mk. var. *muticum* Broth. var. nov. Ceylon. Felsblöcken unter dem Wasserfall bei Nuwara-Eliya, ca. 2000 m, Januar, 06 Th. Herzog." - H-BR, JE, S. "123. An den sonnigen Gipfelfelsen des Kirigalpota, ca. 2450 m, Februar, 06 leg. Th. Herzog." - JE).

Racomitrium javanicum var. *brachyphyllum* Card. et P. Vard. in P. Vard., Rev. Bryol. 50: 17. 1923. - Type: Not indicated. (Lectotype nov.: "S. H. College. Shembaganur. Musci madur. Indiae merid.lis exsic. No. 30. *Rhacomitrium subsecundum* (H & G) Jaeg. var. *brachyphyllum* Card. var. nov. *Habit.* Pambar torrent, Kodaikanal, on ground. *Alt.* 2300 m. 20/1/12 Leg. G. Foreau & G. Roiné." - PC-P. Varde. Isotype: S. Paralectotype: "... 2400 m, leg. G. Foreau 20/1/12." - PC-P. Varde, BM-Dixon).

Racomitrium javanicum var. *incanum* Broth. in Hand.-Mazz., Symb. Sin. 4: 46. 1929. - Type: "NW-Y.[unnan]: Im birm Mons. im Wald unter dem Doker-la an der tibetischen Grenze (8031). S.[etschwan]: Lung-dschu-schan bei Huili (967). Lose-schan s von Ningyüen, massenhaft (1446). Tschahungnyotscha jenseits des Yaling n von Yenyüen, 28°15' (2264). Hieher wohl auch die Notizen vom Passe Döko sw Muli und im birm. Mons. auf sandigem Wiesenmoorboden beim See im Hintergrund des Doyon-lumba in der Mekong-Salwin-Kette, massenhaft." (Lectotype nov.: "Nr. 1446 *Rhacomitrium javanicum* Dz. Mk. var. *incanum* Broth. n.v. Prov. Setschwan austro-occid.: In montis Lose-schan ad merid. urbis Ningyüen regione temperata ad alpinam copiosissime. alt. s.m. ca. 3200-4250 m. Leg. 16.IV.1914. Dr. Heinr. Frh. v. Handel-Mazzetti. (Diar. Nr. 352)." - H-BR. Isolectotypes: BM, E, JE, S, WU. Paralectotypes: No. 8031 - H-BR, WU; No. 967 - H-BR, S, WU; No. 2664 - H-BR,WU).

Plants dark brown below and lighter brown or olivaceous above, but sometimes light or dark throughout and sometimes grayish due to long hair-points, in loose or dense, often wide mats or cushions. **Stem** up to 12 cm or more, but usually 3-6 cm, from slightly or not branched to irregularly, subpinnately or rarely

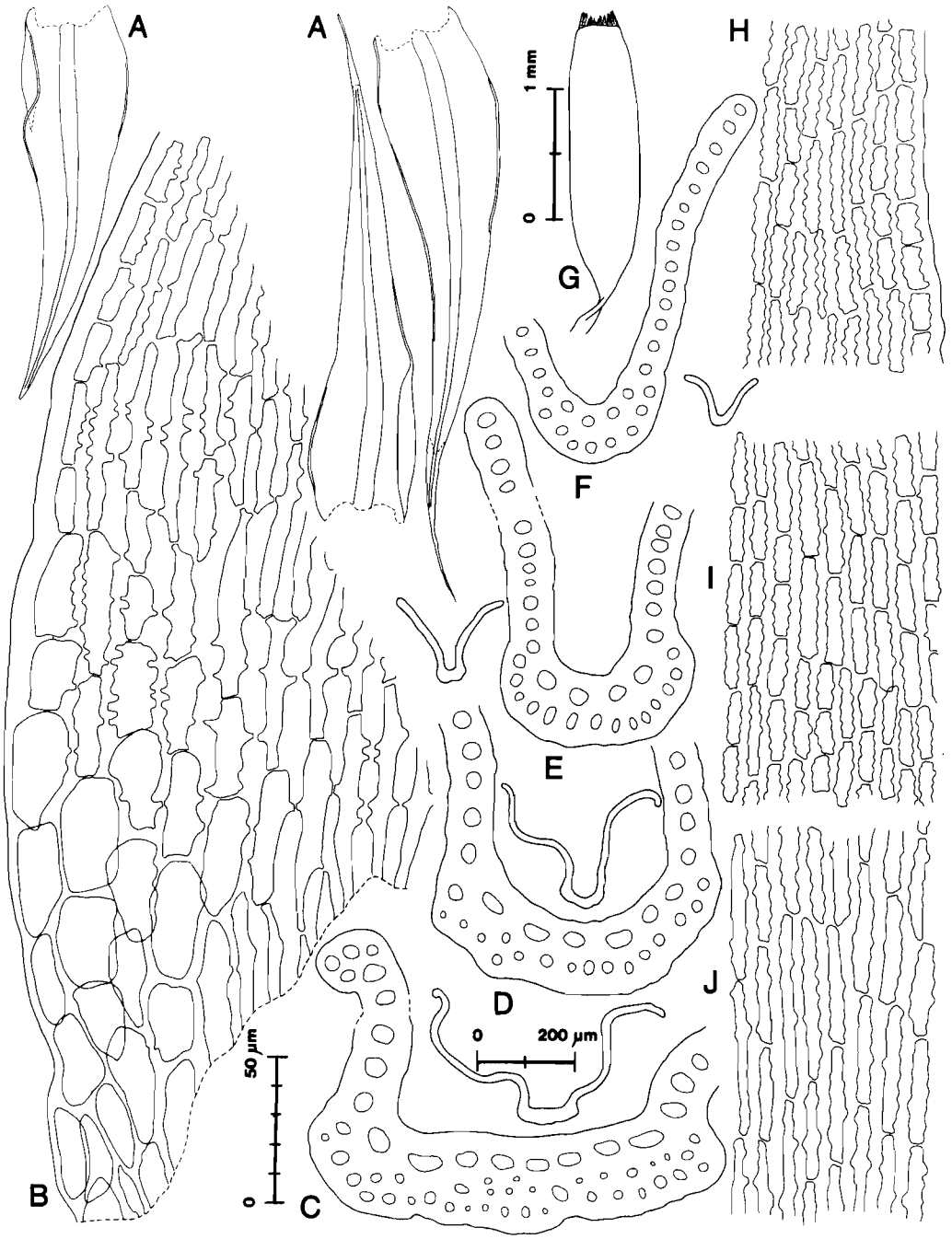

Fig. 60. *Racomitrium subsecundum*. a. Leaves. b. Alar and supra-alar cells. c-f. Leaf cross sections. g. Capsule. h-j. Cells from the upper, lower middle and basal part of the leaf. - Lectotype (BM).

pinnately branched, epidermis orange-red. **Leaves** usually distinctly secund at the shoot apex or along the whole shoot, (2)2.6-3.6(4.5) x (0.5)0.65-0.85(0.95) mm. **Hair-point** from absent to short or long (T: up to 1.1 mm; frequently about 0.5 mm), edenticulate or obtusely low-denticulate, not spinulose, distinctly decurrent down margin of lamina in longipilose leaves but otherwise not decurrent. **Margin** folded or broadly recurved to 1/2-3/4(7/8) the leaf length on one side, and more narrowly and usually shortly recurved or flat on the other side, frequently unistratose above and bistratose for one cell row below, or unistratose throughout, not infrequently more strongly thickened with two (to three) bistratose, usually spheroid marginal rows (in t.s.). **Costa** dorsally convex above and flatter or quite flat below, in lower part (75)85-110(125) µm broad, in upper part 35-50(55) µm broad, in pilose plants reaching to or into the hyaline point, in epilose plants ending shortly before or some distance below the apex, in basal part usually three-stratose (d. 14-22, c. 0.4(12), v. (4)5-9(11)), in central part usually bistratose (d. 9-16(19), c. 0-3, v. (3)4-7), in upper part bistratose (d. 6-12(14), c. 0, v. 2-4). **Lamina** unistratose. Basal **laminal cells** elongate (T: 25-80 x 9 µm), middle and upper cells rectangular (T: 14-35 x 7 µm), upper marginal cells quadrate to rectangular (T: 7-28 x 9 µm), cells usually not strongly pseudopapillose (but see Variation). **Alar cells** usually orange or reddish coloured, usually distinctly enlarged and inflated for 2-5 cell rows, but sometimes less or not inflated and then strongly thick-walled and porose with large or very large trigones so that the lumen is stellate, 4-8(10) esinuose basal marginal cells.

Perichaetial leaves squarrose when wet, epilose, ovoid with obtuse-acuminate apex, not hyaline except at the marginal basal part of the (1-2) innermost leaves. **Seta** about 6-14 mm. **Urn** from ovoid to oblong and narrowly oblong-cylindrical (1.7-3.5 x 0.6-0.7 mm), exothecial cells narrow, short or elongate, 5-6 rows of short (also transversely elongate) incrassate cells at the mouth. **Teeth** about 530-610 µm, of 2 prongs which are free and highly papillose, no basal membrane. Spores 12-14 µm.

Diagnostic characters

(1) Plants usually large. (2) Stem usually elongate, epidermis orange-red. (3) Leaf m. long/long and m. broad/broad (2.6-3.6 x 0.65-0.85 mm), usually secund. (4) Hair-point +/(-), 0-0.5 mm, flexuose, almost or quite edenticulate. (5) Margin folded or broadly recurved (long/m. long, short/flat), uni/bi (1-2, in spots or rarely throughout). (6) Costa broad below and narrow above (85-110/35-50 µm), stratosity/ventral cells (3/5-9, 2(-3)/4-7, 2/2-4), frequently quite flat below. (7) Lamina cells usually not or slightly pspp. (8) Alar cells orange or reddish, of several rows of inflated and/or strongly incrassate cells, usually auriculate. (9) Pl squarrose, epilose, not hyaline. (10) Seta long (6-14 mm). (11) Urn long (1.7-3.5 mm). Basal membrane -.

Variation

Racomitrium subsecundum is a widely distributed and variable species. The morphological variations described below are both geno- and phenotypical, but (as usual in such cases) it is difficult to distinguish between the two. The species *sensu lato* has not been well understood and correctly circumscribed before. Gangulee (1972) described and figured, inter alia, *R. crispulum*, *R. heterostichum*, *R. subsecundum* and *R. fuscescens*; according to the quoted herbarium material and his Figures 392-395, all these names refer to *R. subsecundum*. Mixed specimens have been seen, of intermingled pilose and epilose plants; and large and small somewhat different plants have been placed together in the same specimen. And specimens from different areas are dissimilar. The main morphological differences within *R. subsecundum* s.l. are relative and difficult to classify, and I have chosen not to distinguish between taxa. Below, the variation in some characteristics is commented on separately. **Leaves**: The size of the leaves varies much. Some (sub)epilose specimens have very broad leaves with broadly recurved or folded margin and also usually a broad costa; they have a peculiar look, but are hardly worth recognition; such a plant is *R. javanicum* var. *brachyphyllum* (see chapter 8.0). Gracile plants have smaller leaves. I find it likely that some small specimens are more than modifications of larger plants. **Hair-point**: As noted above, epilose and pilose plants sometimes grow intermingled; when no other important difference can be found, I consider that they should not be distinguished as different taxa. Longipilose leaves have long-decurrent hair-point, whereas shorter points are not decurrent down margin of lamina. The hair-points have but low and obtuse marginal teeth, if any. Usually, the points are moderately flexuose, but sometimes they are more strongly flexuose. **Margin**: The "typical" *R. subsecundum* leaf has a margin which is folded and/or recurved to 3/4 the leaf length on one side, and not folded and more narrowly recurved to 1/2 the leaf length on the other side. But the variation includes specimens with more longly recurved margin on both sides, as well as more shortly recurved margins which are flat on the one side. As in other species in the section, the margin may be unistratose or variously thickened (see Description). This difference probably has a genetical basis; but there are all transitions from specimens with unistratose to specimens with strongly bistratose margin. **Costa**: The type of *R. subsecundum* has a broad costa (see chapter 8.0), with 6-9 ventral cells in its basal and 4-7 in its central part. Such a costa is the standard in (robust specimens from) the Himalaya - Yunnan area. In SE Asia the costa is frequently narrower; the type of *R. javanicum* has 4-6 ventral cells in the basal and 3-4 in the middle part of costa. And specimens from high alpine sites (3800-4600 m) in Irian, New Guinea, have 4 ventral cells in the basal and 2-3 in the middle part of costa (Fig. 61a-e). The differences in the structure of the costa are considered to be of taxonomic importance within the collective species. **Alar cells**: The type of *R. subsecundum* has a strongly differentiated group of alar cells, made up of more than 10 inflated thin-walled cells in 3-4 marginal cell rows plus a number of incrassate but not inflated cells. Such an alar group is the standard in the Himalaya - Yunnan area. In specimens from SE Asia there are usually fewer inflated alar cells. The type of *R. javanicum* has less than 10 thin-walled cells in 2 marginal cell rows plus

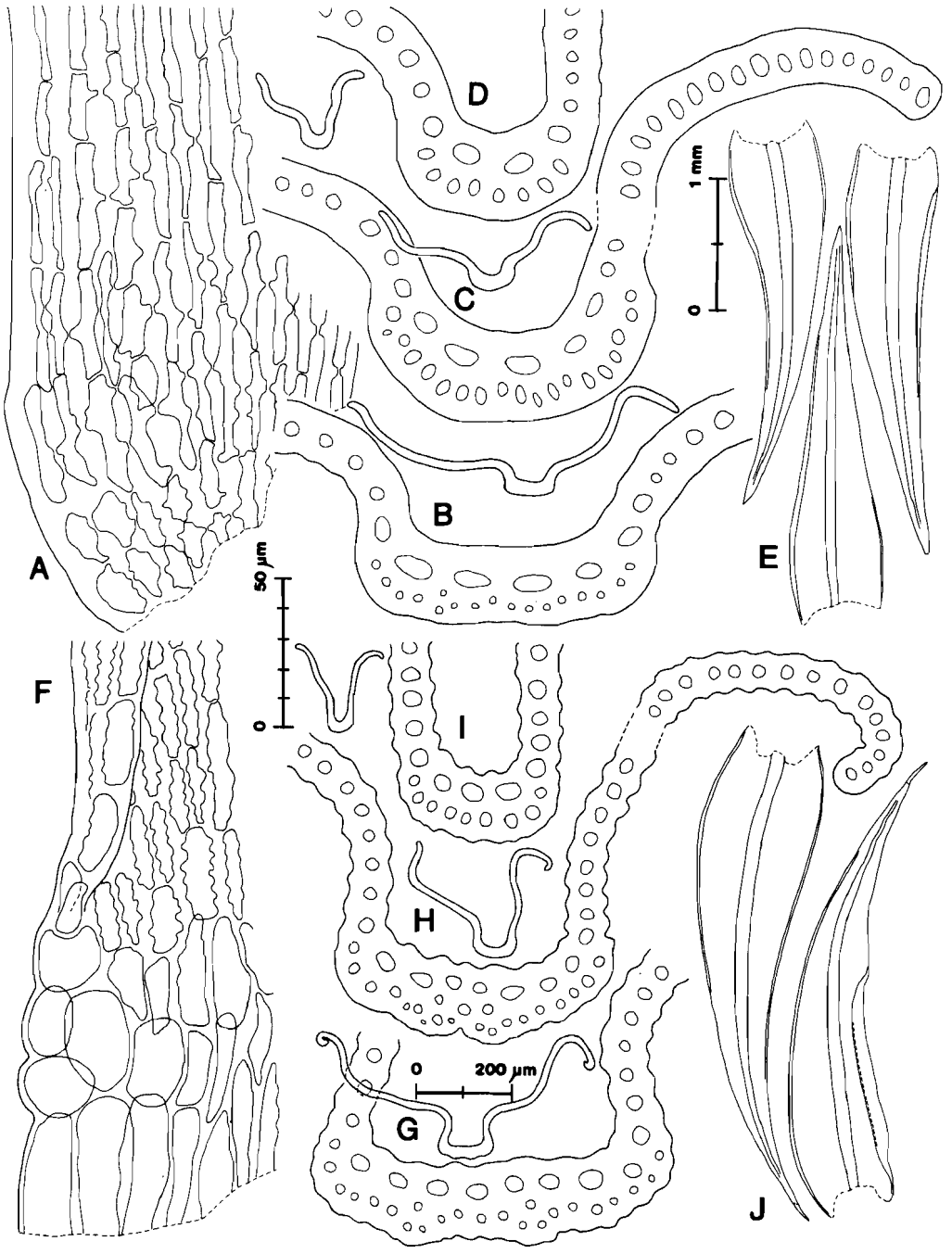

Fig. 61. *Racomitrium subsecundum*. a, f. Alar and supra-alar cells. b-d, g-i. Leaf cross sections. e, j. Leaves. - a-e. SE Asiatic plant (Irian Jaya: Carstensz Mts., Upper Meren Valley, No. CGEM49a - L). f-j. C. Amerian pseudopapillose plant (Mexico: Popocatepetl, Horton 7454 - TENN).

many very incrassate and strongly porose and coloured cells. And the specimens from Irian, New Guinea mentioned above have no inflated cells at all, and the alar group is not auriculate but (often) decurrent and made up of strongly incrassate, slightly or not reddish cells. The specimens are from high-alpine sites and are blackishly pigmented. Sometimes, one or two alar cells may be inflated in single leaves also in some of these specimens, and they are clearly related to the type of *R. javanicum*. - A few SE Asiatic specimens are made up of light brown, subpinnately branched plants with strongly flexuose hair-points. Their leaves possess an orange alar region made up of small incrassate cells. One fertile specimen (Papua New Guinea, Mt. Gilowe, Zanten 683358 - GRO) indicates that the perichaetial leaves are largely pilose. The specimens should probably be recognized taxonomically. However, more specimens ought to be available before this is done. The situation within *R. subsecundum* s.l. in SE Asia is taxonomically interesting. There seem to be isolated (and in part dissimilar) populations on the high mountains of most islands. And although they do not appear to constitute a natural basis for a single taxon (e.g. a subspecies), there is a common trend towards a narrower costa and less inflated alar cells in the bulk of the SE Asiatic specimens.

The C. American specimens are large. Some of them have less differentiated, long-decurrent alar cells; but the structure of their costa closely approaches that of the type of *R. subsecundum* (5-9 basal and 4-7 middle ventral cells in the lectotype of *R. cylindricum*). About one half of the C. American specimens have distinctly pseudopapillose leaf cells (Fig. 61f-j), and this is quite exceptional and are not seen elsewhere. *Racomitrium subsecundum* s.l. probably also occurs in S. America, and this pseudopapillose ecad may have a wider distribution there. But pseudopapillosity alone is not used to establish taxa in the section. Until the total distribution and appearance of the species are well known, no subordinate taxa should be introduced. In spite of the described large (micro)variation of *R. subsecundum* s.l., it is usually an easily recognized taxon.

Comparison with other taxa

Racomitrium subsecundum is a common species in As 3-4 and Am 2, and in some areas it seems to be the only or only common species of sect. *Laevifolia*. A common and widely distributed species naturally grows in many different habitats and includes many modifications and/or genetically different ecads. It is therefore important to be able to recognize and differentiate these from the other more rare species in the area, and comparisons are therefore made in connection with other species. For differences between *R. subsecundum*, and *R. capillifolium* var. *lorifolium*, *R. crispipilum*, *R. cucullatulum*, *R. emersum*, *R. fuscescens*, *R. heterostichum*, *R. himalayanum*, *R. joseph-hookeri*, *R. nitidulum*, *R. pacificum*, and *R. verrucosum*, see these species.

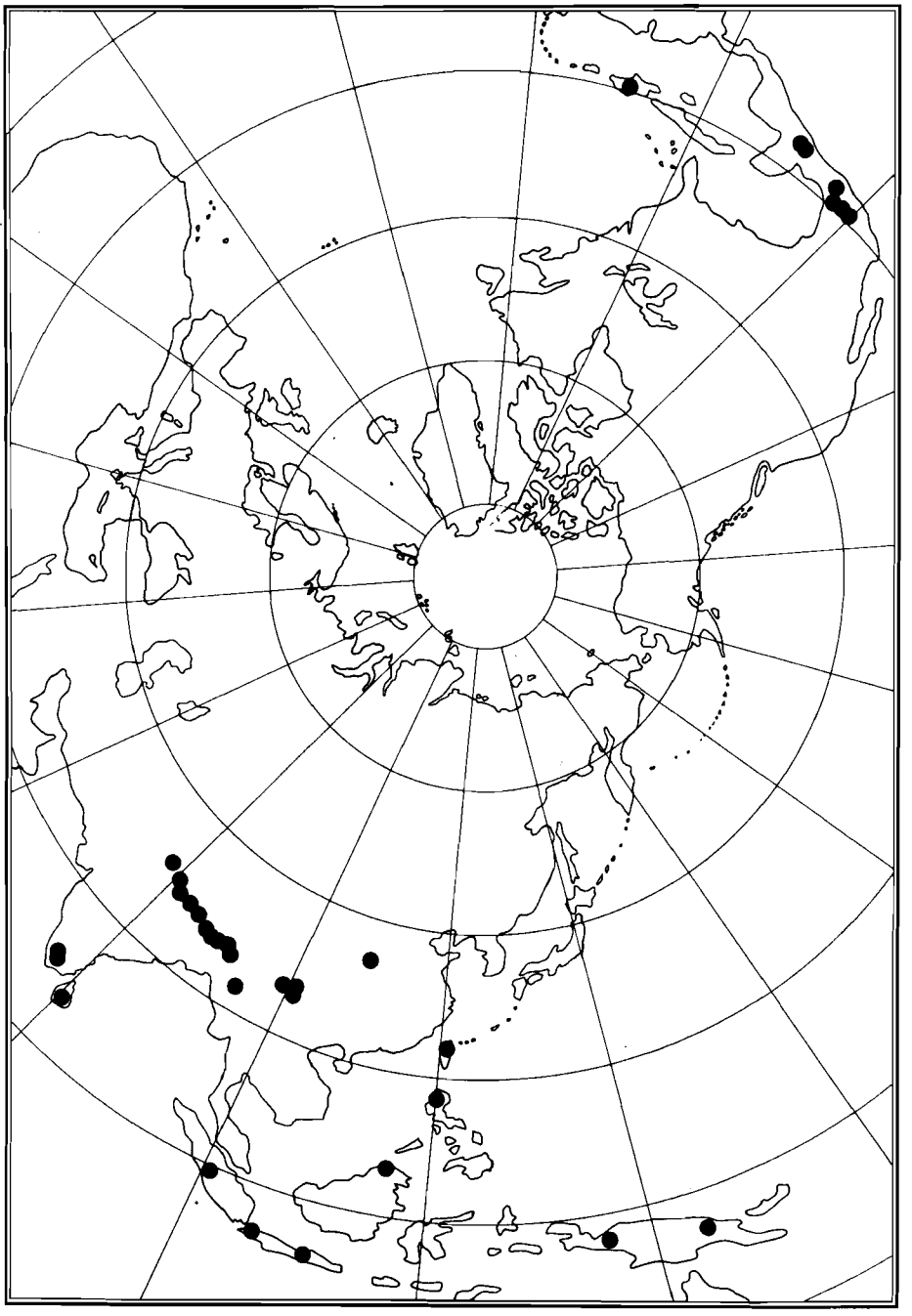

Fig. 62. Distribution of *Racomitrium subsecundum* in the treated area.

Habitat

According to the labels, the main habitat of *R. subsecundum* is dry and wet rocks and gravel ("cliffs, crevices, stones, fresh moraines, loose granite gravel stream fan"). But it is also frequent on the ground ("open summit grass-land, alpine tundra"). And it even grows "on trees" and "on acid peats". It is collected from between 1100 and 4270 m a.s.l.

Distribution

Racomitrium subsecundum is known from Asia and C. America (Fig. 62). In Asia it grows in the Himalayas, from the mountain Kedar Kanta in Tehri Garhwal (India) in the west and throughout Nepal, Sikkim and Bhutan. Other Indian localities are in Nilgiri Hills and Palni Hills in the south, and in Nagaland (Japvo Mt.) in the east. It also grows in the central mountains of Sri Lanka. In China it is known from Yunnan and SW Szechwan; the mountain Tai Pai Shan in Shensi; and from Taiwan. In SE Asia it is known from Luzon (Mt. Pulog, Phillipines); Borneo (Mt. Kinabalu; Sabah, Malaysia); Sumatra (Losir and Kerinci Mts.) and Java (both Indonesia); and New Guinea (Carstenzs Mts., Irian Jaya; Mt. Vilhelm and vicinity, Papua New Guinea). In Central America it grows in the high mountains of southern Mexico (e.g. Popocatepetl, Iztaccihuatl, Nevado de Toluca, Citlaltepetl), Guatemala (Tajamulco and vicinity), and the Dominican Republic (e.g. Alto de la Bandera). *Racomitrium subsecundum* probably also grows in S. America.

5.8 THE *EMERSUM* SUBGROUP

Innermost bracts strongly modified, hyaline and epilose. Hair-point short and stout; margin unistratose; basal marginal border long, hyaline.

One species: *R. emersum*.

(25) *Racomitrium emersum* (C. Müll.) Jaeg.
Fig. 63-64.

Grimmia (*Dryptodon*) *emersa* C. Müll., Bot. Zeit. 562. 1851. - *Racomitrium emersum* (C. Müll.) Jaeg., Ber. S. Gall. Naturw. Ges. 1872-73: 97. 1874 (Ad. 1: 375). - Type: "Van Diemen's Land, ad truncos arborum sylvarum circa montem 'Wellington'. Coll. [Mossman] No. 743." (Isotype: "*G.* (*D.*) *emersa*, C. Müller, Bot. Zeit. 1851, p. 562. 43. Trunks of trees. forests. Mount Wellington V. D. Land [Tasmania], collected by Samuel Mossman 1850." - E; later named *Racomitrium symphyodontum* (C.M.) Par., probably by Mitten).

Plants of a light colour, yellowish or light brown in the upper 1-2 cm and more brownish below, in moderately dense mats or cushions. **Stem** up to 5 cm, from slightly to subpinnately branched. **Leaves** with narrow base, strongly keeled, 2.25-3.0(3.4) x 0.5-0.7 mm, slightly spirally arranged when dry. **Hair-point** short and stout, yellowish, to 75 µm long, not or obtusely denticulate. **Margin** broadly recurvced to 3/4 the leaf length on one side, and shorter and very narrowly recurved to flat on the other side, unistratose throughout or rarely with bistratose spots in lower part. **Costa** strongly convex from base to apex, narrow throughout, in lower part 60-75 µm broad, in upper part 40-45 µm broad, reaching to the point, in basal part bi- (to three-)stratose (d. 9-15, c. 0-1, v. 2-4), in middle part bistratose (d. 7-11, c. 0, v. 2-3(4)), in upper part bistratose (d. 5-8, c. 0, v. 2-3). **Lamina** unistratose. Basal **laminal cells** long (T: 23-63 x 7.5 µm), in middle and upper part rectangular (T: 15-33 x 10.5 µm), upper marginal cells rectangular to quadrate (T: 12-24 x 10.5 µm), cell walls thick and pellucid, strongly sinuose, from slightly to distinctly bulging dorsally and ventrally. **Alar cells** yellowish and not (or almost not) differentiated, one row of pellucid, thin-walled and esinuose cells extending as a border up along the margin, (12)15-20(28) cells in the marginal row, the cells rectangular to quadrate, or elongate with narrow lumen, sometimes the second marginal row also made up of differentiated, usually elongate narrow cells, from 2-10 cells in the second row.

Perichaetial leaves strongly sheathing, ovate, the innermost (2-4) largely hyaline or with broad hyaline border, crenulate. **Seta** (3.5)6-9 mm (two fertile specimens). **Urn** shortly oblong-cylindrical or obovoid, (1.5)1.8-2.2 mm, exothecial cells irregularly rectangular with thick walls, about 4-6 rows of small rounded cells at the mouth. **Teeth** (broken, seemingly short and without basal membrane). Spores ?

Diagnostic characters

(1) Plants of a light colour (above). (2) -. (3) **Leaf** short/m. long and m. broad (2.25-3.0 x 0.5-0.7 mm), strongly keeled. (4) Hair-point +/-, 0-0.075 mm, stout, yellowish. (5) Margin recurved (m. long, short/flat), uni/bi (1, rare spots in lower part). (6) Costa narrow (60-75/40-45 µm), stratosity/ventral cells (2(-3)/2-4, 2/2-3, 2/2-3), strongly dorsally convex. (7) Lamina cells pellucid, with thick and strongly sinuose walls. (8) Bmb of 15-20 or more pellucid cells, and sometimes a second differentiated row of fewer cells. (9) Innermost perichaetial leaves hyaline. (10) Seta long (6-9 mm). (11) Urn short (1.8-2.2 mm). (12) -.

Variation

The taxon varies only a little in the area. The Borneo and Java specimens have 3-4 ventral costal cells in the lower half of their leaves, whereas the plants from New Guinea have 2-3 such cells. The isotype possesses (3-)4 cells in that position. The plants are often yellowish coloured. Two specimens include intermingled strongly pigmented plants of *R. subsecundum* s.l., but *R. emersum* is

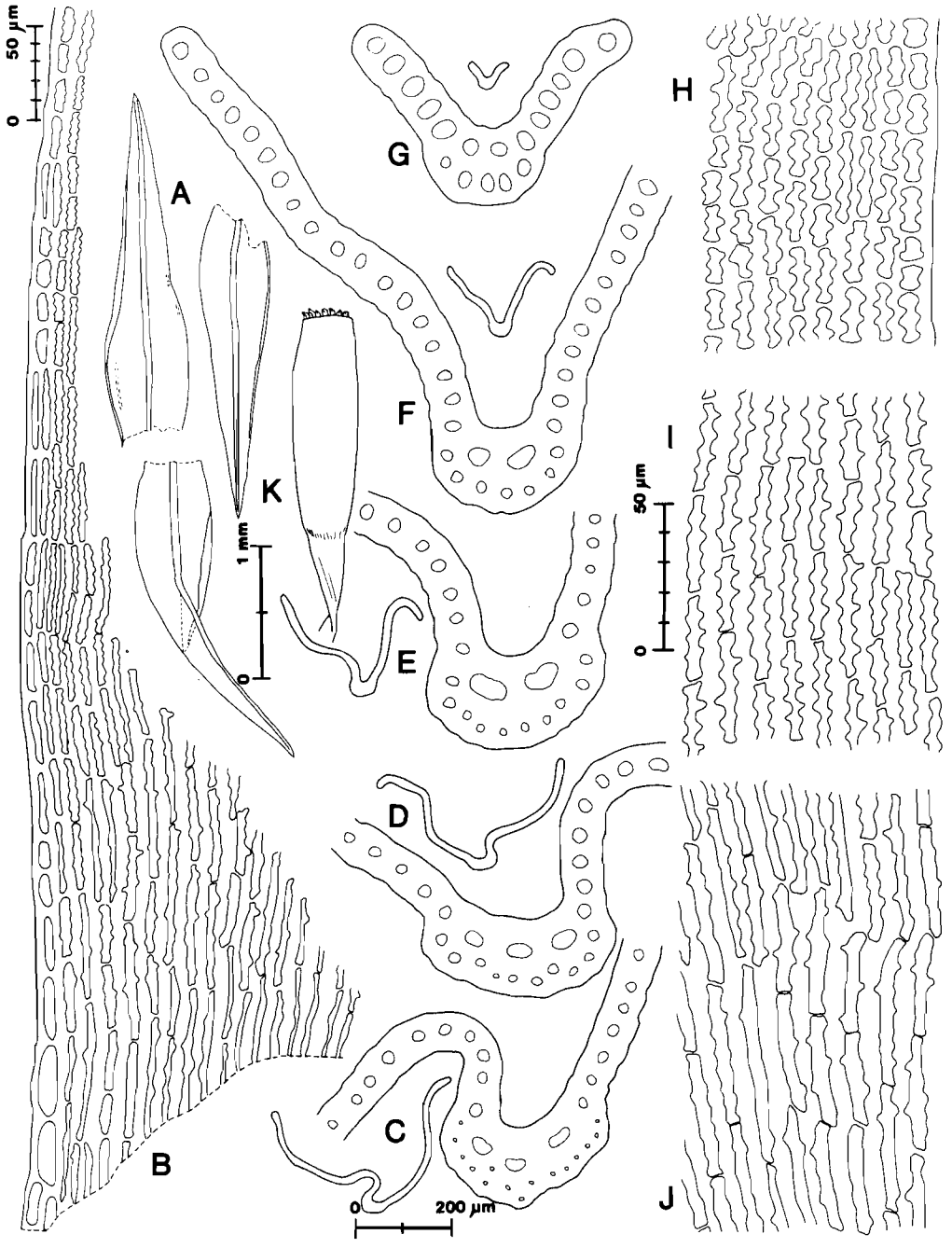

Fig. 63. *Racomitrium emersum*. a. Leaves. b. Alar and supra-alar cells. c-g. Leaf cross sections. h-j. Cells from the upper, lower middle and basal part of the leaf. k. Capsule. (a-j. New Guinea, Mt. Milyin Kolyin, Pullen 5162 - L. k. Mt. Gilowe, Zanten 683411 - GRO.)

still quite pale. However, a few specimens are brownish. It does not belong to the difficult Himalaya - Yunnan group of plants, but is supposed to be more related to taxa in the southern hemisphere.

Comparison with other taxa

1. *Racomitrium crispipilum* (Fig. 37) resembles *R. emersum* in its narrow costa and differentiated basal marginal border. However, *R. crispipilum* is a larger plant, with larger leaves (3-4 x 0.7-1 mm) including a long hair-point (0.5-1 mm in its mod. *pilosum*).

2. *Racomitrium fuscescens* (Fig. 52) is glistening dark or light brown, whereas *R. emersum* usually is of a dull yellowish colour. The leaves of *R. emersum* are more strongly keeled than those of *R. fuscescens*, and the hair-point of the latter, when present, is hyaline and capillaceous and not yellowish and thorn-like as in *R. emersum*. The costa of *R. fuscescens* is broader towards the base, and includes more central cells. *Racomitrium emersum* is usually a slightly larger plant than *R. fuscescens*. The basal marginal border is longer and more hyaline in *R. emersum*. The inner perichaetial leaves are hyaline in *R. emersum* and chlorophyllous in *R. fuscescens*.

3. *Racomitrium subsecundum* (Fig. 60-61) is larger and more branched, and has a longer hair-point (if not brevipilose) and differentiated alar cells (usually reddish inflated and auriculate, but in southeast Asia - where *R. emersum* grows - its alar cells are strongly incrassate and porose). No hyaline basal marginal border is present in *R. subsecundum*.

4. The specimens of *R. emersum* were named *R. crispulum*, which is, however, a strikingly different plant with large bistratose areas in its leaf margin and lamina (Frisvoll 1984c).

Habitat

The label of the Borneo specimen (Wood 1570 p.p.) includes an accurate description of the habitat: "On small patches of sandy, humic loam among granodiorite rocks. Exposed, well drained site in full sun or slight shade, fairly moist. Frequent at this altitude. In sterile, unmixed tufts up to 2 inc. diam. of closely packed stems. Growing closely together with *Campylopus aureus*." Other labels mention habitats like: peaty alpine grassland; rock shelf with bays of vegetation; and rock crevices. The specimens come from alpine sites, 3240-4900 m a.s.l.

Distribution

Racomitrium emersum is known from SE Asia (Borneo, Java, New Guinea; Fig. 64). It also grows in Australia (A.C.T., New South Wales, Tasmania) and New

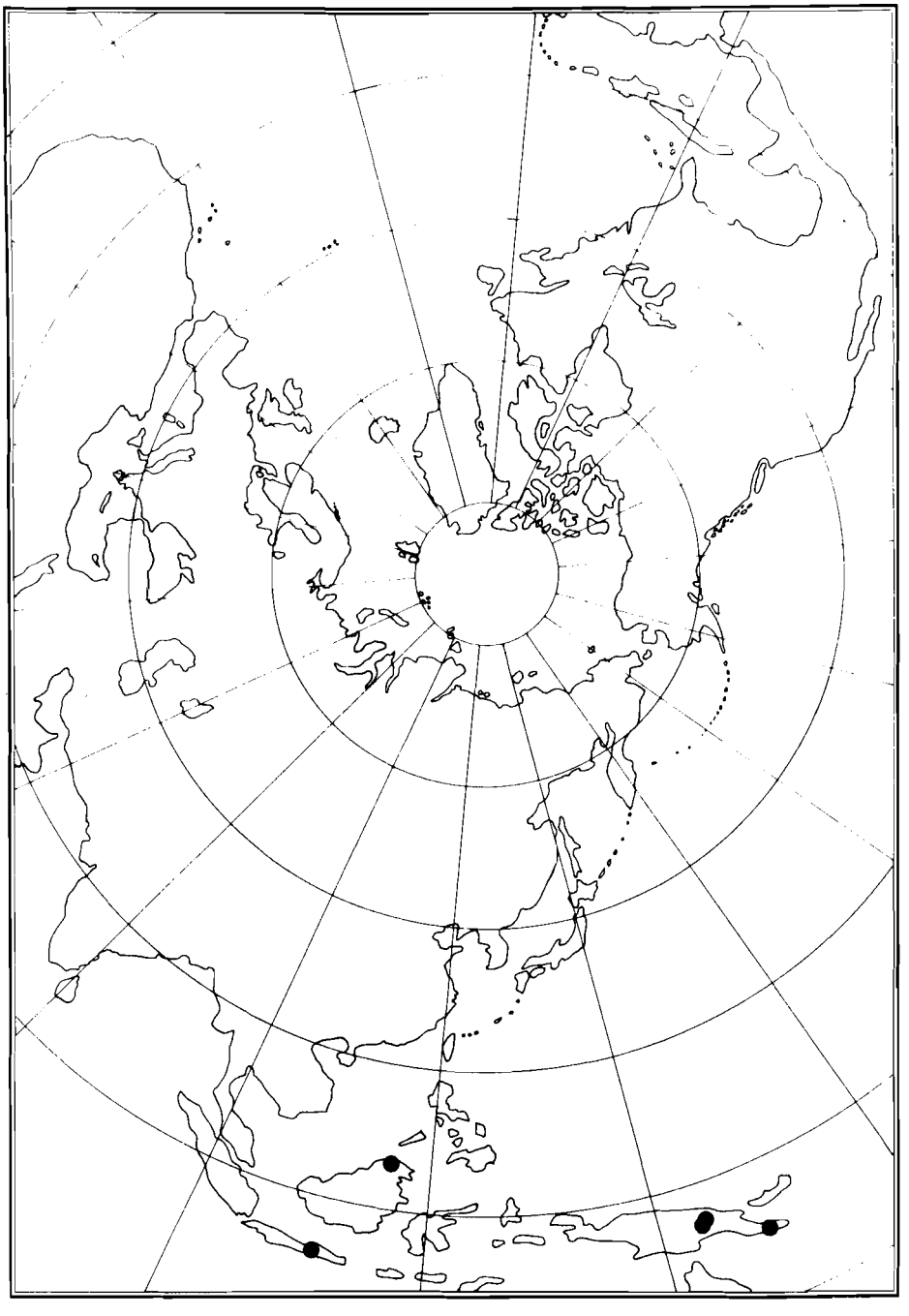

Fig. 64. Distribution of *Racomitrium emersum* in the treated area.

Zealand (North Island) (specimens in CANB). The total range of the species is not known.

Specimens examined

BORNEO: Kota Belud, on summit plateau of Mt. Kinabalu, 1 mile SE of Low's Peak, Wood 1570 p.p. (GRO, L). - JAVA: M-Java, Gg. Lawu, S-Hang des Gipfels, Ruttner 206 (S); Gemäuer unter der Hütte, Ruttner 205 (S). - NEW GUINEA: Mt. Milyin Kolyin, Kubor Range S. of Minj, Western Highlands District, Pullen 5162 (CANB, L); Mt. Wilhelm, Brass 29961, 29962 (L), Walker ANU5233 (CANB, L), Zanten 68622, 68630 (GRO); Papua, Raba Raba Subdistr., Milne Bay, Goe, 9°42'S, 149°02'E, Joint Lae - Leiden - Canberra Expedition, Stevens et Veldkamp s.n., 5.VII.1972 (BM, CANB); N slopes of Mt. Gilowe, Zanten 683358, 683372, 683411 (GRO).

6.0 DISTRIBUTION; GEOGRAPHICAL ELEMENTS

Racomitrium sect. *Laevifolia* has a world-wide distribution, and embraces a considerable number of species. The many species exhibit a wide range of distribution patterns, which are in accord with well-established biogeographical elements. The total distribution patterns of those few species occuring outside the region of the revision, have not been clarified. Below, the species with the widest distribution ranges are treated first, and the endemics at the end. The abbreviated names on the geographical regions used in Index Muscorum, are given.

Contrary to species in sect. *Racomitrium* (viz. *R. canescens, R. ericoides, R. panschii*), sect. *Lanuginosa* (viz. *R. lanuginosum*), and sect. *Papillosa* (viz. *R. fasciculare*), no species in sect. *Laevifolia* reaches the high Arctic. It may also be mentioned that there is no amphi-Atlantic species in sect. *Laevifolia*. And there are no truely cosmopolitan species.

a. **Bipolar range**. One species: *Racomitrium sudeticum* (Am 1, 6. Eur. As 1, 2. Austr 1. Ant). - The species was recently shown to be widespread also in the southern hemisphere (Frisvoll 1986). In the north it has a wide, imperfectly circumboreal distribution (Fig. 18). In the south it is known from the Antarctic Peninsula and some Antarctic and sub-Antarctic islands, southern S. America, and SE Australia. *Racomitrium sudeticum* is often fertile, and it has probably reached the southern hemisphere by long-range dispersal of spores (cf. Zanten & Pocs 1981). Sporophytes are known from Australia and South Georgia, and both sexes have therefore reached these remote areas. It is likely that the spores of *R. sudeticum* have reached the southern hemisphere many times. The bipolar moss element is rich in species (Schofield 1969, 1974). No other *Raco-*

mitrium species is with certainty known to be bipolar; the widespread *R. lanuginosum* is treated among the cosmopolitan mosses.

b. **Tropical alpine range**. One species: *R. crispipilum* (Am 2, 4. Afr 2, Oc). - In the treated area, this species is only known from C. America (Fig. 38). The type specimen comes from Equador, and other specimens indicate that it has a wide distribution in northern S. America. Moreover, a Hawaian specimen is identical to or very close to *R. crispipilum*, and a few central African specimens studied (Mt. Kilimanjaro, Mt. Kenya, Mt. Karisimbi) are also that species. *Racomitrium crispipilum* seems to be a widespread alpine species of tropical and subtropical areas (cf. Schuster 1983: 589).

c. **Asiatic - Latin American range**. One species: *R. subsecundum* (Am 2, 3. As 2, 3, 4). - *Racomitrium subsecundum* occurs in S. Asia and C. America (Fig. 62). It is probably present also in northern S. America. This "fascinating geographical element", with species in Asia and Mexico, is commented on by Sharp and Iwatsuki (1965) and Sharp (1974, 1984). Herzog's (1926: 217) disjunction "Ostasiatische Hochgebirge - Mexico, Südamerica (Anden)" is the same. This is an old bryogeographical element. Its "present distribution may have resulted from a previous continuous range being disrupted by continental separation and movement" (Sharp 1984). It may also be present in Afr. 2.

d. **Australasian range**. One species: *R. emersum* (As 4, Austr 1, 2). - The total range of the species is unknown; in the treated area it is known from Borneo, Java and New Guinea (Fig. 64). The type material comes from Tasmania. The number of Australasian bryophytes is large (Schuster 1983: 570).

The rest of the species are not known from outside the treated area.

e. **Circumboreal or imperfectly circumboreal range**. Three species: *R. microcarpon* (Am 1. Eur. As 1), *R. affine* (Am 1. Eur. As 5), *R. heterostichum* (Am 1. Afr 1. Eur). - Of the species treated here, *R. microcarpon* occupies the most complete circumboreal range (Fig. 41). It has a somewhat continental distribution. - *Racomitrium affine* is known from Asia Minor, Europe, and western and eastern N. America (Fig. 24). - *Racomitrium heterostichum* is absent from Asia Minor but present on some N. African Atlantic islands (Fig. 28). The most striking difference between the range of *R. heterostichum* and *R. affine*, is, however, the absence of the former from eastern N. America. Thus it is one of the many bryophytes which to-day is known from the west side of the Eurasian and N. American continents. The element is treated by Schofield (1969: 195), and its species are interpreted as "persistent remnants of a circumboreal flora, possibly dating back as early as Tertiary time".

f. **Imperfectly circumalpine range**. One species: *R. macounii* subsp. *macounii* (Am 1, Eur), *R. macounii* subsp. *alpinum* (Am 1. Eur. As 2, 5). - *Racomitrium macounii* subsp. *alpinum* is known from the mountains of Turkey, Europe, S. Greenland, western N. America and probably Japan (Fig. 12). Subsp. *macounii* has a

more limited range, and is absent from the Middle-East, northern Europe, Greenland and Japan (Fig. 10). The element is defined by Schofield (1969: 186).

g. **Asiatic (mainly Himalaya - Yunnan) - European disjunction**. One species: *R. himalayanum* (Eur. As 2, 3 - Fig. 55). - Besides *R. subsecundum*, this species has the most remarkable distribution pattern of the treated species. But it seems to have a counterpart, viz. *Dicranodontium subporodictyon* Broth. known from Yunnan, Sikkim and Scotland (Corley & Wallace 1974). The latter species is considered to be a relict, and is mentioned together with a number of famous hepatics like *Herbertus aduncus* (Dicks.) S. Gray, *Anastrophyllum donnianum* (Hook.) Steph., *Scapania ornithopodioides* (With.) Waddel and *Pleurozia purpurea* Lindb. Previously, *R. himalayanum* has most likely had a wider European distribution. It may still turn up in new localities, now when its taxonomy has been clarified.

The next six groups consist of endemic taxa.

h. **European endemic**. One species: *R. obtusum* (Eur - Fig. 32). - The European moss flora is rare in endemic bryophytes. Many are listed by Herzog (1926: 220f.), but few if any of these are treated as species or endemics to-day. If *R. ellipticum* is included in sect. *Laevifolia*, this will be a second European endemic.

i. **Eastern North American endemic**. One species: *R. venustum* (Am 1 - Fig. 36). - Numerous endemic moss species are known from there (Schuster 1983: 536). It was nevertheless unexpected to discover a new *Racomitrium* species in the area.

j. **Western North American endemics**. Six species: *R. brevipes* (Fig. 8), *R. depressum* (Fig. 26), *R. lawtonae* (Fig. 22), *R. obesum* (Fig. 30), *R. occidentale* (Fig. 14), *R. pacificum* (Fig. 34) (all Am 1). - The number of species in this element is remarkably high, about 1/4 of the recognized species belong here. The element is treated in detail by Schofield (1969); the above species belong to several of his subgroups. *Racomitrium depressum* is relatively southern and only known from high mountains; *R. pacificum* is known from low elevation near the coast, etc. *Racomitrium lawtonae* reaches southern Alaska and is present on the most westerly of the Aleutian Islands. To many bryophytes, the Aleutian archipelago has acted as a bridge between Alaska and Asia (Schofield 1965, Schuster 1983: 524), and it is not unlikely that *R. lawtonae* occurs in adjacent parts of Asia. It may therefore belong to the North Pacific element (sensu Schofield 1969: 190).

k. **Endemics of Japan, Korea and adjacent China.** Three species: *R. laetum* (Fig. 20), *R. nitidulum* (Fig. 59), *R. vulcanicola* (Fig. 46) (all As 2). - It is probable that these species (with the possible exception of *R. vulcanicola*) are more common on the Asiatic mainland than the known specimens indicate. The element is treated by Schuster (1983: 533), and consists of a considerable number of mosses.

l. **Himalayan - Yunnan endemics.** Five species: *R. capillifolium* (As 3 - Fig. 49), *R. cucullatulum* (As 2, 3 - Fig. 51), *R. fuscescens* (As 3 - Fig. 53), *R. joseph-hookeri* (As 3 - Fig. 57), *R. verrucosum* (As 2, 3 - Fig. 44). - The area is rich in endemic bryophytes (Sharp 1974, Schuster 1983: 540ff.). The above species are known from relatively few localities, and they probably grow in a wider area than the distribution maps indicate.

m. **Amphi-Beringian endemic.** One form: *R. microcarpon* f. *afoninae* (Am 1, As 1). - The area of the form is poorly known (Fig. 41), but seems to fit into this element. The element is treated by Schofield (1969: 188, 1972: 1122) and includes a few bryophytes.

The geographical information may be summed up as follows (the endemic species of each region are **not** italicized).

Asia: 15 species, of which 8 are endemic (*aff*, cap, cuc, *eme*, fus, *him*, jos, lae, *mac*, *mic*, nit, *sub*, *sud*, ver, vul). - As 1: 2 species (*mic*, *sud*). - As 2: 9 species, 3 endemic (*cuc*, *him*, lae, *mac*, nit, *sub*, *sud*, *ver*, vul). - As 3: 7 species, 3 endemic (cap, *cuc*, fus, *him*, jos, *sub*, *ver*). - As 4: 2 species (*eme*, *sub*). - As 5: 3 species (*aff*, *mac*, *sud*).

Europe: 7 species, 1 endemic (*aff*, *het*, *him*, *mac*, *mic*, obt, *sud*).

Africa 1: 1 species (*het*).

America 1-3: 14 species, of which 7 are endemic. - Am 1: 12 species, 7 endemic (*aff*, bre, dep, *het*, law, *mac*, *mic*, obe, occ, pac, *sud*, ven). - Am 2: 2 species (*cri*, *sub*). - Am 3: 1 species (*sub*).

7.0 TAXA EXCLUDED FROM SECT. *LAEVIFOLIA*

The following 13 names have once been thought to be close to species in sect. *Laevifolia*. For further comments on these names, see chapter 8.0. The relationships of the taxa are indicated parenthetically.

Racomitrium aciculare var. *brachypodium* Besch. 1893 (*Racomitrium* sect. *Papillosa*).

Grimmia arcuatifolia Kindb. ex Kindb. in Macoun 1889 (*Grimmia* sp.).

Racomitrium attenuatum C. Müll. et Kindb. in Macoun et Kindb. 1892 (*Grimmia* sp.).

Racomitrium austro-sudeticum Broth. in Herz. 1916 (*Grimmia* sp.).

Racomitrium brevipes var. *ericoides* (Brid.) Kindb. 1890 (*Racomitrium* sect. *Racomitrium*).

Racomitrium brevipes var. *muticum* Kindb. in Macoun 1890 (*Racomitrium* sect. *Racomitrium*).

Racomitrium depressum var. *nigricans* Kindb. 1910 (*Schistidium* sp.).
Racomitrium doii Sak. 1940 (*Grimmia* sp.).
Racomitrium heterostichum var. **brevipilum* Zett. 1877 *nom. nud.* (*Grimmia* sp.).
Racomitrium heterostichum var. *pulvinatum* Du Buyiss. in Herib. 1899 (*Grimmia* sp.).
Racomitrium microcarpon var. **calvum* Kindb. ex Möll. 1931 *nom. nud. in synon.* (*Racomitrium* sect. *Papillosa*).
Racomitrium microcarpon var. *palmeri* Kindb. in Macoun et Kindb. 1892 (*Racomitrium* sect. *Papillosa*).
Racomitrium sudeticum var. *subellipticum* Card. 1908 (*Racomitrium* sect. *Papillosa*).

8.0 AN ANNOTATED LIST OF THE NAMES (BASIONYMS) PROPOSED IN SECT. *LAEVIFOLIA*

Names in the *Racomitrium heterostichum* group have originally been referred to the genera *Bryum* Hedw., *Dicranum* Hedw., *Dryptodon* Brid., *Grimmia* Hedw., *Racomitrium* Brid., **Rhacomitrium* auct. *nom. illeg.*, and **Trichostomum* Hedw. *nom. rejic.* In the following, the 75 listed specific epithets have been arranged in alphabetical order without regard to the generic names. (Of these, 58 are counted in Table 2; 7 are mentioned and excluded below; 6 are mere references; and the last 4 names are *R. aciculare*, *R. canescens*, *R. ellipticum* and *R. fasciculare*.) The epithets of varieties and forms follow alphabetically and mixed under the respective species epithets. Forms of varieties are treated as forms of species (e.g.: *R. heterostichum* var. *affine* f. *epilosum* Corb., see *R. heterostichum* f. *epilosum*). Invalid and illegitimate names are always marked with an *asterisk. An open ☆ asterisk is used to mark out the few subspecies originally published with an asterisk. Recognized taxa and their taxonomic synonyms *fide* this work are referred to by basionym, author(s) and year of publication; the nomenclatural synonyms of these names are found in the main part. Names not treated in the main part (viz. excluded taxa and names not identified as synonyms), include reference to basionym and nomenclatural synonym(s); their place and date of publication; and type(s). The list includes comments on 160 names which have been thought to belong to sect. *Laevifolia*, by the author(s) of the basionyms or by other authors (Table 2). Ten additional names in the list are not included in Table 2, viz. two names of taxa in sect. *Laevifolia* which do not occur in the treated area (*Dryptodon crispulus*, *Racomitrium heterostichum* var. *tasmanicum*); one name which perhaps belongs to the section (*R. angustifolium*); one name in sect. *Papillosa* (*R. *brevipes* C. Müll.); two names which perhaps belong to sect. *Lanuginosa* (*R. marginatum*, *Grimmia sulcipila*); an unknown subordinate name and a species of *Grimmia* from outside the area (*R. conterminum* var. *andinum* and *R. austro-sudeticum* Broth. in Herz., respectively); one name probably not intended as new (*G. heterosticha* var. **brevipila* "Broth. et Sæl."); and a name excluded from Grimmiaceae (*R. delavayi*). The few nomenclatural synonyms included as references in the list (e.g. *R. occidentale*),

are not included in Table 2. Illegitimate subordinate names which include the type of the higher rank (e.g. *R. heterostichum* var. **vulgare* and var. **eu-heterostichum*) are not mentioned here; they are found in the synonym lists in the main part below their valid nomenclatural synonym.

Table 2. A survey of the treated valid and invalid names (basionyms) proposed in *Racomitrium* sect. *Laevifolia*, and of their corresponding types. Val. = Valid. *Nom. inv./ill. = Nomen invalidum et illegitimum. Excl. = Excluded from sect. *Laevifolia*.

Names of	No	Validly described	*Nom inval.	Type located Val. name	Type located *Nom. inv./ill.	Type not located Val. name	Type not located *Nom. inv./ill.	Excl.
species	58	47	11	42	13	1	2	4
varieties	64	53	11	40	7	12	5	9
forms	38	31	7	23	5	8	2	0
Sum	160	131	29	105	25	21	9	13
		(160)		130		30		
				(160)				

Racomitrium aciculare var. *brachypodium* Besch., Ann. Sc. Nat. Bot. ser. 7, 17: 338. 1893. - *R. brachypodium* (Besch.) Card., Bull. Herb. Boiss. ser. 2, 8: 334. 1908. - *R. heterostichum* var. *brachypodium* (Besch.) Nog., J. Hattori Bot. Lab. 38: 367. 1974. - Type: "Yézo: sur les pierres dans le lit des ruisseaux, novembre 1886 (Faurie, no 202)." (BM, H, O, S). - The type material possesses papillose leaf cells, and belongs to *Racomitrium* sect. *Papillosa*.

Dicranum aciculare var. *pumilum* Turn. 1804. - Holotype (BM). - One large herbarium sheet includes 13 specimens of *Dicranum aciculare* s.l. of Turner (1804). Eleven are *R. aciculare*, and one of these accords with his ß. *fluitans*. Another fits his γ. *gracile*, and it is *R. aquaticum*. Finally there are two small pieces about 1 cm high. These fit the description of δ. *pumilum* ("caule trilinearis; foliis nigricantibus") rather well. According to Stearn (1980: 458) 1 English line is 2.1 mm, and the given height of δ. *pumilum* is shorter than the herbarium specimen. But it is marked δ in pencil (probably not by Turner), and the collector and locality are correct. The specimen is depauperate but typical *R. obtusum* (f. *obtusum*), as supposed for the first time by Lindberg (1875: 553).

Trichostomum affine Schleich. ex Web. et Mohr 1807. - Lectotype (LAU - Frisvoll 1984a: Fig. 1). - This is the basionym of *Racomitrium affine*, see Frisvoll (1984a: 302-304).

Racomitrium affine f. **luxurians* Hag. 1899 *nom. nud.* - The original material (O) is robust *R. macounii* subsp. *alpinum*. This is the only known European name of the taxon.

Trichostomum **alopecurum* Schkuhr 1811 *nom. illeg.*, see *Racomitrium heterostichum* var. *alopecurum* Hüb. 1833.

Racomitrium **alternuatum* C. Muell. et Kindb. in Macoun et Kindb. 1892 *err. pro R. attenuatum* (q.v.).

Grimmia amoena Broth. 1900. - Lectotype (H-BR). - The type material is *Racomitrium sudeticum*, see Frisvoll (1986: Fig. 1h-n).

Racomitrium angustifolium Broth. in Hand.-Mazz., Symb. Sin. 4: 46. 1929. - Type: "NW-Y.[unnan]: Am Granitfelsen der Hg. St. im birm. Mons. hinter dem Gomba-la ober Tschamutong in der Salwin-Irrawadi-Scheidekette gegen den Pass Buschao, 4000-4100 m, c. sp. 10.VII.1916 (9489)." - The following diagnosis is included after a more complete description: "Species *Rh. sudetico* (Funck) Bryol. eur. affinis, sed foliis muticis, cellulis ubique anguste linearibus dignoscenda." Two specimens (H-BR - Fig. 65, S) include much material. The taxon may have affinity to sect. *Laevifolia* s.l.; but it is thought to be distantly related to the species treated in this work, and is therefore not included in the main part. Its diagnostic characters are as follows (cf. Fig. 65): - (1) Plants brownish. (2) Stem from moderately to strongly dichotomously branched, up to 4 cm long. (3) Leaf lanceolate with subulate apex (2.2-2.65 x 0.35-0.45 mm). (4) Hair-point -/((+)), 0-0.1 mm, edenticulate. (5) Margin slightly recurved (short, flat), bi ((1)2-4(5) throughout). (6) Costa narrow (50-75/45-55 µm), in basal part three-stratose (d. 12-16, c. 4-7(11), v. 3-4), in middle part three-stratose (d. 9-10, c. 2-4, v. 3), in upper part three-stratose (d. 8-9, c. 2-4, v. 2), percurrent and filling up the apex. (7) Lamina unistratose (except in uppermost part where it is bistratose and confluent with the bistratose margin), basal cells elongate (T: 33-50 x 7 µm, with walls 5 µm), middle and upper cells elongate (T: 12-30 x 6 µm), upper marginal cells rectangular (T: 10-20 x 7 µm), ± pspp. (8) Bmb of 12-20 hyaline cells, bordering on thick-walled bistratose cells. (9) Pl much broader than vegetative leaves, sheathing, not squarrose, epilose, not hyaline. (10) Seta m. long (T: 5.5 mm). (11) Urn short (T: 1.3 mm). (12) Teeth 260 µm long, split above and less so below, papillose, basal membrane + (35 µm), spores 9-13 µm. - Gangulee (1972: 819) placed *R. angustifolium* in synonymy of *R. crispulum*, but the leaf form alone makes such a placing impossible. Other important differences are found in the structure of the lamina (unistratose in *R. angustifolium*, p.p. bistratose in *R. crispulum*) and the length of the seta (about 1.5 mm in *R. crispulum*, about 5.5 mm in *R. angustifolium*) (Frisvoll 1984c). *Racomitrium angustifolium* is a species in its own right. The mixing of marginal hyaline and submarginal incrassate cells in the bistratose border (cf. 5 and 8 above, and Fig. 65c) is strange. I have come across no specimens matching the type material.

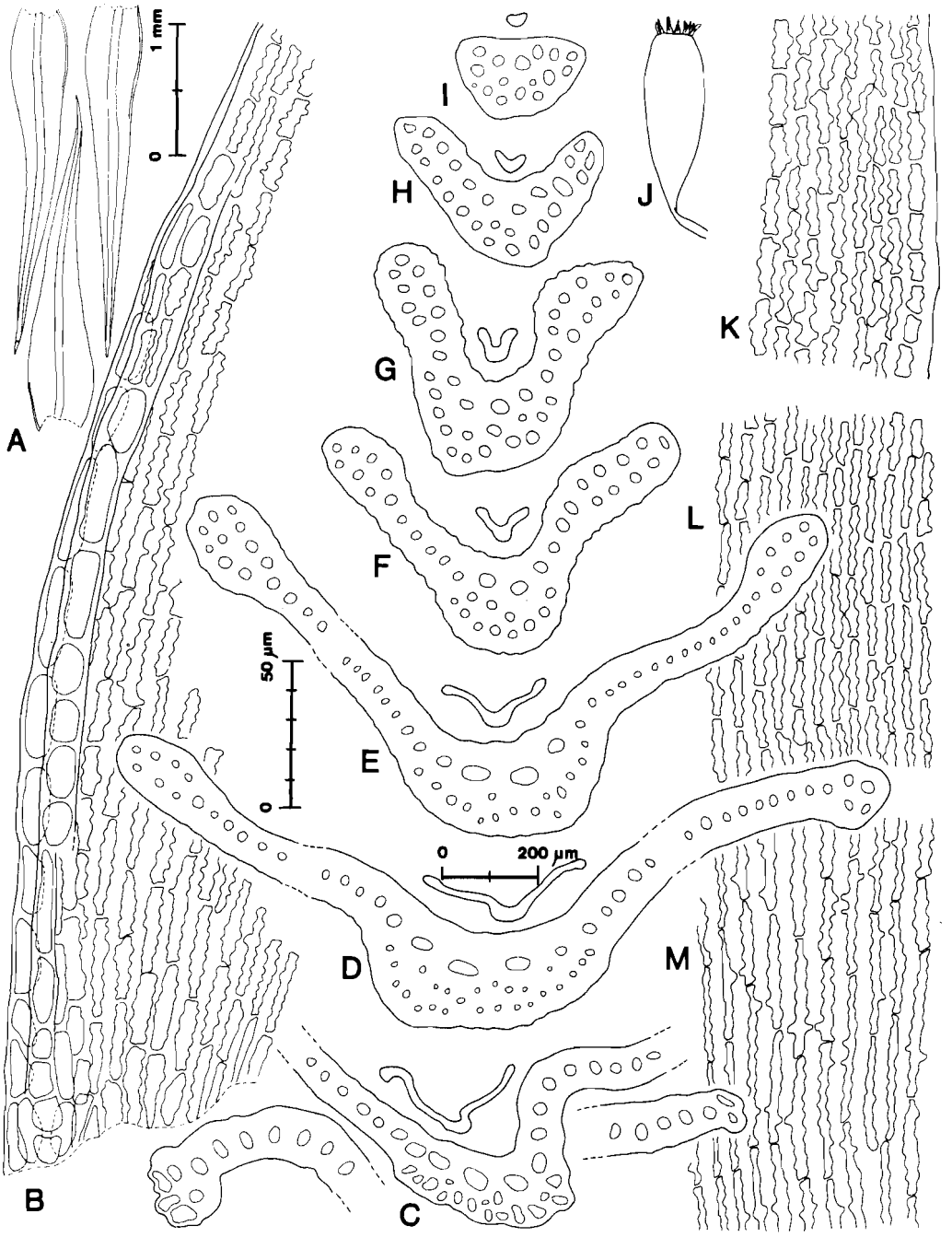

Fig. 65. *Racomitrium angustifolium*. a. Leaves. b. Alar and supra-alar cells. c-i. Leaf cross sections. j. Capsule. k-m. Cells from the upper, lower middle and basal part of the leaf. - Syntype (H-BR).

Grimmia arcuatifolia Kindb. ex Kindb. in Macoun, Bull. Torr. Bot. Cl. 16: 83. 1889 (*G. arcuatifolia* Kindb., Enum. Bry. Exot. 61. 1888 *nom. nud.* et Bull. Torr. Bot. Cl. 15: 185. 1888 *nom. nud.*). - Type: "Abundant on dry rocks at Cedar Hill, near Victoria, Vancouver Island. April 21, 1887. John Macoun." - No specimen with the data of the protologue has been seen. The printed outside label of a (CANM) specimen reads: "Canadian Musci. 608. *Grimmia arcuatifolia*, Kindb. On dry rocks, Mount Tolmie. Near Victoria, V. I. April 21st, 1887 Coll. J. Macoun", but the inside original label reads "On rocks, Mount Tolmie, Vancouver Island, 14/5/87." The material is *Racomitrium heterostichum* plus a little *R. occidentale* plus one shoot *Grimmia* sp. (see also Ireland & Ley 1984: 19). The material in (S) is surely original, it is labelled: ~~Racomitrium sudeticum ?~~ *Grimmia* ~~decipiens~~ *arcuatifolia* Kindb. n. sp. N. Amer., Vancouver Island, dry rocks, 14/5 87 J. Macoun." The specimen fits the description completely (e.g. "tuft blackish ... stem 5 cm long, denudate at base ... leaves ... with a short denticulate hair-point"), and is probably a holotype. The specimen belongs to the genus *Grimmia*.

Racomitrium attenuatum C. Müll. et Kindb. in Macoun et Kindb., Cat. Canad. Pl. 6: 73. 1892 ('*alternuatum*') (*R.* **attenuatum* C. Müll. et Kindb. ex Kindb., Öfv. K. Vet. Ak. Förh. 47: 455. 1890 *nom. nud.*). - *Grimmia attenuata* (C. Müll. et Kindb. in Macoun et Kindb.) Kindb., Eur. N. Am. Bryin. 2: 228. 1897. - Type: "Canadian Musci, No. 524. On boulders at the base of Avalanche Mountain, Rogers Pass, Selkirk Mountains, B.C., Aug. 5th [sic], 1890. (Macoun)." - The problems associated with this name and its type are typically Kindbergian. Firstly, in the protologue the taxon is called *R. alternuatum*; the printed label of Canadian Musci 524 has the orthographical variant *alternatum*, whereas the printed label of Canadian Mosses 99a reads *alternuatum* as in the protologue. However it was originally called *attenuatum* by Kindberg (1890). And secondly: Much material is present in several herbaria, but no specimen includes the exact locality and date of the protologue. The printed label of Canadian Musci 524 reads "On rocks along the C.P.R'y at the summit of Roger's Pass, Selkirk Mountains, Aug. 6th [sic], 1890". However, there are reasons to believe that the material is from a different date and locality: The specimen in S-Kindberg is labelled ~~"Grimmia ancistrodes Dur. et Mont.?~~ elatior? *Racomitrium attenuatum*. N. Amer., Rocky mts, Hector, rocks, 13/8 90" in Kindberg's hand, and the same date are written by hand on the inner envelope of the (CANM) and (NY) specimens of Canadian Musci 524 (outside label printed as above), and of the (NY) specimen of Canadian Mosses 99a (label hand-written). Additionally, I have seen a specimen of Canadian Musci 524 (FH) with the printed label only; one hand-written label of Canadian Mosses s.n. dated Aug. 6, 1890; one (NY) specimen sent to E.G. Britton by J. Holzinger ("of *Rh. alternatum* [sic] CM & K, I am enclosing you a bit. It is a part of what Dr. Yasey gave me of the Nat'l Herb. specimen, with no further label except as I send it. Ex Can. Musci 524."); and finally one specimen of Canadian Musci 524 with the printed date Aug. 6th, 1890, but with the hand-written date 17/5/93 on the original envelope. The situation is very confusing. The specimen in S-Kindberg seems to be original, but includes many sporophytes which are not described in the protologue. *Racomitrium attenuatum* was made a synonym of *R. heterostichum* var. *macounii*

by Jones (1933, see also Wijk et al. 1967). This is in accordance with the protologue, where it is placed between *R. macounii* and *R. robustifolium*, and stated to be allied to the former. However, all the above specimens belong to the genus *Grimmia* (see also Möller 1929), and *R. attenuatum* is therefore excluded from the genus *Racomitrium*.

Racomitrium austro-georgicum Par. is a *nom. nov.* for *Grimmia austro-patens* C. Müll. in Neum. (q.v.)

Racomitrium austro-georgicum var. *kranckii* Roiv. 1955 - Holotype (H). - The name is a synonym of *R. sudeticum*, see Frisvoll (1986).

Grimmia austro-patens C. Müll. in Neum. 1890. - A lectotype (HBG) is selected by Frisvoll (1986: Fig. 1a-f); the name is a synonym of *Racomitrium sudeticum*.

Racomitrium **austro-sudeticum* Broth. ex Watts et Whitel. 1902 *nom. nud.* - Orig.: "Given in Melb. Census for VIC." - G.A.M. Scott, Univ. of Melbourne, gives the following information (in litt.): "I have no idea what the Melbourne Census might be, possibly it was an unpublished manuscript of Baron von Mueller. After his death, by an extraordinarily piece of beaucratic incompetence, a whole room full of his papers was burned ... What was lost we shall never know, but the Census might have been part of it." However, there seems to be no doubt any longer what *R. austro-sudeticum* Broth. ex Watts et Whitel. is, and it seems that the correct author citation is as above. The material is from the same mountain as *Grimmia amoena* Broth. 1900, and in accord with the type of that name, and it is *Racomitrium sudeticum*. It is unknown why Brotherus changed the specific epithet, but he used it later for a Bolivian plant (*R. austro-sudeticum* Broth. in Herz. 1916), see Frisvoll (1986) and below.

Racomitrium austro-sudeticum Broth. in Herz., Biblioth. Bot. 87: 60. 1916. - The many syntypes of this name belong to the genus *Grimmia* (Frisvoll 1986).

Racomitrium **brevipes* C. Müll ex Jaeg., Ber. S. Gall. Naturw. Ges. 1877-78: 419. 1880 (Ad. 2: 683) *nom. nud.* - Orig.: "Japonia, Niko trans Yokohama (Schaal)." (BM, NY). Referable to sect. *Papillosa*.

Racomitrium brevipes Kindb. in Macoun 1890. - Holotype (S - Fig. 7). - No material has been located with the collecting date Aug. 8 and the elevation 6700 feet as stated in the protologue (see also Lawton 1971: 147). The specimen marked *R. micropus* n. sp. in S-Kindberg is collected Aug. 9 at 9000 feet, and many duplicates of this specimen exist. The specimen in (S) is marked 395 in accordance with the protologue, and the disagreement between the existing specimens and the collecting data in the protologue leads one to believe that the protologue must be erroneous on these points. Otherwise there is a confusion of numbers on the different specimens: Two (CANM, NY) have four handwritten numbers on the inside original envelope: 395, 30, 40 (the latter two crossed out), and 614, and the last is also the number of the outside printed label: Canadian Musci 614. - The sporophyte is described in the protologue:

"Capsule small, oblong-cylindrical with a short oblique beak; pedicel short, 0.5 cm. Peristome not examined." No capsule is present in the holotype specimen to-day, but at least one broken young and one old seta are seen. The (NY) specimen includes three immature sporophytes with strongly shrunken urn and operculum; in the other specimens there are no sporophytes but a few broken setae. It appears that a few young sporophytes were present in the original large collection, and that this is the reason why Kindberg could not examine the peristome. - An interesting letter from L. Loeske to H. Möller is included with the holotype; it reads: "Eine solche Form habe ich aus Europa noch nicht gesehen. Die Blätter sind oberwärts besonders auf dem Rücken, höckerig papillös, ähnlich wie bei *Gr. patens*. Ferner hat die Haarspitze einen ganz anderen Charakter, als sonst im *Rh. heterostichum* - Kreise: sie ist dicker, mehr rund als verflacht, und mehreren Reihen ringsum stärker gezähnt, uberhaupt grobzähnig. Jede der drei Proben des *Rh. micropus* gehört meiner Überzeugung nach einer anderen Art an. Diese hier (van 9/8 89) lässt sich, glaube ich, als Art halten. L. Loeske 13/9 28."

Racomitrium brevipes var. *ericoides* (Brid.) Kindb. in Macoun 1890, is a nomenclatural synonym of *R. ericoides* (Brid.) Brid., see Frisvoll (1983a: 61).

Racomitrium brevipes var. *muticum* Kindb. in Macoun 1890. - Lectotype (S). - This is the basionym of *R. muticum* (Kindb. in Macoun) Frisvoll, a species in the *R. canescens* group, see Frisvoll (1983a).

Grimmia **calvescens* Stirt. 1901 *hom. illeg.* - A lectotype (GLAM) was selected by Frisvoll (1985a: Fig. 1g-l); it is *R. sudeticum*.

Trichostomum canadense Michx. 1803. - Isotypes (BM, G). - When described, the material of this name was said to have affinity to *R. lanuginosum*. On the other hand it was said to have a stature agreeing with Dillenius' (1741) Table 47, Fig. 28, which depicts *R. fasciculare* (Dillenius' Fig. 32 of *R. lanuginosum* is not mentioned!). Bridel (1806: 239, 1826: 217) placed *R. canadense* close to *R. lanuginosum*. Lindberg (1875: 549) made it an uncertain synonym of *R. lanuginosum* var. *subimberbe* (Hartm.) Lindb., while Wijk et al. (1969) left out the question mark of Lindberg. Material labelled *Trichostomum canadense* Mx in G-Hedw./Schwaegr. and BH-Hookerianum is *R. microcarpon*; the latter is made up of two specimens, one marked Reichard (err. pro Richard?) and one P. de Beauv.; leaves, perichaetia and peristome of P. de Beauvois' specimen were delineated on the herbarium sheet by W. Wilson 13 June 1833. No other material has been located. Nothing in the description prevents *T. canadense* from being a synonym of *R. microcarpon*. Unfortunately, the supposed original material in Michaux's herbarium (PC, cf. Vitt & Horton 1981) was not sent on loan. But the studied specimens are considered isotypes, and *T. canadense* placed as a synonym of *R. microcarpon*.

Racomitrium canescens var. *brevisetum* Brid. 1826. - This varietal name is thought to be a synonym of *R. heterostichum* by Frisvoll (1983a: 144). However, it is difficult to be sure about this, and it is perhaps best to regard it as a *nomen dubium*.

Dryptodon carnosus (Dicks.) ex Brid. 1826. - A holotype of this name is in B-Bridel (Frisvoll 1984a: 307), it is typical pilose *R. heterostichum*.

Racomitrium **carnosum* Wils. in Mitt. et Wils. 1857 *nom. nud.* - The (NY) specimen is labelled "303 *R. subsecundum* var. *pilif.* W[ilson]", but the locality is "Nangkli 8000" which is different from "Tonglo" given in the publication and on a (BM) specimen. However, the structure of the two is exactly similar, and they are probably duplicates. The only important difference between No. 303 and the type of *R. subsecundum*, is that No. 303 has a more strongly thickened leaf margin.

Grimmia contermina C. Müll. 1851. - Lectotype (C). - The type material (Fig. 37) consists of robust, up to 12 cm long and pinnately branched plants. The habit of the type is impressive, and may appear to be different from much of the other material in the area. The following typed comment on the original of *G. contermina* was made by E.B. Bartram, 17.9.1926, in a specimen so named by him (Standley 43878, Costa Rica, Cerro de las Vueltas, Prov. de San José - NY): "The stem of *Rhacomitrium conterminum* (C.M.) Jaeg. gave me sort of a shock when I opened it on account of being so much more robust than Standleys No. 34878 [sic] but a microscopical examination fails to reveal any outstanding differences. The hair point in both specimens is crisped to about the same degree, maybe a trifle more in No. 43878, and there is a possibility that *R. conterminum* is only a synonym for *Rhacomitrium crispipilum* (Tayl.) Jaeg., a species that I do not know." I agree with him in every respect. Both robust and not robust specimens have been collected in Costa Rica, and are clearly modifications of the same taxon. The habit of the large, pinnate plants of the type of *R. conterminum* is not unlike similarly developed plants of *R. lanuginosum*. See also *R. crispipilum*, Variation.

Racomitrium conterminum var. *andinum* Broth., Rev. Bryol. 47: 10. 1921. - I have not tried to see the type of this S. American taxon. A part of the type is in (WTU); it is said to be *R. heterostichum* (Lawton 1973: 260), but this is hardly correct.

Trichostomum crispipilum Tayl. 1846. - Holotype (FH). - The holotype consists of few (5?) plants about 4 cm high. They are, however, strongly branched so that the type includes a large number of secondary stems and branches (about 25 top shoots). In addition there are two stems in a small envelope. The isotype consists of one single shoot, and drawings made by Wilson. To the isotype sheet is also added more material labelled "Jameson 94. W summit of Pichincha 1848." The mentioned locality is the 4701 m high mountain in Quito, Equador, and may as well be the type locality. *Racomitrium crispipilum* was made a synonym of *R. crispulum* by Bartram (in Lloydia 5: 258. 1842, fide Index Muscorum), and

Clifford (1955) and Lawton (1972: 259) treated it in the same manner. Later, Lawton (1973) changed her mind and treated it as a separate species, with *R. conterminum* as its synonym; the same treatment is adopted in this paper. However, Deguchi (1984) found *R. crispipilum* to be the oldest name of a taxon which has its (main) distribution farther south in S. America, and which has been described as *R. striatipilum* Card. 1905, *R. integripilum* Dus. 1907, *R. gemminatum* Roiv. 1955, and *R. substriatipilum* Roiv. 1955. I have seen some material of this southern taxon, including an isotype of *R. striatipilum* ("Svenska Sydpolarexpeditionen 1901-03. Ser. N:r 74. *R. striatipilum* Card. sp. nov. Tierra del Fueg. Bahia Tekenika, 5/11 1902 Carl Skottsberg, det. J. Cardot" - S) and a holo- or isotype of *R. integripilum* ("Patagon. occ., Rio Aysen in saxis, Febr. 1897 P. Dusén" - S). The types and the other material of that taxon have a very broad and dorsally flat costa towards the base of the leaf, with as much as 7-10 ventral costal cells (cf. Deguchi 1984: Fig. 18-20). (Its costa is somewhat similar to that of *R. subsecundum*, which, however, is different in a number of other important characteristics.) The type of *R. crispipilum* has a much narrower costa, with usually 3 ventral cells towards the base of its leaves. I therefore treat *R. crispipilum* as a taxon different from the more southern species, whose oldest name seems to be *R. striatipilum* Card. - The type material of *R. crispipilum* possesses three sets of sporophytes: Very young ones concealed in the perichaetial leaves; ripe deoperculate capsules; and old shrunken urns. The holotype is made up of several female and one male plant. Only one C. American specimen with sporophytes has been seen (Standley 43878 - NY, see comment on *R. conterminum*). The scarcity of sporophytes may be due to lack of male plants.

Dryptodon crispulus Hook. f. et Wils., London J. Bot. 3: 544. 1844. - *Grimmia* **crispula* (Hook. f. et Wils.) C. Müll., Syn 1: 804. 1849 *hom. illeg. non* (Hedw.) Turn., Musc. Hib. 28. 1804 [≡ *Dicranoweisia crispula* (Hedw.) Milde]. - *Racomitrium crispulum* (Hook. f. et Wils.) Hook. f. et Wils., Fl. Nov. Zel. 2: 75. 1854. - Type material is selected, described and figured by Frisvoll (1984c). *Racomitrium crispulum* must be one of the most misused bryological names, at least within Grimmiales. Different names were put in its synonymy by a number af authors, in the second half of the nineteenth and beginning of the twentieth century. Clifford (1955) contributed much to the confusion, by confirming the previous decisions and in placing altogether no less than 39 names as its synonyms; among them are *R. conterminum*, *R. crispipilum*, *R. cylindricum*, *R. fragile*, *R. javanicum* and *R. emersum* treated in this paper. (The first name is a synonym of the second, the next three are synonyms of *R. subsecundum*, and the last is the oldest name of a species.) *Racomitrium crispulum* possesses many special and distinctive morphological characteristics, both in its gametophyte and sporophyte, and no matching material has been seen from Asia or C. America (compare with the map in Clifford 1955: Fig. 1). It also seems to be lacking in southern S. America and Antarctica; a number of Clifford's synonyms from there have been treated differently by recent authors: Deguchi (1984) placed *R. nigritum* Jaeg. 1874 and *R. symphyodontum* (C. Müll. 1849) Par. as synonyms of *R. didymum* (Mont. 1845) Lor.; *R. lamprocarpum* (C. Müll. 1849) Jaeg. is treated independently with *Grimmia subnigrita* C. Müll. 1885 as its

synonym; and *G. genuflexa* C. Müll. 1883 and *R. stenocladum* Dus. 1907 are considered synonyms of *R. orthotrichaceum* (C. Müll. 1883) Par. Frisvoll (1986) placed *R. austro-georgicum*, *R. skottsbergii*, and *R. substenocladum* as synonyms of *R. sudeticum*. Regardig *R. integripilum*, see *R. crispipilum*.

Racomitrium cucullatulum Broth. in Hand.-Mazz. 1929. - Lectotype (H-BR - Fig. 50). - No doubt, Brotherus first described and designated specimen No. 9976 as *R. cucullatulum* (material in H-BR, S, WU). The size of the plants ("ad 2 cm"), apex of the leaves ("cucullatula, rotundato-obtusa") etc., fit that number better than 951. Specimen No. 951 was given a new unpublished (and therefore not quoted) name *in sched.*, and later considered to be identical to No. 9976. Both are listed in the protologue and have the same status as syntypes. The two are different: No. 9976 is quite similar to the lectotype material of *R. himalayanum*, and is, indeed, one of some very few known specimens matching that type. No. 951 is made up of much material of a taxon which is poorly known so far. It is treated as a species in this work, and No. 951 is selected as its lectotype. Material from exactly the same locality as No. 951, is distributed as "3089 *Rhacomitrium cucullat[ul]um* (sic) Broth." in Kryptogamae exsiccatae editae a Mus. Hist. Nat. Vindabon. (BM, H, H-BR, S, WU; the BM specimen is stamped 20. Jul. 1928 which is previous to the publication of the name). The exsiccate material is even from ca. 3550-3675 m as stated in the protologue (not ca. 3600-3675 m as written on the label of No. 951). The habit of the exsiccate material is exactly like the lectotype (same colour, size, branching and maturity of the operculate sporophytes, etc.), and I am inclined to consider the exsiccate specimens as duplicates of the type.

Racomitrium cylindricum Schimp. in Besch. 1872. - Lectotype (BM). - The name is a *nomen novum* based on *Grimmia cylindrica* C. Müll. 1849 - an illegitimate homonym (ICBN Art. 72). The plants in the lectotype are robust and falcate like the lectotype of *R. subsecundum*, and the leaf characteristics are also nearly the same. The type of *R. cylindricum* has a reddish alar region. But many leaves are long-decurrent with inflated cells only in the marginal row, and some leaves have no inflated cells at all. However, typical *R. subsecundum*-auricles (more than 10 inflated cells in 3-5 rows) are quite numerous in some plants. Long-decurrent leaves with few or no inflated cells are also seen in Asiatic specimens. I can find no taxonomically important characteristics separating the lectotype of *R. cylindricum* from *R. subsecundum*. The (BM) paralectotypes have also decurrent leaf bases with few inflated cells, and Liebmann 65 is made up of gracile plants with pseudopapillose leaves. The specimen in (S) has large auricles in most leaves, and is perhaps not a duplicate of any of the (BM) specimens. Original material may also be in BM-Hampe and BM-Bescherelle, but no collector is indicated on these specimens.

Racomitrium (*Dryptodon*) *delavayi* Broth. et Par. in Par., Rev. Bryol. 35: 126. 1908 ('*Delavayi*'). - Type: "Cette mousse a été prise, dans l'herbier de Zi Ka Weï, sur un échantillon de *Daphne* ... recueilli à Mo So yn, dans le Yunnan, le 17 mai 1887 par l'abbé Delavay." - The holotype is located (H-BR); it is labelled "1079. *Rhacomitrium Delavayi* n. sp. Yunnan. Mo So yn, ad *Daphne* ...

17.5.87 Leg. Delavay." In the protologue the new species is said to differ from other *Dryptodon* species in its extremely short seta. The leaf cells are said to be papillose. The material fits the description and is referable to the genus *Orthotrichum*!

Racomitrium depressum Lesq. 1868. - Isotype (NY - Fig. 25). - An (NY) specimen is marked TYPE; it includes a note (in the impossible handwriting of E.G. Britton) which states that the meagre specimen ex herb. Lesquereux was without locality, collector or date. The specimen is made up of three branched plants. It is probable that more plentiful original material exists, and I have therefore not selected a lectotype. One (TRH) specimen is labelled: "From the United States National Herbarium. Mosses, determined by Mrs. E.G. Britton. *Racomitrium depressum* Lesq. Falls of the Yosemite, California. Coll. Henry N. Bolander. June 1870"; this is a plentiful topotype. But another specimen similarly labelled is *R. aciculare*.

Racomitrium depressum var. *nigricans* Kindb., Ottawa Natural. 23: 181. 1910. - Type: "Collected on Southampton Island near Fullerton, northwest of Hudson Bay, by Commander A.P. Low in 1904, also at Whale River, Labrador, in 1896." - Two original specimens from Southampton Island (dated 10.VII. and 20.VIII.04) and one from Labrador (dated 13.VIII.98 (sic)) have been seen (S), and all are made up of much material of *Schistidium andreaeopsis* (C. Müll.) Laz. (cf. Frisvoll 1987).

Racomitrium dicarpum Broth. in Hand.-Mazz. 1929. - Lectotype (H-BR). - The type material is made up of depauperate (about 0.5-1.5 cm high) strongly branched plants with epilose or brevipilose leaves. The plants are abundantly fertile, sometimes with two sporophytes from the same perichaetium (hence the specific epithet). The lectotype and its duplicates are quite like J.D.H. 321 (one of the syntypes of *R. himalayanum*, q.v.), except that that material is epilose. One piece of *Schistidium* sp. is excluded from the type. Curiously enough, the type material of *R. dicarpum* resembles the lectotype specimen of *R. himalayanum* more, than any of the other specimens which have been named so.

Racomitrium diminutum Card. 1908. - Lectotype (H-BR). - Regarding the reasons for placing this name as a synonym of *R. laetum*, see the latter. The type material of *R. diminutum* must have grown in a very exposed site, because many shoots are dead and the leaves eroded or rotten. Because all three duplicates are quite similar, they do certainly originate from the same cushion or place. The specimen at (H-BR) includes some intact shoots and are selected as lectotype. It is made up of about 2.5 cm long plants with leaves about 1.5-1.9 x 0.3-0.4 mm, including a hair-point about 0.1 mm long; they have a unistratose leaf margin and a hyaline basal marginal border of up to 12 cells. Dead stems may have been more robust. The (PC) specimen is very bad, with hardly one typical undamaged shoot, and it is therefore not selected as lectotype. One of the syntypes of *R. laetum* is Faurie No. 3384 (the type of *R. diminutum* is Faurie No. 3383 from the same locality and elevation); it is made up of large and robust plants. Sakurai (1937: 136) studied a part of Faurie 3383, and although

he monographed the Japanese *Racomitrium* species, he was unable to place the material but wondered whether it was "Eine *Grimmia*?".

Racomitrium divergens Stirt. 1907. - A lectotype (GLAM) was selected by Frisvoll (1985a: Fig. 2g-l); it is *R. heterostichum*.

Racomitrium doii Sak., Bot. Mag. Tokyo 54: 6. *3*. 1940. - Type: "Prov. Ohsumi, Utinoura, Tarumi, auf Felsen (Leg Y. Doi Typus in Herb. K. Sakurai Nr. 11716 30 Maerz 1938."). - The author compared the new species with *R. sudeticum*. I have seen the type (MAK), and it is a *Grimmia*. Deguchi (1979: 201) placed *R. doii* in synonymy of *Grimmia pilifera* P. Beauv., as an extreme modification from a shaded habitat.

Dryptodon **ellipticiformis* Vilh. 1923 *nom. inval.*, is a manuscript name of *D. ellipticus* var. *tatrensis*, see below.

Dryptodon ellipticus var. *tatrensis* Vilh. 1923. - Holotype (PRC). - The type specimen includes plants with pilose leaves, and is therefore not always epilose as stressed in the protologue ("mutica, semper sine pilo acuminata"). It is nothing but depauperate *R. sudeticum*. This was indicated already by Loeske (1930: 205), who did *not* make the combination *R. ellipticum* var. *tatrense* (Vilh.) Loeske as stated by Wijk et al. (1967).

Grimmia emersa C. Müll. 1851. - Isotype (E). - The isotype is numbered 43, whereas the protologue states 743; however, very probably this is original material (right date, habitat, locality and collector), and it is also marked isotype. About 12 shoots - including 3 capsules - are glued to a small piece of paper. They are quite like specimens from SE Asia. The isotype has been renamed *R. symphyodontum* (C. Müll.) Par. (see also Wijk et al. 1967), which is an older name (*Grimmia*, 1849); its two syntypes are figured by Deguchi (1984: Fig. 24-25); they include leaves with bistratose margin for two to five cell rows. The oldest name of this taxon is *R. didymum* (Mont.) Jaeg. (*Grimmia*, 1845) fide Deguchi (1984). *Racomitrium didymum* and *R. emersum* do not appear to be synonyms, but they may be closely related. - One or more names introduced for Australian or New Zealand plants by Müller (1898: 166-168, viz. *Grimmia sullivanii*, *G. pseudo-patens*, *G. pycnotricha*, *G. elegans*, and *G. helvola*) are probable synonyms of *Racomitrium emersum*.

Grimmia ericoides Pyl. ex Brid. 1826. - Lectotype (B-Bridel). - Two sheets of *G. ericoides* are in B-Bridel. The material on the one is described as the main species. It is made up of 5-6 intricately branched plants of *R. microcarpon* plus one small shoot of *R. fasciculare*. The material on the second sheet is labelled "*Grimmia ericoides*. Varietas crassior, minus nigricans" and is described by Bridel (1926): "Variat in iisdem locis caule ramisque crassioribus, colore lurido minus nigricante, et foliis omnibus muticis." This is *R. fasciculare*. The leaves of the main species are said to be "saepius canus vel pilifer, rarius muticis". The *R. microcarpon* element is selected as lectotype of *Grimmia ericoides* Pyl. ex Brid.,

which should not be confused with *G. *ericoides* (Brid.) Lindb. 1879 *hom. illeg.* ≡ *Racomitrium ericoides* (Brid.) Brid.

Racomitrium fasciculare var. **minor* Mitt. et Wils. 1857 *nom. nud.* - The original material of this invalid name is also a syntype of *R. himalayanum*, and is described in connection with that name (J.D.H. 321). It is *R. himalayanum*.

Trichostomum fastigiatum (Hoffm.) ex Wallr. 1831. - Neotype (GZU). - It has not been possible to locate type material of this name, neither of Wallroth's own material nor of Hoffmann's *Bryum fastigiatum* which is cited as a synonym. The name and description in Hoffmann (1796) is given in a parenthesis, in a comment on *B. heterostichum*. He cites "Dill. Musc. tab. 47. fig. 30?" (Dillenius 1741) as an uncertain synonym; according to Frisvoll (1984a) this figure refers to *Racomitrium obtusum*. Original Hoffmann material may be at (MW) or (LE). Wallroth (1831) quotes Hoffmann's description, with some supplementary notes on leaves and sporophytes. Diagnostic characteristics include the phrases "caule ramoso ... foliis ... acuminatis apice integro diaphanis margine revolutis, flaventi-viridulis ... sporangio ovato sensim acuminato." The name was placed as a synonym of *R. affine* by Hampe (1837: 281, as *R. heterostichum* ß *alopecurum* Schw. Syn. *fastigiatum* Wallr.), and later authors followed him in that (e.g. Limpricht 1890, which cited *R. fastigiatum* in synonymy of his *R. affine*). Paris (1898, 1905) and Wijk et al. (1967) list *RACOMITRIUM fastigiatum* as the original name, but that combination is not validly published. - One specimen named *Racomitrium fastigiatum* is present in GZU-Hoppe. No locality or collector is given, and J. Poelt (in litt.) considers this an indication of that the specimen may be original and not collected by Hoppe himself. The specimen is typical fertile and pilose *R. affine*. In the absence of certain original material it is selected as neotype of *Trichostomum fastigiatum* Wallr. - According to Sayre (1977) and Vitt et al. (1985) Wallroth's herbarium is at (PR), see also Limpricht (1890: 77). But H. Franklova (PR) states (in litt.): "This is to inform you that all original Wallroth's material of Cryptogams is held in Institute de Botanique de l'Université Louis Pasteur, 28, Rue Goethe 67083 Strassbourg, France. In the herbarium of National Museum in Pruhonice only the Wallroth's collection of Phanerogams is deposited." A letter to Strassbourg remained unanswered.

Racomitrium fragile Ren. et Card. 1909. - Isotype (S). - One shoot, 3 cm long, and some leaves wrapped in paper constitute an isotype. The leaves possess large red inflated auricles, and a broad costa which becomes narrower and disappears in the apex. In the protologue, *R. fragile* is compared with *R. cylindricum*: "a *Rh. cylindrico* Sch. foliis epilosis jam distinctum". This is a weak basis for a new species in *Racomitrium*; and *R. fragile* is, like *R. cylindricum*, a synonym of *R. subsecundum*.

Racomitrium fuscescens Wils. in Mitt. et Wils. 1857. - Lectotype (BM). - Much type material of this name exists. The shoots are glistening dark brown and about 4 cm long, and the bulk of the material is made up of an epilose or usually subepilose plant with short point in the upper leaves. In addition, there is a longipilose plant in one of the specimens. Because of this mixing, I have

selected a lectotype specimen made up of plants with only short point in the upper leaves (plus fragments of a *Grimmia* sp.). The isolectotype in (NY, not seen) is figured by Deguchi (1980: Fig. 3), and the figure depicts the brevipilose plant. The longipilose plant belongs to *R. capillifolium* var. *capillifolium*.

Grimmia fuscoviridis Stirt., Ann. Scott. Nat. Hist. 10(38): 112. 1901. - Dixon (1923) referred this plant to "the subobtuse-leaved form of *Rhacomitrium heterostichum* var. *alopecurum* (*G. obtusa* Lindb.)", but it is *R. ellipticum* (Frisvoll 1985a: Fig. 2a-f).

Trichostomum gracile Hornsch. ex Fürnr. 1827. - Lectotype (BM). - No material labelled Kärnthner Alpen has been located (cf. protologue and Hübener's 1833: 202 "in Kärnthen"). The Freund Müller (cf. protologue) can only be Franz August Müller (1798-1871), Apothekergehilfe bei Bruch in Zweibrücken, according to E. Hertel (comm. J. Poelt, in litt.). Many specimens named *Racomitrium gracile* Hornsch. and collected by August Müller in Alpes Salisburiae in 1826, exist. According to J. Poelt (in litt.) the material may come from the border district between the two mountain areas: ("Alpes Salisburiae versus Kärnthner Alpen: Most of the old material is collected in the mountains now named Hohe Tauern, where the borderline between the two provinces goes over the highest ridges. So it may come from the border region.") I consider this is the original material of *Trichostomum gracile*; it is typical fruiting *Racomitrium sudeticum*. The specimens are blackish with olivaceous apices ("dünkel grüne", according to the protologue), and it seems that all quoted specimens are duplicates of a large collection. One specimen labelled exactly like *Racomitrium gracile*, but named *R. sudeticum* Funck, is *R. macounii* subsp. *alpinum* (BM-Hampe).

Trichostomum **gracile* Schleich. ex Hüb., Musc. Germ. 208. 1833 *nom. nud. in synon.* [of *Racomitrium heterostichum*]. - I have not met with this name elsewhere, and it is therefore quite obscure. *Trichostomum gracile* Hornsch. is given as a synonym of *Racomitrium sudeticum* in the same work (p. 202, as *R. microcarpon* ß. *sudeticum*), so there is no evident confusion with regard to that name.

Trichostomum heterostichum Hedw. ex Hedw. 1801. - The name was typified, and the lectotype (G-Hedw./Schwaegr.) was illustrated by Frisvoll (1984a: Fig. 2).

Racomitrium heterostichum var. *alopecurum* Hüb. 1833. - Lectotype (LAU). - The protologue of the names *Trichostomum* **alopecurum* Schkuhr 1811 and *Racomitrium* **alopecurum* Brid. 1819 includes a reference to the type of *T. affine* Web. et Mohr 1807, and they are therefore superfluous and illegitimate. Hübener's (1833) var. *alopecurum* is regarded as a new taxon (ICBN Art. 72 Note 1). The selected lectotype is the same as for *R. affine*. *Racomitrium heterostichum* var. *alopecurum* 1833 antedates *R. heterostichum* var. *affine* 1846, and has priority in that position.

Racomitrium heterostichum var. **alpestre* Schimp. ex Limpr. 1889. - Orig. spec. (BP). - The plentiful original specimen is a mixture of *R. obtusum* f. *obtusum* and f. *trichophorum*, and both possess mature sporophytes. Limpricht (1890) considered var. *alpestre* to be a mixture of *R. affine* and its var. *obtusum* (≡ *R. obtusum*), and his description of these taxa is based on the single Schimper specimen. "... Limpricht hat auch hier keine Art, sondern ein Individuum ... beschrieben." (Loeske 1913: 186, 1930: 210). Limpricht's long and detailed description of *R. affine* therefore refers to *R. obtusum* (f. *trichophorum*). Now, when this is known, it is easier to realize why *R. affine* has been so misunderstood. Later authors used Limpricht's description, which, of course, is misleading on several crucial points. The leaf margin is said to be bistratose in one or two cell rows, and also the lamina is said to include bistratose spots. The bulk of the specimens of *R. affine*, including its type, have a unistratose lamina and a unistratose margin with rare bistratose spots! The costa is said to be strong, very broad (0.085-0.14 mm), and possess up to 15 ventral cells. Such a costa is found in *R. obtusum* but not in *R. affine*. See also *R. heterostichum* var. *limprichtii*.

Racomitrium heterostichum var. **alpestre* Meyran, Ann. Soc. Bot. Lyon 39: 54. 1915 *nom. nud.* - Orig: "Savoie: Hortaz (Payot)." - Not seen.

Racomitrium heterostichum var. *amblyphyllum* Stirt. 1902. - A lectotype (BM) was selected by Frisvoll (1985a: Fig. 3g-k); it is *R. heterostichum*.

Racomitrium heterostichum f. *atrum* Möll., Ark. Bot. 24A(2): 86. 1931 ('*atra*'). - Type: "Halland, Hishult 1926 Sm.; Bohuslän, Uddevalla 1879 N.C. Scheutz; Dalarna, Bäckhagen 1911 M." [in loc. list p. 88, 90, 92]. - The last-mentioned specimen (labelled "Dalarna, St. Kopparberg, Bäckhagen, 23/4 1911 Hj. Möller") is annotated by the author; it is blackish *R. sudeticum* with strong costa (sometimes four-stratose) and strongly thickened margin (bistratose in one or two cell rows). Otherwise I have seen two specimens fitting the other localities, but neither is annotated by Möller: "Halland, Hishult, Hishults by, 1/6 1926 C. Stenholm", is *R. heterostichum* of a rather light colour; "Boh., Uddevalla, 1879 Scheutz", is blackish *Grimmia* sp. (all specimens in S-Möller). Possible annotated specimens of f. *atrum* from these localities should be sought before the name is placed as a synonym of *R. sudeticum*.

Racomitrium heterostichum f. **brevipilum* Zett. 1861 *nom. nud.* - All exsiccate specimens of No. 30a are gracile, pilose plants of *R. affine*. No. 30b is called *R. heterostichum planta mascula gracilescens brevipila* (LD, 2 sp.; TRH); it is fairly like No. 30a, and the (TRH) specimen even includes female plants with one mature sporophyte.

Racomitrium heterostichum var. **brevipilum* Zett., K. Vet. Ak. Nya Handl. 15(1): 13. 1877 *nom. nud.* - Orig.: "in saxis umbrosiusculis viget, ut Hunneberg supra Nygård et Halleberg ad Granbacken." - Probable orig. spec.: "*Racomitrium heterostichum* Brid. var. *brevipilum*. Västergötland, Halleberg. 22/6 76 J.E. Zetterstedt." (LD); this is *Grimmia hartmanii* Schimp. as stated by Möller (1931:

86, 94). The label is written by Möller, whereas four specimens of *G. hartmanii* from Hunneberg include Zetterstedt's original labels (1 as *G. hartmanii*, 1 as *G. incurva* Schwaegr. and 2 as *G. elatior* Br. eur.). Var. *brevipilum* is not described and therefore a *nomen nudum* (cf. Wijk et al. 1967).

Grimmia heterosticha var. **brevipila* "Broth. et Sæl.", Act. Soc. Fl. Fenn. 6(4): 80. 1890 *nom. nud.* - Orig.: Not indicated. - The name is simply mentioned in the description of another taxon: "*Gr. microcarpa* f. *subheterosticha* Sæl., *Gr. heterostichæ* C. Müll. var. *brevipilæ* habitu simillima, ..." The label of the original of f. *subheterosticha* includes a reference as follows: "('*R. heterostichum* f. *simplicior brevipila*' Zett. in litt.)". Var. *brevipila* of Brotherus et Sælan does not seem to have been intended as a new epithet, but as a reference to Zetterstedt's. The lack of other specimens in (H/H-BR) labelled var. *brevipila* by Brotherus or Sælan seems to confirm this (P. Isoviita, in litt.).

Racomitrium heterostichum var. **canescens* Meyran, Ann. Soc. Bot. Lyon 39: 54. 1915 *nom. nud.* - Orig.: "Melangé au type, mais plus rare." - This is considered to be a similar plant as f. *incanum* Limpr., but no original material has been seen.

Racomitrium heterostichum f. d. *cinerascens* Boul., Fl. Crypt. Est, Musc. 643. 1872. - Type: "Sur les schistes métamorphiques entre Bussang et le col de même nom." (not seen). - I am unable to place this form according to the description.

Racomitrium heterostichum var. *compactum* Röll 1886. - Lectotype (WB). - The lectotype is made up of six pieces with fertile plants about 2-3 cm long. Most plants have a well delimited three- to four-stratose costa in the lower part of the leaf, and are typical *R. affine*. But a few shoots of *R. heterostichum* are present in one of the pieces. The meagre diagnosis ("sehr niedrig, polsterförmig") does not include important distinguishing characteristics between the two. The more plentiful *R. affine* element is selected as lectotype. The Schmiedefeld specimen has not been seen.

Grimmia heterosticha var. *elongata* T. Jens. 1856. - Lectotype (S). - I have seen two specimens collected and named *Racomitrium heterostichum* forma *elongata* by the author of *Grimmia heterosticha* var. *elongata*, one in (S) collected 1854 and one in (C) collected August 1856. The name was published in 1856, and the older specimen has been selected as lectotype. It is made up of sterile elongate and moderately branched plants with pilose leaves, and is typical *R. affine*. In 1854 T. Jensen also collected a large specimen at Bornholm (C), which he named "var. *alopecura* Br. dan"; but this name is not used in his book; the specimen is similar to var. *elongata*.

Racomitrium heterostichum var. **epilosum* Mat., Mitteil. Ver. Naturf. Reichenberg 37: 7. 1906 *hom. illeg. non* fo. *epilosum* Corb., Mem. Soc. Sc. Nat. Cherbourg 26: 259. 1889. - *R. heterostichum* subsp. **vulgare* f. **epilosum* Podp., Consp. 294. 1954 *hom. illeg.* - Type: "Herrschaft Krumau in Südböhmen, steril (Jungbauer 1840 als *Trichostomum ericoides* Schrad.)" (not seen). - Diagnosis: "Saum der

Blätter einschichtig; die Zellen der Blattspitze quadratisch. Blatthaare fehlend." This is perhaps *R. affine*, but as long as the original is lacking this will be but a guess.

Racomitrium heterostichum [var.] ß *affine* f. *epilosum* Corb. 1889. - Syntype (S). - A specimen (S) of Musci Galliæ No. 74 is *R. obtusum*, and f. *epilosum* Corb. is considered a synonym of that species. Possible original specimens referred to in the protologue should be studied before a lectotype is selected.

Racomitrium heterostichum f. *falcatum* Möll. 1931. - One specimen (S) named f. *falcata* by the author of the name has been seen, it is *R. heterostichum* with not unusually strongly falcate leaves; it is selected as lectotype of the name.

Trichostomum heterostichum var. *fasciculatum* Bruch et Schimp. in Moug. et Nestl. 1840. - The name embraces the type of *Racomitrium affine*, of which it is a nomenclatural synonym. The exsiccate specimens seen are made up of *R. affine* or a mixture of *R. affine* and *R. obtusum* s.l.

Racomitrium heterostichum var. *gracilescens* Bruch et Schimp. in B., S. & G. 1845. - Lectotype (BM - Fig. 66). - Some bryophyte names have been used about habitat modifications of several closely related taxa. The taxa have often been treated as one collective species. Examples of such names in Grimmiaceae are *Schistidium apocarpum* (Hedw.) Bruch et Schimp. in B., S. et G. var. *gracile* (Roehl.) Bruch et Schimp. in B., S. & G., *Racomitrium canescens* var. *epilosum* H. Müll. (Frisvoll 1983a), and the present var. *gracilescens*. Gracile modifications of all (European) species of sect. *Laevifolia* have been named var. *gracilescens*, but it has been very frequently used about elongate, lowland specimens of *R. sudeticum*. - The plentiful type material is made up of an epilose plant mixed with one or two shoots of a pilose plant, and both are described and figured in the protologue: "foliis obtusis vel apiculo diaphano brevissimo instructis" (Bruch et al. 1845: 145; Table 266, Fig. γ2a and γ3). The hair-point is frequently longer than illustrated in the protologue, and the pilose plant (Fig. 66d) is similar to the lectotype of *R. affine* (Frisvoll 1984a). The epilose plant is selected as lectotype of *R. heterostichum* var. *gracilescens*. - Since they grow together the epilose plant is not a mere modification of the pilose plant. It is also more yellowish coloured. The stems are much branched, contrary to what is stated in the handbooks. Cross sections of leaves indicate a close relationship to *R. affine* (cf. Frisvoll 1984a: Fig. 1). The costa ends shortly before the apex; it is four-stratose towards the base, three-stratose in the middle of the leaf and bistratose towards the apex. In its lower part it is dorsally convex, and in upper part it is flatter. The margin is unistratose with bistratose spots in one or rarely in two cell rows, and the lamina is unistratose with rare bistratose spots in the upper part. At the basal leaf margin there are a few yellowish-hyaline and esinuose cells. The capsule is about 1.7 mm long. - I have seen a few additional European specimens of what seems to be the genuine epilose var. *gracilescens*. One specimen (Norway: Hordaland, Bergen, Smørås, Natlandsveien, 16.VII.1985 Blom - TRH) is fertile with elongate urns (ca. 2.5 x 0.6 mm),

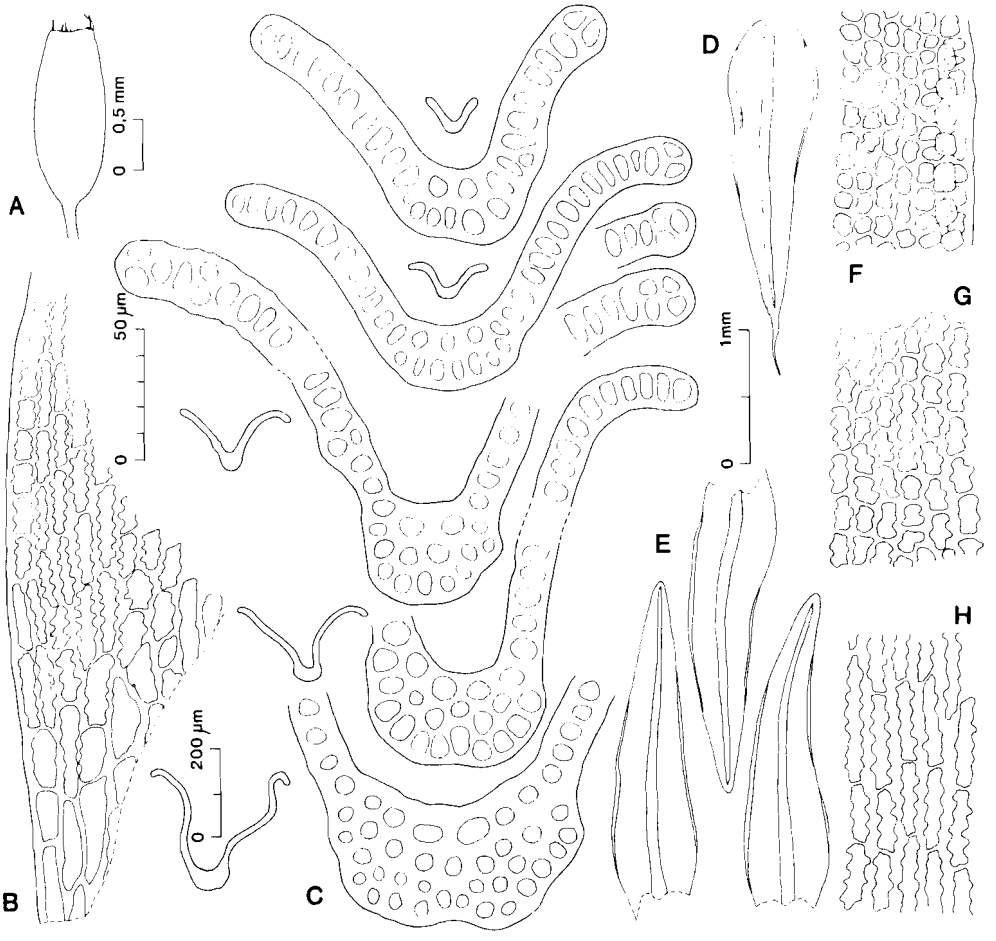

Fig. 66. *Racomitrium heterostichum* var. *gracilescens*. a. Capsule. b. Alar and supra-alar cells. c. Leaf cross sections. d-e. Leaves. d. Pilose plant. e. Epilose plant. f-h. Cells from the upper, lower middle and basal part of the leaf. a-c, e-h. Lectotype. d. *R. affine*. All from lectotype specimen (BM).

and the size of the urn can therefore not be of great importance. Var. *gracilescens* is included as a synonym of *R. affine* in this paper.

Racomitrium heterostichum f. *incanum* Limpr. 1889. - Type not seen. - The short description: "eine sehr langhaarige, weissgraue Form", places f. *incanum* within *R. heterostichum*, because none of the other European taxa in the section fit this description. The name is now and then used on labels of herbarium specimens, and always about *R. heterostichum* mod. *longipilum*.

Racomitrium heterostichum var. *lanatum* Bauer 1900. - Isotype (OP). - This is described as "Eine Form mit langen Blatthaaren und meist dunkelbrauner Färbung." A duplicate of the type is nothing but pilose *R. heterostichum* from a sandy and muddy habitat.

Racomitrium heterostichum var. *limprichtii* Loeske 1913. - Lectotype (JE). - Var. *limprichtii* was introduced as a substitute for *R. heterostichum* var. *alopecurum* Hüb. p.p. or *R. affine* Lindb. emend. Limpricht (1890). The remaining part of var. *alopecurum* was referred to robust forms of var. *gracilescens* (Loeske 1913: 185 bottom). The name was put forward because of a supposed disagreement between Lindberg's (1875) and Limpricht's concept of *R. affine*: One specimen collected and named *R. affine* by Lindberg was found to be *R. sudeticum* by Warnstorf (1906: 311) (I have myself seen many such specimens), and another specimen seen by Loeske did not fit Limpricht's description of *R. affine*. Limpricht (1890) described "*R. affine* (Schleich.) Lindb. Act. soc. sc. fenn. X. p. 552 (1875) emend." and its "var. ß *obtusum* (Sm.; Lindb.).": "Aus den oberen Vogesen vertheilte Schimper beide Formen in demselben Convolut als *R. heterostichum* var. *alpestre*; diese Exemplare liegen meiner Beschreibung zu Grunde." Limpricht's description of *R. affine* is based on *R. obtusum* f. *trichophorum* (see *R. heterostichum* var. **alpestre* Schimp ex Limpr.). The Schimper/Limpricht specimen could have been selected as lectotype of var. *limprichtii*, but, if possible, var. *limprichtii* should be treated as a synonym of *R. affine* and not of *R. obtusum*. Two specimens mentioned by Loeske (1913) in the protologue of var. *limprichtii* are located, and also many topotypes (e.g. Bruchhauser Steine, 7 specimens, coll. Schemann; Schmidt; Winter - JE, all as *R. affine* s.l.) and some undated or post-1913 specimens of var. *limprichtii* collected or confirmed by Loeske. - The lectotype (probably an isosyntype) is made up of elongate, moderately branched plants with leaves up to 3 mm long including the ca. 0.6 mm long, narrow hair-point; the margin is usually bistratose in upper part (sometimes even in two cell rows); and the costa is up to 110 µm broad in its basal part, and there four-stratose with 5-6(7) ventral cells; the urn is 2.0-2.5 mm long. It is interesting that the lectotype has been studied by Limpricht, who noticed: "*Racomitrium affine* Lndbg. Perichaetialblätter innere: Ränder der stumpfen Spitze crenulirt." This characteristic is also stressed by Limpricht (1890) as present in *R. affine* s.l. [= *R. obtusum*!] and not in *R. heterostichum*. However, such a difference does not exist.

Racomitrium heterostichum var. *micropoides* Kindb. in Röll 1896. - Holotype (S). - The taxon was compared with *R. microcarpon* by its author: "Obere Blattzellen

oft schmal, wie bei *Rac. microcarpon* Brid.", and on the specimen sheet: "cellulæ superior interdum rectangulæ." The holotype specimen, however, is typical *R. affine*, with narrow three- to four-stratose costa towards the leaf base, and a standard mixture of short and elongate cells in the upper part of the lamina. Five other specimens in S-Kindberg, collected by Macoun from 1890 to 1908 and named ✯*micropoides* by the author of the name, are *R. sudeticum* (four) and *R. affine*.

Racomitrium heterostichum [var.] δ. *ramulosum* f. *muticum* Corb., Mem. Soc. Sc. Nat. Cherbourg 26: 260. 1889 ('*mutica*'). - *R. microcarpon* f. *muticum* (Corb.) Podp., Consp. 296. 1954. - Type: "f. *mutica* mihi in herb." (not seen).

Racomitrium heterostichum var. *nigrescens* Amann 1919. - Lectotype (ZT). - The exsiccate material is made up of large blackish plants with narrow leaves including distinct hair-point, three-stratose costa, and predominantly bistratose margin as in *R. sudeticum*. Var. *nigrescens* belongs to that species.

Racomitrium heterostichum f. **nigrescens* Feld, Sitzungsber. Naturhist. Ver. preussischen Rheinlande u. Westfalen 1926: 67. 1927 *nom. nud.* - Orig.: "Langeviese." (not seen).

Racomitrium heterostichum var. *occidentale* Ren. et Card. 1890. - Lectotype (FH). - Unambiguous type material has been located; and all specimens seem to be duplicates of the original collection (Fig. 13), because they include the same fragments of bryophytes (*Ptilidium*, *Dicranum*) and conifer needles. No specimen was sent from (PC) (where the main herbaria of the authors are housed), but the four known specimens are stated to originate from F. Renauld and/or J. Cardot's herbarium or their Musci Americae Septentrionalis Exsiccati. An (FH) specimen is selected as lectotype; the heading of its outside label is Herb. J. Cardot, while the inside envelope is stamped Herb. Renauld.

Racomitrium heterostichum var. *pulvinatum* Du Buyss. in Herib., Mem. Ac. Sc. Clermont-Ferrand ser. 2, 14: 339. 1899 ('*pulvinata*'). - Type: "Puy-de-Dôme. - Rochers du bois de Valcivière près d'Ambert (F. Gasilien)." - Plentiful original material is located: "*Rhacomitrium heterostichum* Brid. forma *pulvinata* R. Du Buysson. Rochers pres de Valcivière (P. d. D), 27 Mai 1884 Fre Gasilien." (BM); and it is *Grimmia ovalis* (Hedw.) Lindb. Two similar specimens (S, TRH) are dated 26. Juin 1884; and also another without collector but dated 16 Juin 1884 (BM) may be original.

Racomitrium heterostichum f. *repens* Chal. 1882. - Lectotype (H). - The lectotype is made up of small, creeping plants with leaves about 1.85 x 0.4 mm; a short hair-point is often present, and the margin is largely bistratose above. ("Folia minuta, breviuscula, mutica solis supremis brevissime pilosis. Margo ... bistratosum vel unistratosum", according to the protologue.) The leaf characteristics are typical of *R. sudeticum*, of which f. *repens* Chal. is a habitat modification.

Racomitrium heterostichum f. *subepilosum* Möll. 1931. - Three specimens are cited by the author, and all are *R. microcarpon*. The author's specimen from Gästrikland is selected as lectotype (S). Such subepilose or epilose specimens of *R. microcarpon* are easily known by the structure of their costa, basal laminal cells and marginal border.

Racomitrium heterostichum f. *suppapillosum* A. Latzel, Hedwigia 66: 140. 1926. ('*suppapillosa*'). - Type: "K: Speikkogel 2100 m." (not seen). The epithet is perhaps an orthographic error of *subpapillosum*. Its status is uncertain; the epithet probably refers to pseudopapillae sensu this paper.

Racomitrium heterostichum var. *tasmanicum* Hamp., Linnaea 25: 714. 1854. - *R. crispulum* var. *tasmanicum* (Hamp.) Lawt., Bull. Torr. Bot. Cl. 100: 233. 1973. - I have not seen the protologue of this the only southern hemisphere name within *R. heterostichum*. It certainly does not belong to that species but probably to *R. emersum* (see Lawton l.c. for a description and illustrations).

Racomitrium heterostichum var. *tatrense* Chal., Obidka Pamietnika Fizyjogr. 6: 62. 1886. - Type: "Kalatówki. - Kondracka dol. - Ponizéj Waksmundzkiéj polany i az do Rybiego. - Pod Kopa Królowéj. - Dol. Stawów Gasienicowych az do Czarnego stawu. - Dol. Bialéj wody. - 500.-2555. M." (not seen). - Var. *tatrense* is said to be made up of very small plants, 0.2-1.0(1.5) cm altis, and may belong to *R. sudeticum*.

Grimmia himalayana Mitt. 1859. - Lectotype (NY). - The protologue mentiones six specimens as types, viz. Sikkim: J.D. Hooker No. 298, 301, 305, 321, 326, and Nepal: Wallich s.n. All specimens are present in NY-Mitten. Of all - except 298 - there are two small packets, one *with* a number on it, and one *without* a number; below they are marked a and b, respectively. The specimens consists of the following material: 298 *R. verrucosum* var. *verrucosum* (a bad specimen); 301a *R. himalayanum*, 301b *R. himalayanum* plus a few shoots *R. subsecundum*; 305a and b *R. subsecundum*; 321a and b *R. himalayanum*; 326a *R. himalayanum*, 326b *R. himalayanum* plus a single branched shoot of *R. verrucosum* var. *verrucosum* (same as 298); Wallich s.n. a and b *R. fuscescens*. Thus there are four species in the material cited as the type of *R. himalayanum*! Deguchi (1980) selected a lectotype, viz. No. 326b. His Fig. 4 l-q indicate that the leaf lamina and margin are strongly bistratose above. I have studied both sectioned and unsectioned leaves of the lectotype; it may be described as follows: **Plants** very depauperate, brown and blackish and full of sand and mud. **Stem** 0.5-1.5 cm, strongly irregularly branched. **Leaves** 1.7-2.1 x 0.4-0.5 mm. **Hair-point** absent. **Margin** broadly and strongly recurved to the apex on both sides, unistratose with rare bistratose spots below, and unistratose with frequent bistratose spots above in most leaves and with more bistratose spots in some. **Costa** broad, 75-95 µm below and 50-70 µm above, percurrent and filling up the apex, in basal part three-stratose (d. 15-20, c. 1-6, v. 7-10), in middle part three-stratose (d. 14-19, c. (0-)3, v. 6-9), in upper part bi- (to three-)stratose (d. 8-15, c. 0-1, v. 5-6). **Lamina** unistratose below, and with bistratose spots close to the apex, rarely with bistratose spots further down the lamina. **Laminal cells** thin-walled

(as is usual in moist-growing ecads) and sinuose, distinctly pseudopapillose (in younger leaves) (regarding their size, see the main description). **Alar cells** not much differentiated, the basal marginal border of 6-11 esinuose, slightly widened and not quite thin-walled cells. **Seta** about 4 mm long. **Urn** about 1.5 mm long. - In the area there is a taxon which possesses much the same characteristics as the lectotype of *R. himalayanum*. They have in common: (1) a leaf margin which is broadly recurved from base to apex (different from *R. fuscescens* and *R. subsecundum*), (2) a costa which is broad towards the leaf apex (diff. from *R. fuscescens* and *R. subsecundum*), (3) a short basal marginal border made up of not quite hyaline cells (diff. from *R. fuscescens* and *R. verrucosum*), (4) distinctly bulging leaf cell walls (diff. from *R. fuscescens* and *R. subsecundum*); and they lack: (5) a reddish leaf base with auricles (diff. from *R. subsecundum*), and (6) a leaf margin and lamina which are mainly bistratose or have frequent bistratose spots towards the base (diff. from *R. verrucosum*). But the lectotype is untypical for the taxon in question, being a strongly depauperate epilose modification (probably from a moist habitat). This modification of *R. himalayanum* may easily be confused with the same modification of *R. verrucosum* var. *verrucosum*. A reliable difference between them, which fortunately is maintained also in depauperate epilose ecads, is that *R. himalayanum* has a short basal marginal border made up of 4-12(16) moderately thick-walled cells, whereas *R. verrucosum* has a long border of (12)16-22(25) thin-walled hyaline cells. A plant of *R. verrucosum* s.l. is present in the lectotype specimen of *R. himalayanum*; it is excluded from the lectotype. - J.D.H. No. 321 is epilose like the lectotype, but has probably a quite unistratose lamina and a margin which is almost always unistratose (seen 2-3 bistratose spots in t.s. of the NY and BM specimens). No. 301 (Fig. 54) is more robust with pilose leaves, and is a much better match for the bulk of the specimens of *R. himalayanum*. Till now I have seen almost no other specimens which match the epilose Hooker specimens No. 321 and 326. Hooker's main, more plentiful material is at (BM), and all numbers (except 298, where the BM specimen is a *Grimmia*) are identical with the (NY) material (except for fragments).

Racomitrium javanicum Doz. et Molk. in Zoll. 1855. - Lectotype (L). - The lectotype consists of up to 4.5 cm long stems which are slightly, fastigiately branched. It possesses much the same characteristics as the lectotype of *R. subsecundum*; the main differences between them may be summed up as follows: **Leaves** (*jav*: 2.6-2.8 x 0.55-0.7 mm; *sub*: (2.5)3.0-4.5 x 0.65-0.85 mm), **margin** (*jav*: unistratose; *sub*: unistratose above, bistratose below), **costa, width** (*jav*: 85-100 µm below, 35-40 µm above; *sub*: 100-125 µm below, 40 µm above), **costa, stratosity** (*jav*: in lower part d. 12-19, c. 0-3, v. 4-6 - in middle part d. 9-13, c. 0-1, v. 3-4 - in upper part d. 6-7, c. 0, v. 2-3; *sub*: in lower part d. 16-24, c. 2-4, v. 6-9 - in middle part d. 12-20, c. 0-3, v. 4-7 - in upper part d. 7-13, c. 0, v. 2-4), **alar cells** (*jav*: thin-walled cells usually less than 10 and only in the first and second marginal row, the other coloured cells rather or very incrassate, 4-6 differentiated basal marginal cells; *sub*: thin-walled cells usually more than 10 and in 3-5 rows, 6-7 differentiated basal marginal cells). - The leaves of *R. javanicum* are smaller than those of *R. subsecundum*, and the leaf parameters differ accordingly. The difference in the structure of the alar cells

is one of the main distinctions between the Himalayan and SE Asiatic populations of the taxon. Many specimens from SE Asia have no inflated cells at all, but a strongly coloured alar group of (extremely) thick-walled and porose (stellatiform) cells. And although it is not of this extreme kind, the trend is clearly seen also in the type of *R. javanicum*. - Material without locality and collector is also present in (L), but it is difficult to know whether this is the other syntype material of the protologue. A probable duplicate of the lectotype, labelled "Java, legit Teysmann" is at (TRH). Duplicates of the lectotype may also be at (BM) (several specimens labelled "*R. javanicum* Doz. et Mb. Java", and of these especially one marked ex herb. Dozy), but the collector Teysmann is on none of these labels. Also a specimen at (S) may be original (ex herb. v. d. Sande Lacoste).

Racomitrium javanicum var. *brachyphyllum* Card. et P. Vard. in P. Vard. 1923. - Lectotype (PC). - Diagnosis: "A typica forma differt foliis brevioribus." This is not quite true. The leaves in the syntypes are about 2.1-3.2 x 0.8-0.95 mm, which is not very short but rather relatively broad leaves for the species in question. The leaves of the lectotype of *R. javanicum* are 2.6-2.8 x 0.55-0.7 mm; those of the lectotype of *R. cylindricum* are 2.8-3.0 x 0.75-0.85 mm; those of the lectotype of *R. subsecundum* are 2.5-4.5 x 0.65-0.85 mm. Both epilose and pilose leaves occur in var. *brachyphyllum*. The type of the variety has large inflated and auriculate alar cells quite as the type of *R. subsecundum*. For comments on the collectors Foreau and Roine, and the publication of the exsiccate Musci Madurenses, see Sayre (1971: 201f.).

Racomitrium javanicum var. *incanum* Broth. in Hand.- Mazz. 1929. - Lectotype (H-BR). - This is specimens of *R. subsecundum*, with longipilose leaves to 4.5 x 0.8 mm including a strongly flexuose hair-point up to 2.0 mm long. When compared with *R. subsecundum*, these leaf measurments are not remarkable; the leaves of its type are up to 4.5 x 0.85 mm with hair-point to 1.1 mm. Var. *incanum* possesses the usual broad and flat costa (at the base), and the orange-red inflated alar cells. The margin is comparatively broadly and longly recurved (sometimes to the hyaline point), but such plants of *R. subsecundum* are not infrequently met with in the high mountains of Himalaya - Yunnan.

Racomitrium javanicum var. *molle* Broth. ex Herz. 1910. - Lectotype (H-BR). - The type specimens resemble *R. subsecundum* closely. One specimen from "Pedrutalagala (a name which rejoices in as many variants in spelling as it does in syllables!)" was named var. *molle* by Dixon (1915). However, he stated: "This agrees with the brief diagnosis of Herzog's plant, ... and is moreover from the same station. No. 93 is intermediate between the type [*R. javanicum*] and variety, while No. 83 has the long hair-points of the var., but the rigid habit and often subsecund leaves of the type." There is nothing more to add about the taxonomic value of the variety. The plants have leaves with large inflated alar groups; the margin is slightly recurved or sometimes almost flat. It is likely that Herzog saw the plant, but no specimen of var. *molle* was included with the loan from (JE). It should perhaps be quoted as var. *molle* Broth. *in* Herz.

Racomitrium javanicum var. **muticum* Broth. ex Herz. 1910 *nom. nud.* - Specimens from Nuwara Eliya are epilose, but one from Kirigalpota is made up of plants which are usually pilose with long points! Leaf form, recurvance of the margin, and structure of costa and auricles are as in *R. subsecundum*. The costa has more central cells in the middle part of the leaf than the type of *R. subsecundum*, but this is frequently the case in the area.

Racomitrium jensenii Kindb., see *R. sudeticum* var. *papillosum* C. Jens.

Racomitrium laetum Besch. et Card. in Card. 1908. - Lectotype (PC - Fig. 19). - The protologue includes 14 specimen numbers; of these I have seen 7 (No. 506 (2 sp.), 515, 1060, 1061, 2812 - PC; 2812, 87 - S; 3384 - H-BR). All specimens are essentially similar (No. 1060 and 2812 are more dark-coloured than the other) and have e.g. unistratose leaf margin; they belong to the same taxon. The lectotype is made up of about 4 cm long, slightly branched plants; the leaves have a long hair-point; a unistratose margin with rare bistratose spots; and a hyaline basal marginal border of 10-15 or more cells. The only extra-Japanese specimen (No. 87) is more gracile but not different in any other way. No specimen includes sporophytes (and they are not described in the protologue). *Racomitrium laetum* and *R. diminutum* were described at the same time on the same page. Nobody has so far treated *R. laetum* as a synonym of *R. diminutum* or vice versa, at the species level (H. Deguchi, in litt.). Noguchi (1958) treated *R. diminutum* as a variety of *R. heterostichum*, with *R. laetum* as one of its synonyms, stating (translated from Japanese by H. Deguchi, in litt.): "*R. diminutum* and *R. laetum* ... are identical, although the plants of the latter are slightly larger than those of the former." I agree, but prefer to treat *R. diminutum* as a synonym; firstly because the type material of that name is in a bad state, and is depauperate and scanty and therefore not representative of the taxon in question; and secondly because the plants of the taxon is usually not diminutive but rather large (up to more than 10 cm long).

Racomitrium laetum var. *gracile* Sak. 1937. - Lectotype (MAK). - Two syntypes are located, and both are unusually plentiful. The leaf margin of No. 6984 is frequently bistratose, whereas No. 7084 has a unistratose margin. When this characteristic is uncorrelated with other differences, it is considered of no taxonomic importance in the species group concerned. No. 6984 is selected as lectotype of the name, which is a synonym of *R. laetum*.

Racomitrium laetum var. *olivaceum* Sak. 1937. - Lectotype (MAK). - Ten specimen numbers are mentioned in the protologue, three from Kyushu, six from Honshu, and one from Hokkaido; of these I have seen all except one (No. 7816). No. 7039 (MAK) has bistratose leaf margin, the others have unistratose margin. The protologue states: "Caulis perelongatus, 7-10 cm longus"; and a robust specimen with stems up to 10 cm is selected as lectotype. The colour of the plants is considered of no taxonomic importance in the studied group (moreover, I cannot see any difference between these and other specimens), and var. *olivaceum* is a synonym of *R. laetum*.

Racomitrium lawtonae Irel. 1970. - Holotype (CANM). - A plentiful holo- and isotype material has been studied. The species is named after the well-known American bryologist, but she did not accept it (Lawton 1971: 144, 341; 1972: 255).

Racomitrium **lorifolium* Hampe ex Jaeg. 1874 *nom. nud.* - The original material of this undescribed name is selected as holotype of the new *R. capillifolium* var. *lorifolium.*

Racomitrium macounii Kindb. ex Kindb. in Macoun 1889. - Lectotype (CANM - Fig. 9). - I have located one specimen of *R. macounii* collected in August 1885, as stated in the protologue; it is selected as lectotype and is from Selkirk Mountains. An (FH) specimen from the same mountain is collected in 1885 and sent to J. Cardot by Kindberg; it is regarded as original. The other type locality is in Rocky Mountains, but I have seen no specimen labelled "between Cathedral Mountains and Mount Stephens near Field." Possible original material from Rocky Mountains is labelled "near Hector, July 29, 1885." The (TRH) specimen is marked "Type" in Macoun's hand; it is at the same time Canadian Musci 418 (crossed out and changed to) 281, and is similar to the lectotype. One (FH) specimen labelled "Canadian Mosses 101a. *Rhacomitrium Macounii* Kindb. On boulders below Hector B.C. July 29, 1885" is made up of an equal amount of *R. macounii* subsp. *alpinum* and *R. sudeticum*, and another solely of subsp. *alpinum.* An (NY) specimen similarly labelled is *R. macounii* subsp. *macounii.* The label of Canadian Musci 418/281 includes two localities, viz. near Hector mentioned above, and "on the Gold Range north of Griffin Lake, B.C. 1889", and if the locality is not marked (as it sometimes is), it is impossible to know where the specimen comes from. One such specimen (FH) includes subsp. *alpinum* and *R. sudeticum*, whereas another dated 29/7/88 Hector (err. pro 29/7/85?) is subsp. *alpinum.* It is very interesting that Macoun collected both subspecies of *R. macounii* sensu this paper in the same area (near Hector), and that both were included in the concept of *R. macounii* by Kindberg. No possible type specimen is in S-Kindberg.

Bryum **macrocarpon* With. 1801 *hom. illeg.* - Lectotype (OXF-Dill.). - There is an interesting herbarium sheet of *Trichostomum microcarpon* in BM-Turner; it includes at least 13 old specimens. Different specimens are attributed to known bryologists and botanists, like A. Hedwig, (received by Turner?) 1800 (= *Racomitrium sudeticum*); Schwaegrichen, 1802 (= *R. sudeticum*); Dickson, 1802 (= *R. sudeticum*); Stokes, 1803 (= *R. sudeticum*); Mackay, 1804 (from South of Ireland, = *R. sudeticum*); Borrer, 1810 (from Ben Nevis; one specimen is *R. sudeticum*, another "with the habit of *Dic. aciculare*" is *R. macounii* subsp. *alpinum*); Ludwig, 1814 (from Riesengebirge, = *R. sudeticum*). There are also two specimens attributed to Mr. Griffith, 1800 and s.a., and both are *R. sudeticum. Bryum macrocarpon* is given as a synonym of *Trichostomum microcarpon* at the bottom of the herbarium sheet, including a comment: "most probably Withering only wrote this name by mistake for *microc.*" Withering's main herbarium is at (LINN), but the above specimens could be duplicates of the Griffith material cited in the protologue. Withering's literature references are the following: Dill.

47. 29 (Dillenius 1741: Table 47, Fig. 29 = *Bryum hypnoides alpinum, setis et capsulis exiguis* Dill.; the specimen in OXF-Dill. is *R. sudeticum*), Fl. dan. 476 (Oeder 1770: Table 476 is, according to Lindberg 1875: 550, *R. microcarpon*, but the name of Oeder's plant is that of Dillenius' quoted above), Happ. iii. 3 (= ?), and *Br. hypnoides* γ Huds. (Hudson 1762 : 410 = 24 *Bryum hypnoides* γ *Bryum hypnoides alpinum, setis et capsulis exiguis.* Dill. musc. 370. t. 47. f. 29). - *Bryum macrocarpon* With. was at once made a synonym of *Trichostomum microcarpon* Hedw. (Smith 1804: 1244); but as seen from the specimens identified above, this name was at that time largely used about *R. sudeticum* (s.l.). Withering's main reference is Dillenius (1741: Table 47, Fig. 29), and the other quoted authors use Dillenius' name and refer to his Table and Figure. Dillenius' material is selected as lectotype of *Bryum macrocarpon* With., it originates from the same locality as Griffith's (cf. protologue), viz. Snowdon. - It is uncertain whether the epithet was introduced by mistake, as supposed on the herbarium sheet, and it cannot now be treated as an orthographic error. The name *Bryum microcarpon* does not occur in Withering's work, while *B. macrocarpon* is used as a *nomen triviale* on p. 805, and in the Index, p. 876. This is the oldest validly published binomial denoting *R. sudeticum*, but since it is a later homonym of *Bryum macrocarpon* Hedw. 1801 (≡ *Leptostomum macrocarpon* (Hedw.) Pyl.) it is illegitimate.

Racomitrium marginatum Lojacono, Natural. Sicil. 3(4): 66. 1884. - Type: "In scoriis vulcanicis. Nicolosi nelle Sciare sotto Montarso (Zappani)." (not seen). - Because this is regarded a valid species in Index Muscorum (Wijk et al. 1967; they erroneously refer to p. 98), it was considered as a possible member of *Racomitrium* sect. *Laevifolia.* I have seen no type material, but the description indicates that it may be close to *R. lanuginosum* ("folia ... e tertio superiori late marginata membranacea nitida pellucida, ibique denticulata vix inaequaliter cilioluta subundulata, ...). The name could not be placed by Podpera (1954: 299).

Trichostomum microcarpon Hedw. 1801 - Lectotype (G-Hedw./Schwaegr. - Frisvoll 1984a: Fig. 3-4a). - The name was originally used about *Racomitrium sudeticum* plus *R. microcarpon* (see *Bryum macrocarpon*); it was typified by Frisvoll (1984a).

Trichostomum microcarpon var. **alpestre* auct. ex Möll., Ark. Bot. 24A(2): 102, 106. 1931 *nom. nud. in synon.* ('*alpestris*'). - This name is mentioned twice: P. 102 (transl.): 'In (S) is a specimen labelled "*Trich.[ostomum] microcarp.[um]* var. *alpestris* sec.[undum] specimina Swartziana ex Anglia. Danviken och Nacka. Junii 1810." The handwriting is C.A. Agardh's and the specimen ... is certainly collected by him.' (I have not seen the specimen, it is called *R. heterostichum* var. *gracilescens* by Möller). P. 106: 'But in Swartz' herbarium in (S) is a specimen of *sudeticum* which is labelled in Wahlenberg's hand *Trichostomum microcarpon* var. *alpestris.*' (This specimen I have seen, it is *R. affine*). P. 112: 'In Swartz' herbarium in (S) is ... a specimen named "*Trichostomum microstomum alpestre*".' The epithet *microstomum* is probably an error of *microcarpon*; the specimen is referred to that species by Möller (l.c., as *R. ramulosum*), but I have not seen it.

Grimmia microcarpa [fide Lindberg 1875] f. *atra* Sæl. in Broth. et Sæl., Act. Soc. F. Fl. Fenn. 6(4): 80. 1890. - Type: "Ex Umbra ad Mare album (Selin)." (not seen). - The leaf cells are said to be esinuose at the base and rounded in the leaf apex. It is uncertain what the name refers to.

Racomitrium microcarpon var. **calvum* Kindb. ex Möll., Ark. Bot. 24A(2): 121. 1931 *nom. nud. in synon.* - The name is given as a synonym of *R. fasciculare* (as "Kindberg in schedis 1887"). I have not seen the specimen, which probably is in (S).

Racomitrium microcarpon var. *compactum* Röll 1886. - Holotype (WB). - The taxon is briefly described as "Kurz, dick, polsterförmig". The supposed holotype specimen is made up of about 1-2 cm long, quite normal plants of *R. microcarpon.*

Racomitrium microcarpon var. *ericoides* Röll 1886. - Lectotype (WB). - One original specimen of this name is located; it includes much *R. ericoides* (plants about 5 cm long) and a similar amount of *R. microcarpon* (two pieces about 3 cm). The protologue ("schlank, viel- und Kurzästig") fits the *R. ericoides* element best. But it does not quite exclude the *R. microcarpon* element, which is selected as lectotype of the name. The author probably studied this part of the type and identified it as *R. microcarpon*, because in the same article he reports *R. canescens* var. *ericoides* from another locality.

Racomitrium microcarpon f. *fastigiatum* Loeske 1913. - Lectotype (S). - One specimen "von Original", with the label written by the author of the name, has been located. The plants in the type are about 6 cm (see protologue). The stems have many short branchlets, as is usual in *R. microcarpon*, and I cannot see what is special with the specimen. Actually, it seems to be the rule rather than the exception in this species, (firstly) to grow fastigiately or more irregularly branched elongate secondary stems, which (secondly) become subpinnately branched; and if this procedure is repeated the plant may become very intricately branched. F. *fastigiatum* is a synonym of *R. microcarpon.*

Racomitrium microcarpon var. *gracilescens* Röll 1886. - Lectotype (WB). - Both specimens mentioned in the protologue have been located. The one from granite is *Grimmia hartmanii*; that from porphyr is *R. microcarpon.* The latter is selected as lectotype, and fits the protologue's "lang und schlank, wenig- und langästig" well.

Racomitrium microcarpon var. *grimmiaceum* De Not. 1869. - Holotype (RO). - The differential characteristics of var. *grimmiaceum* are found in the structure of its peristome: The teeth are said to be lanceolate, acute or obtuse, entire, close or set apart, and have ladder-like cross-bars. The holotype possesses about 10 old and many immature sporophytes. The peristome teeth are without exception broken and damaged. It therefore seems that the author misinterpreted the structure of the teeth, which, according to the epithet should be *Grimmia*-like. The gametophyte and urn are as in *Racomitrium affine*, which

accordingly is the correct name of the specimen. It is named only *Racomitrium* in sched., but includes the exact data given in the protologue of the variety. Moreover, it is placed on the same sheet as the two specimens of *R. microcarpon* mentioned by De Notaris (1869), viz. "in sylva detle Ghese, leg Anzi" (= *R. microcarpon*) and "in valle Braggia, leg. Garovaglio" (= *R. affine*). It is therefore without doubt the holotype specimen (the same view is held by A. Millozza, RO, in litt.).

Racomitrium microcarpon f. *nigricans* H. Wint. 1910. - Lectotype (JE). - Both syntypes have been located. The one from "Hoitind am Svartisen" (in reality: Höitind or Högtind, meaning the High Peak, just S. of Beiarn centre ab. 30 km N. of the Svartisen glacier, Nordland county), is *R. sudeticum*. The costa of these plants is frequently three-stratose; their margin possesses frequent bistratose spots; and at the base there is no marginal border of *R. microcarpon* type. The other specimen is a mixture of *R. microcarpon* and *R. sudeticum*, with most material of the former. The 'description' ("ganz schwarz") fits all the material. The *R. microcarpon* element is selected as lectotype of the name.

Trichostomum microcarpon [var]. ß. *oblongum* Tayl. in Mackay 1836. - Holotype (BM). - The name was treated by Frisvoll (1984b); it is a synonym of *R. obtusum* f. *obtusum*.

Racomitrium microcarpon [var.] ß. **obtusum* Hampe, Flora 20: 281. 1837 *nom. nud.* - Orig.: Not indicated. - No material so named has been located, and it is uncertain what is meant with this name.

Racomitrium microcarpon var. *palmeri* Kindb. in Macoun et Kindb., Cat. Canad. Pl. 6: 267. 1892 ('*Palmeri*'). - *R. palmeri* (Kindb. in Macoun et Kindb.) Kindb., Rev. Bryol. 23: 19. 1896. - Type: "St. Paul Island, Behring Sea. (Palmer.)" - A probable holotype is at (CANM), it is labelled "St. Paul island, June 10. 1890 Wm. Palmer." On the front of the original cover, Kindberg has written the new name - and the description almost exactly as it appears in the protologue. (Three minor changes have been made: 'the alar ones great [changed to 'large'] and rectangular' 'Differs also from ['the related', added] *Racom. sudeticum*' 'the long upper leaf-cells [changed to 'the narrow leaf-cells']'.) The description is dated Linkoeping 18/3 1892. In (S) is more specimens from St. Paul's Island named var. *palmeri* and marked TYPUS, but none of these are original. They were collected 30.VII.1891 (3 sp.) and 6.VII.1892 by Macoun. - At the same time as Kindberg (1896) made the new combination *R. palmeri* (Kindb.) Kindb., he also described *R. tenuinerve* Kindb. (Type: "Canada: Macoun. Alaska: J.M. Macoun"). Three original specimens named *R. tenuinerve* are at (S): St. Pauls ö, 3.VII.1892 Macoun (2 sp.); and B.C., Revelstoke, 19.V.1890 Macoun. Additionaly, there are three specimens labelled both *R. tenuinerve* and *R. palmeri*: Alaska, Nagai-ön, IX.1892 Macoun; St. Paul Isl. 30.VII.1891 (mentioned also above); and B.C., Skuna, 18.V.1892 Macoun. It therefore seems that Kindberg had no clear concept of his own species. The material is related to *R. fasciculare*, but possesses a short and weak costa. It is perhaps a separate taxon.

Grimmia microcarpa f. *procera* C. Müll., Syn. 1: 805. 1849. - Type: Not indicated. - Diagnosis: "Forma procera, minus ramosa, strictior, ex omnibus partibus autem essentialibus huc certe pertinens." This is *R. sudeticum* fide Lindberg (1875: 559, as *Grimmia microcarpa*), but it more probably belongs to *R. macounii* (subsp. *alpinum*). *Grimmia microcarpa* of Müller (1849) is a synonym of *R. microcarpon* plus *R. sudeticum*.

Racomitrium microcarpon f. *repens* L.I. Savicz in L.I. et V.P. Savicz 1928. - Lectotype (LE). - The description emphasizes dense, adpressed, dark cushions with creeping, radiculose stems. However, the material is typical *R. microcarpon*. According to Sayre (1971) an exsiccate specimen is at (FH).

Grimmia microcarpa [fide Lindberg 1875] f. *subheterosticha* Sæl. in Broth. et Sæl. 1890. - The plentiful holotype specimen (H-BR) is *Racomitrium sudeticum*, and there is nothing special about it. Some plants of *R. microcarpon* adher to the back of one piece (accidental mixture); they are light (whereas *R. sudeticum* is black), and are not considered to belong to the concept of f. *subheterosticha*. See also *Grimmia heterosticha* var. **brevipila* "Broth. et Sæl.".

Racomitrium **micropus* Kindb. in Macoun et Kindb. 1892 *nom. illeg.* - This is a nomenclatural synonym of *R. brevipes* (q.v.).

Racomitrium nitidulum Card. 1908. - Lectotype (PC). - The lectotype is sparse (6-7 plants); but there are 5 isolectotypes (Fig. 58), and altogether there is a plentiful type material. The plants are much branched and include many sporophytes. The specific name alludes to the glistening capsules. The new species was compared with *R. chlorocarpum* (Mitt.) ex Fleisch. and *R. javanicum*; the former is a synonym of *R. crispulum* (Lawton 1972, 1973; Frisvoll 1984c), and the latter a synonym of *R. subsecundum*. Unfortunately, no material of the Korean syntype (No. 627) has been seen.

Trichostomum **nudum* Schleich. ex Schrad., N. J. Bot. (Schrader) 1(2): 198. 1805 *nom. nud.* - Orig.: Plantae Cryptogamae Helveticae. Centuria 3, n. 19. (Orig. spec.: "*Trichostomum nudum*. Ad saxa in valle Servan." - LAU-Schleicher, JE). - Six cushions are included in the large specimen in Schleicher's herbarium, and they are all referable to *Dryptodon patens*. The name was for the first time treated as a synonym of that species by Weber and Mohr (1807: 127). Müller (1849: 805) included it as a possible synonym of his *Grimmia microcarpa* (= *Racomitrium microcarpon/R. sudeticum*), and Jæger and Sauerbeck (1874) as a synonym of *R. sudeticum*.

Racomitrium **obscurum* Kindb. 1888 *nom. nud.* - When the taxon was described, its name was changed to *R. robustifolium* (q.v.). The label of most original specimens includes both names. It is a synonym of *R. macounii* subsp. *macounii*.

Trichostomum obtusum (Retz.) ex Brid. 1801. - Lectotype (OXF-Dill. - Frisvoll 1984a: Fig. 4b-c, 5). - The specific epithet originates from Dillenius' (1741) *Bryum hypnoides alpinum, operculis obtusis*. No species in sect. *Laevifolia* has

obtuse operculum. The problem is discussed by Lindberg (1875, see Frisvoll 1984a). Sometimes when an operculum falls, the teeth keep adhered to each other. The capsule may then (at least by the naked eye) appear to possess an obtuse or mamillate operculum. This phenomenon seems to account for the introduction of the specific epithet *obtusum*, as well as for the epithet of the form *brevirostellatum* (q.v.) of *R. sudeticum*.

Racomitrium obtusum var. *subsimplex* Lindb. 1875. - Holotype (H-SOL). - In accordance with the protologue, the holotype is labelled *R. lanuginosum* by Orr, but it also includes another unpublished specific and varietal epithet written by Lindberg. It seems that Lindberg recognized *R. obtusum* as a species and intended to describe it as new: The specimens quoted by Lindberg (1875: 543) as *R. obtusum*, include the mentioned plus one more unpublished specific epithet *in sched.* (they are not given here, cf. ICBN Rec. 34A). In 1872 Lindberg visited Oxford and studied Dillenius' herbarium including the type of *R. obtusum* (Lindberg 1883). In 1873 he botanized in Ireland and collected the quoted specimens from Lough Bray and Luggielaw (Lindberg 1875). Shortly afterwards he must have recognized the identity of his own and other Irish specimens with Dillenius' *Bryum hypnoides alpinum, operculis obtusis*. The present taxon was accordingly described as a variety of *R. obtusum*. - The description is enormous, it embraces 3 1/2 large pages of Latin text including comments. But the type material is not so interesting as the punctilious description should indicate. It is simply a gracile modification of *R. obtusum* f. *obtusum* concordant with similar modifications of all other species in the section.

Racomitrium occidentale (Ren. et Card.) Ren. et Card., see *R. heterostichum* var. *occidentale*.

Racomitrium pacificum Irel. et Spence 1987. - Holotype (UBC, not seen), isotype (S). - The species was recently described; it was recognized for the first time by Lawton (1971, 1972) as a form of *R. heterostichum* with muticous leaves.

Grimmia papillulata Stirt. 1902. - A lectotype (GLAM) was selected by Frisvoll (1985a: Fig. 3a-f); it is made up of brown plants with narrow leaves including weak margin, weak costa, and elongate upper laminal cells. It belongs to *R. sudeticum*, which is very variable throughout its world-wide distribution area. Plants like *Grimmia papillulata* can hardly be recognized as a taxonomic entity (cf. Frisvoll l.c.).

Racomitrium pergracile Broth. ex Ihs. 1932. - Lectotype (H-BR). - The protologue is in Japanese; regarding Eikichi Ihsiba's (1932) book Nihonsan Senrui no Bunrui, also known as Classification of Mosses in Japan, see Iwatsuki and Noguchi (1979). The protologue of *R. pergracile* reads as follows (transl. H. Deguchi, in litt.): 'Leaves lanceolate to widely lanceolate, with a long hyaline point which is smooth or sparsely and indistinctly low denticulate; upper laminal cells quadrate to slightly elongated rectangular, basal ones elongated; stem slender, up to more than 5 cm long, with short branches.' One specimen (H-BR) is labelled *R. pergracile* Broth. n. sp. by Brotherus, it is selected as lecto-

type. Its plants are 4 rather than 5 cm; but otherwise it fits the description well and is certainly original material. Ihsiba's original specimens were destroyed by fire, but some duplicates are at (NICH) (H. Deguchi, in litt.).

Grimmia **procera* Bals. et De Not. 1838 *nom. illeg.* - De Notaris (1838) gives Belli and De Notaris as collectors. At (RO) there are six specimens from Valle Vigezzo and Valle Anzasca, named *G. procera* and collected by Belli or De Notaris in 1834 or 1835. Four specimens are *Racomitrium sudeticum*, one is *R. macounii* subsp. *alpinum*, and one is *Grimmia hartmanii*. *Grimmia procera* is illegitimate because "*Trichostomum sudeticum*, Funck samml. n. 670 (sic)" (Funck's Kryptogamische Gewächse des Fichtelgebirg's, Heft 28, no. 570 (sic), 1822) is cited as a synonym; regarding a comment on this material, see Frisvoll (1984a: 316); an exsiccate specimen at (RO) has probably been studied by De Notaris.

Racomitrium **pumilum* Wils. in Mitt. et Wils. 1857 *nom. nud.* - The original specimens of *R. pumilum* are also syntypes of *R. himalayanum*, and are described in connection with that name. One specimen (BM) of No. 298 is *Grimmia* sp., while another, which is marked both 298 and 326 and also named *Racomitrium pumilum* Wils. MSS, is *R. himalayanum*. The (NY) specimen No. 298 is *R. verrucosum* s.l., while the (NY) specimen No. 326 is the lectotype of *R. himalayanum*. *Racomitrium pumilum* must be considered an invalid synonym of *R. himalayanum*.

Racomitrium ramulosum Lindb. 1875. - Lectotype (H). - The name was introduced as a *nom. nov.* of *Trichostomum microcarpon* auct. non Hedwig (1801). Hedwig's *T. microcarpon* was included in Lindberg's (1875) "*Grimmia (Eugrimmia) microcarpa* (Dill.; Gmel.) Lindb." together with the type of *Trichostomum sudeticum* Funck. Frisvoll (1984a) selected a lectotype of *T. microcarpon* Hedw. which preserved the traditional interpretation of the name. Thus *Racomitrium ramulosum* is not a nomenclatural synonym of *R. microcarpon*. A lectotype of *R. ramulosum* is selected among the many references given in the protologue. The lectotype specimen is in a bound fascicle of Funck's exsiccate which has been in Lindberg's possession (P. Isoviita, in litt.). The specimen is made up of robust plants with many sporophytes, and is *R. microcarpon*.

Racomitrium ramulosum f. *atrum* Möll. 1931. - Lectotype (S). - Two specimens labelled f. *atra* by Möller, and another probable but not annotated specimen have been located. All are dark-coloured *R. microcarpon*. The lectotype is a blackish mod. *pilosum* with light shoot apices.

Racomitrium ramulosum var. *brevicellulosum* Roiv., Ann. Bot. Soc. Fenn. Vanamo 5(10): 41. 1934. - *R. microcarpon* var. *brevicellulosum* (Roiv.) C. Jens., Scand. Bladmfl. 247. 1939. - Type: "Le, Kilpisjärvi, Siilasmalla, ca. 850 m s.m., ad rupes schistosas horizontales, ster." (not seen.) - I have been unable to locate the type of this name (H, OULU). One specimen so named (Le, Kilpisjärvi, Iso Jehkats, ca. 800 m, 24.7.1934 H. Roivainen - H) is brevipilose *R. lanuginosum*! However, var. *brevicellulosum* is compared with var. *fastigiatum*, and it is likely

that it is a synonym of *R. microcarpon*. But it is of importance to study a specimen.

Grimmia ramulosa f. *crassior* Sæl. in Broth. et Sæl. 1890. - Holotype (H). - It may perhaps be questioned whether the protologue's comparison with *Racomitrium ericoides* ("*Gr. ericoides* subsimili") is a diagnosis or not. One specimen (H) is original. It is labelled ~~*Racomitrium canescens Br.*~~ *microcarpon* f.". It is made up of large, fine plants of *R. microcarpon*.

Racomitrium ramulosum f. **gracile* Möll. 1931 *nom. nud.* - The one specimen mentioned by the author is made up of elongate stems up to 6 cm long; it is typical *R. microcarpon*.

Racomitrium ramulosum f. *humile* Med., Ark. Bot. 20A(10): 36. 1926 (*'humilis'*). - Type: "I Blåhammarfjällets a[lpina] r[egion] ..." (not seen). - Description (translated): 'Merely one cm high, slightly branched, but with typical form of leaf and capsule.' Specimens collected by Medelius from the area are present in the herbaria, but none is marked f. *humilis*. The form is referable to *R. microcarpon* or *R. sudeticum*, and cannot be placed before a specimen turns up.

Racomitrium ramulosum f. **propaguliferum* Möll. 1931 *nom. nud.* - One specimen has been seen. On the inside label it is stated that there are "rikligt groddtrådar å bladen" (plenty of filamentous gemmae on the leaves). This could have happened to be a plant analogous to the gemmiferous *R. vulcanicola*, but it is not. The so-called gemmae are simply blue-green algae which are present on and among the leaves in abundance. The moss is *R. microcarpon*. A specimen from Ucluclet, B.C., Canada, referable to the same species, was labelled f. *propagulifera* by Macoun in sched. (S); and it has a similar blue-green alga on its leaves.

Racomitrium ramulosum f. *repens* Möll. 1931. - Holotype (S). - The plants of the holotype deserve their name, as they really have been creeping on a rock face; and bundles of red-brown rhizoids are present along the whole stems. The old parts of the flat specimen are largely overgrown by thalli and podetia of a *Cladonia* species. But f. *repens* is merely a habitat modification of *R. microcarpon* and not worthy of taxonomic recognition.

Racomitrium ramulosum f. *subepilosum* Möll. 1931. - Lectotype (S). - Four specimens named by the author have been seen, and all are *R. microcarpon*. The selected lectotype includes an inside label as follows: "ytterst liten hårudd, eller saknas" (very short hair-point, or wanting). The specimen is a typical mod. *subepilosum*.

Racomitrium ramulosum var. *terrestre* Hag. 1909. - Lectotype (TRH). - No specimen is labelled var. *terrestre* by Hagen. The Norwegian text quoted as type may be translated as follows: 'Here and there on soil on the highest mountains, everywhere sterile.' '... it grows on the higher mountains, even on the peaks, (Gausta 1800 m, Dyrhaugtinden ca. 2000 m, Gladhøen up to 1800 m, Tronfjeldet

and Knutshøen up to 1700 m).' The following possible type material has been located: Hedmark: Alvdal, Tronfjeldet, varden [the cairn], 1740 m, 29.VII.1908 Borgen (TRH); toppen av [the peak of] Tronfjeldet, Borgen s.a. (TRH, dupl. of the preceding?). Oppland: Galdhø prope lacum Juvvatn, ca. 1800 m, 11.VIII.1887 Hagen (O, TRH). Telemark: Gausta, 5.VIII.1890 Ex herb. Kiaer (TRH). The specimen collected by the cairn of Tronfjeldet is selected as lectotype of var. *terrestre*. It confirms with the Latin description, and the Norwegian description given on p. 85 (translated): 'However, here [on the higher mountains] it occurs in another form than the usual, in that it grows on the bare ground in dense, erect cushions easily falling apart.' Bryologists who have botanized on the high (not too westerly) Scandinavian mountains, know these large beautiful cushions of *R. microcarpon* well. I have collected *R. microcarpon* and *R. sudeticum* by the lake Juvvatnet, 1840 m a.s.l., probably close to the place where var. *terrestre* was collected in 1887 by Hagen. No herbarium specimen of the two or of other taxa in sect. *Laevifolia* has been collected at a higher site in Scandinavia. The locality is close to the highest Scandinavian mountain, Galdhøpiggen, 2469 m a.s.l. I looked for the two along the route from Juvvasshytta (hut) across Juvflyi (mountain plateau) to Styggebreen (glacier), up to 2000 m, but did not find them there. - Hagen's and my material of *R. microcarpon* from Juvvatnet is depauperate, and do not agree well with the description of var. *terrestre*. But the lectotype is taken from a typical cushion and made up of parallel, erect stems about 4 cm high. From field studies I am convinced that the taxon is nothing but a modification. Frequently, the cushions are initiated on stones and are gradually growing large, covering both nearby soil, gravel and stones. And cushions growing entirely on flat stones have the same appearance as those growing on soil. There is nothing in the structure of the plant which separates it from specimens growing on rocks at lower elevation. Var *terrestre* is one of a few subordinate names of *R. microcarpon* which have been included in different floras (Brotherus 1923, Jensen 1939, Nyholm 1956). A supposed distinction between var. *terrestre* Hag. 1909 and var. *fastigiatum* (Loeske) Med. 1926 is discussed by Medelius (1926); he finds it hardly possible that the two are identical. I think they are, and when both are considered mere habitat modifications, the question of priority touched by Medelius becomes uninteresting.

Racomitrium robustifolium Kindb. in Macoun 1890. - Lectotype (S). - No specimen has been located which fits the protologue completely (i.e. which is collected at 5700 feet), but many have the correct date and locality on their label. The specimen in S-Kindberg is selected as lectotype; it includes fragments of *R. aciculare* and other mosses which are excluded from the type. One specimen is *R. macounii* subsp. *macounii* like the lectotype, but another is *R. aciculare*, and a third is *R. occidentale* (all CANM). A (TRH) specimen is a mixture of *R. macounii* subsp. *macounii* and *Dryptodon patens* (p.p. major), whereas an (FH) specimen includes *R. aciculare* and traces of *R. macounii* subsp. *macounii*. The specimens are distributed as Canadian Musci 419 (sometimes crossed out and renumbered)/284, Canadian Musci 245, and Canadian Musci 190a, and named *R. obscurum* (printed) and *R. robustifolium* (hand-written). Specimens of Canadian Musci 419/284 collected Aug. 10, 1889 on the Gold Range N. of Griffin Lake,

are not original material of *R. robustifolium* (fide protologue). The differences between *R. robustifolium* and *R. macounii* mentioned in the protologue are relative and of slight/no taxonomic importance.

Racomitrium sakuraii Broth. ex Sak. 1937. - Lectotype (MAK). - I have located two specimen numbers bearing this name, viz. Sakurai No. 308 and 310 (H, MAK). There is no trace of the protologue's No. 311. One confusing (MAK) specimen is labelled "508, 510 *Rh. Sakuraii*. Shiobara [in Japanese] 11, 1920"; it is annotated as follows (transl. H. Deguchi, in litt.): 'No. 508 and No. 511 were cited as the syntypes in the original description, but on the present sheet No. 508 and 510 are seen together. Disagreement in specimen number seems to be ascribed to miscitation. Jan. 11, 1971 U. Mizushima.' - The sporophyte including calyptra and operculum is described in the protologue, and the (MAK) specimen No. 310 includes all these characteristics, viz. one operculate capsule with and two without calyptra, and two deoperculate old capsules. The (H-BR) specimen No. 310 has but broken old setae, and all three duplicates of No. 308 are sterile. The fertile specimen is selected as lectotype. The name is a synonym of *R. laetum*.

Trichostomum saxatile Tayl. 1843. - Lectotype (BM). - This name was typified by Frisvoll (1984b); it is a synonym of *Racomitrium obtusum*. The specimen labelled "Carig, 4 June 1833" and supposed to be subepilose *R. obtusum* (Frisvoll l.c.), was correctly interpreted.

Racomitrium skottsbergii Card. et Broth. 1923. - Frisvoll (1986: Fig. 2g-l) selected a lectotype (PC) of this name; it is *R. sudeticum*.

*Trichostomum *stenocarpum* Hampe ex Hüb., Musc. Germ. 208. 1833 *nom. nud. in synon.* - Orig.: Not indicated. - When published, this name was treated as a synonym of *Racomitrium heterostichum*. I have seen no original material.

*Racomitrium *subheterostichum* C. Müll. ex Jaeg. 1874 *nom. nud.* - Many original specimens are present in many herbaria. They are in no important characteristic different from the lectotype of *R. subsecundum*; they have, e.g., a broad costa which becomes narrow in the apex, and large red auricles.

Grimmia sublurida Stirt. 1887. - Lectotype (GLAM). - The name was typified by Frisvoll (1985a: Fig. 1a-f); it is a synonym of *Racomitrium sudeticum*.

Trichostomum subsecundum Hook. et Grev. in Hook. 1836. - Lectotype (BM - Fig. 60). - There is no description in the protologue, which is made up of a figure including a cluster of plants with four sporophytes; one leaf; one pilose leaf apex; one capsule with peristome and above that an operculum; and two teeth (Hooker 1836). Since a description is lacking, the epithet has often been ascribed to Mitten (& Wils. 1857, as *Racomitrium*; 1859, as *Grimmia*), cf. Paris (1898, 1905) and Dixon (1915). And with such a late date the supposed synonym *R. javanicum* 1855 would have priority. However, according to ICBN Art. 44, 1-2 (Voss 1983) "The name of a species ... published before 1. Jan. 1908 is

validly published if it is accompanied only by an illustration with analysis." "Single figures of non-vascular plants showing details aiding identification are considered as illustration with analysis"; see also Art. 32.6 Note 1. *Trichostomum subsecundum* was therefore validly published in 1836. - No original locality or specimen is given in the protologue. However, from annotations on the specimens named *T. subsecundum* in BM-Hookerianum, and from specimens cited by Mitten (1859), it is clear that the original material is that collected in Nepal by Wallich. No exact model for the Figure is found in the herbarium. But the appearance of the arcuate, slightly or not branched stems with strongly secund leaves, and the elongate setae with operculate and deoperculate elongate capsules, is as in the figure. The pencil drawing forming the basis for Hooker's Table 17, Fig. 5 is glued to the sheets in two versions, none of which is exactly like the published figure. The material is split into two larger (on one sheet) and three smaller portions (on another sheet), and all are marked "H 2716", "H 2716 dup" or "orig. spm" and also "H. Ic. Pl. t. 17. f. 5". This appears to have been done by Wilson, June 9. 1857, perhaps when he was preparing his account on J.D. Hooker and Thomson's Indian mosses (Mitten & Wilson 1857). - *Trichostomum subsecundum* is the oldest name of a polymorphous taxon with a very wide distribution, and the characteristics of the type material are of great importance; the lectotype may be described as follows (Fig. 60): **Plants** yellowish brown. **Stem** not or slightly dichotomously branched. **Leaves** falcate, especially at the shoot apices, 3.0-3.2 x 0.65 mm in epilose leaves and to 4.5 x 0.85 mm in large pilose leaves, orange-red close to the base. **Hair-point** up to 1 mm, lowly and obtusely denticulate in long points, and almost or quite edenticulate in short ones, somewhat decurrent in the longest points but otherwise not. **Margin** broadly recurved or folded to 1/2(-3/4) the leaf length on one side, and more narrowly recurved in the broadest part of the leaf or rarely flat on the other side, unistratose above and mostly bistratose for one cell row below. **Costa** reaching into the hair-point, or ending very close to the apex in epilose leaves, dorsally convex and canaliculate above and flatter below or quite dorsally and ventrally flat close to the base, 100-125 µm broad at the base and about 40 µm broad above, in lower part three- (to four-)stratose (d. 16-24, c. (0)2-14, v. 6-9), in middle part bi- to three-stratose (d. 12-20, c. 0-3, v. 4-7), in upper part bistratose (d. 7-13, c. 0, v. 2-4). **Lamina** unistratose (except for one bistratose spot seen in t.s.). Basal **laminal cells** elongate (25-50 x 9 µm in epilose leaves, 40-80 x 10 µm in pilose leaves), middle and upper cells rectangular (15-35 x 7 µm), upper marginal cells quadrate to rectangular (7-28 x 9-10 µm). **Alar cells** strongly differentiated, orange-red and auriculate, thin-walled and inflated in 3-5 cell rows and for 6-7(10) cells in the marginal row, the marginal cells immediately above the alar group thick-walled and usually sinuose. **Seta** about 1.6 cm. **Urn** about 2.5 mm.

Racomitrium substenocladum Card. 1911. - Lectotype (PC). - The name is a synonym of *R. sudeticum*; the lectotype is from the southernmost known locality of that species, viz. from the Antarctic Peninsula (Frisvoll 1986: Fig. 2a-f).

Racomitrium substenocladum f. **nigrescens* Card. et Broth. 1923 *nom. nud.* - The original material of this name (H-BR, S) is *R. sudeticum*.

Trichostomum sudeticum Funck 1820. - Lectotype (M - Frisvoll 1984a: Fig. 6). - The lectotype was selected, described and figured by Frisvoll (1984a).

Racomitrium sudeticum var. *alaskanum* Card. et Ther. 1902. - Isotype (NY). - The known isotype is made up of six shoots, about 1 cm long, including four deoperculate sporophytes. The plants possess all characteristics of *R. sudeticum*: The leaves are narrow, the cells distinctly pseudopapillose, and the margin uni- and bistratose. The hair-point is short or absent ("foliis subepiliferis vel apiculo hyalino omnino destitutis", fide protologue), but long in perichaetial and subperichaetial leaves. No specimen was received from PC-Cardot/Theriot, but a holotype is thought to be there.

Racomitrium sudeticum f. *alpinum* Lawt. 1971. - Holotype (WTU). - The type of f. *alpinum* possesses leaves which are imbricate and not contorted; their margin is bistratose for 2-4 cell rows and includes three-stratose spots, and their costa is four-stratose. The name is the oldest known valid one of a widespread taxon related to *R. macounii*, and it is considered to be a subspecies of that taxon. The leaf cells of the holotype are not at all so strongly pseudopapillose as in Lawton's (1971: Pl. 77, Fig. 5) original figure. Holzinger's Musci Acrocarpi Boreali-Americani Nos. 272 and 622 are quoted and must be considered as paratypes; I have seen several duplicates of No. 272, and it is subsp. *macounii*.

Racomitrium sudeticum f. *americanum* Lawt. 1971. - Holotype (WTU). - The type material is made up of plants about 1-2 cm long. Their leaves are short, ± 1.9 mm, with a strongly thickened, two- to four-stratose margin which in upper part is confluent with a more or less bistratose lamina; their costa is four- (to five-)stratose and comparatively robust in such a small leaf. It is a curious plant, which is related to *R. macounii* subsp. *alpinum*. The holotype seems to include a few robust plants matching the type of subsp. *alpinum*, but no doubt Lawton (1971) described the plentiful, small plant. More specimens of it exist from the type mountain (e.g. "Mt. Rainier, alt. 6000 ft., along rivulets, Aug. 1895, Piper 258" - NY), and some few specimens from nearby localities seem to be the same. F. *americanum* is probably not a mere modification of subsp. *alpinum*, but is placed as a synonym of that name. A few south European specimens seem to have much the same leaf characteristics as f. *americanum*.

Racomitrium sudeticum var. *aquaticum* Mol., Flora 47: 583. 1864. - *R. heterostichum* subsp. *sudeticum* f. *aquaticum* (Mol.) Podp., Consp. 296. 1954. - Type: "[Italy] Caoria, Lagetto (della Cimadasta)." (not seen). - Boulay (1884) stated that var. *aquaticum* "est une forme de la var. *validius*", and Limpricht (1890) placed var. *aquaticum* "in den Formenkreis von var. *validius*". This is likely, but whereas var. *validior* Jur. is a synonym of *R. macounii* subsp. *macounii*, var. *aquaticum* may belong to subsp. *alpinum* and eventually be an older name of the taxon (see also *Grimmia microcarpa* fo. *procera*). The question connot be solved without a specimen. Diagnosis: "caulibus laxifoliis procumbentibus, foliis humidis recurvis, junioribus apice hyalinis, reti seniorum genuino generis."

Racomitrium sudeticum var. *atratum* Hesselb. 1918. - Lectotype (C). - The Danish text of the lectotype's label tells that similar plants are common on rocks in the area. The specimen is depauperate and (sub)epilose; it has a three-stratose costa and a bi- and unistratose margin, and belongs to *R. sudeticum*.

Racomitrium sudeticum f.**atratum* Sak. 1937 *hom. illeg.* - Holotype (MAK). - The type is made up of black plants; their leaves are small, with narrow apex with or without a hair-point; their margin is bistratose (for one cell row) with unistratose spots, and their costa three-stratose. It is not principally different from the lectotype of *R. sudeticum*.

Racomitrium sudeticum var. *baurii* Loeske, Laubm. Eur. 1: 180. 1913 ('Baurii'). - Type: "aus Norwegen (bei Finse, 1300 m, im August 1911 mit teilweise bedeckelten Sporogonen, l. W. Baur)." - The taxon is thoroughly described and is very probably a depauperate modification of *R. sudeticum*. However, depauperate *R. microcarpon* has often been named *R. sudeticum*, and a specimen should be studied before var. *baurii* is definitely placed.

Racomitrium sudeticum f. *brevirostellatum* Vilh. 1925. - Lectotype (PRC). - No specimen is labelled f. *brevirostellatum* by Vilhelm. I have seen 14 specimens collected by Vilhelm at the syntype localities. One of the labels includes a simple drawing of an elongate capsule with a short central rostrum or mamilla, agreeing with the description's "Operculum brevirostratum vel mamillare". There are many deoperculate capsules in the specimen. One agrees with the drawing and description, which, however, are based on a curious misinterpretation. The same error was made, I think, when Dillenius (1741) described *Bryum hypnoides alpinum, operculum obtusis*, see *Trichostomum obtusum*. The fact seems to be as follows: When the operculum falls, the teeth do not always spread out but remain in exactly the same position as before. They therefore form something like a cupola or tent at the top of the urn. In a bad microscope this structure may imitate a short-beaked or mamillate operculum. Three other Vilhelm specimens exhibit the same sort of capsules. Two of these include as well operculate capsules with long-rostrate operculum, and are therefore not considered. The specimen with the drawing seems to be the only safe choice when a lectotype is to be selected. It is made up of much *R. microcarpon* and one piece *R. sudeticum*; the latter includes two capsules with spreading or broken teeth, whereas *R. microcarpon* includes one capsule matching the drawing. Therefore, the *R. microcarpon* element is selected as lectotype of f. *brevirostellatum*.

Racomitrium sudeticum f. *canescens* Boul., Muscin. France 362. 1884. - Type: "On trouve au Hohneck ..." (not seen). - The form is compared with *R. sudeticum* var. *longipilum* Warnst. and supposed to belong to *R. affine* by Loeske (1930: 216); I have seen no specimen.

Racomitrium sudeticum f. *compactum* Limpr. 1889. - Lectotype (BP). - One specimen collected by the author at the type locality and labelled *R. sudeticum* forma, agrees well with the protologue and is selected as lectotype. It is made up of dense, blackish and subepilose plants of *R. sudeticum*.

Racomitrium sudeticum var. **epilosum* H. Müll. ex Torre et Sarnth., Fl. Tirol. 5: 276. 1904 *nom. nud.* - Orig: "M Mittereck bei St. Valentin auf der Heide 26-2900 m (Breidl.)." (not seen).

Racomitrium sudeticum f. *epilosum* Vilh. 1925. - Lectotype (PRC). - Five specimens named f. *epilosa* by Vilhelm have been seen. One is *Dryptodon patens*, one *R. macounii* subsp. *alpinum*, and three *R. sudeticum*. The protologue allows a hair-point to be present ("folia epilosa vel brevissime pilosa"); none of the specimens of *R. sudeticum* are epilose (cf. also the subepilose state of the lectotype of *R. canescens* var. *epilosum* H. Müll., Frisvoll 1983a: 145). One *R. sudeticum* specimen is selected as lectotype.

Racomitrium sudeticum f. **epilosum* Mönkem. 1927 *nom. nud.* - No original specimen has been seen, but the name is surely a synonym of *R. sudeticum*.

Racomitrium sudeticum f. *fastigiatum* Vilh. 1925. - Lectotype (PRC). - Five specimens from the type locality have been studied, two are named *R. sudeticum* f. but none f. *fastigiatum*. However, no doubt the specimens are original, and one is selected as lectotype. All are referable to *R. sudeticum*. There is nothing special with the lectotype or the other specimens, but Vilhelm supposed that f. *fastigiatum* was "Forma transitoria ad *R. heterostichum* vel forma transitoria *R. heterosticha* ad *R. sudeticum*." He was apparantly interested in such possible intermediates; previously (Vilhelm 1922) he had described *R. microcarpon* ♀ x *heterostichum* ♂ (*R. tatrense*, q.v.).

Racomitrium sudeticum var. *grimmioides* Trautm. ex Loeske, Laubm. Eur. 1: 180. 1913. - Type: "im Kanton Tessin bei Fusio am Sasello-Pass auf Gneis bei 2400 m, leg. Trautmann." (not seen). - This is probably *R. sudeticum*, but a specimen must be studied before this can be definitely known.

Racomitrium sudeticum var. *longipilum* Warnst., Krypt. Fl. Brandenburg 2: 311. 1904. - *R. heterostichum* subsp. *sudeticum* f. *longipilum* (Warnst.) Podp., Consp. 296. 1954. - Type: "Renauld sammelte diese Pflanze in den Pyrenäen bei 2000 m und Römer an Conglomeratfelsen im oberen Weezetal bei Eupen." (not seen). - The type of var. *longipilum* may belong to *R. affine*, see Loeske (1913: 180, 1930: 216), but this can only be established by studying the original material.

Racomitrium sudeticum var. *minus* Spruce, Ann. Mag. Nat. Hist. ser. 2, 3: 495. 1849. - Type: "in loco alpina Port de Bénasque dicto." (not seen). - This is probably *R. sudeticum*. The taxon is said to have a peristome with a basal membrane. The original should be studied.

Racomitrium sudeticum var. *molle* Röll 1903. - The holotype (WB) is not at all remarkable, and is *R. sudeticum*. The protologue is insignificant ("Rasen weich, durch längere Haarspitzen grau-gelbgrün.").

Racomitrium sudeticum var. *obtusifolium* Loeske 1903. - Neotype (S). - The label of the neotype is written by Loeske, and the specimen is collected at one of the given type localities. The specimen is epilose and may not have been able to develope hyaline points. Similar epilose plants have also been found mixed with pilose plants (cf. also *R. heterostichum* var. *gracilescens*). The name may be used about such genetically fixed epilose plants of *R. sudeticum*. The structure of the other parts of the leaf is not different from pilose ecads of *R. sudeticum*: The leaf margin is unistratose with frequent bistratose spots in upper part; the costa is three-stratose; and there are 5-10 pellucid basal marginal cells. The type locality is the same as for *R. sudeticum* var. *subepilosum* Warnst.

Racomitrium sudeticum f. **obtusifolium* Vilh. 1925 *hom. illeg.* - The holotype (PRC) is made up of plants with obtuse and brevipilose leaves; the leaf margin is sparsely thickened but has frequent bistratose spots in upper part; and the costa is weak but often three-stratose. F. *obtusifolium* is a synonym of *R. sudeticum*.

Racomitrium sudeticum var. **obtusum* Velen. ex Vilh. 1925 *nom. nud. in synon.* - This is the original label name of the lectotype of *R. sudeticum* f. *obtusifolium* Vilh., see above.

Racomitrium sudeticum var. *papillosum* C. Jens. 1887. - Lectotype (C). - Diagnosis: "Folia minute, sed evidenter papillosa." The "papillae" of var. *papillosum* are probably the same as those of *Grimmia papillulata*, viz. false papillae resulting from disorganization and bleaching of the cell walls (Frisvoll 1985a). It is nothing special about the blackish, depauperate plants of the type, they are *R. sudeticum* with no true papillae. The cells are slightly pseudopapillose as usual in the species, but I do not think the name was meant to characterize these pseudopapillae.

Racomitrium sudeticum var. *robustum* Lindb. ex Vent. 1899. - Lectotype (H-BR). - The plants of the type material are robust and elongate - up to 7 cm in the lectotype, with stems not or slightly branched. The leaves are narrow towards their apex and they sometimes include a distinct yellowish-hyaline hair-point (up to 200 µm long); the margin is strongly thickened, sometimes it is 3-4 stratose. Some characteristics, like the hair-point and the narrow leaf apex, approach *R. macounii* subsp. *alpinum*; but when all characteristics (and especially the contorted leaves) are considered, the variety seems nearer to subsp. *macounii* - of which it is treated as a synonym. But plants like var. *robustum* is one of the reasons why subsp. *macounii* and subsp. *alpinum* are treated as such in this work, and not as proper species.

Racomitrium sudeticum var. **robustum* Broth. ex Ihs. 1932 *hom. illeg.* - ? Holotype (H-BR). - This illegitimate homonym is the only synonym of *R. nitidulum*. When compared with the type material of that name, the type of var. *robustum* is really robust, with plants up to 6 cm long. They grew in a sandy habitat. About three stems of *R. laetum* are closely intermingled with *R. nitidulum* (they are inconspicuous and are not regarded as a part of the type). The Japanese

protologue reads (translated): 'This specimen deviates from the species ('original') as follows: It is larger and coarser, the leaf hair-points are shorter and more sharply pointed, and the cells are elongate and partly longer than in the species.' The name of the type specimen is hand-written by Brotherus, and may be a holotype (if more specimens exist, perhaps in some Japanese herbarium, it becomes the lectotype).

Racomitrium sudeticum var. *subellipticum* Card., Bull. Herb. Boiss. ser. 2, 8: 333. 1908. - *R. subellipticum* (Card.) Sak., Bot. Mag. Tokyo 51: 105. 1937. - Type: "Japon: Onikobe (n. 161); Iwakisan (n. 2634); Takayu, rochers, 1200-1600 m. (n. 2863, 2872, 2879); Ubayu, rochers, à 1300 m. (n. 2816, 3194); Hokkado, pierres, à 1300 m. (n. 2935, 2938, 2951 in parte, 2952 in parte, 2953); Komagatake, rochers, à 2300 m. (n. 3381, 3393, 3394, 3395, 3396)." - I have seen some syntypes of this name (H, NY, S); they possess papillose leaf cells and belong to sect. *Papillosa.*

Racomitrium sudeticum var. *subepilosum* Warnst. 1893. - No original material has been seen. The cited topotype is made up of epilose and subepilose plants which fit the diagnosis ("Rasen dicht und polsterförming. Blätter fast haarlos."). *Racomitrium sudeticum* is common in the area, and subepilose depauperate modifications like this will always be present.

Racomitrium sudeticum f. **subepilosum* Möll. 1931 *hom. illeg.* - Lectotype (S). - I have seen two specimens collected at Surte glasbruk (glassworks) in 1900. The plants grew in sand 'by the sand gutter' and are made up of epilose and some subepilose stems. They were originally named *R. obtusum* by the collector, and f. *subepilosa* by Möller in 1929. Additional specimens were collected by Hjärne at the same locality in 1902; they are named similary by him and later by Möller. One specimen (S) includes the following label: "Entspricht ungefär *Rh. sudeticum* f. *subepilosa.* Zellen weit herab kurz. Det. L. Loeske." The form should therefore probably be called f. *subepilosum* Loeske ex Möller. The 1902 material includes the same expression of *R. sudeticum* plus a different plant which is considered to be extremely depauperate *R. heterostichum* (almost unidentifiable but very interesting epigeic modification).

Racomitrium sudeticum [var.] γ. *tenellum* Boul., Muscin. France 362. 1884. - *R. sudeticum* f. *tenellum* (Boul.) Vilh., Vestn. K. Cesk. Spol. Nauk. Tr. 2: 24. 1925. - Type: "la var. *tenellum*, htes Vosges, sur un tas de pierres entre le Hohneck et le Rotabac (Musc. de l'Est. p. 652), Mt-Dore, Aiguilles de Bozat (Lamy)." (not seen). - Limpricht (1890: 800) and Loeske (1930: 216) referred this name to *R. microcarpon*, but they had not seen any specimen. It is said to possess a delicate long hair-point. A specimen is needed before the name can be finally placed.

Racomitrium sudeticum f. *terrestre* Bauer 1924. - Lectotype (S). - The exsiccate material of f. *terrestris* is collected near the locus classicus of *R. sudeticum*, and the two are similar.

Racomitrium sudeticum var. *trichophyllum* Warnst., Schr. Naturwissensch. Ver. Harzes in Wernigerode 1893: 29. 1893. - Type: Not indicated, but collected on "Exkursionen in der Nähe von Wernigerode und über Schierke nach dem Brocken." [p. 27] (not seen). - The short diagnosis ("Rasen höher [than var. *subepilosum*, q.v.], weniger dicht, Blätter fast alle mit verlängertem Glashaar.") indicates that it perhaps not belongs to *R. sudeticum*. Maybe it is similar to *R. sudeticum* var. *longipilum* Warnst. (q.v.), which the author later treated as *R. affine*. But original material should be seen before this is established.

Racomitrium sudeticum var. *validior* Jur. 1882. - Lectotype (GJO). - I have seen six syntypes, from all localities mentioned in the protologue, and they belong to *R. macounii* subsp. *macounii*. The material is very plentiful. The sporophyte is described in the protologue, and two of the specimens are fertile. The lectotype has very short or no hair-points, as emphasized in the protologue. The other fertile specimen has longer hair-points more like subsp. *alpinum*, but the leaves of all specimens are contorted when dry as opposed to those of subsp. *alpinum*. The lectotype has a very robust, four- or sometimes five-stratose costa; its leaf margin is bistratose for 2-3 cell rows and includes three-stratose spots above, and bistratose for one or more cell rows almost to the base.

Grimmia sulcipila C. Müll., Syn. 1: 805. 1849. - *Racomitrium sulcipilum* (C. Müll.) Par., Ind. Bryol. 1081. 1898. - Type: "India orientalis, litus Coromandel: ex Hb. Tilesii habuit Kunze." - I have located one specimen labelled "*Racomitrium sulcipilum* (C.M.). Cap." (S-Ångström). It is inadequately labelled, but is perhaps a part of the original (Ångström lived from 1813 to 1879). The material belongs to *R. lanuginosum* s.l.

Racomitrium tatrense Vilh. 1922. - Holotype (PRC). - The supposed hybrid is described by Vilhelm (1922, 1925); the Czech text of the latter reference is translated into English by Z. Soldan (in litt.): 'I further observed an interesting case in this species [*R. microcarpon*], in a specimen collected from granitic rock in a fir-tree forest between the villages Matliary and Kezmarské zleby by the little town Tatranská Lomnice in Vysoke Tatry in August 1919. Wholly probably it is *R. microcarpon* ♀ x *heterostichum* ♂ (*R. tatrense* Vilh.). The gametophyte of this hybrid is quite normal and identical with *R. microcarpon*, while the sporophyte corresponds to *R. heterostichum*. This case shows that this species [*R. microcarpon*] will be independent [from *R. heterostichum*].' I do not fully understand the 1922 text, but it appears to tell the same. The quoted passage is considered to fulfil the requirements of a diagnosis, and hence *R. tatrense* is regarded as validly published. The ICBN does not seem to mention sporophyte hybrids of mosses (cf. Art. 40, H. 1-12), despite the fact that such hybrids are described in many moss genera. Although it is not an important field of moss taxonomy and nomenclature, the task should be paid attention to by a note in the Code. - Because *R. tatrense* is the only mentioned hybrid in *Racomitrium*, I was anxious to see the original. Its gametophyte is without doubt *R. microcarpon*. Unfortunately, only one single capsule is present now, but some broken setae indicate that there have been more. The urn is about 2.0 x 0.3 mm, with narrow mouth and dull, wrinkled, light brown exothecium. The length of the

urn is as in small capsules of *R. heterostichum*, but that species has urns with smooth (glistening, when not too old) exothecium. The size of the urns of the species in sect. *Laevifolia* varies much, and I do not believe that the variation is due to hybridization and that deviating capsules generally are sporophyte hybrids. Such hybrids between moss species with similar sporophytes may be difficult to demonstrate at all. Short capsules of *R. heterostichum* and *R. affine* are always glistening and firm like their large capsules. And when *R. microcarpon* has long capsules (I have seen some specimens with capsules as long as that of *R. tatrense*), they are dull and wrinkled just as the shorter more average ones. Möller (1931: 113) noted about *R. microcarpon* (translated): 'The capsule is usually rather short cylindric but may now and then be elongated.' I therefore conclude that the supposed sporophyte hybrid *R. x tatrense* is but sporophytes of *R. microcarpon* with elongate theca. See also *R. sudeticum* f. *fastigiatum* Vilh.

Racomitrium tenuinerve Kindb., see *R. microcarpon* var. *palmeri*.

9.0 NAMES WITHOUT LOCATED TYPES

The following 30 names (including 8 *nom. inval.*) probably belong to sect. *Laevifolia*, and 5 of them have also been placed in synonymy of names in the section, but so far original material has not been studied. *Grimmia heterosticha* var. *brevipila* "Broth. et Sæl." was probably not intended as a new name. For additional comments, se chapter 8.0.

Racomitrium canescens var. *brevisetum* Brid. 1826.
Trichostomum fastigiatum Wallr. 1831 (= *aff*).
*T. *gracile* Schleich. ex Hüb. 1833 *nom. nud. in synon.*
Racomitrium heterostichum var. **alpestre* Meyran 1915 *nom. nud.*
(*Grimmia heterosticha* var. **brevipila* "Broth. et Sael." 1890 *nom. nud.*)
Racomitrium heterostichum var. **canescens* Meyran 1915 *nom. nud.*
R. heterostichum f. *cinerascens* Boul. 1872.
R. heterostichum var. **epilosum* Mat. 1906 *hom. illeg.*
R. heterostichum f. *incanum* Limpr. 1889 (= *het*).
R. heterostichum var. *ramulosum* f. *muticum* Corb. 1889.
R. heterostichum f. **nigrescens* Feld 1927 *nom. nud.*
R. heterostichum f. *suppapillosum* A. Latzel 1926.
R. heterostichum var. *tatrense* Chal. 1886.
Grimmia microcarpa [fide Lindberg 1875] f. *atra* Sæl. in Broth. et Sæl. 1890.
Racomitrium microcarpon var. **obtusum* Hampe 1837 *nom. nud.*
Grimmia microcarpa f. *procera* C. Müll. 1849.
Racomitrium ramulosum var. *brevicellulosum* Roiv. 1934.
R. ramulosum f. *humile* Med. 1926.
*Trichostomum *stenocarpum* Hampe ex Hüb. 1833 *nom. nud. in synon.*
Racomitrium sudeticum var. *aquaticum* Mol. 1864.

R. sudeticum var. *baurii* Loeske 1913.
R. sudeticum f. *canescens* Boul. 1884.
R. sudeticum var. **epilosum* H. Müll. ex Torre et Sarnth. 1904 *nom. nud.*
R. sudeticum f. **epilosum* Mönkem. 1927 *nom. nud.* (= *sud*).
R. sudeticum var. *grimmioides* Trautm. ex Loeske 1913.
R. sudeticum var. *longipilum* Warnst. 1904.
R. sudeticum var. *minus* Spruce 1849.
R. sudeticum var. *obtusifolium* Loeske 1903 (= *sud*).
R. sudeticum var. *subepilosum* Warnst. 1893 (= *sud*).
R. sudeticum var. *tenellum* Boul. 1884.
R. sudeticum var. *trichophyllum* Warnst. 1893.

10.0 JOSEPH D. HOOKER'S HIMALAYAN *RACOMITRIUM* SPECIMENS

In 1857, W. Mitten and W. Wilson published a paper entitled "Enumeration of the Mosses collected in India by Dr. J.D. Hooker ... and Dr. Thomas Thomson ... with their habitats, elevations, and the numbers under which they have been distributed ..." The paper includes numerous new bryophyte names, and among them many invalid manuscript names. *Racomitrium fuscescens* is described here, and its diagnosis ("fol. patulo-squarrosis") approaches the minimum of what is required. Only one specimen (No. 321, NY) is dated, viz. 20. June 1849. Also two specimens from Ceylon collected by Gardner are treated. All Himalayan *Racomitrium* specimens except No. 300, are stated to have been collected solely by J.D.H.[ooker]. His collection is still among the most valuable and plentiful from the area; it originates from Sikkim and the adjacent part of Nepal. In all, three valid and two invalid specific *Racomitrium* names and one invalid varietal name, have been based on his specimens. The specimens are named by Mitten and Wilson (1857) as follows: *R. fasciculare* var. *minor* nom. nud. (No. 314, 321), *R. fuscescens* sp. nov. (304), *R. heterostichum* (313, 322), *R. microcarpon* (323), *R. pumilum* nom. nud. (298, 326), *R. subsecundum* (*R. carnosum* nom. nud.) (302, 303, 308, 312, 324), var. alt. (280, 300), var. alt. (*minor*) (301), var. alt. ? (305), *Racomitrium* sp. (allied to *R. protensum*) (310). All these specimen numbers refer to taxa in sect. *Laevifolia*. In addition, one number is named *R. canescens* var. *ericoides* (306, BM = *R. canescens*, cf. Frisvoll 1983a: 128, Fig. 40), and two are named *R. lanuginosum* (309, 315, not seen).

Hooker's *Racomitrium* specimens are often referred to in works treating mosses from the area (see e.g. Mitten 1859, Gangulee 1972, Deguchi 1980), and it may be of interest to know the correct names of the partly heterogeneous material. The specimens possess a printed label, with the heading *Herb. Ind. Or. Hook. fil. & Thomson*, and the entries *Hab./Regio/Alt./Coll.*; the specimen number, the name, and the other more or less complete information fitting the label, are written by hand. The genus of the label is for the most part *Grimmia*. The correct identifications *fide* this paper, are as follows:

280 : *R. subsecundum* - BM (3 sp.), L, NY, S (2 sp.).
298 : *Grimmia* sp. - BM (2 sp.), S; *R. verrucosum* - NY.
300 : *R. subsecundum* - BM.
301 : *R. himalayanum* - BM (2 sp.), NY.
302 : *R. subsecundum* et *R capillifolium* var. *lorifolium* - BM, L (2 sp.), NY, S; *R. himalayanum* et *R. capillifolium* var. *lorifolium* - BM; *R. capillifolium* var. *lorifolium* - H.
303 : *R. subsecundum* - BM (2 sp.), NY (different loc.).
304 : *R. fuscescens* - BM (2 sp., lectotype), L; *R. fuscescens* et *R. capillifolium var. capillifolium* - BM; *R. fuscescens* and fragments of *R. himalayanum, R. subsecundum* and *Grimmia* sp. - S.
305 : *R. subsecundum* - BM (2 sp.), NY.
308 : *R. subsecundum* - BM, NY (Ceylon, leg. Gardner).
310 : *R. subsecundum* - BM (Ceylon, leg. Gardner).
312 : *R. subsecundum* - BM (3 sp.); *R. subsecundum* et *R. joseph-hookeri* - NY.
313 : *R. joseph-hookeri* - BM (3 sp.); *R. subsecundum* - NY.
314 : *R. verrucosum* var. *verrucosum* - BM, L, NY.
318 : *R. cucullatulum* - NY (not in Mitten & Wilson 1857).
321 : *R. himalayanum* - BM, NY.
322 : *R. joseph-hookeri* - BM (2 sp.), S; *R. joseph-hookeri* et *R. fuscescens* - BM (holotype of *R. joseph-hookeri*), L (2 sp.).
323 : *R. fuscescens* - BM (2 sp.); *R. fuscescens* et *R. joseph-hookeri* - L.
324 : *R. subsecundum* - BM (2 sp.), NY.
326 : *R. himalayanum* - BM (2 sp., one also marked 298), NY (2 sp., lectotype).

11.0 *RACOMITRIUM* SECT. *LAEVIFOLIA* IN NORWAY

Six species of the *R. heterostichum* group are known from Norway, viz. *R. affine, R. heterostichum, R. macounii, R. microcarpon, R. obtusum* and *R. sudeticum*. The following subordinate taxa are known: Of *R. affine* the common pilose ecad as well as the very rare consistently epilose ecad ('var. *gracilescens*'); of *R. macounii* only subsp. *alpinum*; of *R. microcarpon* only f. *microcarpon*; of *R. obtusum* the two common ecads named f. *obtusum* and f. *trichophorum*; and of *R. sudeticum* the common f. *sudeticum* and the rare f. *kindbergii* and f. *terricola*, as well as the very rare consistently epilose ecad.

(a) The Mainland. All the above-mentioned six species and their subordinate taxa are known from the Norwegian mainland.

Racomitrium affine (Fig. 67A) has a western and slightly southern distribution in Norway. It is known north to Gildeskål in Nordland county, but does certainly occur in Lofoten (farther to the north). The species fits well into the *Plagiothecium undulatum* group of Størmer (1969); the species in this group "occur on moist rock faces, on small ledges, and in fissures in rock faces in

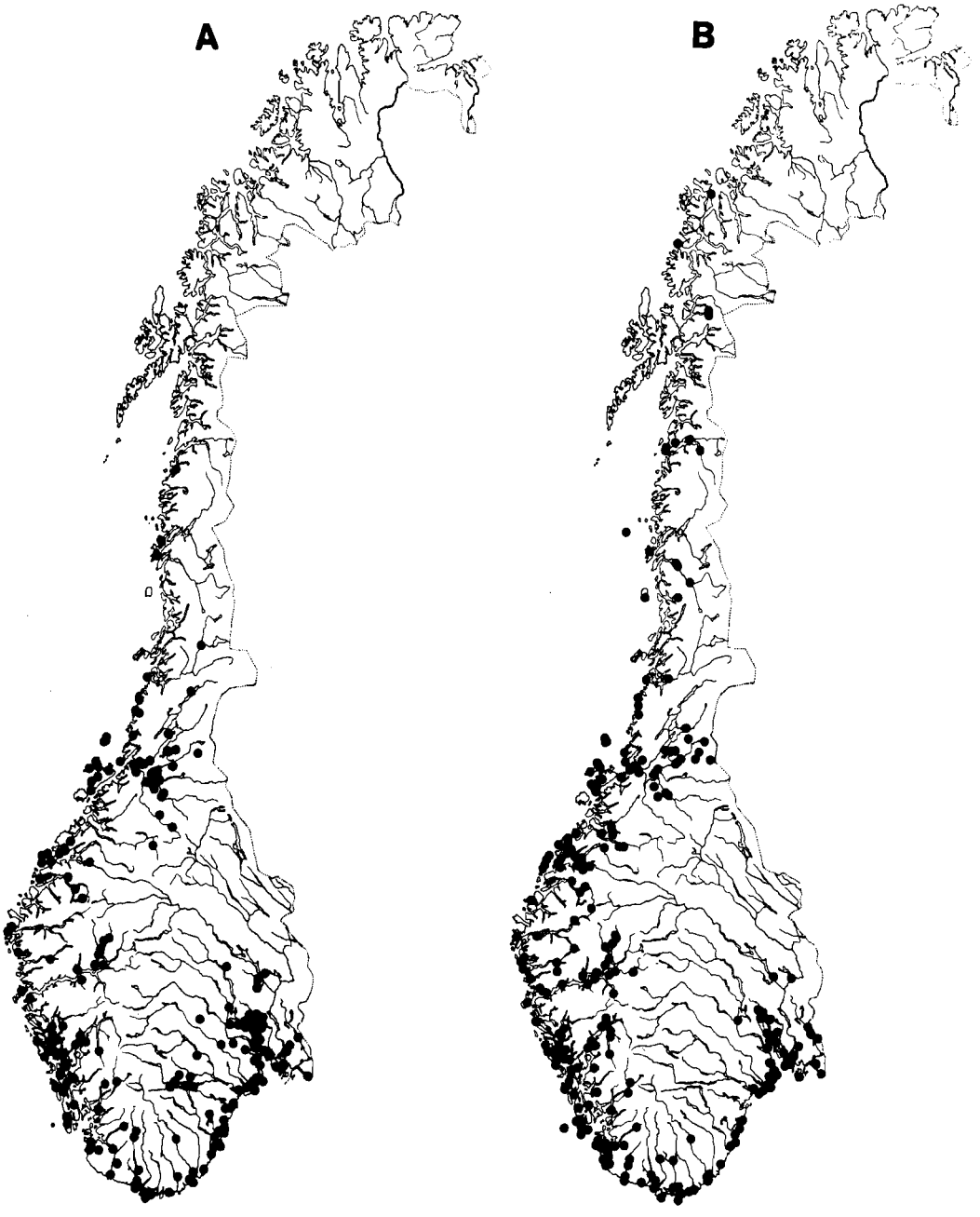

Fig. 67. Distribution of (A) *Racomitrium affine* and (B) *R. heterostichum* in the Norwegian mainland.

Fig. 68. Distribution of (A) *Racomitrium macounii* and (B) *R. microcarpon* in the Norwegian mainland.

Fig. 69. Distribution of (A) *Racomitrium obtusum* and (B) *R. sudeticum* in the Norwegian mainland.

shady, *humid* localities." Another species in the group is *R. aquaticum*, which is often associated with *R. affine*.

Racomitrium heterostichum (Fig. 67B) has a Norwegian distribution similar to that of *R. affine*, but it is known north to Karlsøy in Troms county. This species can also be referred to Størmer's (1969) *Plagiothecium undulatum* group.

Racomitrium macounii (Fig. 68A) is a mountain moss. It is common in the humid, western and central mountains of S. Norway, but seems to be lacking in the dry eastern mountain areas. Like many other mountain plants it sometimes grows at sea level in Vestlandet.

Racomitrium microcarpon (Fig. 68B) has an eastern distribution in Norway. The western limit seems to be quite distinct. This is the only species in sect. *Laevifolia* with a continental distribution pattern in Norway.

Racomitrium obtusum (Fig. 69A) has a western and southern distribution in Norway. Its northernmost known locality is in Froan in Frøya, Sør-Trøndelag county. The species seems to fit into the *Campylopus brevipilus* group of Størmer (1969, cf. especially *Orthotrichum pulchellum* and *Zygodon conoideus*, Fig. 170-173). The species in this group are mainly known from the Atlantic coast and islands.

Racomitrium sudeticum (Fig. 69B) is known from all Norwegian counties. It seems to be absent from the central parts of Østlandet, but is perhaps present in the mountains also there; the common moss in this continental area is *R. microcarpon* (Fig. 68B).

(b) Svalbard and Jan Mayen. There are no true arctic mosses among the species in the *R. heterostichum* group. *Racomitrium sudeticum* grows on Bjørnøya (Frisvoll 1983b: Fig. 5a) and Jan Mayen (Frisvoll 1983c), which both belong to the Mid Arctic zone (Brattbakk 1986). The species is common on Jan Mayen (71°N), whereas it appears to be rare on Bjørnøya (74°30'N) - which is the northernmost known locality of any species in the group.

12.0 SUMMARY

Racomitrium sect. *Laevifolia* (≡ the *R. heterostichum* group or complex) has been considered to include some of the most difficult bryophytes to handle taxonomically. It consists of species with epapillose leaves, but its delimitation *sensu lato* is not clear. This revision treats the taxa most obviously related to the type species of the section (*R. heterostichum*), in N. and C. America, N. Africa, Europe, and Asia; the area corresponds to Am 1-3, Afr 1, Eur, and As 1-5 of

Index Muscorum (Wijk et al. 1967). Notes are also given on the same or other taxa in the rest of the world (Am 4-6, Afr 2-4, Austr 1-2, Oc, Ant). The treatment is based on the study of about 11 000 specimens from 58 herbaria.

A historical review shows that previously some authors distinguished fairly well between many taxa. More recently, authors have treated the group in a collective, unsatisfactory way.

Thorough field studies demonstrate that many genotypes may occur in an area, and due to the similar autecology of the ecads mixed collections are easily obtained. The genotypes are found in different constellations and habitats, and laboratory work has revealed many stable morphological characteristics within taxa of the group. Useful mixed specimens were also found in herbarium material, of familiar taxa and of taxa which could not be studied in the field.

The taxa are easily modified by differences and changes in their habitats. The most important modifiable characteristics are quantitative, and include: length of hair-points (relatively long in dry, short or absent in moist sites); branching habit (from pinnately branched to unbranched in most taxa, but with a tendency of many taxa to be either strongly or slightly branched); robustness and size (variation and tendency as above); colour (usually olivaceous but frequently blackish, etc.); and orientation of stems (creeping, ascending or erect).

The stable taxonomic characteristics are gametophytic, and found in the vegetative and perichaetial leaves. A number of character states of the vegetative leaves are treated in detail, the most important ones being: the size, shape and orientation of the leaf; the length, orientation and structure of the hair-point; the recurvature, stratosity and outline of the margin; the length, width, form (in t.s.), and structure of the costa; the stratosity and areolation of the lamina; and the structure of the alar cells. The structure of the costa is probably the most important single characteristic. All the recognized taxa can be determined from a few (typical) leaves.

On the basis of differences in *orientation* and *structure*, the perichaetial leaves can be grouped into four. Some taxa possess hyaline inner perichaetial leaves; some chlorophyllous and pilose (almost like vegetative leaves); and some taxa possess chlorophyllous and epilose (erect or squarrose) perichaetial leaves. These differences seem to sort the taxa better than any other characteristics; and in accord with differences in the perichaetium, six informal subgroups of sect. *Laevifolia* are recognized. The length of the seta, size of the sporophyte, and length and structure of the peristome teeth have some taxonomic importance, but no sporophyte characteristics have been used as a main criterion for distinguishing between taxa in the section.

The subgroups are named after their oldest specific name, and the species are listed alphabetically within each subgroup. Keys are given, to the subgroups; to the taxa of five of the subgroups; and to the taxa in each of the main continents (America, Europe, Asia).

The taxa are described in the following way: (1) Name of the taxon and reference to figures; (2) a list including all taxonomic and nomenclatural synonyms, with citation of type localities and types and their location; (3) a description including characterization of plants, stem, leaves, hair-point, margin, costa, lamina, lamina cells, alar cells, perichaetial leaves, seta, urn, peristome teeth, and spores (if known); (4) a Figure, with drawings of leaves, alar and supra-alar cells, leaf cross sections from base to apex, one capsule, and cells from the upper, lower middle, and basal part of the leaf lamina; (5) a paragraph called Diagnostic characters, where the essence of the description is listed in twelve points; (6) comments on the morphological variation of the taxon; (7) a thorough comparison with related taxa; (8) a short note on the habitat; (9) summary of the known distribution of the taxon, with reference to (10) a map; and (11) a list of specimens examined (considers 18 taxa).

In all, 25 species, 1 subspecies, 2 varieties, and 4 forms are recognized from the treated area; a complete list of the subgroups and their respective taxa are found in the Abstract.

Different taxa exhibit a wide range of distribution patterns, and the following are recognized: (a) Bipolar range (1 species), (b) tropical alpine range (1 sp.), (c) Asiatic - Latin American range (1 sp.), (d) Australasian range (1 sp.), (e) circumboreal/imperfectly circumboreal range (3 spp.), (f) imperfectly circumalpine range (1 sp.), (g) Asiatic - European disjunction (1 sp.), (h) European endemic (1 sp.), (i) Eastern N. American endemic (1 sp.), (j) Western N. American endemics (6 spp.), (k) endemics of Japan, Korea and adjacent China (3 spp.), (l) Himalaya - Yunnan endemics (5 spp.) and (m) Amphi-Beringian endemic (1 form). There are 15 Asiatic species (of which 8 are endemic), 7 European species (1 endemic), 1 N. African species, and 14 Asiatic species (7 endemic).

About 160 names (130 valid, 30 invalid) have been described in sect. *Laevifolia* within the treated area, and comments are given on all names. The type or original material of 130 names (legitimate, illegitimate, invalid) is known. whereas the type or original of 30 names has not been traced. Thirteen names attributed to *Racomitrium* sect. *Laevifolia* are excluded from the section.

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13.0 REFERENCES

Anderson, L.E. 1963. Modern species concepts: mosses. *Bryol.* 66: 107-119.

Banu, K. 1969. *The* Rhacomitrium heterostichum *complex in British Columbia.* IV + 48 pp., 22 pl. Master's Degree Thesis, Univ. British Columbia; unpubl.

Boulay, N. 1884. *Muscinées de la France.* 1. CLXXIV + 624 pp. Paris.

Brattbakk, I. 1986. *Vegetation regions - Svalbard and Jan Mayen.* Nasjonalatlas for Norge. Hovedtema 4: Vegetasjon og dyreliv. Kartblad 4.1.1. Statens kartverk.

Bremer, B. 1981. A taxonomic revision of *Schistidium* (Grimmiaceae, Bryophyta) 3. *Lindbergia* 7: 73-90.

Bridel, S.-E. de. 1798. *Muscologia recentiorum.* 2(1). X + 222 pp. Gothae, Parisiis.

- 1801. Animaduersiones in Muscologiae recentiorum tomum secundum, ab ipso auctore propositae. *J. f. Bot.* 1800 1(2): 268-299. Göttingen.
- 1806. *Muscologia recentiorum supplementum seu species muscorum.* 1. VIII + 271 pp. Gothae.
- 1826. *Bryologia universa.* 1. XLVI + 856 pp. Lipsiae.

Brotherus, V.F. 1923. Die Laubmoose Fennoscandias. *Flora Fennica* 1: 1-XIII, 1-635. Helsingfors.

- 1929. *Symbolae sinica* (ed. H.F. von Handel-Mazzetti). *4. Musci.* V + 147 pp., 5 pl. Wien.

Bruch, P., W.P. Schimper & T. Gümbel. 1845. *Bryologia Europaea seu genera muscorum Europaeorum monographice illustrata.* - Racomitrium. Vol. 3: 135-147. *262-271.* (Fasc. 25-28: 1-13; *1-2, 1-8.*) Stuttgartiae.

Cardot, J. 1908. Mousses nouvelles du Japon et de Corée. (Suite.) *Bull. Herb. Boiss.* ser 2, 8: 331-336.

Churchill, S.P. 1981. A phylogenetic analysis, classification and synopsis of the genera of the Grimmiaceae (Musci). pp. 127-144 in V.A. Funk & D.R. Brooks (eds.); *Advances in cladistics.* Proceedings of the first meeting of the Willi Hennig Society. The New York Botanical Garden.

Clifford, H.T. 1955. On the distribution of *Rhacomitrium crispulum* (H. f. & W.) H. f. & W. *Bryol.* 58: 330-334.

Corley, M.F.V., A.C. Crundwell, R. Düll, M.O. Hill & A.J.E. Smith. 1981. Mosses of Europe and the Azores; an annotated list of species, with synonyms from the recent literature. *J. Bryol.* 11: 609-689.

Corley, M.F.V. & E.C. Wallace. 1974. *Dicranodontium subporodictyon* Broth. in Scotland. *J. Bryol.* 8: 185-189.

Crum, H. & L.E. Anderson. 1981. *Mosses of Eastern North America.* 1-2. 1328 pp. New York.

Deguchi, H. 1977. An undetermined *Racomitrium* species with endogenous gemmae of *Grimmia trichophylla* type. *Hikobia* 8: 193-196.

- 1979. A revision of the genera *Grimmia, Schistidium,* and *Coscinodon* (Musci) of Japan. *J. Sci. Hiroshima Univ., Ser. B, Div. 2,* 16: 121-256.
- 1980. Note sur quatre espèces himalayennes de la famille des Grimmiacées (Musci). *Hikobia* 8: 259-268.
- 1984. Studies on some Patagonian species of Grimmiaceae (Musci, Bryophyta). pp. 17-72 in H. Inoue (ed.); *Studies on cryptogams in southern Chile.* Tokyo.

De Notaris, G. 1838. *Syllabus muscorum in Italia et in insulis circumstantibus hucusque cognitorum.* XX + 331 pp. Taurini.
- 1869. *Epilogo della briologia italiana.* XXIV + 781 pp. Genova.
Dillenius, J.J. 1741. *Historia muscorum.* XVI + 576 pp., 85 pl. Oxonii.
Dixon, H.N. 1915. Ceylonese mosses collected by the Rev. C.H. Binstead in 1913. *J. Bot.* 53: 257-297.
- 1923. Dr. Stirton's new British mosses revised. *J. Bot.* 61: 10-17, 46-52, 69-75.
Dixon, H.N. & H.G. Jameson. 1896. *The student's handbook of British mosses.* [Ed. 1.] XLVI + 520 pp., 60 pl. London.
- 1924, repr. 1970. *The students handbook of British mosses.* Ed. 3. XLVIII + 582 pp., 63 pl. Codicote.
Dozy, F. & J.H. Molkenboer. 1855. [Seen protologue of *R. javanicum* but not the whole article; published in] H. Zollinger (ed.); *Systematisches Verzeichniss der im indischen Archipel in den Jahren 1842-1848 gesammelten sowie der aus Japan empfangenen Pflanzen.* Zürich.
Frisvoll, A.A. 1975. *Moseflora og -vegetasjon på steiner og bergvegger i et subalpint område ved Kongsvold, Dovrefjell Nasjonalpark.* 1-3. Thesis (cand. real.) Univ. Trondheim; unpubl.
- 1978. The genus *Tetraplodon* in Norway. A taxonomic revision. *Lindbergia* 4: 225-246.
- 1981a. *Schistidium pulvinatum* new to Fennoscandia. *Lindbergia* 7: 35-38.
- 1981b. Oversikt over norske moser. 2. Fagermosefamilien - Mniaceae. *Blyttia* 39: 165-188.
- 1983a. A taxonomic revision of the *Racomitrium canescens* group (Bryophyta, Grimmiales). *Gunneria* 41: 1-181.
- 1983b. Revision of Svalbard bryophytes. 2. The genus *Racomitrium. Lindbergia* 9: 41-52.
- 1983c. Bryophytes from Jan Mayen, including twenty-five species new to the island. *Bryol.* 86: 332-341.
- 1984a. Lectotypification of *Racomitrium affine, R. heterostichum, R. microcarpon, R. obtusum,* and *R. sudeticum. J. Hattori Bot. Lab.* 57: 299-318.
- 1984b. The identity of *Trichostomum saxatile* Tayl. and *T. microcarpon* ß *oblongum* Tayl., two names in the *Racomitrium heterostichum* group. *J. Bryol.* 13: 291-292.
- 1984c. Taxonomic note on *Racomitrium crispulum* (Hook f. et Wils.) Hook f. et Wils. *J. Bryol.* 13: 285-290.
- 1985a. James Stirton's new *Racomitrium* taxa revised. *J. Bryol.* 13: 377-383.
- 1985b. Lectotypifications including nomenclatural and taxonomical notes on *Ditrichum flexicaule* sensu lato. *Bryol.* 88: 31-40.
- 1986. Southern hemisphere synonyms of *Racomitrium sudeticum* (Funck) Bruch et Schimp. *J. Bryol.* 14: 339-346.
- 1987 ('1986'). The status of *Schistidium andreaeopsis*, with notes on the Krause collection from the Chuck peninsula. *Bryol.* 89: 276-278.
Fritsch, R. 1982. Index to plant chromosome numbers - bryophyta. *Regnum veg.* 108: 1-XIV, 1-268.
Frye, T.C. 1917-1918. The *Rhacomitriums* of western North America. *Bryol.* 20: 91-98. 1917; 21: 1-16. 1918.

Funck, H.C. 1801 ('1802'). *Kryptogamische Gewächse des Fichtelgebirg's.* Heft 1. [4] pp., 25 specimens. Hof.

- 1820. *Deutschlands Moose. Ein Taschenherbarium zum Gebrauch auf botanischen Excursionen.* 70 pp. + specimens. Baireuth.

Gangulee, H.C. 1972. *Mosses of Eastern India and adjacent regions - a monograph.* 3. pp. I-XV, 567-830. Calcutta.

Geheeb, A. & T. Herzog. 1910. Bryologia atlantica. Die Laubmoose der atlantischen Inseln. *Bibl. Bot.* 73: 1-71, pl. 1-20. Stuttgart.

Hämet-Ahti, L., T. Ahti & T. Koponen. 1974. A scheme of vegetation zones for Japan and adjacent regions. *Ann. Bot. Fenn.* 11: 59-88.

Hagen, I. 1909. Forarbeider til en norsk løvmosflora. IX. Grimmiaceæ. X. Timmiaceæ. XI. Schistostegaceæ. XII. Hedwigiaceæ. *K. norske Vidensk. Selsk. Skr.* 1909(5): 1-114.

Hampe, E. 1837. Musci frondosi Germaniæ ad methodum naturalem dispositi. *Flora* 20: 273-287.

Hansen, H.V. & O. Seberg. 1984. Proposals to amend Art. 7 regarding para- and paralectotypes. *Taxon* 33: 745.

Hedwig, J. 1789. *Descriptio et adumbratio microscopico-analytica muscorum frondosorum.* 2. 112 pp., 40 pl. Lipsiae.

- 1801. *Species muscorum frondosorum.* VI + 353 pp., 77 pl. Lipsiae.

Herzog, T. 1926. *Geographie der Moose.* XI + 439 pp., 8 pl. Jena.

Hesselbo, A. 1918. The bryophyta of Iceland. pp. 395-677 in L.K. Rosenvinge & E. Warming (eds.); *The botany of Iceland.* 1(2). Copenhagen.

Hirohama, T. 1978. Spore morphology of bryophytes observed by scanning electron microscope, 4. Grimmiaceae. *Bull. Natn. Sci. Mus., Ser. B (Bot.)* 4(1): 33-41, pl. 1-8.

Hoffmann, G.F. 1796. *Deutschlands Flora oder Botanisches Taschenbuch. Zweyter theil für das iahr 1795. Cryptogamie.* 200 pp., 14 pl. Erlangen.

Hooker, J.D. 1854. *Himalayan journals; or, notes of a naturalist in Bengal, the Sikkim and Nepal Himalayas, the Khasia mountains, &c.* 1. XXVII + 408 pp., 2 maps; 2. XII + 487 pp. London.

Hooker. W.J. 1836. *Icones plantarum; or figures with brief descriptive characters and remarks, of new or rare plants, selected from the authors herbarium.* 1. 50 pl. London.

Horton, D.G. 1982. A revision of the Encalyptaceae (Musci), with particular reference to the North American taxa. Part 1. *J. Hattori Bot. Lab.* 53: 365-418.

- 1983. A revision of the Encalyptaceae (Musci), with particular reference to the North American taxa. Part 2. *J. Hattori Bot. Lab.* 54: 353-532.

Hudson, W. 1762. *Flora anglica.* VIII + [8] + 506 + [22] pp. Londini.

Hübener, J.W.P. 1833. *Muscologia Germanica oder Beschreibung der deutschen Laubmoose.* XVIII + 722 pp. Leipzig.

Ireland, R.R. 1970. *Rhacomitrium lawtonae*, a new moss species from British Columbia and Washington. *Bryol.* 73: 707-712.

- 1976. Alar cells of *Rhacomitrium lawtonae. Bryol.* 79: 238-241.

Ireland, R.R. & L.M. Ley. 1984. Type specimens of bryophytes in the National Museum of Natural Sciences, National Museums of Canada. *Syllogeus* 47: 1-69.

Iwatsuki, Z. & A. Noguchi. 1979. Critical re-examination of Japanese mosses mainly described by Eikichi Ihsiba. *J. Hattori Bot. Lab.* 45: 365-373.

Jæger, A. & F. Sauerbeck. 1874. *Genera et species muscorum systematice disposita seu adumbratio floræ muscorum totius orbis terrarum.* Pars 4. pp. 339-514. Sancti Galli.

Jensen, C. 1939. *Skandinaviens bladmossflora.* 535 pp. København.

Jones, G.N. 1933. Grimmiaceae. pp. 1-65 in A.J. Grout (ed.); *Moss flora of North America north of Mexico.* 2(1). Newfane, Vermont.

Juratzka, J. 1882. *Die Laubmoosflora von Oesterreich-Ungarn.* VIII + 385 pp. Wien.

Kawai, I. 1963. Observation on the midrib-structures of some species in *Rhacomitrium. Ann. Rep. Noto. Marine Lab. Kanazawa Univ.* 3: 59-62.

- 1965. Studies on the genus *Grimmia*, with reference to the affinity of gametophyte. *Sci. Rep. Kanazawa Univ.* 10(2): 79-132.
- 1968. Taxonomic studies on the midrib in Musci. (1) Significance of the midrib in systematic botany. *Sci. Rep. Kanazawa Univ.* 13(2): 127-157.

Kindberg, N.C. 1890. Bidrag till kännedomen om Canada-områdets mossflora. *Öfv. K. Vet. Ak. Förh.* 47: 449-455.

- 1896. New or less known species of acrocarpous mosses from North America and Europe. *Rev. Bryol.* 23: 17-23.
- 1897. *(Species of) European and N. American Bryineæ (Mosses) (synoptically described). Part 2. Acrocarpous.* pp. 153-410. Linköping.

Lawton, E. 1971. *Moss flora of the Pacific Northwest.* XIII + 362 pp., 195 pl. Nichinan.

- 1972. The genus *Rhacomitrium* in America and Japan. *J. Hattori Bot. Lab.* 35: 252-262.
- 1973. *Rhacomitrium crispulum* and some related species. *Bull. Torr. Bot. Cl.* 100: 230-235.

Lesquereux, L. 1868. A catalogue of the species of mosses found, up to the present time, on the North-West Coast of the United States, and especially in California. *Mem. California Ac. Sc.* 1(1): 1-38, 95-98.

Lesquereux, L. & T. James. 1884. *Manual of the mosses of North America.* 447 pp., 6 pl. Boston.

Limpricht, K.G. 1890. *Die Laubmoose Deutschlands, Oesterreichs und der Schweiz.* Dr. L. Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. 4(1): 1-X, 1-836. Leipzig.

Lindberg, S.O. 1875. Hepaticæ in Hibernia mense Julii 1873 lectæ. *Act. Soc. Sci. Fenn.* 10: 467-559.

- 1879. *Musci Scandinavici in systemate novo naturali dispositi.* 50 pp. Upsaliae.
- 1883. *Kritisk granskning af mossorna uti Dillenii Historia muscorum.* 59 pp. Helsingfors.

Loeske, L. 1913. Grimmiaceae. *Die Laubmoose Europas* 1: I-XVI, 1-207. Berlin-Schöneberg.

- 1930. Monographie der Europäischen Grimmiaceen. *Bibl. Bot.* 101: I-IX, 1-236. Stuttgart.

Mårtensson, O. 1956. Bryophytes of the Torneträsk area, northern Swedish Lappland. 2. Musci. *K. svenska Vet.-akad. avhandl. Naturskyddsärenden* 14: 1-321.

Macoun, J. 1890. Contributions to Canadian bryologi. - No. 3. *Bull. Torr. Bot. Cl.* 17: 271-280.

Macoun, J. & N.C. Kindberg. 1892. *Catalogue of Canadian plants. Part 6. Musci.* V + 295 pp. Montreal.

Medelius, S. 1926. Mossvegetationen i Storlien med omnejd. *Ark. Bot.* 20A(10): 1-77.

Michaux, A. 1803. *Flora Boreali-Americana, sistens caracteres plantarum quas in America septentrionali collegit et detexit.* 2. 340 pp., pl. 30-51. Parisiis.

Mitten, W. 1859. Musci Indiæ orientalis; an enumeration of the mosses of the East Indies. *J. Proc. Linn. Soc. Bot. Suppl.* 1: 1-171.

Mitten, W. & W. Wilson. 1857. Enumeration of the mosses collected in India by Dr. J.D. Hooker, F.R.S., and Dr. Thomas Thomson, F.R.S., with their habitats, elevations, and the numbers under which they have been distributed; arranged by W. Mitten, Esq., and named by W. Wilson, Esq. *Hooker's Journal of Botany and Kew Garden Miscellany* (*Kew J. Bot.*) 9: 289-370.

Möller, H. 1929. A revision of some new species and varieties of *Rhacomitrium* described by N.C. Kindberg from North America. *Rev. Bryol. n.s.* 2(56): 82-86.

- 1931. Lövmossornas utbredning i Sverige. XI. Grimmiaceæ 1. *Hydrogrimmia, Coscinodon, Schistidium, Rhacomitrium. Ark. Bot.* 24A(2): 1-177.

Müller, C. 1849. *Synopsis muscorum frondosorum omnium hucusque cognitorum.* 1. 812 pp. Berolini.

- 1851. *Synopsis muscorum frondosorum omnium hucusque cognitorum.* 2. 772 pp. Berolini.

- 1898. Symbolae ad bryologiam Australiae 2. *Hedwigia* 37: 76-171.

Noguchi, A. 1958. [A review of the Japanese *Rhacomitrium.*] *Misc. Bryol. Lichen.* 1(15): 1-3.

- 1974. Musci Japonici. 10. The genus *Racomitrium. J. Hattori Bot. Lab.* 38: 337-369.

Nyholm, E. 1956. *Illustrated moss flora of Fennoscandia. 2. Musci.* Fasc. 2. pp. 85-189. Lund.

Oeder, G.C. 1770. *Flora Danica.* 3(7-9). Köbenhavn.

Paris, E.G. 1898. *Index bryologicus.* pp. 965-1284. Parisiis.

- 1905. *Index bryologicus.* Ed. 2. 4(21). pp. 121-184. Paris.

Podpera, J. 1954. *Conspectus muscorum Europaeorum.* 697 pp. Praha.

Ramsay, H.P. & W.B. Schofield. 1981. Chromosome studies on some mosses from northwestern North America. *J. Hattori Bot. Lab.* 49: 319-334.

Revold, R. 1963. *Fargene i farger.* 236 pp. Oslo.

Sakurai, K. 1937. Beobachtungen über Japanische Moosflora. 14a. Systematik der japanischen *Rhacomitrium*-Arten. *Bot. Mag.* 51: 103-109, 133-141. Tokyo.

Sayre, G. 1971. Cryptogamae exsiccatae - An annotated bibliography of published exsiccatae of Algae, Lichens, Hepaticae, and Musci. 4. Bryophyta. *Mem. New York Bot. Gard.* 19(2): 175-276.

- 1977. Authors of names of bryophytes and the present location of their herbaria. *Bryol.* 80: 502-521.

Schofield, W.B. 1965. Correlations between the moss floras of Japan and British Columbia, Canada. *J. Hattori Bot. Lab.* 28: 17-42.

- 1969. Phytogeography of northwestern North America: bryophytes and

vascular plants. *Madroño* 20: 155-207.
- 1972. Bryology in arctic and boreal North America and Greenland. *Can. J. Bot.* 50: 1111-1133.
- 1974. Bipolar disjunctive mosses in the southern hemisphere, with particular reference to New Zealand. *J. Hattori Bot. Lab.* 38: 13-32.

Schuster, R.M. 1983. Phytogeography of the bryophyta. pp. 463-626 in R.M. Schuster (ed.); *New manual of bryology*. 1. Nichinan.

Sharp, A.J. 1974. Some geographic relations in the Himalayan bryoflora. *J. Hattori Bot. Lab.* 38: 33-37.
- 1984. Geographical relationships in the bryoflora of Mexico. *J. Hattori Bot. Lab.* 56: 15-17.

Sharp, A.J. & Z. Iwatsuki. 1965. A preliminary statement concerning mosses common to Japan and Mexico. *Ann. Missouri Bot. Gard.* 52: 452-456.

Smith, A.J.E. 1978. *The moss flora of Britain and Ireland*. 706 pp. London.

Smith, J.E. 1804. *Flora Britannica*. 3. pp. 917-1407. Londini.

Stafleu, F.A. & R.S. Cowan. 1981. Taxonomic literature. A selective guide to botanical publications and collections with dates, commentaries and types. 3: Lh-O. *Regnum veg.* 105: I-XII, 1-980.

Stearn, W.T. 1980. *Botanical Latin. History, grammar, syntax, terminology and vocabulary*. XIV + 566 pp. London.

Størmer, P. 1969. *Mosses with a western and southern distribution in Norway*. 288 pp. Oslo.

Turner, D. 1804. *Muscologiæ Hibernicæ spicilegium*. X + 200 + XIV pp., 16 pl. Yermuthæ.

Vilhelm, J. 1922. La germination des protonema, la multiplication végétative et la bâtardisation des Grimmiaceae. *Preslia* 2: 141-147.
- 1925. Monografie rodu *Racomitrium* v Ceskoslovensku. *Vestn. Král. Cesk. Spol. Nauk* Tr. 2, 1925(5): 1-35.

Vitt, D.H., S.R. Gradstein & Z. Iwatsuki. 1985. Compendium of bryology. A world listing of herbaria, collectors, bryologists, and current research. *Bryophyt. Bibl.* 30: I-VII, 1-355.

Vitt, D.H. & D.G. Horton. 1981. Typification of *Climacium americanum* Brid. *Taxon* 30: 305-306.

Vitt, D.H. & H.P. Ramsay. 1985. The *Macromitrium* complex in Australasia (Orthotrichaceae: Bryopsida). Part 1. Taxonomy and phylogenetic relationships. *J. Hattori Bot. Lab.* 59: 325-451.

Voss, E.G. 1983. International code of botanical nomenclature. Adopted by the thirteenth international botanical congress, Sydney, August 1981. *Regnum veg.* 111: 1-XV, 1-472.

Wagner, W.H. & F.S. Wagner. 1983. Genus communities as a systematic tool in the study of New World *Botrychium* (Ophioglossaceae). *Taxon* 32: 51-63.

Wallroth, F.W. 1831. *Flora Cryptogamica Germaniae* [copy of pp. 174-177]. Norimbergae.

Warnstorf, C. 1906. *Kryptogamenflora der Mark Brandenburg und angrenzender Gebiete. 2. Laubmoose*. XII + 1160 pp. Leipzig.

Weber, F. & D.M.H. Mohr. 1807. *Botanisches Taschenbuch auf das Jahr 1807. Deutschlands kryptogamische Gewächse. 1. Abt. Filices, Musci frondosi et Hepaticae*. Kiel.

Wijk, R. v.d., W.D. Margadant & P.A. Florschütz. 1967. Index muscorum. 4. *Regnum veg.* 48: 1-604.

- 1969. Index Muscorum. 5. *Regnum veg.* 65: 1-XII, 1-922.

Wyatt, R., D.M. Lane & A. Stoneburner. 1982. The misuse of mixed collections in bryophyte taxonomy. *Taxon* 31: 698-704.

Zanten, B.O. van & T. Pócs. 1981. Distribution and dispersal of bryophytes. pp. 479-562 in W. Schultze-Motel (ed.); *Advances in bryology.* Vol. 1. Vaduz.

Zetterstedt, J.E. 1861. *Revisio Grimmiearum Scandinaviæ.* 139 pp. Upsaliæ.

14.0 INDEX

Names of accepted taxa in sect. *Laevifolia* (in the area covered by the monograph); the place of their detailed taxonomic treatment; and the pages including figures or maps, are in **boldface**. Synonyms of accepted taxa in sect. *Laevifolia*, and the general page references, are in Roman type. Names not included in sect. *Laevifolia* (in the area), and the page(s) with the comment on the basionym and its type (or, with regard to invalid names, the original material) are in *italics*. Reference is also made to the standard abbreviations of the names of accepted taxa in sect. *Laevifolia* (e.g. *aff* = R. affine, see p. 5).

The names and epithets (of genera, subgenera, sections, species, varieties and forms) are listed alphabetically and mixed. Epithets are followed by the generic name (and, where appropriate, the specific epithet) of their basionym and by all other combinations referred to in the work. Only the final epithet is referred to (reference is, e.g., made to f. *muticum* in the combination *R. heterostichum* var. *ramulosum* f. *muticum* Corb., but not to the specific and varietal epithets). Identical epithets are listed chronologically, and include reference to the authors of the basionyms or oldest listed combinations. Illegitimate and invalid names and combinations are marked with an asterisk; the date of basionyms is enclosed in brackets; the date of other names and combinations is put in parenthesis. Phrase-names and names of taxa above the rank of genus are not included in the index.

Abbreviations: D = *Dryptodon*, G = *Grimmia*, R = *Racomitrium*, S = *Schistidium*, T = **Trichostomum*; plus all standard abbreviations of accepted taxa (see p. 5).

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