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The genus *Grimmia* (Musci, Grimmiaceae) in the Himalaya

EVA MAIER

In memoriam
Patricia Geissler

ABSTRACT

MAIER, E. (2002). The genus *Grimmia* (Musci, Grimmiaceae) in the Himalaya. *Candollea* 57: 143-238. In English, English, French and German abstracts.

A revision of available specimens of the genus *Grimmia* in the Himalaya is presented. Methods of specimen preparation are explained. Vertical as well as horizontal distribution of the species in the Himalaya is compared with those in European mountain areas. Variability is commented on. A glossary is supplied. Keys are provided for plants with and without capsules, based on costa and sporophyte characters, as well as for forms with leaves without hair-points. Twenty-five species are recognised and described, costal and peristome characters are emphasized. Drawings of morphological and anatomical characters as transverse sections of leaves and longitudinal sections of peristome teeth are given. Five new synonymies are established. An appendix provides the list of the Himalayan specimens provided by David G. Long, Edinburgh, and an identification list of selected specimens.

RÉSUMÉ

MAIER, E. (2002). Le genre *Grimmia* (Musci, Grimmiaceae) dans l'Himalaya. *Candollea* 57: 143-238. En anglais, résumés en anglais, français et allemand.

Une révision du genre *Grimmia* dans l'Himalaya est présentée. Des méthodes de préparation sont expliquées. La distribution verticale ainsi qu'horizontale des espèces dans l'Himalaya est comparée à celle dans les montagnes européennes. La variabilité est commentée. Un glossaire est mis à disposition. Des clés ont été élaborées pour plantes avec et sans capsules, basées sur les caractères de la veine et du sporophyte; une clé pour plantes avec feuilles sans poils hyalins est jointe. Vingt-cinq espèces sont reconnues et décrites, les caractères de la veine et du péristome sont mis en évidence. Des dessins de caractères morphologiques et anatomiques comme des coupes transversales de feuilles et longitudinales de dents du péristome sont ajoutés. Cinq nouvelles synonymies sont établies. La liste des spécimens himalayens de David G. Long, Edimbourg, ainsi qu'une liste des déterminations des spécimens sélectionnés sont fournies en appendice.

ZUSAMMENFASSUNG

MAIER, E. (2002). Die Gattung *Grimmia* (Musci, Grimmiaceae) im Himalaya. *Candollea* 57: 143-238. In Englisch, englische, französische und deutsche Zusammenfassungen.

Eine Revision der Gattung *Grimmia* im Himalaya wird unterbreitet. Präparationsmethoden werden erklärt. Die vertikale und horizontale Verbreitung der Arten im Himalaya wird mit der Verbreitung in europäischen Gebirgen verglichen. Die Variabilität wird besprochen. Die Fachausrücke werden erläutert. Für Pflanzen mit und ohne Sporogone wurden Schlüssel ausgearbeitet,

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beruhend auf den Rippen- und Kapselmerkmalen; ein Schlüssel für Pflanzen mit Blättern ohne Glashaar ist beigefügt. Fünfundzwanzig anerkannte Arten werden beschrieben, die Rippen- und Peristommerkmale hervorgehoben. Zeichnungen von Blattquerschnitten und Peristomzahnlängsschnitten zeigen die morphologischen und anatomischen Merkmale. Fünf neue Synonymien wurden aufgestellt. Im Anhang eine Liste der von David G. Long zur Verfügung gestellten Proben und eine Liste der untersuchten Proben.

KEY-WORDS: *Grimmia* – Musci – Himalaya – Preparation methods – Distribution – Variability – Glossary – Keys – Descriptions – Illustrations – Costa and peristome anatomy.

Introduction

At the suggestion of David G. Long, Edinburgh (UK), the treatise presented here has been attempted, to revise the material of the Himalayan *Grimmia*. Another objective was the identification of the *Grimmia* specimens in D. G. Long's rich collections. The area under study comprises, not conforming to political boundaries, Punjab (West Himalaya), Pakistan, NW-Himalaya of India, Kashmir, Nepal, Sikkim, Darjeeling, Bhutan, a "clearly defined and floristically sound unit" (D. G. Long in litt.). The earlier work of GANGULEE (1972) covers only part of a Himalayan region, i.e. Nepal, Sikkim and Bhutan. Later on, CAO & VITT (1986) treated the Chinese species of the genus, including those of Xizang (Tibet).

The nomenclature follows WIJK & al. (1962), CORLEY & al. (1981), and CROSBY & al. (1992). The abbreviations of authors' names are taken from BRUMMITT & POWELL (1992). The designation of the different countries and territories do not imply any judgement with respect to their juridic status, their authorities or their frontiers or limits.

Twenty-five species are recognized and described, eight of which are from the study-area, six of which have been compared with their types. A perfect congruence of the characters examined has been observed, especially of the anatomical characters of the costa as seen in transverse section. For two of the species (*G. percarinata* (Dixon & Sakurai) Deguchi and *G. pilifera* P. Beauv.) this examination had been done previously by recognized bryologists. For lectotypification of those Central European species, also extending to the Asian bryoflora, see GEISSLER & MAIER (1995). The following five new synonymies are presented: *G. ochyriana* J. Muñoz under *G. atrata* Hornsch., *G. redundia* Mitt. under *G. elongata* Kaulf., *G. tergestina* f. *epilosa* Limpr., *G. obtusifolia* C. H. Gao & T. Cao, and *G. limprichtii* Kern under *G. tergestina* Bruch & Schimp.

Material

The study is based mainly on the comprehensively labelled collections made by D. G. Long during expeditions to Bhutan, Nepal, Sikkim, and adjacent China (Yunnan and Qinghai Provinces) (see Appendix 1). They are housed in E. The given specimen data are of great value because they indicate the ecological conditions under which these plants were growing. They are especially useful as most other specimens at hand were assembled by collectors during the nineteenth century; data on the labels of these specimens are often limited only to geographical indications and the collector's name.

Also available were specimens of the herbaria of ALTA, BM, G, E, GZU, H-Broth., H-SOL, NY, S, W, WU, Z+ZT. Recently collected specimens are housed in the private herbaria of J. P. Gruber, Austria, Salzburg, of T. A. J. Hedderson, BOL, and R. Porley, Thatcham, Berks. (UK). In several cases the condition of the material has necessitated the additional study of newly collected specimens in order to complete the descriptions of the species. Especially for the description of the sporophyte, specimens were taken from the European material housed in the author's private herbarium.

Of the six hundred and twenty-four specimens studied, five hundred and ninety-seven are *Grimmia* species and twenty-seven are members of other genera such as *Racomitrium*,

Schistidium, even *Tortula* or other *Pottiaceae*. Two hundred and thirty specimens are from outside the study-area, but are nevertheless useful for a study of the species and for some of the descriptions. Half of the remaining three hundred and sixty-seven specimens are *G. ovalis* (Hedw.) Lindb. and *G. longirostris* Hook. (= *G. affinis* Hornsch.). Thus, most of the twenty-five species treated are represented by between ten and twenty specimens. The scantiness of the material and the often deficient quality of the older collections may have influenced negatively an appropriate evaluation of the variability.

Of particular interest are the specimens collected by J. D. Hooker and T. Thomson as they are cited by MITTEN (1859). He affixed a mark of exclamation to the name of the collector whose specimens had been examined by him. All specimens “collected by T. Thomson in Northwest India and Western Tibet, and by J. D. Hooker in the Sikkim-Himalaya and East Nepal, and in conjunction with T. Thomson in the Khasia Mountains in East Bengal” (MITTEN, 1859) were available for this study. They are housed in BM and provided with printed labels, completed by handwritten data. A series of specimens under the same numbers but not labelled and with incomplete data are housed in NY. The here revised identifications correspond with those given by Mitten except the following numbers: 284 as *G. ovata* F. Weber & D. Mohr (= *G. longirostris* Hook.), is partly *G. mammosa* C. H. Gao & T. Cao and partly *G. longirostris* Hook.; 285 as *G. ovata* F. Weber & D. Mohr, is *G. percarinata* (Dixon & Sakurai) Deguchi (see also DEGUCHI, 1986); 287 not identified on label, but cited by Mitten as *G. anodon* Bruch & Schimp., is *G. orbicularis* Wilson; 296 as *G. subfuscata* Wilson MSS or *G. leucophaea* Grev. (= *G. laevigata* (Brid.) Brid.), is *G. mammosa* C. H. Gao & T. Cao; 299 not identified on label, but cited by Mitten as *G. ovata* F. Weber & D. Mohr, is *G. donniana* Sm., and a second specimen of 299 as *G. ovata* F. Weber & D. Mohr (two specimens on the sheet), is also *G. donniana* Sm.; 319 as *G. commutata* Huebener (= *G. ovalis* (Hedw.) Lindb.), is partly *G. unicolor* Hook.

Methods

A first impression of a *Grimmia* species is given by the cushion habit. Young shoots, in many cases useful for identification of species, are best viewed on the reverse side and internal part of the cushion. Wetting induces the typical state of the leaves, which is observable under the dissecting microscope by pushing a plant into a drop of water. Development of sexual organs may influence the expression of cell pattern in the leaf base, therefore plants in a vegetative state should be chosen to obtain comparable and reproduceable results in morphological and anatomical investigation. These are prepared by gently heating in a basic solution of 1% or at most 2% KOH or detergent. This is a simple but indispensable method used to soften dry and even old material, to reconstitute the natural structure of the cell pattern, and to confer to the tissue transparency and stability, thus preventing the shrinking of cells provoked by imbedding agents.

Leaves which are not too young, from the upper stem area, are carefully taken off one by one to prevent damage to the tissue at the leaf base showing specific characters. To remove dirt a fine soft brush as used for water-colours is helpful. Transverse sections of the stem and the leaves are cut free-hand with a razor blade directly on the slide. Comparable transverse sections are obtained only when the razor blade is placed in a perpendicular position and at right angles to the leaf axis. To obtain an instructive series of transverse sections, two leaves should be used. One is cut from the apex down to mid-leaf, the other from the insertion up to mid-leaf. This is a good method to establish the place where sections have been made.

Sporogonia are prepared in the same manner. Comparable results are obtained by using mature capsules, preferably not deoperculate. The softened capsule is cut lengthwise in two equal halves, the spores are removed with a fine spatula, the spore sac cautiously extracted, and the preparation cleaned with the brush and water. Finally the rounded capsule base is cut off to obtain a flat object, which is kept on the slide with hooked forceps. To accomplish longitudinal sections which clearly show the specific characters, especially those at insertion, it is necessary to make cuts as finely as possible, executed along the axis of the capsule. Observed at the capsule base are the stomata, on the upper half the dorsal and the ventral sides of the peristome. As the

peristome is highly transparent, attention must be paid to correct focussing, allowing the papillosity of the outer and inner sides of the teeth to be accurately observed. The operculum is cut longitudinally to observe the cell pattern.

Distribution

Twenty-five species are recognized within the Himalaya, seventeen of these are also members of the European mountain bryoflora. The eight other species are, with the year of description: *G. pilifera* P. Beauv. (1805); *G. khasiana* Mitt., *G. macrotheca* Mitt., *G. nepalensis* Mitt., all described in 1859; *G. handelii* Broth. (1924); *G. indica* (Dixon & P. de la Varde) Goffinet & Greven (as *Trigonodictyon indicum* Dixon & P. de la Varde, 1928); *G. percarinata* (Dixon & Sakurai) Deguchi (as *Didymodon percarinatus* Dixon & Sakurai, 1936); *G. mammosa* C. H. Gao & T. Cao (1981). No new species were detected in the present study.

The European mountain species *G. anomala*, *G. caespiticia*, *G. curvata*, *G. hartmanii*, *G. muehlenbeckii*, *G. incurva* and *G. torquata* are not present in the Himalayan material studied, whereas a single finding of *G. finalis* could have been included from the Eastern frontier of India (Manipur), just outside the defined study-area. The absence of the alpine *G. incurva* is surprising, all the more so by the fact that the species is cited in REDFEARN & al. (1996) as being present in Tibet. On the other hand, *G. crinita* has been collected twice in Pakistan and once in the Chinese neighbourhood at altitudes between 3000 and 3200 m. This is an astonishing appearance as *G. crinita* is known to colonize mortar in walls in vineyard regions at low altitudes in Central and Southern Europe.

In the Himalaya *G. alpestris*, *G. atrata*, *G. donniana*, *G. fuscolutea*, *G. longirostris*, and *G. ovalis* advance to the highest altitudes between 4500 and 6000 m. A study undertaken in the European Alps (MAIER & GEISSLER, 1997) shows that it is *G. sessitana* which reaches the highest altitude at 4550 m, followed by *G. alpestris* (3800 m), *G. finalis* (3750 m), and *G. incurva* (3650 m). *Grimmia donniana*, *G. fuscolutea*, *G. elongata*, and *G. torquata* attain 3100 m. Only *G. alpestris*, *G. donniana* and *G. fuscolutea* show comparable behaviour in both regions, considering the difference of altitudinal zones in Asia and Europe. LIMPRICHT (1888-1889) considered *G. fuscolutea* a true high alpine moss. On the other side of the spectrum can be found *G. pulvinata* and *G. orbicularis*. Both species do not advance above 2000 m, neither in Asia nor in Europe.

Grimmia fuscolutea, *G. laevigata*, *G. longirostris*, and *G. ovalis* are widespread in the area of investigation whereas the exclusively Asian *Grimmia* species are restricted to the Eastern part of the Himalaya such as Nepal, Sikkim, and Bhutan. Of these *G. handelii*, *G. khasiana*, *G. macrotheca*, *G. nepalensis*, and *G. pilifera* are very rare in this area. *Grimmia* species which also appear in European mountain regions are mainly present in the Western part of the area studied.

Variability

Grimmia species grow on rocks at low to high altitudes. Collectors appear to favour species found at lower altitudes as the number of collected specimens proves: 75% of the species have been collected at altitudes up to 4500 m. Habit and colour of specimens advancing to altitudes between 5000 and 6000 m become uniform, and naming them in the field seems impossible and even under the dissecting microscope a careful investigation is necessary for correct identification. Morphological characters within a species show great variability, demonstrating a highly dynamic process of adaptation to extremely severe life conditions. Leaf shape may be altered beyond recognition, leaf length reduced, hair-points shortened or not developed at all, their dentation weakly to strongly developed. At the leaf base, cell patterns show a tendency to be shortened, cells becoming thick-walled. Lamina stratosity may vary from unistratose to quadristratose in species which are generally bistratose. High altitude is certainly not the only factor contributing to variability. Plants grown at lower altitudes in extremely arid or shady areas may

also undergo modifications. Stress during the growing period of the sporophyte may cause aberration of the seta form and the regular development of the peristome. These examples show that morphological characters are especially subject to variability. Consequently they should be used cautiously for the construction of identification keys. The earlier mentioned scantiness of the material available for this study adds to the difficulties.

These facts necessitated the elaboration of a clearer view of the more stable anatomical characters of costae and sporophytes. An earlier study of the costal architecture (MAIER & GEISSLER, 1995) was based on the work of LORENTZ (1868). For the present paper, a preliminary study of the peristome is based on the works of LANTZIUS-BENINGA (1844, 1847, 1850) and his successors (MAIER, 1999). The descriptions of the species focus the attention on these important characters.

Glossary

Commonly used terms are taken from MAGILL (1990) and SMITH (1978)

Angulate: see costa angulate.

Channelled: see costa channelled.

Concave: see leaf concave.

Costa channelled: shape on ventral side, described as “hollowed out like a gutter and semi-circular in transverse section” (MAGILL, 1990), determined as widely channelled, channelled; *G. atrata* (Fig. 3.17) shows all states from insertion up to apex.

Costa angulate: shape on dorsal side, as in *G. alpestris* (Fig. 1.10), *G. elatior* (Fig. 6.9, 6.10), *G. pilifera* (Fig. 21.10, 21.11); slightly angulate or unevenly rounded: *G. longirostris* (Fig. 13.12).

Costa prominent: shape on dorsal side, seen in transverse section; prominence is produced by contraction of costa at insertion of lamina, as in *G. alpestris* (Fig. 1.10), *G. donniana* (Fig. 5.10), *G. elatior* (Fig. 6.9, 6.10), *G. fuscolutea* (Fig. 8.9, 8.19), *G. percarinata* (Fig. 20.10), and *G. sessitana* (Fig. 23.20).

Costa rounded: shape on dorsal side, expressed in breadth: thickness ratio, determined as widely rounded \approx 3-3,5:1, rounded \approx 1,5-2:1; unevenly rounded or slightly angulate: *G. longirostris* (Fig. 13.12).

Diagnostic characters: consistent diagnostic characters observed for each species. The more specimens examined, the fewer diagnostic features remain, a process resulting in a selection of strong, differentiating characters.

Furrow: indentation formed by lamina halves inserted on costa in the same direction before spreading, as in *G. alpestris* (Fig. 1.10) and *G. sessitana* (Fig. 23.20g-i).

Guide cells: large, vacuolated costal cells, in *Grimmia* species ventrally arranged, their number is of taxonomic value.

Hydroids: thin-walled costal cells arranged dorsally between guide cells (“Begleiterzellen”, LORENTZ, 1868) and stereids or substereids. In younger leaves walls thin, in mature leaves cells are star-shaped with concave walls appearing in groups in stereid bands.

Insertion: the lowest row of cells at the leaf base, the inferior delimitation of a leaf, counterpart of “the place or line of attachment of a structure” (MAGILL, 1990).

Joint thickenings: thickenings (DEGUCHI, 1979), seen in transverse section, developed on both ends of vertical cell walls where two cells come into contact, as in *G. fuscolutea*.

Keel, keeled: see leaf keeled.

Lamina: part of leaf extending from above leaf base up to apex, divided in lower part of lamina, upper part of lamina, and a short part in leaf point designated as apical part.

Leaf base: lowest part of leaf extending from insertion up to transitional part, generally the broadest part of leaf, mostly 1/3 to 1/4 of leaf length, $\approx 1/5$ in *G. laevigata*. Cell shape, especially that of the elongated paracostal cells, is different from cell shape above transitional part. An exception is the differentiation of cell shape conspicuously below the broadest part of leaf in *G. indica* (Fig. 10.8).

Leaf concave: description of leaf form in situ seen in outlines of a series of transverse sections shown at low magnification, determined as widely concave, concave, narrowly concave or tubulose, as in *G. ovalis* (Fig. 19.7) and *G. unicolor* (Fig. 25.7, 25.8).

Leaf form in situ: the natural tridimensional form of a leaf in wet state as it appears inserted on the stem, to be seen in a series of outlines of transverse sections at low magnification.

Leaf keeled: description of leaf form in situ, originated by disposition of lamina relative to leaf axis, seen in outlines of a series of transverse sections shown at low magnification, opening expressed in degrees of circle, determined as widely keeled $>45^\circ$, keeled $\approx 45^\circ$, narrowly keeled $<45^\circ$, spreading $\approx 90^\circ$.

Prominent: see costa prominent.

Rounded: see costa rounded.

Trabeculae: transverse bars formed from residual horizontal cell walls on dorsal side of peristome teeth, described as broad, small, thin, as in *G. alpestris* (Fig. 1.15).

Transitional part of leaf: zone between leaf base and lamina, generally in broadest part of leaf, where elongated cells of leaf base with smooth or nodulose walls change to shorter cells of laminal part with mostly sinuose walls. At the same place the elongated costal cells change to short cells. In *G. indica* the transitional part is conspicuously below the broadest part of leaf (Fig. 10.8, 10.9).

Ventral cells: costal cells at insertion of an undefined number on adaxial surface of leaves with broad costae. Most of them are guide cells, joined to them on both sides of costa are cells with narrow lumen, probably paracostal cells, as in *G. mammosa* (Fig. 15.9).

Identification keys

Key to related genera of *Grimmiaceae*

1. Cells in leaf base elongated with conjointly thickened and sinuose walls; seta in dry state twisted from right side below to left side above *Racomitrium*
- 1a. Cells in leaf base never elongated with conjointly thickened and sinuose walls; seta not as above 2
2. Costa cells in transverse section differentiated; seta in dry state twisted from left side below to right side above, at dehiscence of capsule columella not attached to operculum *Grimmia*
- 2a. Costa cells in transverse section scarcely differentiated; seta in dry state not twisted, at dehiscence of capsule columella remains attached to operculum *Schistidium*

Key to Himalayan species of *Grimmia*, for plants bearing sporophytes

Seta examined in wet state

1. Seta curved 2
- 1a. Seta straight 13

2. Seta short, more or less of capsule length 3

2a. Seta much longer than capsule 5

3. Costa, seen on dorsal side, indistinct in upper laminal part; guide cells in laminal part, seen in transverse section (**Fig. 24.11**), barely distinct or indistinct due to similarity with lamina cells; capsule immersed, ventricose or symmetric, exothecium cell walls thickened, seen when focussing on surface (**Fig. 24.13**); calyptra mitrate; peristome teeth inserted at orifice, perforated and slit in several fine branches **24. *G. tergestina***

3a. Costa, seen on dorsal side, clearly delimited 4

4. Lamina unistratose with bistratose patches, margin bistratose in one or two rows of marginal cells; leaf broadest below mid-leaf; costa (**Fig. 2.11, 2.21**) with a median group of hydroids throughout, neither stereids nor substereids; capsule ventricose, after dehiscence orifice widened; annulus of one to three rows of isodimorphic cells, partly persistent (**Fig. 2.18**); peristome absent **2. *G. anodon***

4a. Lamina and margin unistratose; leaf shape obovate, in leaf base markedly narrowed, greatest width of leaf in upper laminal part (**Fig. 4.6, 4.7**); costa with hydroids, in upper laminal part with few substereids; capsule ventricose, after dehiscence orifice narrowed; annulus of three or four rows of large cells, most of them persistent; peristome inserted at orifice (**Fig. 4.19, 4.20**) **4. *G. crinita***

(2a.) Seta curved, much longer than capsule

5. Guide cells at insertion (**Fig. 6.9**) arranged in two rows, number variable; costa dorsally prominent (**Fig. 6.9**); costa cells except guide cells nearly uniform, no hydroids; seta after spore release upright, twisted; capsule ribbed; operculum with long beak; calyptra mitrate **6. *G. elatior***

5a. Guide cells at insertion arranged in one row, numbering more than four or four 6

6. Costa at insertion (**Fig. 10.10, 10.11**) with more than four guide cells; leaf muticous, apex obtuse or apiculate, translucent; lamina cells near costa occasionally star-shaped (**Fig. 10.9**); costa without hydroids; innermost perichaetal leaf tubulose, muticous; young capsule with marked apophysis **10. *G. indica***

6a. Costa at insertion with four guide cells 7

7. Margin plane throughout; at margin of leaf base of all leaves of a stem with some rows of elongate-rectangular, hyaline cells (**Fig. 5.7**), longitudinal and transverse walls smooth and thin, vanishing above broadest part of leaf; calyptra mitrate; annulus cells, seen on surface view (**Fig. 5.17**), rounded with narrow lumina, lumina in immature capsule not yet developed; mature capsule bright-coloured, with age turning brownish **5. *G. donniana***

7a. Margin recurved on both sides or only on one side, or revolute on both sides or revolute on one side and recurved on other side 8

8. Margin recurved on both sides, or only on one side 9

8a. Margin revolute on both sides, or revolute on one side and recurved on other side 11

9. Margin recurved on one side only (**Fig. 7.8**), at margin some rows of elongate-rectangular, thin-walled, hyaline cells (**Fig. 7.9, 7.23**), reaching from leaf base up to above of broadest part of leaf, vanishing gradually, the outermost row ending with short-rectangular or some quadrate cells; capsule ovoid or obloid; operculum conical, blunt; inner and upper outer side of peristome teeth covered with rough, rounded as well as sharp papillae, lower outer side sparingly ornamented with fine papillae (**Fig. 7.18**) **7. *G. elongata***

9a. Margin recurved on both sides, either only on mid-leaf, or from leaf base on one side and from above leaf base up to mid-leaf on other side 10

10. Margin recurved on both sides at mid-leaf; leaf broadest at mid-leaf; lamina unistratose, on one side one marginal cell row bistratose, margin inconspicuous (**Fig. 18.11, 18.12**), rarely both margins unistratose; capsule ovoid, finely ribbed; operculum mammillate or with short beak; calyptra cucullate **18. *G. orbicularis***

10a. Margin recurved on one side from leaf base, on other side from above leaf base, on both sides up to above mid-leaf (**Fig. 22.5, 22.16**); leaf of more or less similar width from insertion up to above mid-leaf; lamina unistratose, on both sides some rows of marginal cells bistratose, margin, seen in transverse section, conspicuous (**Fig. 22.9**); capsule obloid, markedly ribbed when mature; operculum rostrate; calyptra mitrate **22. *G. pulvinata***

11. Margin revolute on both sides, on one side from insertion, on other side from above leaf base up to mid-leaf; hair-point appearing twisted due to obliquely arranged cells with distinct lumen, bluntly denticulate (**Fig. 14.7**), if elongated then decurrent in apical part as border of two rows of elongate-rectangular thick-walled cells, distal walls bluntly protruding (**Fig. 14.8**); seta twisted, nearly straight when dry, enlarged to short apophysis; capsule cylindrical, horizontal when wet (**Fig. 14.3**) **14. *G. macrotheca***

11a. Margin revolute on one side, recurved on other side 12

12. Exterior walls of lamina cells bulging or with joint thickenings, costa dorsally mammillose (**Fig. 8.9**); hair-point not twisted, smoothly denticulate; guide cells in laminal part narrowed, markedly obliquely arranged to leaf axis (**Fig. 8.9, 8.19**); seta curved; capsule ovoid, with apophysal part, after dehiscence constricted below orifice; operculum conical, beak short **8. *G. fuscolutea***

12a. Exterior walls of lamina cells and costa dorsally smooth; hair-point appearing twisted due to obliquely arranged cells with distinct lumen, bluntly denticulate (**Fig. 14.7**), if elongated then decurrent in apical part as border of two rows of elongate-rectangular thick-walled cells, distal walls bluntly protruding (**Fig. 14.8**); guide cells not obliquely arranged; seta arcuate, enlarged to short apophysis; capsule cylindrical, horizontal (**Fig. 14.3**); operculum conical, beak long **14. *G. macrotheca***

(1a.) Seta straight

13. Seta short, more or less of capsule length 14

13a. Seta much longer than capsule 18

14. Costa without hydroids (**Fig. 21.10, 21.11**); leaf from broad oval base narrowed to lanceolate laminal part, thus forming more or less strongly marked shoulder (**Fig. 21.5**); margin in leaf base on both sides recurved, occasionally on one side only weakly so (**Fig. 21.7**); capsule immersed, ovoid, smooth; operculum rostrate **21. *G. pilifera***

14a. Costa with hydroids 15

15. Costa with four guide cells at insertion (**Fig. 5.11**); margin plane throughout (**Fig. 5.6**); at margin of leaf base of all leaves of a stem with some rows of elongate-rectangular, hyaline cells, longitudinal and transverse walls thin, vanishing above broadest part of leaf (**Fig. 5.7**); calyptra mitrate; annulus cells, seen on surface view, rounded, with narrow lumina (**Fig. 5.17**), lumina of immature capsules not yet developed; mature capsule brightly coloured, with age turning brownish **5. *G. donniana***

15a. Costa with more than four guide cells at insertion 16

16. Apex muticous; leaves lanceolate-lingulate (**Fig. 3.7**); costa in leaf base stout, broad (**Fig. 3.9, 3.10, 3.17**); capsule cylindrical with distinct short apophysis; operculum rostrate, beak short or long, straight or oblique; annulus of four or five rows of singly detaching cells of specific shape (**Fig. 3.23, 3.26**) **3. *G. atrata***

16a. Apex with hair-point 17

17. Margin on larger side recurved (**Fig. 13.8**); leaf in laminal part keeled (**Fig. 13.8**); guide cells in lower laminal part distinct; costa in transverse section in lower laminal part unevenly rounded or slightly angulate, in upper part nearly indistinct (**Fig. 13.12, 13.27**); capsule cylindrical, with short neck, narrowed at orifice, smooth; peristome teeth inserted below orifice, entire or slit in two or three branches **13. *G. longirostris***

17a. Margin plane; leaf in laminal part concave (**Fig. 24.9**); guide cells in laminal part, seen in transverse section, slightly distinct or indistinct (**Fig. 24.11**) due to similarity with lamina cells; costa in transverse section in lower laminal part rounded, in upper part nearly indistinct; capsule obloid or ovoid; walls of exothecium cells thickened, seen when focussing on surface (**Fig. 24.13**); peristome teeth inserted at orifice, perforated and slit in several fine branches **24. *G. tergestina***

(13a.) Seta straight, much longer than capsule

18. Costa at insertion with more than six cells, mostly guide cells 19

18a. Costa at insertion with six or four guide cells 24

19. Costa, seen on dorsal side, clearly delimited, in leaf base stout, broad (**Fig. 3.9, 3.10, 3.17**); leaves lanceolate-lingulate, apex muticous (**Fig. 3.7**); capsule with distinct, short apophysis; operculum rostrate, beak short or long, straight or oblique; annulus of four or five rows of singly detaching cells of specific shape (**Fig. 3.23, 3.26**) **3. *G. atrata***

19a. Costa, seen on dorsal side, indistinct from above leaf base up to apex 20

20. Margin in leaf base on one side recurved (**Fig. 11.5**); leaf lingulate, in apical part concave (**Fig. 11.9, 11.10, 11.19**); seta up to 8 mm; capsule obloid or cylindrical, smooth; operculum with oblique beak half length of capsule **11. *G. khasiana***

20a. Margin plane throughout 21

21. Apex muticous, rounded (**Fig. 25.4-6**); lamina (**Fig. 25.10**) in upper leaf part bi- to tristratose, marginal part multistratose; costa of nearly uniform cells, with neither stereids nor hydroids (**Fig. 25.10**); capsule ovate or elongate-ovate, smooth **25. *G. unicolor***

21a. Apex with hair-point 22

22. Lamina cells dorsally and ventrally papillose due to bulging distal ends of cell walls (**Fig. 15.6**); costa in laminal part without distinct guide cells (**Fig. 15.9**); capsule cylindrical **15. *G. mammosa***

22a. Lamina cells dorsally and ventrally smooth; costa throughout with distinct guide cells 23

23. Margin unistratose except at apex (**Fig. 12.8, 12.10**); transverse section of costa in upper part of leaf with two guide cells sunken in narrow channel, their adaxial cell walls strongly thickened (**Fig. 12.8b, 12.10c-f**); calyptra mitrate **12. *G. laevigata***

23a. Margin bistratose throughout, rarely tristratose; transverse section of costa in upper part of leaf with four to two guide cells not sunken in narrow channel (**Fig. 19.11**); calyptra cucullate **19. *G. ovalis***

(18a.) Costa at insertion with six or four guide cells

24. Costa at insertion with six guide cells (**Fig. 13.12**); margin on larger side recurved from leaf base up to mid-leaf; leaf in laminal part keeled (**Fig. 13.8**); costa, seen in transverse section, in lower laminal part unevenly rounded or slightly angulate (**Fig. 13.12**); capsule cylindrical, with short neck, narrowed at orifice, smooth; operculum rostellate, beak of different length **13. *G. longirostris***

24a. Costa at insertion with four guide cells 25

25. Margin at least in leaf base recurved on one side 26

25a. Margin at least in leaf base plane 28

26. Lamina cells mammillose (**Fig. 20.10, 20.14**), with bistratose cell rows, appearing on surface view as irregular ridges (**Fig. 20.9**); costa dorsally mammillose, without hydroids **20. *G. percarinata***

26a. Lamina cells smooth 27

27. At margin with some rows of elongate-rectangular, thin-walled, hyaline cells, reaching from leaf base up to above broadest part of leaf, vanishing gradually, the outermost row ending with short-rectangular or quadrate cells (**Fig. 7.9, 7.23**); capsule ovoid or obloid; annulus cells seen on surface view rounded, lumina narrow (**Fig. 7.18**) **7. *G. elongata***

27a. At margin of upper stem leaves (**Fig. 23.7**) with some rows of elongate-rectangular, hyaline cells, reaching from leaf base up to broadest part of leaf, in lower stem leaves (**Fig. 23.8**) hyaline marginal cells distinctly shorter, all transverse walls thickened; capsule oblong-ovoid; annulus cells seen on surface view quadrate or transversely rectangular, lumina large (**Fig. 23.16**) **23. *G. sessitana***

28. Margin plane at least in leaf base, in laminal part erect or incurved 29

28a. Margin plane throughout 30

29. Margin in laminal part erect (**Fig. 1.6, 1.10**); lamina from above leaf base up to apical part on both sides of costa nearly horizontally spreading, in apical part keeled; costa recessed in furrow (**Fig. 1.10**); in transverse section exterior walls of lamina cells slightly bulging (**Fig. 1.10**), of nearly quadrate shape; capsule elongate-ovate, seldom with stomata **1. *G. alpestris***

29a. Margin in laminal part incurved (**Fig. 16.6, 16.10, 16.11**); lamina above leaf base spreading, from mid-leaf to apex keeled; costa ventrally narrowly channelled; in transverse section exterior walls of lamina cells smooth, of short-rectangular shape (**Fig. 16.10, 16.11**); capsule obloid, smooth, never with stomata **16. *G. montana***

30. At margin of leaf base of upper stem leaves (**Fig. 23.7**) with few rows of elongate-rectangular, hyaline cells, reaching up to broadest part of leaf, at margin of leaf base of lower stem leaves hyaline marginal cells distinctly shorter (**Fig. 23.8**), all transverse walls thickened; calyptra cucullate; annulus cells, seen on surface view, quadrate or transversely rectangular, lumina large (**Fig. 23.16**) **23. *G. sessitana***

30a. At margin of leaf base of all stem leaves with some rows of elongate-rectangular, hyaline cells, vanishing above broadest part of leaf, longitudinal and transverse walls very thin (**Fig. 5.7**); calyptra mitrate; annulus cells, seen on surface view, rounded, with narrow lumina (**Fig. 5.17**), at immature capsules lumina not yet developed **5. *G. donniana***

Key to Himalayan species of *Grimmia*, for plants without sporophytes

1. Guide cells at insertion arranged in two rows, number variable (**Fig. 6.9**); costa dorsally prominent; costa cells except guide cells nearly uniform, with neither hydroids nor stereids; lamina bistratose in laminal part, lamina cells mostly papillose (**Fig. 6.8, 6.9**), rarely smooth (**Fig. 6.10**) **6. *G. elatior***

1a. Guide cells at insertion arranged in one row 2

2. Costa at insertion with more than six cells, mostly guide cells 3

2a. Costa at insertion with six or less than six guide cells 12

3. Costa, seen on dorsal side, clearly delimited throughout or indistinct only in upper part of lamina 4

3a. Costa, seen on dorsal side, indistinct from above broadest part of leaf up to apex 8

4. Costa, seen on dorsal side, clearly delimited throughout 5

4a. Costa, seen on dorsal side, indistinct only in upper part of lamina 7

5. Apex with hair-point; hair-point short or elongated, occasionally brownish, sharply denticulate; from broad, ovate leaf base narrowed to lanceolate part, thus forming more or less strongly marked shoulder (Fig. 21.5); margin on both sides weakly to markedly recurved from leaf base up to broadest part of leaf (Fig. 21.7, 21.10); costa without hydroids (Fig. 21.10, 21.11) 21. *G. pilifera*

5a. Apex without hair-point 6

6. Leaves from ovate base lanceolate-lingulate, apex obtuse (Fig. 3.8), occasionally cucullate (Fig. 3.6, 3.7); margin on one side recurved from insertion up to above broadest part of leaf (Fig. 3.9, 3.10); lamina irregularly bistratose (Fig. 3.16, 3.17) with tristratose patches; costa with a median band of substereids (Fig. 3.17) 3. *G. atrata*

6a. Leaves from narrowed base lanceolate or ovate-lanceolate, apex obtuse or apiculate, cells translucent; margin on both sides recurved from leaf base up to broadest part of leaf (Fig. 10.4, 10.7); lamina unistratose, occasionally bistratose in upper part in places (Fig. 10.11); costa cells uniform, except guide cells in upper half of leaf (Fig. 10.10, 10.11) 10. *G. indica*

7. Margin plane; margin in laminal part bistratose, even in nearly unistratose leaves one or two marginal cell rows bistratose (Fig. 24.36, 24.37); costa with a median group of hydroids; in upper laminal part the two guide cells barely distinct or indistinct, due to similarity with lamina cells (Fig. 24.11, 24.34); leaf without marked shoulder, lingulate; leaf concave throughout (Fig. 24.9) 24. *G. tergestina*

7a. Margin on both sides recurved from insertion up to broadest part of leaf (Fig. 21.7, 21.10); costa without hydroids; guide cells clearly distinct from lamina cells; leaf from broad ovate base narrowed to lanceolate part, thus forming more or less strongly marked shoulder (Fig. 21.5); leaf in laminal part widely keeled (Fig. 21.10, 21.11) 21. *G. pilifera*

8. Lamina cells on dorsal and on ventral sides strongly mammillose (Fig. 15.6), due to strongly bulging distal cell walls; costa large at insertion, completely indistinct in laminal part on dorsal and on ventral sides, clearly defined guide cells lacking (Fig. 15.9) 15. *G. mammosa*

8a. Lamina cells on dorsal and on ventral sides smooth 9

9. Margin on one side recurved from leaf base up to broadest part of leaf (Fig. 11.5, 11.9); from ovate leaf base narrowed to lingulate or lanceolate laminal part, thus forming smoothly or strongly rounded shoulder (Fig. 11.5); seen in outlines of transverse sections (Fig. 11.6, 11.19) lower laminal part widely channelled, upper laminal part concave 11. *G. khasiana*

9a. Margin plane throughout 10

10. Leaf base short, \approx 1/5 of leaf length, rounded, half-sheathing, slightly decurrent (Fig. 12.7); in sheathing part cells towards margin transversely rectangular or oval, transverse walls thicker than longitudinal walls (Fig. 12.7); margin unistratose from leaf base up to below apex (Fig. 12.10c-f); costa at insertion with three groups (Fig. 12.8a, 12.10a-c) or one large band of hydroids, in laminal part the two guide cells sunken in narrow channel, their adaxial cell walls strongly thickened (Fig. 12.10d-f) 12. *G. laevigata*

10a. Leaf base long, \approx 1/3 of leaf length 11

11. Apex with more or less elongated, denticulate hair-point (Fig. 19.5, 19.6, 19.10); margin stratosity not different from lamina stratosity; costa cells not uniform, costa with a central group of hydroids (Fig. 19.11) 19. *G. ovalis*

11a. Apex muticous, rounded (**Fig. 25.4, 25.6**); lamina in upper part bi- to tristratose, marginal part multistratose; costa cells uniform, with neither stereids nor hydroids (**Fig. 25.10**) **25. *G. unicolor***

(2a.) Costa at insertion with six or less than six guide cells

12. Costa at insertion with six guide cells 13

12a. Costa at insertion with four guide cells (in some cases the two outer guide cells can be considered as contiguous to basal paracostal cells) 18

13. Costa, seen on dorsal side, indistinct from above broadest part of leaf up to apex; in transverse section with a central group of hydroids (**Fig. 19.11**); leaf concave throughout, seen in outlines of transverse sections (**Fig. 19.7**); margin plane **19. *G. ovalis***

13a. Costa, seen on dorsal side, clearly delimited throughout or indistinct only in upper part of lamina 14

14. Costa, seen on dorsal side, clearly delimited throughout 15

14a. Costa, seen on dorsal side, indistinct only in upper laminal part 16

15. Apex without hair-point; apex obtuse or apiculate, cells translucent; leaf from narrowed base lanceolate or ovate-lanceolate (**Fig. 10.4**); lamina cells in places star-shaped (**Fig. 10.9**); costa cells small, uniform, except guide cells in upper half of leaf (**Fig. 10.10, 10.11**) **10. *G. indica***

15a. Apex with hair-point; hair-point short or elongated, occasionally brownish, sharply dentate; from broad, ovate leaf base narrowed to lanceolate part, thus forming more or less strongly marked shoulder (**Fig. 21.5**); lamina cells never star-shaped; costa cells large, except substereids (**Fig. 21.10, 21.11**) **21. *G. pilifera***

16. Margin plane; costa in upper laminal part with the two guide cells barely distinct or indistinct, due to similarity with lamina cells (**Fig. 24.11**); margin at least in laminal part bistratose, even in nearly unistratose leaves one or two marginal cell rows bistratose (**Fig. 24.36, 24.37**); leaf concave throughout (**Fig. 24.9**) **24. *G. tergestina***

16a. Margin on larger side only or on both sides recurved from insertion up to mid-leaf 17

17. Margin recurved from insertion up to mid-leaf on larger side only (**Fig. 13.6**); leaf in upper laminal part keeled or narrowly so (**Fig. 13.8, 13.12**); shoulder not markedly expressed (**Fig. 13.6**); in transverse section costa in lower part of lamina unevenly rounded or slightly angulate (**Fig. 13.12, 13.23, 13.27**), occasionally with hydroids **13. *G. longirostris***

17a. Margin recurved from insertion up to mid-leaf on both sides (**Fig. 21.7**); leaf in laminal part widely keeled (**Fig. 21.10**); from broad ovate leaf base narrowed to lanceolate part, thus forming more or less strongly marked shoulder (**Fig. 21.5**); in transverse section costa in lower laminal part rounded, without hydroids (**Fig. 21.10, 21.11**) **21. *G. pilifera***

(12a.) Costa at insertion with four guide cells

18. Costa without hydroids 19

18a. Costa with hydroids 20

19. Plants originating from young shoots of bristly aspect (**Fig. 9.1, 9.4**); leaves muticous, apex acute (**Fig. 9.7**), occasionally with few transparent cells (**Fig. 9.8**); margin in leaf base on one side markedly recurved, on other side slightly so (**Fig. 9.9**); lamina cells and costa smooth except at insertion; costa with stereids (**Fig. 9.13, 9.14**) **9. *G. handelii***

19a. Plants without young shoots of bristly aspect; leaf with hair-point; margin on one side from leaf base up to mid-leaf slightly recurved (**Fig. 20.6**); lamina cells and costa mammillose (**Fig. 20.10**); lamina with bistratose cell rows appearing on surface view as irregular ridges (**Fig. 20.9**); costa cells uniform, without stereids (**Fig. 20.10, 20.14**) **20. *G. percarinata***

20. Margin plane at least in leaf base 21

20a. Margin recurved or revolute not only in leaf base 28

21. Margin plane throughout 22

21a. Margin plane in leaf base, erect or incurved in laminal part 26

22. Leaf base markedly narrowed, greatest width of leaf in upper part (**Fig. 4.6, 4.7**); lamina and margin unistratose (**Fig. 4.12**); costa becoming stronger to apex, running through hyaline apical part, excurring to slightly denticulate hair-point (**Fig. 4.8**) **4. *G. crinita***

22a. Leaf base not narrowed, greatest width of leaf below upper part 23

23. Leaf concave throughout (**Fig. 24.9**); costa in upper laminal part with two guide cells barely distinct or indistinct, due to similarity with lamina cells (**Fig. 24.11**); margin at least in laminal part bistratose, even in nearly unistratose leaves one or two cell rows bistratose (**Fig. 24.36, 24.37**) **24. *G. tergestina***

23a. Leaf keeled in laminal part 24

24. At margin with some rows of rectangular hyaline cells (**Fig. 2.9**); lamina unistratose with bistratose patches (**Fig. 2.11, 2.20, 2.22**); margin plane, bistratose in one or two rows of cells (**Fig. 2.11, 2.20-22**); costa markedly broader in upper laminal part **2. *G. anodon***

24a. At margin with some rows of elongate-rectangular hyaline cells; leaf broadest in lower part of leaf 25

25. At margin of leaf base of all leaves of a stem with some rows of elongate-rectangular, hyaline cells (**Fig. 5.7**), longitudinal and transverse walls smooth and thin, gradually vanishing, exterior row reaching up to above broadest part of leaf, thus forming between hyaline and thicker walled chlorophyllose cells a delimitation, running obliquely from costa to margin **5. *G. donniana***

25a. At margin of leaf base of upper stem leaves few rows of elongate-rectangular, hyaline cells, reaching up to broadest part of leaf (**Fig. 23.7, 23.9**), at margin of leaf base of lower stem leaves marginal cells distinctly shorter (**Fig. 23.8**); transverse walls of all marginal cells thicker than longitudinal walls **23. *G. sessitana***

26. Margin in laminal part incurved (**Fig. 16.10, 16.11**); in leaf base marginal cells short-rectangular or quadrate, transverse walls markedly thicker than longitudinal walls (**Fig. 16.7**); above shoulder at margin with a row of transversely oval cells (**Fig. 16.8**); seen in transverse section lamina cell walls smooth, of short-rectangular shape (**Fig. 16.10, 16.11**) **16. *G. montana***

26a. Margin in laminal part erect 27

27. In leaf base towards margin cells short-rectangular to quadrate, transverse cell walls thickened (**Fig. 1.7**); lamina from above leaf base up to apical part on both sides of costa nearly horizontally spreading (**Fig. 1.10**); in transverse section costa recessed in furrow, lamina cells slightly bulging, of nearly quadrate shape (**Fig. 1.10**) **1. *G. alpestris***

27a. In leaf base of upper stem leaves towards margin few rows of elongate-rectangular hyaline cells, reaching up to broadest part of leaf (**Fig. 23.7, 23.9**) in leaf base of lower stem leaves towards margin hyaline cells distinctly shorter (**Fig. 23.8**), all transverse walls thickened; on one or both sides of costa lamina nearly horizontally spreading (**Fig. 23.20**), but in lower half of lamina only (**Fig. 23.20d-g**); in transverse section costa narrowly channelled, lamina cells rounded **23. *G. sessitana***

(20a.) Margin recurved or revolute not only in leaf base

28. Margin recurved on one side from leaf base, on other side from above leaf base up to mid-leaf, or on one side or on both sides from leaf base up to mid-leaf, or on both sides recurved only in mid-leaf 29

28a. Margin revolute on both sides from leaf base up to mid-leaf, or revolute on one side and recurved on other side from leaf base at least up to mid-leaf 34

29. Margin recurved on one side from leaf base up to mid-leaf, on other side from above leaf base up to mid-leaf (**Fig. 22.5**); in laminal part two or three marginal cell rows bi- rarely tristratose, margin, seen in transverse section, conspicuous (**Fig. 22.9**); leaf in laminal part widely keeled 22. *G. pulvinata*

29a. Margin recurved on one side or on both sides from leaf base up to mid-leaf, or on both sides recurved only in mid-leaf 30

30. Margin recurved on one side from leaf base up to mid-leaf 31

30a. Margin recurved on both sides from leaf base up to mid-leaf, or only on both sides in mid-leaf 33

31. At margin of upper stem leaves in leaf base few rows of elongate-rectangular, hyaline cells (**Fig. 23.7**), reaching from leaf base up to broadest part of leaf (**Fig. 23.9**), in lower stem leaves marginal hyaline cells distinctly shorter (**Fig. 23.8**), all transverse walls thickened; lower lamina cells short-rectangular or quadrate, lumen rounded, walls smooth or slightly sinuose 23. *G. sessitana*

31a. At margin of all stem leaves in leaf base few rows of elongate-rectangular cells 32

32. Marginal cells reaching from leaf base up to above broadest part of leaf, vanishing gradually, the outermost row ending with short-rectangular or quadrate cells (**Fig. 7.9, 7.23**); basal cells more or less nodulose; lower lamina cells rectangular, walls either strikingly or slightly sinuose; lamina cells smooth (**Fig. 7.13**), rarely slightly bulging 7. *G. elongata*

32a. Marginal cells reaching up to broadest part of leaf, not vanishing gradually (**Fig. 20.7**); basal cells smooth; lower lamina cells short-rectangular, sinuose (**Fig. 20.8**); exterior walls of lamina cells mammillose (**Fig. 20.10**) 20. *G. percarinata*

33. Margin recurved on both sides from leaf base up to mid-leaf; leaf broadest below mid-leaf (**Fig. 8.5**); lamina unistratose, occasionally bistratose in places, exterior cell walls bulging (**Fig. 8.9**) or with joint thickenings; margin on both sides with a few marginal rows bistratose, margin conspicuous; guide cells in laminal part narrow, arranged obliquely to leaf axis (**Fig. 8.9**) 8. *G. fuscolutea*

33a. Margin recurved on both sides at mid-leaf only (**Fig. 18.4**); leaf broadest at mid-leaf; lamina unistratose, smooth; margin on one side with one cell row bistratose (**Fig. 18.11, 18.12**), margin inconspicuous, rarely both margins unistratose; guide cells neither narrowed nor obliquely arranged 18. *G. orbicularis*

(28a.) Margin revolute on both sides from leaf base up to mid-leaf, or revolute on one side and recurved on other side from leaf base at least up to mid-leaf

34. Margin revolute on both sides from leaf base up to mid-leaf (**Fig. 14.13**); hair-point bluntly denticulate, appearing as twisted (**Fig. 14.7**), cells with distinct lumina; if hair-point elongated (**Fig. 14.8**) then decurrent in apical part as border of two rows of elongate-rectangular, thick-walled cells, distal walls bluntly protruding 14. *G. macrotheca*

34a. Margin revolute on one side, recurved on other side at least up to mid-leaf 35

35. Margin revolute on one side, recurved on other side, on both sides from leaf base up to upper laminal part (**Fig. 8.7**); hair-point not appearing twisted, smoothly denticulate; lamina cells strongly (**Fig. 8.8**) to slightly (**Fig. 8.18**) sinuose, seen bulging in transverse sections (**Fig. 8.9, 8.19**) or with joint thickenings; costa dorsally mammillose; guide cells in laminal part narrowed, arranged obliquely to leaf axis (**Fig. 8.9, 8.19**) 8. *G. fuscolutea*

35a. Margin revolute on one side, recurved on other side, on both sides from leaf base up to mid-leaf (**Fig. 14.9**); hair-point bluntly denticulate, appearing twisted (**Fig. 14.7**), cells with distinct lumina; if hair-point elongated (**Fig. 14.8**) then decurrent in apical part as border of

two rows of elongate-rectangular, thick-walled cells, distal walls bluntly protruding; lamina cells smooth; costa dorsally smooth; guide cells neither narrowed nor obliquely arranged
..... 14. *G. macrotheca*

**Key to those Himalayan species of *Grimmia*
with plants often imbedded in decaying substratum and with muticous leaves**

1. Lamina unistratose with bistratose patches, margin bistratose, plane 2
- 1a. Lamina unistratose throughout, margin unistratose or bistratose, margin recurved or plane 3
2. Leaf concave especially in apical part (Fig. 24.33-36) 24. *G. tergestina*
- 2a. Leaf keeled in laminal part (Fig. 2.7, 2.11) 2. *G. anodon*
3. Margin unistratose on one side, bistratose on other side (Fig. 18.11, 18.12), on both sides recurved at mid-leaf 18. *G. orbicularis*
- 3a. Margin unistratose on both sides, plane or recurved at mid-leaf 4
4. Margin plane throughout, leaf from strongly narrowed leaf base tapering to broadest part above mid-leaf (Fig. 4.6, 4.7) 4. *G. crinita*
- 4a. Margin recurved on both sides at mid-leaf, leaf ovate-lanceolate, broadest at mid-leaf 18. *G. orbicularis*

Descriptions

The descriptions of the plants are based on moistened material, those of growth forms on dry specimens. Leaves are measured without hair-points, setae without vaginula. The description of perichaetial and perigonal leaves refers to the innermost ones. Calyptra and vaginula descriptions are included in the sporophyte description. Exothecium cells are drawn from the middle of the capsule. The descriptions conform to the following scheme:

Gametophyte: *sexual condition.* **Female:** perichaetial leaf, length, shape; **male:** perigonia, perigonal leaf, length, shape, paraphysia. **Growth form:** plant, stem. **Leaves:** length, disposition on stem in dry and wet state, shape; *leaf form in situ*; cell pattern in leaf base, in transitional part, in laminal part; stratosity of leaf base and lamina. **Costa:** dorsal view, shape and architecture seen in transverse section.

Sporophyte: **seta:** form, length, vaginula. **Capsule:** shape, exothecium cells, stomata, annulus. **Calyptra.** **Operculum:** shape, marginal cells. **Peristome:** insertion of peristome teeth, dorsal view, and longitudinal section of peristome tooth.

Spores.

Diagnostic characters.

Comments.

Arguments for synonymy.

Comparison with the type specimen.

Provenance.

Habitat.

Specimens examined: the cipher in bold-face indicates the number of specimens at disposition regardless the geographical region.

Specimens selected for the description: list of specimens selected.

1. *Grimmia alpestris* (F. Weber & D. Mohr) Schleich., Cat. Pl. Helv. ed. 2: 29. 1807.

≡ *Trichostomum pulvinatum* var. *alpestre* F. Weber & D. Mohr, Bot. Taschenbuch: 110. 1807.

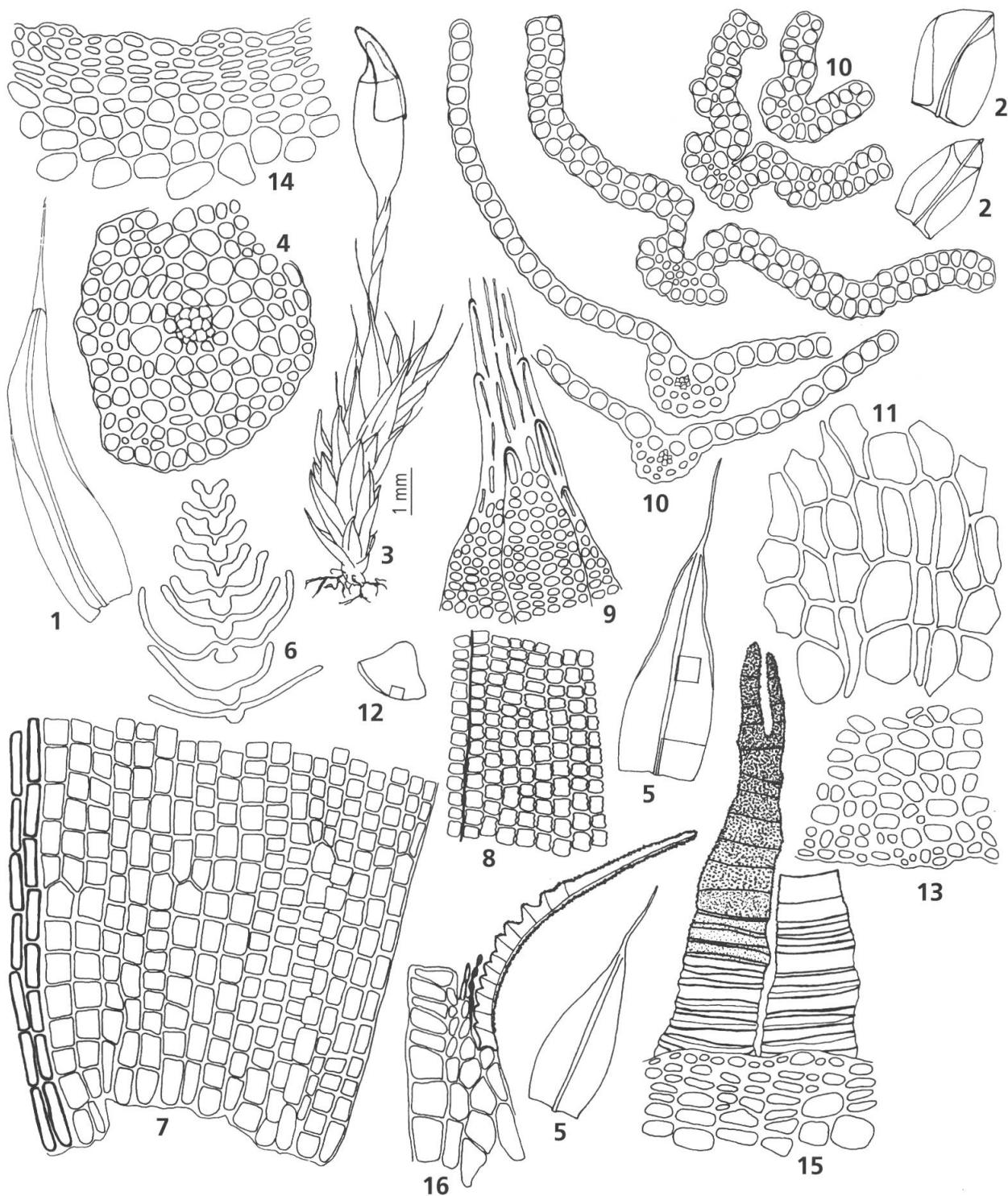
Gametophyte. Dioicous. Female: innermost perichaetal leaf (**Fig. 1.1**) 2,6-2,8 mm, slightly sheathing up to upper third, from broad base broadly lanceolate, at leaf base cell walls thin, in upper part cell pattern scarcely different from that of stem leaf, costa stout, excurring to slightly denticulate hair-point; **male** plants as separate cushions, perigonia as multifoliate buds terminal and in leaf axils, several in one plant, innermost perigonial leaf (**Fig. 1.2**) up to 0,8 mm, sheathing up to upper third, tubulose, cordiform, hyaline cells of varied extent, costa stout, percurrent to muticous, blunt or mucronate apex, paraphysis short, few. **Growth form:** cushion dense, compact, adherent to substrate by rhizoids, plants erect, branched, radiculose at base, stem (**Fig. 1.3**) up to 17 mm, central strand (**Fig. 1.4**) weakly developed. **Leaves** (**Fig. 1.5**) small in lower part of stem, becoming gradually longer, up to 2 mm, appressed to stem when dry, older leaves bending slightly backwards, young leaves scarcely moving when moistened, erectopatent when wet, from scarcely narrowed leaf base lanceolate, hair-point short or elongated, nearly smooth; **leaf form in situ:** (**Fig. 1.6**) at insertion and leaf base concave, in laminal part keeled, from above leaf base up to apical part lamina nearly horizontally spreading, in upper laminal part costa in furrow, margin plane, erect in upper part of leaf; in leaf base (**Fig. 1.7**) some rows of rectangular paracostal cells, towards margin short-rectangular to quadrate, at margin some rows with thickened transverse walls, one or two rows hyaline, all cell walls smooth, lamina cells mostly isodiametric (**Fig. 1.8**), if thin-walled then slightly sinuose, if thick-walled then smooth, at apex cells rounded (**Fig. 1.9**), seen in transverse section (**Fig. 1.10**) cells isodiametric, exterior cell walls slightly bulging; leaf base unistratose, lower laminal part unistratose, bistratose at places, on surface view seen as striae, on upper part bistratose, occasionally tristratose, margin at insertion and leaf base unistratose, in laminal part bistratose, rarely at places tristratose. **Costa**, seen on dorsal side, weak at insertion and leaf base, gradually enlarged up to apical part, excurrent, seen in transverse section (**Fig. 1.10**), costa on dorsal side at insertion and leaf base rounded, in laminal part prominent, somewhat angulate, on ventral side at insertion and leaf base channelled, in laminal part recessed in furrow, at insertion and leaf base four ventral cells, two of them guide cells, two outer ones belonging partly to basal paracostal cells, at insertion the outer ones markedly larger, above broadest part of leaf two guide cells, from insertion up to apical part a median group of hydroids.

Sporophyte. Seta straight (**Fig. 1.3**), up to 5 mm, vaginula 0,8-1 mm. **Capsule** erect, exserted, elongate-ovate, smooth, exothecial cells irregular (**Fig. 1.11**), rounded, penta- and hexagonal, walls slightly thickened, stomata none or in very rare cases few and mostly imperfect, at orifice (**Fig. 1.14**) four or five rows of transversely rectangular persistent cells, suggesting annulus. **Calyptra** cucullate (**Fig. 1.3**), reaching to middle of capsule, at maturation fugacious. **Operculum** conical (**Fig. 1.12**), blunt, margin (**Fig. 1.13**) smooth, two marginal rows of small, rounded cells, in conical part oval or transversely rectangular cells with rounded lumen, walls thickened. **Persistome** (**Fig. 1.15**) inserted deeply below orifice, teeth erect when dry, broad at base, lanceolate, entire or in upper half slit to two or three fine branches, trabeculae in lower part broad, in middle part small, in upper part thin; seen in longitudinal section (**Fig. 1.16**) two cell rows between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side covered with low, rounded papillae, below three or four plates granulose, the lowest ones smooth, trabeculae neared, protruding, mostly a short prostome.

Spores 10-14 µm, granulose.

Fig. 1. – *Grimmia alpestris* (F. Weber & D. Mohr) Schleich.: 1, perichaetal leaf; 2, two innermost perigonial leaves; 3, plant with sporophyte; 4, transverse section of stem; 5, leaves; 6, outlines of transverse sections of leaf; 7, cells in leaf base; 8, lamina cells; 9, cells at apex, hair-point; 10, transverse sections of leaf; 11, exothecial cells; 12, operculum; 13, cells at margin of operculum; 14, cells at orifice; 15, peristome, outer side; 16, longitudinal section of peristome tooth.

[1, 11-14, Maier 5650; 2, Maier 8680; 3, 6, Maier 3825; 4-5, 7-10, Townsend 87/341; 15-16, Maier 11371]



0,1 mm
4,7-11,13-16

0,4 mm
6

1 mm
1-2,5,12

Diagnostic characters. — **Gametophyte:** in transverse section lamina spreading on both sides from costa, from above leaf base up to apical part margins erect, lamina cells quadrate, exterior cell walls bulging slightly (Fig. 1.10). Costa with hydroids. **Sporophyte:** cells at orifice persistent; peristome inserted deeply below orifice.

Comments. — Short-rectangular or quadrate cells at the base of all stem leaves distinguish *G. alpestris* from *G. sessitana*. Lamina cells in transverse section (Fig. 1.10), quadrate with slightly bulging exterior cell walls distinguish *G. alpestris* from *G. montana*.

Regarding the use of the name *G. alpestris* see MUÑOZ (1997). Patricia Geissler's comment on the argument of J. Muñoz, in preparation for inclusion here, was not yet complete at the moment of her tragic death.

Provenance. — India, Kashmir, NW Himalaya, Pakistan.

Habitat. — On dry rocks and boulders, at altitudes between 3500 and 5300 m.

Specimens examined. — **Twenty-one**, fourteen of them from the study-area. The selected ones are: **INDIA.** “Lahul, Bhaga Valley; on stones, 16,000”, 27.VIII.1928, *Badhwar* 951 (BM). “NW Himalaya, Rotang Pass, 13,500”, VII.1938, *N. L. Bor* 451 (BM). **KASHMIR.** “Astor Valley, Kalapani, Kamri Nala 13.000 p.”, 10.VII.1901, *Inayat Khan* 2864 (BM, H-BR). “On dry rocks above the flat marshy area below Vishensar Lake, c. 3400 m”, 25.VII.1987, *Townsend* 87/341 (ALTA, NY). **PAKISTAN. Northern Areas, Baltistan:** “Deosai National Park, Valley of Bara Pani River, eastern slope of ridge just east of the river. Lat 35°00'N Long 75°26' E 4295 m. Steep granitic and basaltic rock cliffs and turf vegetation on bouldery slopes with snowbeds”, 23.VII.1998, *Hedderson* 12285 (BOL).

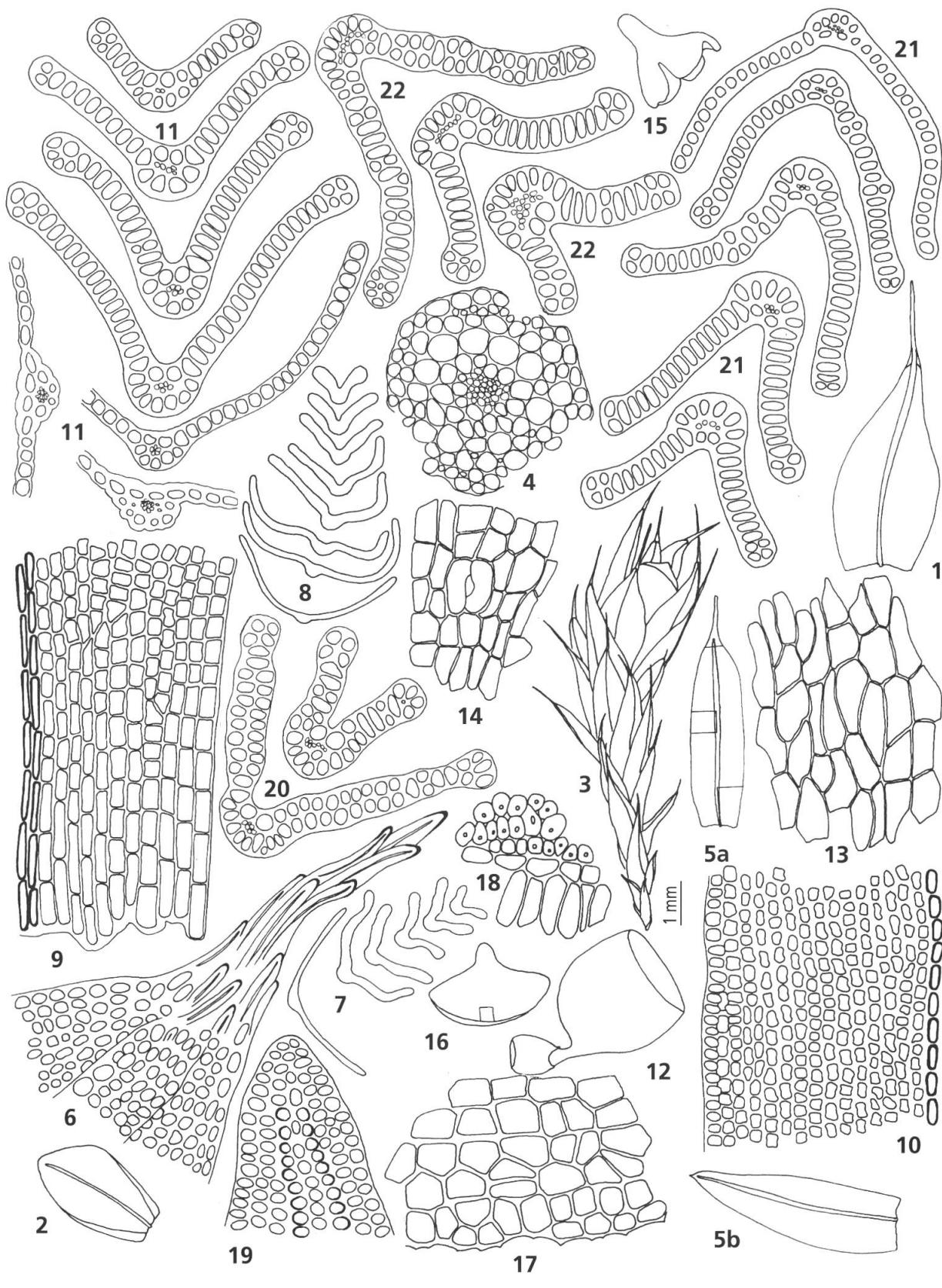
Specimens selected for the description. — **SWITZERLAND. Canton of Grisons:** “Davos, Sertig 2080 m, alpine meadow, siliceous boulder”, 28.VI.1991, *Maier* 5650 (G). **Canton of Obwalden:** “Engelberg, Trüebsee 1750 m, alpine meadow, sandstone boulder”, 1.VIII.1993, *Maier* 8680 (G). **Canton of Valais:** “Ausserberg, Baltschiedertal, 1390 m, siliceous boulders”, 7.IV.1998, *Maier* 11371 (G); “Hérémence, Lac de Dix, 2400 m, siliceous boulder”, 26.VII.1990, *Maier* 3825 (G).

2. *Grimmia anodon* Bruch & Schimp. in Bruch & al., Bryol. Eur. 25-28: 8. 1845.

Gametophyte. Monoicous. Female: innermost perichaetial leaf (Fig. 2.1) 1,5-2,0 mm, sheathing in lower, concave part, broad-ovate, broader than stem leaves, at margin 2-3 rows of elongate-rectangular, hyaline cells, vanishing in broadest part, costa stout in upper laminal part, excurring to broad, elongated hair-point; **male:** perigonia on subperichaetial branches, terminal, as multifoliate buds, innermost perigonial leaf (Fig. 2.2) 1,0-1,2 mm, lower part keeled, sheathing, ovate, apex obtuse, hyaline up to 2/3 of leaf, costa enlarged in apical part, percurrent, paraphysis in young perigonia numerous, end cell hooked. **Growth form:** cushions dense, rarely disintegrating, plants erect, branched, radiculose at base; stem (Fig. 2.3) up to 15 mm, central strand (Fig. 2.4) developed. Lower **leaves** (Fig. 2.5a) ovate, muticous, apex rounded, upper leaves (Fig. 2.5b) oblong or lanceolate, 1,2-1,5 mm, loosely disposed on stem, imbricate, erect when dry, scarcely spreading when moistened, erect when wet, from elongated leaf base ovate or broad-lanceolate, apex rounded, hair-point (Fig. 2.6) short to elongated, weakly denticulate; **leaf form in situ:** leaf base concave (Fig. 2.7 drawn from stem leaf, Fig. 2.8 drawn from perichaetial leaf), laminal part keeled or obtusely keeled, margin plane throughout; basal paracostal cells (Fig. 2.9) elongate-rectangular, walls smooth or faintly nodulose, towards margin cells rectangular or quadrate, at margin 2-3 rows of rectangular, hyaline cells, vanishing in broadest part of leaf, walls smooth, in transitional part short-rectangular or quadrate, walls more or less sinuose, upper lamina cells (Fig. 2.10) rounded-quadrate or short-rectangular, walls smooth or faintly sinuose, thickened; leaf base unistratose, lamina unistratose or irregularly bistratose in places,

Fig. 2. — *Grimmia anodon* Bruch & Schimp.: 1, perichaetial leaf; 2, perigonial leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaves, a, lower, b, upper leaf; 6, cells at apex, hair-point; 7, outlines of transverse sections of stem leaf; 8, outlines of transverse sections of perichaetial leaf; 9, cells in leaf base; 10, upper lamina cells; 11, transverse sections of leaf; 12, seta, capsule; 13, exothelial cells; 14, stoma; 15, calyptra; 16, operculum; 17, cells at margin of operculum; 18, cells at orifice, cells of annulus; 19, apex, muticous; 20-22, transverse sections of leaves.

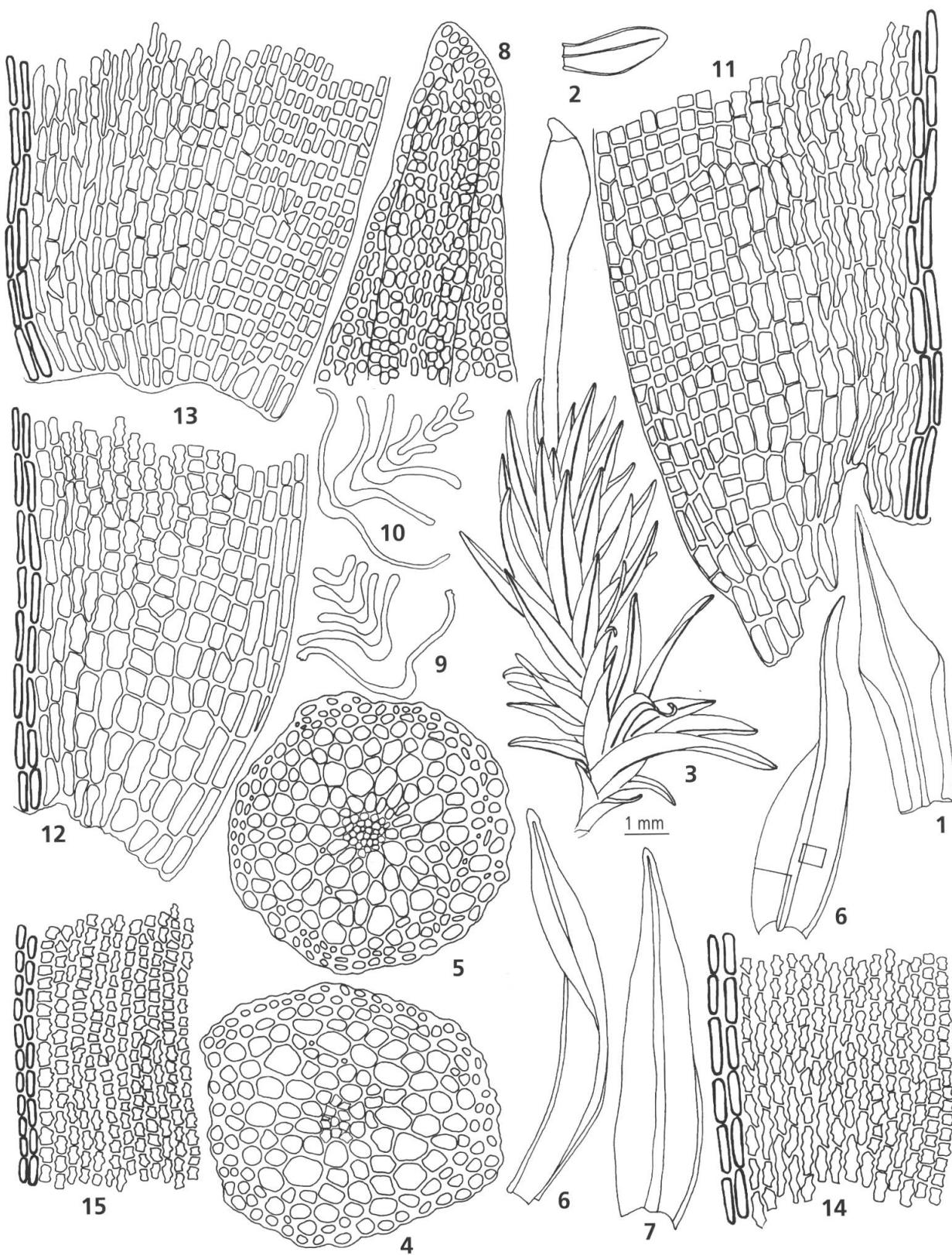
[1, 2, 4-17, Thomson 290; 3, Maier 5495; 18, Long 27017; 19, Thomson 287; 20, Long 26842; 21, Walker 431; 22, Kurz s.n.]



0,1 mm
4,6,9-11,13-14,
17-22

0,4 mm
7-8

1 mm
1-2,5a-b,12,
15-16



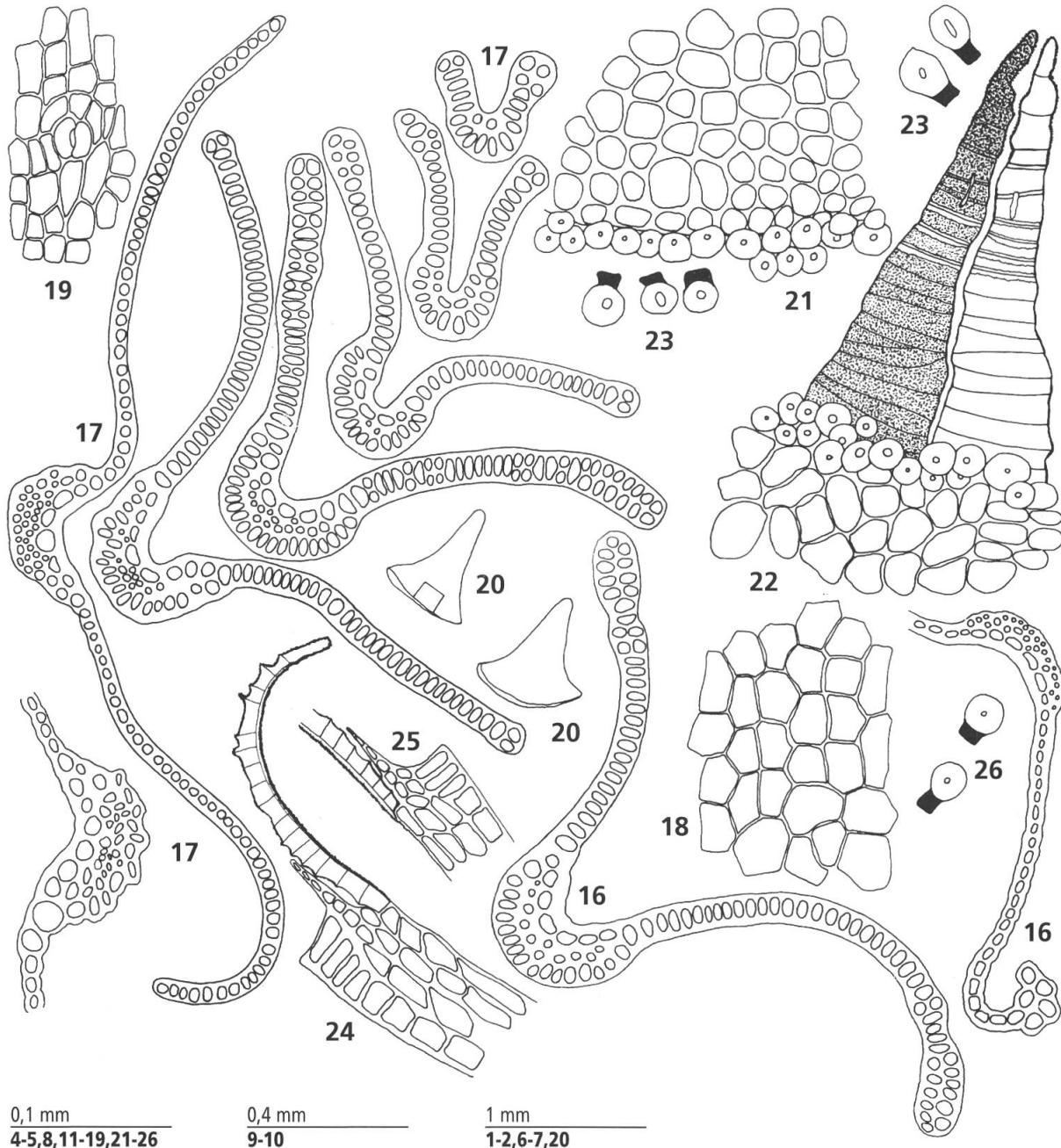


Fig. 3. – *Grimmia atrata* Hoppe & Hornsch.: 1, perichaetial leaf; 2, perigonial leaf; 3, plant with sporophyte; 4-5, transverse sections of stems; 6-7, leaves; 8, apex, muticous; 9-10, outlines of transverse sections of leaves; 11-13, cells in leaf bases; 14-15, lamina cells in transitional part of leaf; 16-17, transverse sections of leaves; 18, exothelial cells; 19, stoma; 20, opercula; 21, cells at margin of operculum; 22, peristome, outer side; 23, cells of annulus; 24, longitudinal section of peristome tooth; 25, peristome at insertion; 26, cells of annulus.

[1-2, 5-6, 8, 10-11, 15, 17-21, Long 20936; 3, Maier 6139; 4, 16, Long 22611; 7, 9, 12, 14, Long 16861; 13, 25-26, Zimmerman 558; 22-23, Hochstettler s.n.; 24, Sauter s.n.]

margin of leaf base unistratose, in laminal part one or two marginal cell rows bistratose. **Costa**, seen on dorsal side, in lower part of leaf narrow, in upper laminal part enlarged, stout, in lower, muticous leaves percurrent, in upper leaves excurrent to hair-point, seen in transverse section (Fig. 2.11), costa on dorsal side at insertion, leaf base and transitional part rounded, in upper laminal part occasionally more so, on ventral side at insertion and leaf base slightly concave, in transitional part widely channelled, in laminal part channelled, at insertion and from leaf base up to part where costa becomes enlarged four guide cells, the two outer ones may belong partly to paracostal cells, from enlarged costa part up to apical part two guide cells, a median group of hydroids throughout, neither stereids nor substereids.

Sporophyte. *Seta* (Fig. 2.12) slightly arcuate, up to 0,7 mm, vaginula 0,2 mm, with short ochrea, foot swollen. *Capsule* immersed, globose, ventricose, leptodermous, smooth, wide-mouthed after dehiscence, exothelial cells (Fig. 2.13) mostly elongated, thin-walled, stomata (Fig. 2.14) large at transition between seta and base of capsule, annulus (Fig. 2.18) of one to three rows of cells, if detaching then singly or as small groups. *Calyptra* (Fig. 2.15) mitrate, lobed, fugacious. *Operculum* (Fig. 2.16) broad, flat, vaulted, mucronate, at margin (Fig. 2.17) slightly crenulate, one or two marginal rows of nearly isodiametric cells, in conical part cells irregular, mostly quadrate or pentagonal, thick-walled. **Peristome** none.

Spores 6-10 μ m, smooth.

Diagnostic characters. – **Gametophyte:** margin plane throughout, 1-2 marginal cell rows bistratose; costa in upper laminal part enlarged, stout, with a median group of hydroids throughout, neither stereids nor substereids present. **Sporophyte:** capsule wide-mouthed after dehiscence, peristome none.

Comments. – Plants with muticous leaf apices (Fig. 2.19) are not very rare. They are found occasionally in plants buried in decaying substratum.

Stratosity is variable; leaves with alternating uni- and bistratose cell patches (Fig. 2.20) as well as totally unistratose (Fig. 2.21) or in apical part bistratose laminae (Fig. 2.22) may be found.

One specimen found in BM, leg. Kurz, in herb. Hampe, 1881, is labelled as “*Grimmia subanodon* C. Müll.” [nom. nud.], and, on the same label, as “*Grimmia subnuda* C. Müll.” [nom. nud.]; it is *G. anodon* (Fig. 2.22).

Provenance. – India, NW Himalaya, Pakistan, Tibet.

Habitat. – On dry and exposed limestone rocks in crevices, from 2000-4600 m; one specimen found at 6000 m, the highest altitude reached by a species in present study.

Specimens examined. **Thirty-nine**, sixteen of them from the study-area. The selected ones are: **INDIA.** “Himalaya, s.d., Kurz s.n., Herbarium Hampe (BM). **PAKISTAN. Karakorum, Baltistan:** “Endmoränengebiet des Biafro-Gletschers, Strauchsteppe in Schotterebene 3080 m”, 15.V.1962, Hartmann M 35 (Z+ZT). **Northern Areas, Baltistan:** “Deosai National Park. Valley of the Shatung River, Bari La area, along road to Matiyal. Lat 35°01'N Long 75°34'E, 4200 m. Steep S-facing cliffs of basalt, gabbro and granite”, 3.VIII.1998, Hedderson 12486 (BOL). **TIBET.** “Chitichun, 16 000-18 000”, VIII.1899, Herb. Dixon, Walker 431 (BM). “Iskardo, Balti, 7000”, Herb. Ind. Or. Hook. fil. & Thomson, Thomson 290 (BM, NY). “Rondu, 6000”, Herb. Ind. Or. Hook. fil. & Thomson, Thomson 287 (BM, NY).

Specimens selected for the description. **CHINA. Qinghai, Henan County:** “Xiawate, Zhihoumao Xiang S of Henan, 34°31'20"N, 101°31'13"E; steep slopes below limestone cliffs, on dry limestone cliff, 3800 m”, 15.VII.1997, Long 27017 (E, G). **Maduo County:** “Ang'lexiao Pass, SE of Huashixia, 35°49'N, 99°02'E; open rocky hillside; in limestone block scree, 4620 m”, 5.VII.1997, Long 26842 (E, G). **SWITZERLAND. Canton of Fribourg:** “Montbovon, Col de Bonaudon 1755 m, limestone”, 1.VI.1991, Maier 5495 (G).

3. *Grimmia atrata* Hoppe & Hornsch. in Flora 2: 85. 1819.

= *G. ochyriana* J. Muñoz in Nova Hedwigia 66: 235. 1998, **syn. nov.**

Gametophyte. Dioicous. Female: innermost perichaetal leaf (Fig. 3.1) 2,8-4,4 mm, sheathing nearly completely up to upper third, from broad-rectangular base tapering to narrow, muticous, acuminate apex, sheathing part hyaline, costa strong in lower part, attenuated in upper part,

vanishing below apex; **male** plants smaller, in separate cushions, perigonia as buds on short terminal stalks and in leaf axils, several in a plant, innermost perigonial leaf (**Fig. 3.2**) 0,8 mm, sheathing, concave, ovate, apex rounded, at margin two rows of hyaline cells, vanishing in broadest part, other cell walls thickened, costa vanishing below apex, paraphysia not seen. **Growth form:** cushion dark green or blackish green, interwoven with rhizoids, plants erect, strongly radiculose at base, branched in upper part, stem (**Fig. 3.3**) up to 60 mm, central strand lacking or poorly (**Fig. 3.4**) to strongly (**Fig. 3.5**) developed. **Leaves** (**Fig. 3.6, 3.7**) 2,5-2,7 mm, when dry imbricate, appressed to stem, upper part contorted around stem, when moistened older leaves bending backwards, younger leaves scarcely spreading, erectopatent when wet, from ovate base lanceolate-lingulate, muticous (**Fig. 3.8**), apex obtuse, occasionally cucullate; **leaf form in situ:** (**Fig. 3.9, 3.10**) at insertion slightly concave, at leaf base obtusely keeled, in lower laminal part keeled, in upper part narrowly so, margin on one side recurved from insertion up to above broadest part of leaf; basal paracostal cells (**Fig. 3.11-13**) elongate-rectangular, walls thickened, nodulose, towards margin cells elongate- to short-rectangular, at margin a row of quadrate cells, all cell walls smooth, transverse walls thickened, in transitional part (**Fig. 3.14, 3.15**) cells rectangular, walls incrassate, sinuose, lamina cells mostly isodiametric, lumen rounded (**Fig. 3.8**), walls faintly sinuose; leaf base unistratose, laminal part (**Fig. 3.16**) irregularly bistratose, rarely with tristratose patches, both margins at insertion and leaf base bistratose or unistratose, as well as bistratose on one side only, in laminal part bistratose of different extent. **Costa**, seen on dorsal side, stout, broad at insertion and leaf base, attenuated in laminal part, obscure below apex, not reaching apex in all leaves, seen in transverse section (**Fig. 3.17**), costa on dorsal side at insertion and leaf base widely rounded, occasionally irregularly mammillose, from transitional part up to apical part rounded, slightly contracted at origin of lamina, on ventral side from insertion up to upper laminal part widely channelled to channelled, in upper laminal part narrowly so, at insertion and leaf base eight guide cells, in transitional part six, gradually reduced to two in apical part, from insertion up to laminal part a median band of substereids, if hydroids then vanishing in transitional part.

Sporophyte. **Seta** straight (**Fig. 3.3**), 1,5-5 mm, vaginula 1,2-1,7 mm, ochrea small. **Capsule** emergent or partly hidden between leaves, erect, cylindrical, with short distinct apophysis, narrowed at orifice when deoperculate, smooth, exothecium cells (**Fig. 3.18**) irregular, hexagonal, isodiametric, walls thin, stomata (**Fig. 3.19**) few to numerous in apophysal part, annulus of four or five rows of singly detaching cells of specific shape (**Fig. 3.23, 3.26**): lower part short-cylindrical, brownish, upper part globular, hyaline, lumen narrow. **Calyptra** mitrate-campanulate (LIMPRICHT, 1888-1889: 792). **Operculum** (**Fig. 3.20**) rostrate, beak short or long, straight or oblique, at margin (**Fig. 3.21**) smooth, some marginal rows of small, rounded cells, in conical part irregular, isodiametric, rectangular, walls thickened. **Peristome** teeth (**Fig. 3.22**) broad, entire or weakly perforate, neared at base, recurved to capsule wall when dry, inserted below orifice, trabeculae in lower part thin, in upper part thickened; seen in longitudinal section (**Fig. 3.24**) between exothecium and teeth two cell rows, a paradental cell row extending as uniseriate prolongation of three to five cells, outer layer of teeth thicker than inner one, both sides densely covered with fine papillae, trabeculae neared, scarcely protruding.

Spores 12-14 μm , granulose.

Diagnostic characters. – **Gametophyte:** leaves lanceolate-lingulate, muticous, obtuse, keeled in laminal part; costa broad, stout at leaf base. **Sporophyte:** annulus cells of a particular shape, a unique feature among the species in present study, at insertion of peristome a paradental uniseriate cell row present.

Comments. – A central strand is present in most Asian specimens, it may be weakly (**Fig. 3.4**) or well developed (**Fig. 3.5**), different states of development may be observed in one and the same stem. European specimens lack a central strand.

Bistratose alar cells, a regular feature of European specimens, are not present in all specimens under study. Both, unistratose (**Fig. 3.17**) or bistratose (**Fig. 3.16**) margins on both sides, as well as a bistratose margin on one side only, have been seen. Central strand development and

variation of stratosity of margins at the leaf base are not correlated to costal architecture and peristomial characters.

The described shape of the annulus cells is a unique feature as far as it has been observed in a species under study. DIHM (1894) examined specificity of annulus cells, DEGUCHI (1979) recognized three types of annuli.

An incompletely developed peristome has been seen in a specimen collected at 4460 m, traces of peristome plates remained in the operculum, the short seta – 1,8 mm, including the vaginula 1,2 mm – and bleached operculum may indicate poor maturation conditions (MAIER, 1999).

Arguments for synonymy. – In the specimen *Zimmermann 558* (G, designated as a paratype of *G. subdonniana* Nog. (= *G. fuscolutea* Hook.)), collected in Nepal at 5100 m, Muñoz found some plants which he described as *G. ochyriana* (MUÑOZ, 1998c). The leaf shape, muticous apex, costal architecture, uniserrate prolongation of a parandinal cell row at peristome insertion (Fig. 3.25), and particular shape of annulus cells (Fig. 3.26) show no essential differences from characters of *G. atrata*. Thus it is reasonable to place *G. ochyriana* in synonymy with *G. atrata*.

Provenance. – Nepal, Sikkim.

Habitat. – On rocks, moraines, between 4400 and 5100 m.

Specimens examined. – **Fourteen**, six of them from the study-area. The selected ones are: **NEPAL**. “1 km below Lhonak, Kangchenjunga Glacier, 27°47'N, 88°02'E; moraine ridges on valley side; on soil at base of boulder, c. 4630 m”, 12.IX.1989, *Long 16861* (E, G). “Près du camp de Base, en direction de Lobuje, alt. 5100 m”, 31.V.1952 [not 1964 as erroneously indicated in MUÑOZ, 1998c], *Zimmermann 558* (G, IBA). **NEPAL. Sankhuwasabha District:** “Upper Barun Khola valley above Mera, 27°49'N, 87°07'E; dry rocky river valley; in crevices of dry rocks, c. 4460 m”, 4.X.1991, *Long 20936* (E, G). **SIKKIM. West District:** “Glacial lake below icefall S of Kabru Dome, 27°33'N, 88°07'E: Cliffs above lake; forming cushions on rock face, c. 4650 m”, 15.VII.1992, *Long 22611* (E, G).

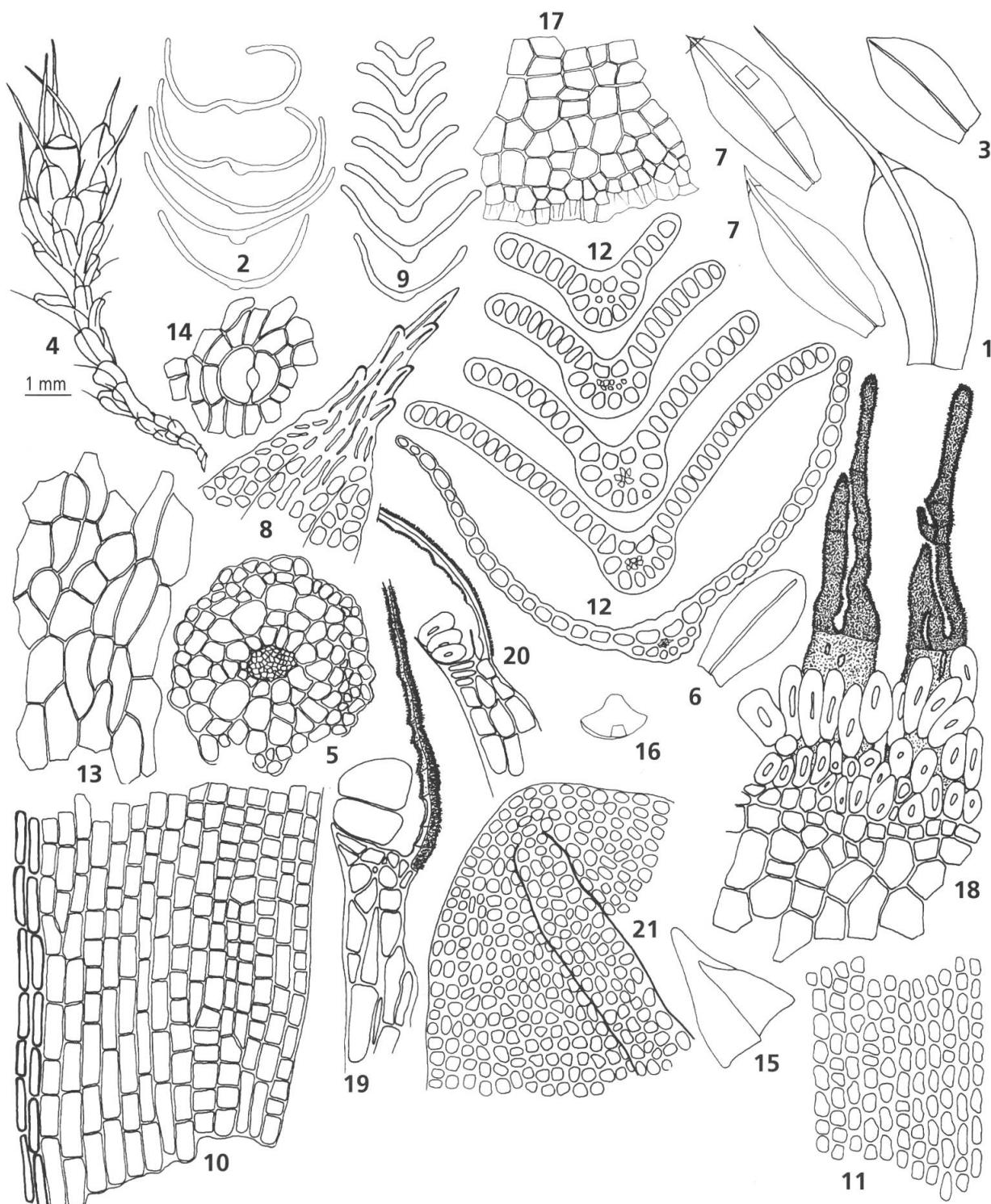
Specimens selected for the description. – **AUSTRIA. Salzburg:** “Salzburgeralpen”, 1848, *Hochstettler s.n.* (G). **FRANCE.** “Pyrénées, Lai blue”, 1851, *Sauter s.n.* (G). **NORWAY.** “Vorstigen 1050 m, humid rock”, 7.VII.1991, *Maier 6139* (G).

4. *Grimmia crinita* Brid., Muscol. Recent. Suppl. 1: 95. 1806.

Gametophyte. Monoicous. Female: innermost perichaetial leaf (Fig. 4.1) up to 2,5 mm, sheathing up to apical part, concave (Fig. 4.2) throughout, shaped as stem leaves, at margin some rows of elongate-rectangular, hyaline cells, vanishing in broadest part of leaf, costa excurrent to elongated, nearly smooth hair-point; **male:** perigonia on subperichaetial branch as buds on short stalks, innermost perigonial leaf (Fig. 4.3) 0,6 mm, sheathing, ovate, leaf base hyaline, at margin some rows of hyaline cells vanishing in apical part, costa percurrent, paraphysia few. **Growth form:** cushion dense, adherent to substrate by rhizoids, of lustrous gray colour caused by long hair-points pointing in same direction, interwoven with young shoots originating from older stems, plants branched, scarcely radiculose, stem erect (Fig. 4.4), up to 10 mm, central strand (Fig. 4.5) well developed. **Leaves** crowded, lower ones (Fig. 4.6) muticous, apex rounded, upper leaves (Fig. 4.7) up to 1,5 mm, imbricate, appressed to stem when dry, scarcely moving when moistened, erectopatent when wet, obovate, leaf base markedly narrowed at insertion, greatest width above mid-leaf, apex rounded, hyaline to variable extent, hair-point short (Fig. 4.8) to elongated, faintly denticulate, lumina of hyaline cells distinct; **leaf form in situ:** (Fig. 4.9) leaf base concave, laminal part keeled, margin plane or slightly recurved in upper part; basal cells (Fig. 4.10) elongate-rectangular, broad, walls smooth, at margin some cell rows short-rectangu-

Fig. 4. – *Grimmia crinita* Brid.: 1, perichaetial leaf; 2, outlines of transverse sections of perichaetial leaf; 3, perigonial leaf; 4, plant with sporophyte; 5, transverse section of stem; 6, lower leaf; 7, upper leaves; 8, cells at apex, hair-point; 9, outlines of transverse sections of stem leaf; 10, cells in leaf base; 11, lamina cells in upper part of leaf; 12, transverse sections of stem leaf; 13, exothelial cells; 14, stoma; 15, calyptra; 16, operculum; 17, cells at margin of operculum; 18, peristome, outer side, with annulus; 19, 20, longitudinal sections of peristome teeth; 21, apex, muticous.

[1, 5-12, 20, Dickoré F 2; 2-3, 13-17, Maier 8444; 4, Maier 7972; 18-19, 21, Maier 10424]



0,1 mm
5,8-14,17-21

0,4 mm
2

1 mm
1,3,6-7,15-16

lar to quadrate, transverse walls thickened, smooth, upper lamina cells short-rectangular, walls sinuose or nearly smooth (**Fig. 4.11**), thickened; lamina and margin unistratose. **Costa**, seen on dorsal side, weak in lower part of leaf, becoming stronger in apical part, passing through hyaline apical part, excurring to hair-point, in muticous leaves vanishing below apex, seen in transverse section (**Fig. 4.12**), costa on dorsal side at insertion, leaf base and transitional part rounded, in laminal part more so, on ventral side channelled, at insertion, leaf base and lower laminal part four guide cells, the two outer belonging partly to basal paracostal cells, in apical part two guide cells, a median, central group of hydroids, in upper part transformed to few substereids.

Sporophyte. *Seta* arcuate, of capsule length, vaginula 0,6 mm, ochrea small. **Capsule** immersed, slightly inclined or horizontal, ovoid, ventricose, after dehiscence narrow-mouthed, faintly ribbed, exothecial cells (**Fig. 4.13**) multiform, mostly elongated, walls thin, stomata large (**Fig. 4.14**), numerous between enlarged seta and capsule base, annulus of four cell rows, persisting even in nearly decomposed capsules, only distal row detaching as single cells. **Calyptra** cucullate (**Fig. 4.15**), small. **Operculum** short-conical, beak short, obtuse (**Fig. 4.16**), margin uneven (**Fig. 4.17**), a marginal row of quadrate cells, in conical part cells enlarged, angulate, walls smooth, thin. **Peristome** inserted at margin of orifice, teeth (**Fig. 4.18**) erect when dry, slit to two or three fine branches, perforate, trabeculae thin, seen in longitudinal section (**Fig. 4.19**, **4.20**) teeth recurved to capsule wall, one row of cells between exothecium and teeth, their inner and outer layer of same thickness, both sides densely covered with long, fine papillae, except some smooth outer lower cell plates, hidden by persistent annulus cells, trabeculae distant, scarcely protruding.

Spores 10-12 μ m, smooth.

Diagnostic characters. – **Gametophyte:** leaf from strongly narrowed base widening to broadest part above mid-leaf; margin plane, unistratose. **Sporophyte:** seta short, curved; annulus persistent; the peristome inserted at the margin of orifice, recurved to capsule wall, as seen in longitudinal section, is a unique feature among *Grimmia* species presented in this study.

Comments. – The typical gray colour is due to the long hair-points pointing in the same direction, as in European specimens from low altitude growing as a xerophyte exclusively on vertical side of mortar-covered concrete walls in vineyard regions. This colour is lacking in the Asian samples examined. They are dark green due to the mostly muticous leaves (**Fig. 4.21**), grown under harsh conditions and at relatively high altitudes. Old and immature capsules have been seen in May, old capsules in August; maturity in June or July? *Grimmia anodon* is associated with the specimen from Korofon, Pakistan.

Provenance. – Pakistan.

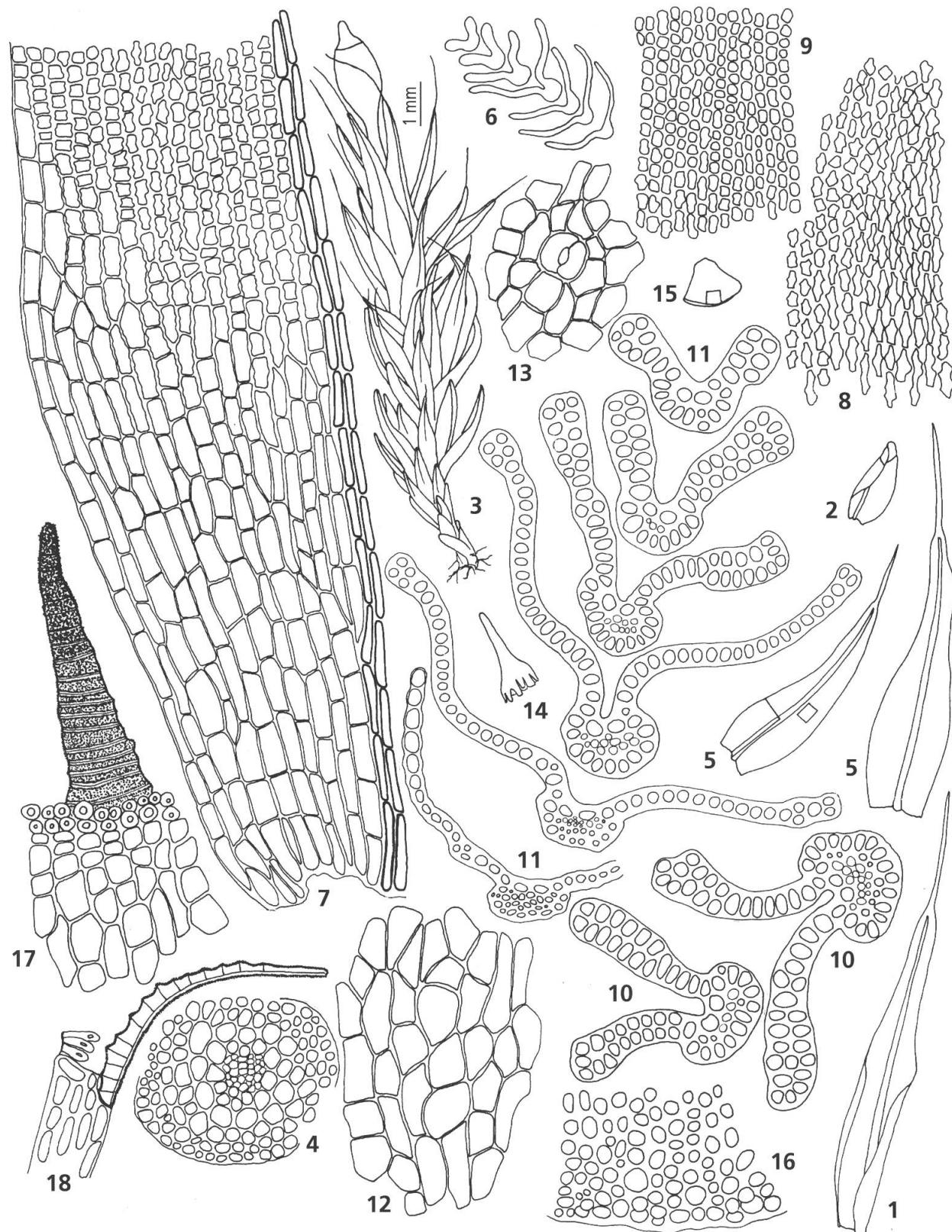
Habitat. – On loess, alluvia, in river valley, on siliceous boulder, at altitudes between 3000 and 3150 m.

Specimens examined. – **Three**, two of them from the study-area: **PAKISTAN. Karakorum, Baltistan:** “Korofon, 3150 m, an Felsblock, Paragneis, in Artemisia-Steppe, Schweizerische Expedition zum Biafo-Gletscher 1962”, 29.V.1962, Hartmann s.n. (Z+ZT); **Northern area:** “Chapursan Valley, W Kil, 3025 m, Alluvionen, Halbwüste”, 12.VII.1998, Gruber 1934 (Herb. Gruber).

Specimens selected for the description. – **CHINA. Xinjiang Prov.:** “Nordwestlicher Kunlun Shan, an der Strasse Yecheng-Mazar, ca. 1 km südl. Kodi, im Flusstal (N 36°50' E 76°50''), 3050 m, Schwemmlöss im Flusstal, Wüste mit Nitraria schoberi, Berberis ulicina, etc., ebene Lössfläche. Deutsch-chinesische K2-Expedition 1986”, 20.VIII.1986, Dickeré F 2 (GZU). **SWITZERLAND. Canton of Neuchâtel:** “St. Blaise 460 m, Limestone wall SW-exposure”, 11.IV.1995, Maier 10424 (G). **Canton of Vaud:** “Chexbres, 480 m, on mortar on vineyard wall, SW-exposure”, 30.IV.1993, Maier 7972 (G); “Cully, Chenaux 570 m, on mortar on vineyard wall”, 4.XI.1993, Maier 8444 (G).

Fig. 5. – *Grimmia donniana* Sm.: **1**, perichaetial leaf; **2**, perigonial leaf; **3**, plant with sporophyte; **4**, transverse section of stem; **5**, leaves; **6**, outlines of transverse sections of leaf; **7**, cells in leaf base; **8-9**, lower lamina cells; **10-11**, transverse sections of leaves; **12**, exothecial cells; **13**, stoma; **14**, calyptra; **15**, operculum; **16**, cells at margin of operculum; **17**, peristome, outer side; **18**, longitudinal section of peristome tooth.

[**1-2, 4, 6, 11**, Long 20957; **3, 14**, Maier 8585; **5, 7, 10, 12-13, 15-18**, Hooker 299; **8**, Maier 7544; **9**, Greter 7846]



0,1 mm
4,7-13,16-18

0,4 mm
6

1 mm
1-2,5,14-15

5. *Grimmia donniana* Sm., Engl. Bot. 18: 1259. 1804.

Gametophyte. Monoicous. Female: innermost perichaetial leaf (**Fig. 5.1**) up to 2,5 mm, sheathing up to mid-leaf, not very different from stem leaves in shape and cell pattern, lower part of leaf hyaline, costa percurrent to long, denticulate hair-point; **male:** perigonia on short subperichaetial branches as buds on short stalks in leaf axils, innermost perigonial leaf (**Fig. 5.2**) 0,8 mm, sheathing up to broadest part, ovate, obtuse or mucronate, muticous or with acute hyaline end cell, from base up to below leaf tip or only in lower part hyaline, costa weak, percurrent, paraphysia few. **Growth form:** cushions dense, compact, adherent to substrate with rhizoids, young shoots originating from rhizoids or older stem parts, leaflets muticous, apex acute, plants erect, branched, radiculose at base, stem (**Fig. 5.3**) up to 20 mm, central strand (**Fig. 5.4**) developed. Lower **leaves** small, muticous, upper leaves (**Fig. 5.5**) up to 2,4 mm, laxly disposed on stem, apices slightly bent towards stem when dry, longer leaves bending backwards, shorter leaves moving slightly when moistened, erectopatent when wet, from narrow base elongate-lanceolate, tapering to rounded or obtuse apex, hair-point elongated, smoothly denticulate; **leaf form in situ:** (**Fig. 5.6**) insertion and leaf base concave, lower laminal part keeled, upper part narrowly so, margins plane throughout; basal paracostal cells (**Fig. 5.7**) elongate-rectangular, walls smooth, towards margin some rows of elongate-rectangular, hyaline cells, longitudinal and transverse walls of even thickness, thin and smooth, the rows gradually vanishing, outermost row reaching up to above broadest part of leaf, thus forming between hyaline and thicker walled chlorophyllose cells a delimitation, running obliquely from costa to margin, in transitional part near costa cells rectangular, walls sinuose, towards margin some hyaline cells with finely sinuose walls, lower lamina cells short-rectangular, walls more (**Fig. 5.8**) or less sinuose (**Fig. 5.9**), thickened, at upper laminal part cells mostly isodiametric, walls thickened, smooth or sinuose; lamina unistratose or bistratose in places, occasionally totally bistratose (**Fig. 5.10**) in upper part except near costa, margin unistratose at leaf base, in laminal part several rows bi- or tristratose. **Costa**, seen on dorsal side, small at leaf base, becoming gradually broader in laminal part, indistinct at apex, percurrent or excurrent, seen in transverse section (**Fig. 5.11**), costa on dorsal side at insertion and leaf base angulate or rounded, in laminal part rounded or occasionally prominent, on ventral side at insertion nearly plane, at leaf base widely channelled, in lower part of lamina channelled, in upper part narrowly so, at insertion and leaf base four guide cells, from transitional part up to apical part two guide cells, from insertion up to upper laminal part a median group of hydroids, at insertion and leaf base costa cells substereid.

Sporophyte. Seta straight (**Fig. 5.3**), occasionally curved, of different length, from 0,8-3 mm, vaginula 0,8 mm, ochrea broad. **Capsule** erect, horizontal at curved seta, ovoid with short neck, bright-coloured when mature, with age turning to brownish, smooth, exothecial cells (**Fig. 5.12**) irregular, quadrate, hexagonal, elongated, thin-walled, stomata (**Fig. 5.13**) large above short neck, annulus of two rows of cells, if detaching then singly, seen on surface view round with small lumen. **Calyptra** (**Fig. 5.14**) mitrate, lobed, covering operculum. **Operculum** (**Fig. 5.15**) conical, mammillate, margin (**Fig. 5.16**) smooth, cells rounded, thick-walled. **Peristome** (**Fig. 5.17**) inserted below orifice, teeth incurved or recurved when dry, broad at base, mostly entire at apex, trabeculae small in lower half, thin in upper half, seen in longitudinal section (**Fig. 5.18**) between exothecium and teeth two cell rows, outer layer thicker than inner one, inner and outer upper side densely covered with fine papillae, minute in outer lower half, trabeculae more or less distant, prominent in lower half, scarcely marked in upper part.

Spores 8-9 μm , smooth.

Diagnostic characters. – **Gametophyte:** on margin, even of the lowest leaves, are some rows of elongate-rectangular, hyaline cells, with longitudinal and transverse walls of even thickness, very thin, vanishing above broadest part of leaf; margin never recurved; calyptra mitrate. **Sporophyte:** annulus cells seen on surface view round with narrow lumen.

Comments. – Plants may be found with leaves muticous or with hair-points reduced to a few hyaline cells.

The marginal, hyaline cell rows at the base of all stem leaves, even the youngest ones, are a distinctive feature of *G. donniana* (see comment under *G. sessitana*).

Lamina and margin stratosity is variable and lamina cell walls can be strongly or only faintly sinuose.

Seta length and curvature are influenced by growing conditions. Plants with very short setae, even shorter than capsules, and often incompletely developed peristomes, are found at high altitudes in Europe between 2000 and 3000 m. Setae from 0,8-2,5 mm length can appear in one and the same cushion (LOESKE, 1913: 95-97). Curved setae are often a sign of the immature state of the sporogonia or are present in plants growing in shady places. Such varieties have been named as *G. triformis* Carestia & De Not. (LIMPRICHT, 1888-1889) (seta short) or *G. arenaria* Hampe (seta curved). (Neither type seen). Costal architecture, morphological and peristomial characters show these taxa to be identical to *G. donniana* (MAIER, 1999). In LIMPRICHT's view (1888-1889: 735) "G. arenaria is a dwarf *G. donniana*" (translation EM), and following LOESKE's opinion (1930: 114, 115) their taxonomic rank is that of forma. CORLEY & al. (1981) consider *G. arenaria* to be a synonym of *G. donniana*.

Capsules from plants grown under extreme ecological conditions appear never to ripen completely. In these, papillosity of peristome teeth is poorly developed and the lumen of the annulus cells is not formed.

Provenance. – Nepal, Sikkim.

Habitat. – On siliceous rocky ridges, boulders, at exposed places, at altitudes between 4500 and 5240 m.

Specimens examined. – **Seventeen**, nine of them from the study-area. The selected ones are: **NEPAL. Sankhuwasabha District:** "SE ridge of Makalu, above Base Camp, 27°52'N, 87°05'E; exposed rocky ridge; on boulder; c. 5110 m", 5.X.1991, Long 20957 (E, G). **Khumbakarna-Himal, Dhankuta Distr.:** "Upper Barun Valley 4800 m", 25.IX.1972, Wra-ber s.n. (GZU). **SIKKIM.** "Himalaya, Lachung 15 000", Herb. Ind. Or. Hook. fil. & Thomson, Hooker 299 (BM).

Specimens selected for the description. – **SWITZERLAND. Canton of Obwalden:** "Engelberg, Niedersurenen 1300 m", 15.IX.1931, Greter 7846 (G); "Engelberg, Laubersgrat 1970 m, on upper edge of slab", 29.VII.1993, Maier 8585 (G). **Canton of Uri:** "Wassen, Meiental 1140 m, boulder near stream, shady", 18.IX.1992, Maier 7544 (G).

6. *Grimmia elatior* Bals.-Criv. & De Not. in Mem. Reale Accad. Sci. Torino 40: 340. 1838.

Gametophyte. Dioicous. Female: inner two perichaetial leaves shorter than stem leaves, 3,2-3,6 mm, sheathing up to broadest part, concave at leaf base, the outer suddenly narrowed to lanceolate upper part, the innermost lanceolate (Fig. 6.1), lower third hyaline, at margin a row of elongate-rectangular hyaline cells, vanishing above broadest part of leaf, costa stout, excurring to elongated, denticulate hair-point; **male** plants in separate cushions, strongly branched, leaves with short hair-point, perigonia as multifoliate buds on short stalks in leaf axils, several on stem, innermost perigonial leaf (Fig. 6.2) up to 1 mm, sheathing, from broad-ovate leaf base tapering to acute, muticous apex, hyaline except extreme leaf tip, costa percurrent, paraphysia few. **Growth form:** cushion lax, plants ascending or erect, dichotomously branched, scarcely radiculose at base, on lower stem part leaves rotten, stem (Fig. 6.3) up to 80 mm, central strand (Fig. 6.4) developed in comal tuft, lacking in lower stem part and branches. **Leaves** (Fig. 6.5) up to 4 mm, imbricate, lower part appressed to stem, upper part homomallous, apices at stem tip bent backwards when dry, leaves bending backwards when moistened, patent when wet, from oblong to ovate, decurrent leaf base elongate-lanceolate, hair-point very short to elongated, smoothly denticulate; *leaf form in situ:* (Fig. 6.6) at insertion and leaf base widely concave, in lower laminal part keeled, in upper part narrowly so, margin from insertion up to above mid-leaf on one side revolute, on other side from above leaf base to mid-leaf slightly recurved, in upper leaf part both sides plane; basal paracostal cells (Fig. 6.7) elongate-rectangular, walls nodulose, at margin some rows rectangular, hyaline, walls smooth, lower lamina cells short-rectangular, walls faintly to strongly sinuose, in upper laminal part cells (Fig. 6.8) isodiametric, lumen rounded, exterior cell walls either irregularly papillose (Fig. 6.9) or smooth (Fig. 6.10); leaf base unistratose, at places bistratose, in laminal part bistratose, margin unistratose at leaf base, tri- to

quadristratose in laminal part. **Costa**, seen on dorsal side, stout, of nearly uniform breadth throughout, excurrent, seen in transverse section (Fig. 6.9, 6.10), costa on dorsal side at insertion and leaf base rounded, occasionally angulate, in transitional and lower laminal part prominent, papillose or smooth, in upper laminal part angulate or rounded, on ventral side from insertion up to lower laminal part channelled, in upper part narrowly so or recessed in deep furrow, at insertion costa enlarged by subcostal cells, two to four guide cells, dorsally added a second row of three or four guide cells, from leaf base up to transitional part gradually reduced to two ventral and two dorsally added guide cells, in upper part two guide cells, those of second row vanishing, costal cells nearly homogeneous, occasionally substereids, no hydroids.

Sporophyte. *Seta* arcuate (Fig. 6.3) at mature state and when wet, straight after spore release, up to 3 mm, vaginula 1,2 mm, ochrea distinct. *Capsule* emergent, horizontal or pendent, obloid, ribbed, exothelial cells quadrate, rectangular or of variable shape, walls thin, stomata (Fig. 6.11) numerous on short neck, annulus of three or four rows of cells, detaching as spirals. *Calyptra* (Fig. 6.12) conical, mitrate, lobed, covering operculum. *Operculum* (Fig. 6.13) conical, beak long, straight, margin (Fig. 6.14) uneven, one or two rows of small, isodiametric marginal cells, in conical part two rows of elongate-pentagonal or –hexagonal cells, above irregularly shaped cells. *Peristome* (Fig. 6.15) inserted at orifice, teeth erect when dry, linear-lanceolate, perforate or deeply slit to two or three fine branches, trabeculae small in lower, thin in upper part, lower outer side in places with traces of prostome, seen in longitudinal section (Fig. 6.16) one or two rows of large cells between exothecium and teeth, their outer layer thicker than inner one, inner side and upper half of outer side densely covered with fine papillae, lower outer side smooth, trabeculae neared, in lower third scarcely, in upper part markedly protruding, with prostome.

Spores 12-15 μm , granulose.

Diagnostic characters. – **Gametophyte:** costa dorsally stout, ventrally in upper part narrowly keeled or deeply recessed in furrow, from insertion up to lower laminal part, guide cells arranged in two ventral rows, no hydroids. **Sporophyte:** capsule ribbed; peristome with prostome.

Comments. – Plants growing under harsh conditions as at high altitudes or in exposed places show modifications of growth, leaf shape, development of hair-point, and particularly of cell pattern at leaf base; papillosity of lamina cells is strongly expressed. A specimen collected by J. Amann in the Swiss Alps at 3100 m as *G. alpestris* f. *nana* (MAIER & GEISSLER, 1997) shows strongly modified morphological characters: leaf length reduced to 1,2 mm (Fig. 6.17), hair-points reduced to few hyaline cells, at leaf base cells (Fig. 6.18) quadrate, rounded or transversely oval except for two paracostal rows of short-rectangular cells with walls thickened. Such features may suggest *G. alpestris*. As costal architecture is not altered, transverse sections indicate *G. elatior*. See also comments under *G. fuscolutea*, *G. longirostris*, and *G. ovalis*.

Paracostal cells at the leaf base are subject to variability in length and nodulosity, very elongated or strongly shortened cells may be observed, also lamina cells may be nearly smooth or densely papillose. These features are not correlated to costal architecture or peristome characters.

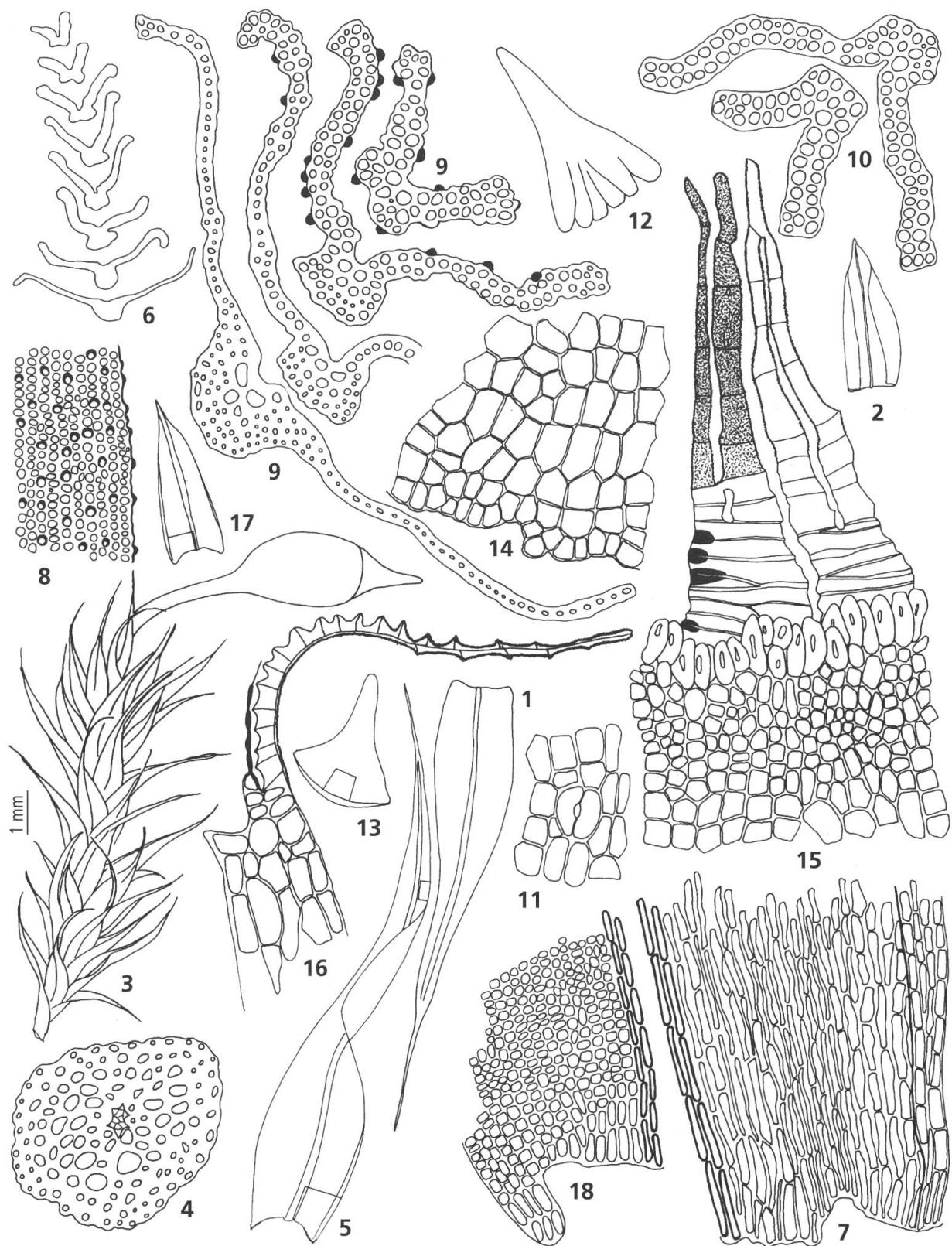
Provenance. – Kashmir, Pakistan.

Habitat. – On rocks at altitudes between 3000 and 4290 m.

Specimens examined. – **Fifteen**, eight of them from the study-area. The selected ones are: **KASHMIR**. “On rock ledges on a bluff facing N.E. in the Michinai Valley ca 22 km. N.W. of Sonamarg c. 3350 m”, 27.VII.1987, *Townsend* 87/343 (ALTA). **PAKISTAN. Baltistan:** “Rupal Valley, Tarishing S Chhichi gol (valley), *Pinus wallichiana* und *Picea*

Fig. 6. – *Grimmia elatior* Bals.-Criv. & De Not.: 1, perichaetial leaf; 2, perigonial leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaf; 6, outlines of transverse sections of leaf; 7, cells in leaf base; 8, upper lamina cells; 9-10, transverse sections of leaves; 11, stoma; 12, calyptra; 13, operculum; 14, cells at margin of operculum; 15, peristome, outer side; 16, longitudinal section of peristome tooth; 17, leaf; 18, cells in leaf base.

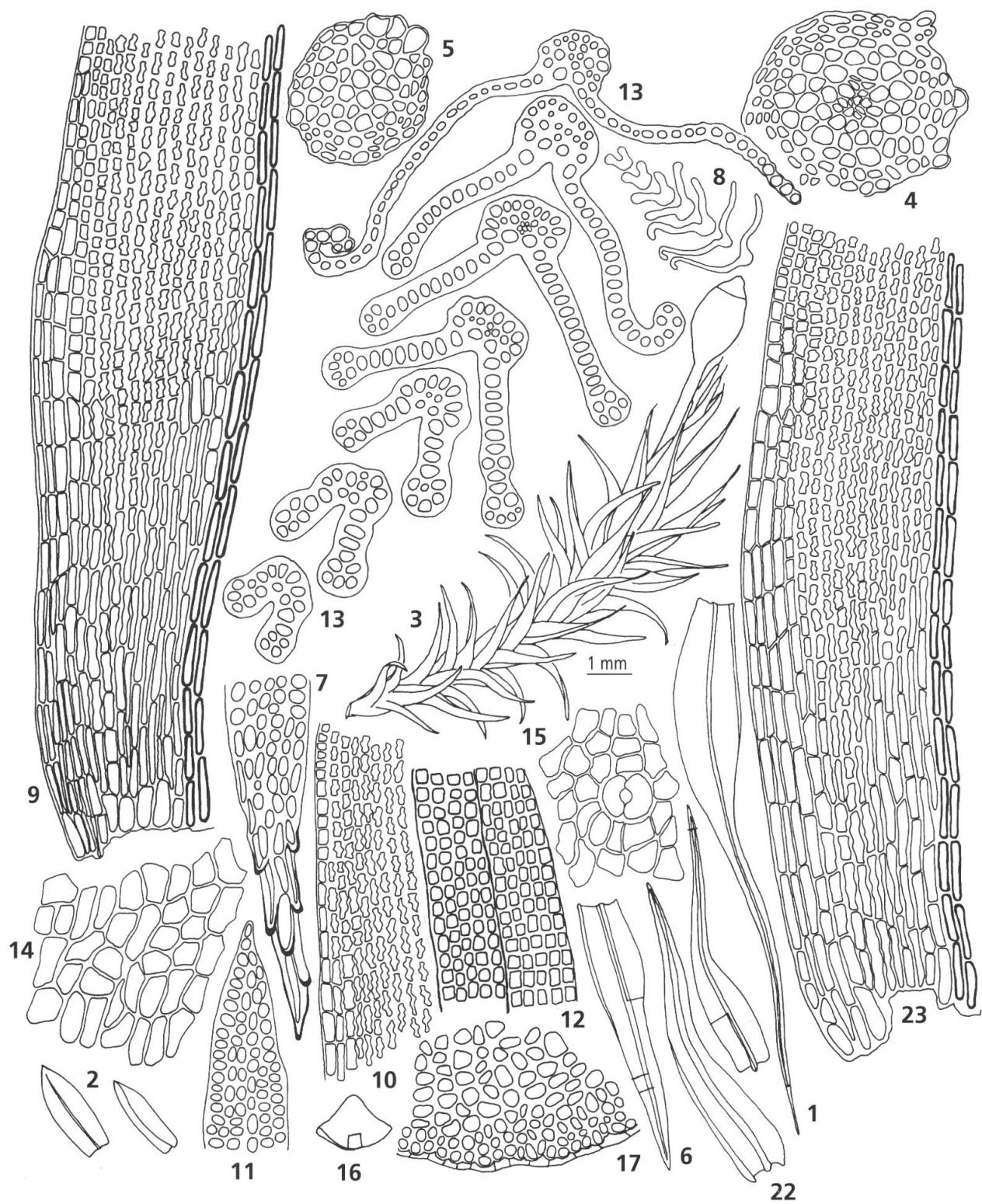
[1, 11-16, Maier 10459; 2, Maier 11761; 3, Maier 6860; 4-9, Gruber 2098; 10, Maier 5712; 17-18, Amann s.n.]



0,1 mm
4,7-11,14-16,18

0,4 mm
6

1 mm
1-2,5,12-13,17



smithiana Bestände, Alm, Glimmerschiefer 2980 bis 3200 m", 8.VII.1999, *Gruber 2098* (Herb. Gruber). **Northern Areas, Baltistan:** "Deosai National Park. Valley of Bara Pani River, eastern slope of ridge just east of the river. Lat 35°00'N Long 75°26'E, 4295 m. Steep granitic and basaltic rock cliffs and turf vegetation on bouldery slopes with snowbeds", 23.VII.1998, *Hedderson 12265* (BOL).

Specimens selected for the description. – SWITZERLAND. Canton of Grisons: "Bergün, Lantsch, Val Tuors 1580 m, siliceous boulder", 29.VI.1991, *Maier 5712* (G). **Canton of Valais:** "Ried, Riederfurka 1830 m, siliceous slab", 23.IX.1998, *Maier 11761* (G); "Salvan, near river 710 m, siliceous boulders in ancient scree, clearing", 15.V.1992, *Maier 6860* (G); "Visp, Zeneggen 1460 m, alpine meadow, siliceous boulder", 2.VI.1995, *Maier 10459* (G); "Zinal, Cabane de Mountet, 3000-3100 m", *Amann s.n. (Z+ZT)*.

7. *Grimmia elongata* Kaulf. in Sturm, Deutschl. Fl., Abt. 2, 13: tab. 24. 1812.

= *G. redundans* Mitt. in J. Proc. Linn. Soc. Bot. Suppl. 1: 43. 1859, **syn. nov.**

Gametophyte. Dioicous. Female: innermost perichaetial leaf (Fig. 7.1) 2,8-3,5 mm, sheathing up to mid-leaf, from ovate, elongated base above mid-leaf constricted to narrow upper part, leaf base hyaline, some rows of hyaline cells vanishing above broadest part, costa stout, excurring to short, weakly denticulate hair-point; **male** plants in separate cushions, perigonia as small buds on short stalks in leaf axils, several on stem, innermost perigonial leaf (Fig. 7.2) 0,7 mm, sheathing, ovate, strongly keeled, apex muticous, acute, hyaline up to broadest part, costa percurrent, paraphysia few. **Growth form:** cushion dense, disintegrating easily, young shoots originating from older stems, leaflets muticous, appressed to stem, plants somewhat radiculose at base, erect, branched, stem (Fig. 7.3) up to 40 mm, thin, central strand poorly (Fig. 7.4) or not developed at all (Fig. 7.5). **Leaves** (Fig. 7.6) 1,2-1,8 mm, imbricate, in short-leaved form

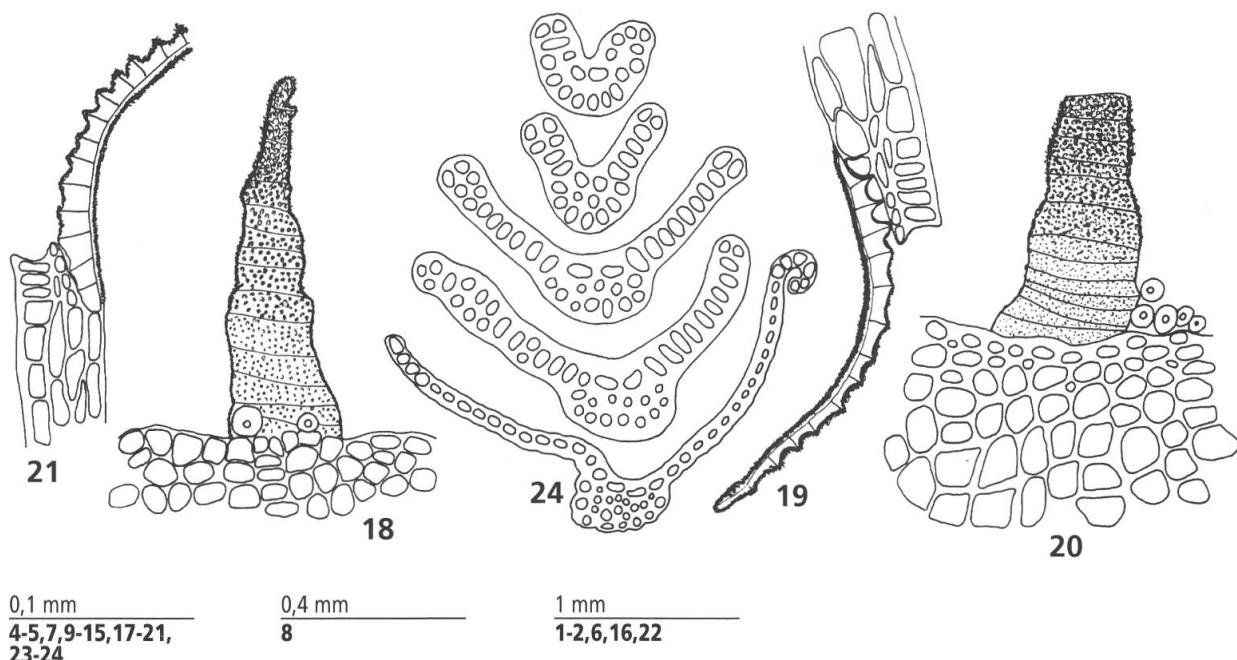


Fig. 7. – *Grimmia elongata* Kaulf.: 1, perichaetial leaf; 2, perigonial leaves; 3, plant with sporophyte; 4, transverse section of stem, from below ramification; 5, transverse section of stem, from base of stem; 6, leaves; 7, cells at apex, hair-point; 8, outlines of transverse sections of leaf; 9, cells in leaf base; 10, cells in transitional part of leaf; 11, apex, muticous; 12, cells of costa and paracostal cells on dorsal side in upper part of lamina; 13, transverse sections of leaf; 14, exothecial cells; 15, stoma; 16, operculum; 17, cells at margin of operculum; 18, peristome, outer side; 19, longitudinal section of peristome tooth; 20, peristome, outer side; 21, longitudinal section of peristome tooth; 22, leaf; 23, cells in leaf base; 24, transverse sections of leaf.

[1, 7-8, 10-11, 13-17, Long 21451; 2, Molendo s.n.; 3, 12, Reuter s.n.; 4-6, 9, Long 17014; 18-19, Maier 9138; 20-24, Hooker 294]

appressed to stem, in long-leaved form slightly twisted and loosely disposed on stem when dry, bending backwards when moistened, leaf base appressed to stem, laminal part patent, from narrow oval leaf base elongate-lanceolate, straight or somewhat falcate, on one side above broadest part markedly narrowed to apical part, thus forming shoulder, on nearly straight side margin recurved from leaf base up to mid-leaf, short leaves muticous, slightly cucullate, longer leaves apiculate, hair-point short, smoothly denticulate (Fig. 7.7), cells with narrow lumen; *leaf form in situ*: (Fig. 7.8) at insertion and leaf base one side concave, other side plicate near costa, in transitional part lamina spreading from costa, lower laminal part keeled, upper part narrowly so, margin on one side from insertion up to mid-leaf recurved; basal cells (Fig. 7.9) elongate-rectangular, walls smooth except some cell rows between margin and paracostal cells with faintly nodulose walls, at margin three or four rows narrowly elongate-rectangular, hyaline, thin-walled cells, gradually vanishing, outermost row ascending up to above broadest part of leaf, cells becoming short-rectangular to quadrate, lamina cells rectangular or elongate-rectangular, walls either strikingly (Fig. 7.10) or scarcely sinuose, in upper part oval to isodiametric, lumen rounded (Fig. 7.11), walls thickened; leaf base unistratose, lamina in places or entirely bistratose, margin unistratose at leaf base, in laminal part some cell rows bi- or tristratose. *Costa*, seen on dorsal side, weak at leaf base, stout in laminal part, reaching apex, in upper part dorsal cells (Fig. 7.12) similar in shape to proximate lamina cells, seen in transverse section (Fig. 7.13), costa on dorsal side rounded at insertion and leaf base, occasionally stronger in laminal part, in rare cases faintly mammillose, on ventral side at insertion and leaf base channelled, in laminal part narrowly so, at insertion and leaf base four guide cells, in laminal part two guide cells, at insertion and leaf base substereids, in upper part cells rounded, homogeneous, hydroids from insertion up to mid-leaf.

Sporophyte. *Seta* erect, (Fig. 7.3), inclined or arcuate, 2,0-3,5 mm, vaginula 0,8-1,2 mm, ochrea small. *Capsule* emergent, erect, inclined or cernuous, ovoid or obloid, smooth, exothecial cells (Fig. 7.14) of variable shape, isodiametrically or elongated penta- and hexagonal, walls curvilinear, slightly thickened, stomata (Fig. 7.15) more or less numerous at short neck, annulus of two or three rows of cells detaching singly, lumen narrow, round. *Calyptra* mitrate-cucullate (LIMPRICHT, 1888-1889: 753). *Operculum* (Fig. 7.16) conical, blunt, margin (Fig. 7.17) smooth, three or four marginal rows of rounded cells, in conical part ovate, walls thickened. *Peristome* (Fig. 7.18) inserted below orifice, teeth erect or recurved when dry, broad at base, rarely slit or perforate, trabeculae thin, seen in longitudinal section (Fig. 7.19) two cell rows between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side covered with rough, rounded and sharp papillae, lower outer side sparingly ornamented with fine papillae, trabeculae neared, protruding below orifice, scarcely protruding in lower part, conspicuously protruding in upper part.

Spores 12-16 μm , granulose.

Diagnostic characters. – **Gametophyte:** margin recurved on one side, margin with several rows of elongate-rectangular, thin-walled, hyaline cells, which extend from insertion up to above the broadest part of leaf, vanishing gradually, outer row ending in short-rectangular to quadrate cells; in upper part of leaf dorsal costal cells not differing from proximal lamina cells (DEGUCHI, 1979). **Sporophyte:** papillosity of peristome teeth.

Comments. – The stratosity of the lamina and margin is variable; the leaf base is unistratose, the laminal part is to a varied extent bistratose, the margins may be tristratose.

Arguments for synonymy. – The setae are in most cases straight or slightly inclined. However plants with inclined or arcuate setae and longer leaves may be found especially at high altitudes. Forms with inclined setae, with longer, patent leaves, from European Alps, have been named *G. elongata* var. *patula* (LIMPRICHT, 1888-1889: 754). MITTEN (1859) described plants collected in India, Sikkim, at 13.000', by J. D. Hooker and Th. Thomson under No. 294, named *G. redundans* by W. Wilson, name validated by Mitten. In a comment in the protologue MITTEN (1859) notes a similarity between *G. elongata* and the new species, and emphasizes as differences a diverging disposition of the leaves and the curved seta of *G. redundans*. Mitten's and

Limprecht's observations correspond concerning the form of the seta and disposition of leaves in plants of high altitude. Comparison of peristomes of *G. elongata* (Fig. 7.18, 7.19) with erect setae and of *G. redundans* (Fig. 7.20, 7.21) with curved setae shows conformity of peristomial characters. Morphological features such as leaf shape (Fig. 7.22), margin recurved on one side only, 4-5 marginal rows (Fig. 7.23) of elongate-rectangular, thin-walled, hyaline cells reaching from insertion up to above broadest part of leaf, and architecture of costa (Fig. 7.24) also agree well. All these facts indicate conspecificity of both taxa. Consequently, *G. redundans* is regarded as synonymous with *G. elongata*. The type specimen is labelled as follows (THIERS, 1992): *Grimmia redundans* Wilson ex Mitten [Sikkim,] Jongri, 13.000 ft, Dr. Hooker 294 [holotype: NY].

Provenance. – Nepal, Sikkim.

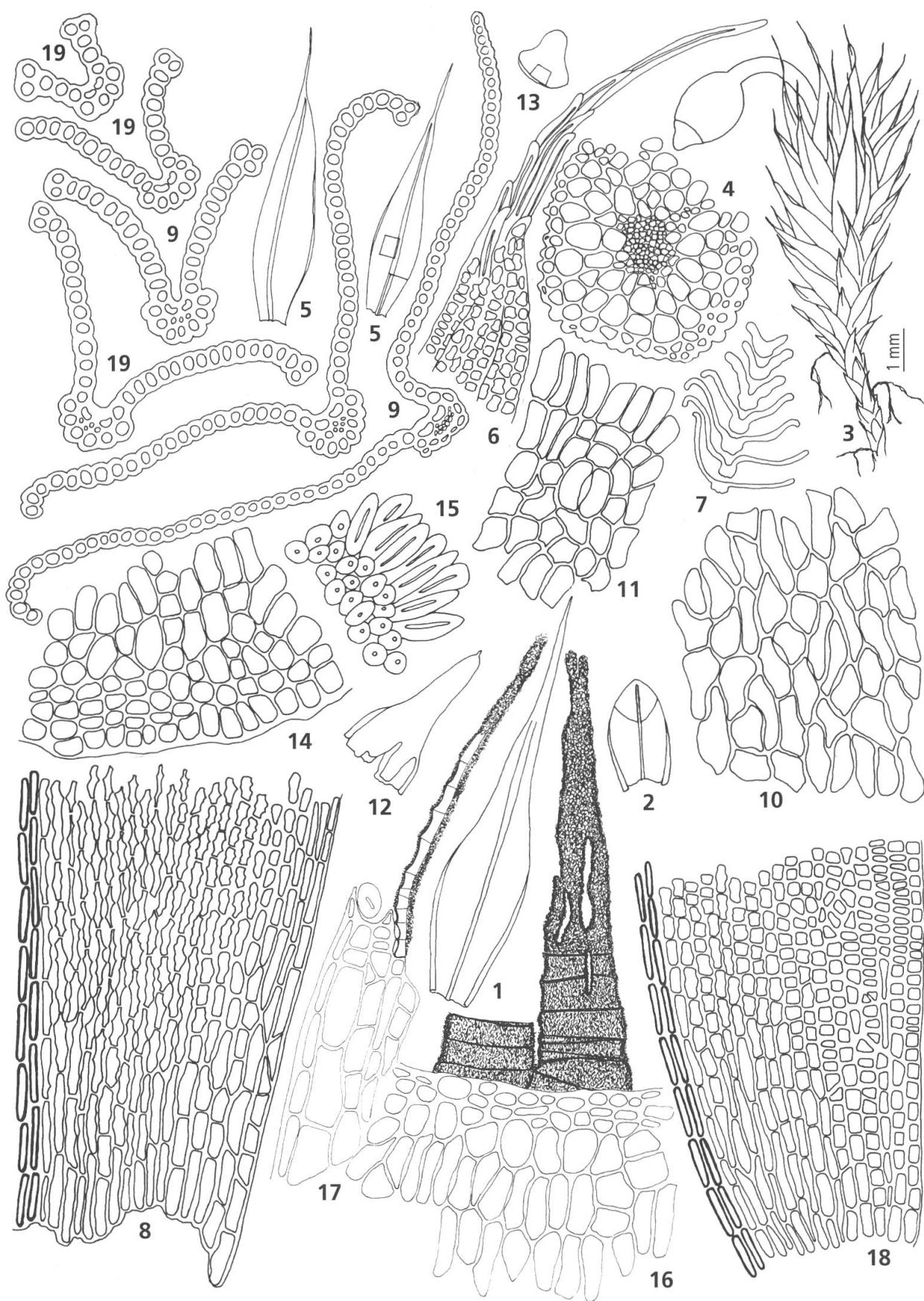
Habitat. – On rocks and boulders, particularly at proximity of streams and glaciers, at altitudes between 3700 and 4800 m.

Specimens examined. – **Thirty**, fourteen of them from the study-area. The selected ones are: **NEPAL**. “Mirgin La, summit 27°33'N, 87°57'E; on stones in stream, c. 4500 m”, 16.IX.1989, *Long 17014* (E, G); **Taplejung District**: “Ridge S of Jaljale Pokhari, between Jaljale Himal and Milke Danda, 27°28'N, 87°28'E; steep S-facing cliffs; on boulder under cliff, c. 4025 m”, 21.X.1991, *Long 21451* (E, G). **SIKKIM**. “Jongri [= Dzongri], Sikkim Himalaya 13 000”, Herb. Ind. Or. Hook. fil. & Thomson, *Hooker 294* (BM, NY); “Singalelah, Sikkim Himalaya 11 000”, Herb. Ind. Or. Hook. fil. & Thomson, *Hooker 293* (BM).

Specimens selected for the description. – **AUSTRIA**. **Salzburg**: “Hagener Hütte, Nassfeld, alpine meadow, slopes, schist, 2320 m”, 27.VIII.1994, *Maier 9138* (G). **Tirol**: “Felbertauern 2100-2200 m”, 1865, *Reuter s.n.* (G); “Velbertauern 64-6600”, 1865, *Molendo s.n.* (GOET).

8. *Grimmia fuscolutea* Hook., *Musci Exot.* 1: 63. 1818.

Gametophyte. Monoicous. Female: innermost perichaetal leaf (Fig. 8.1) up to 3,8 mm, sheathing in lower part, shape and cell pattern as in stem leaves, lower third hyaline, costa excurring to elongated, denticulate, slightly decurrent hair-point; **male:** perigonia below perichaetium in leaf axil as bud on short stalk, innermost perigonial leaf (Fig. 8.2) 0,8 mm, slightly sheathing, ovate, apex rounded or obtuse, hyaline up to 2/3 of leaf length, costa percurrent, paraphysia short, few. **Growth form:** cushion compact, adherent to substratum with rhizoids, from there originating young shoots, leaflets muticous, apex acute, patent, plants erect, branched in upper part, rhizoids in leaf axils, stem (Fig. 8.3) up to 15 mm, central strand (Fig. 8.4) well developed. **Leaves** (Fig. 8.5) up to 1,5 mm, crowded, imbricate, appressed to stem and somewhat contorted when dry, slowly spreading when moistened, erect, stiff when wet, from ovate base lanceolate or broad-lanceolate, slightly asymmetric, tapering to acuminate apex, hair-point (Fig. 8.6) of different length, smoothly denticulate; *leaf form in situ*: (Fig. 8.7) concave at leaf base, weakly pli-ate on one side, keeled in lower laminal part, narrowly keeled in upper laminal part, margin recurved or revolute on larger side from leaf base up to laminal part, on other side more or less recurved, in upper part both sides plane; basal paracostal cells (Fig. 8.8) elongated, walls smooth or nodulose, thin- or thick-walled, at margin 2-3 rows of hyaline cells, vanishing above leaf base, above broadest part of leaf cells rectangular, walls strongly or scarcely sinuose, arranged as strict, perpendicular rows parallel to costa, lamina sometimes cleft along longitudinal cell walls, dorsal and ventral exterior cell walls distinctly bulging or with joint thickenings, upper cells (Fig. 8.6) short-rectangular, walls sinuose; leaf base unistratose, laminal part unistratose, bistratose in places, apical part partly bistratose, in laminal part one or two marginal cell rows bistratose. **Costa**, seen on dorsal side, at insertion and leaf base weak, enlarged in laminal part, excurring to hair-point, in muticous leaves vanishing below apex, seen in transverse section (Fig. 8.9), costa on dorsal side at insertion and leaf base rounded, in laminal part prominent, mammillose, on ventral side channelled, narrowly so in upper part, at insertion and leaf base four ventral cells, two median ones are guide cells, the two outer ones belonging partly to basal paracostal cells, above broadest part of leaf reduced to two narrow guide cells, to leaf axis obliquely arranged, at insertion and leaf base a median group of hydroids or stereids, transformed to substereids in upper laminal part, vanishing in apical part.



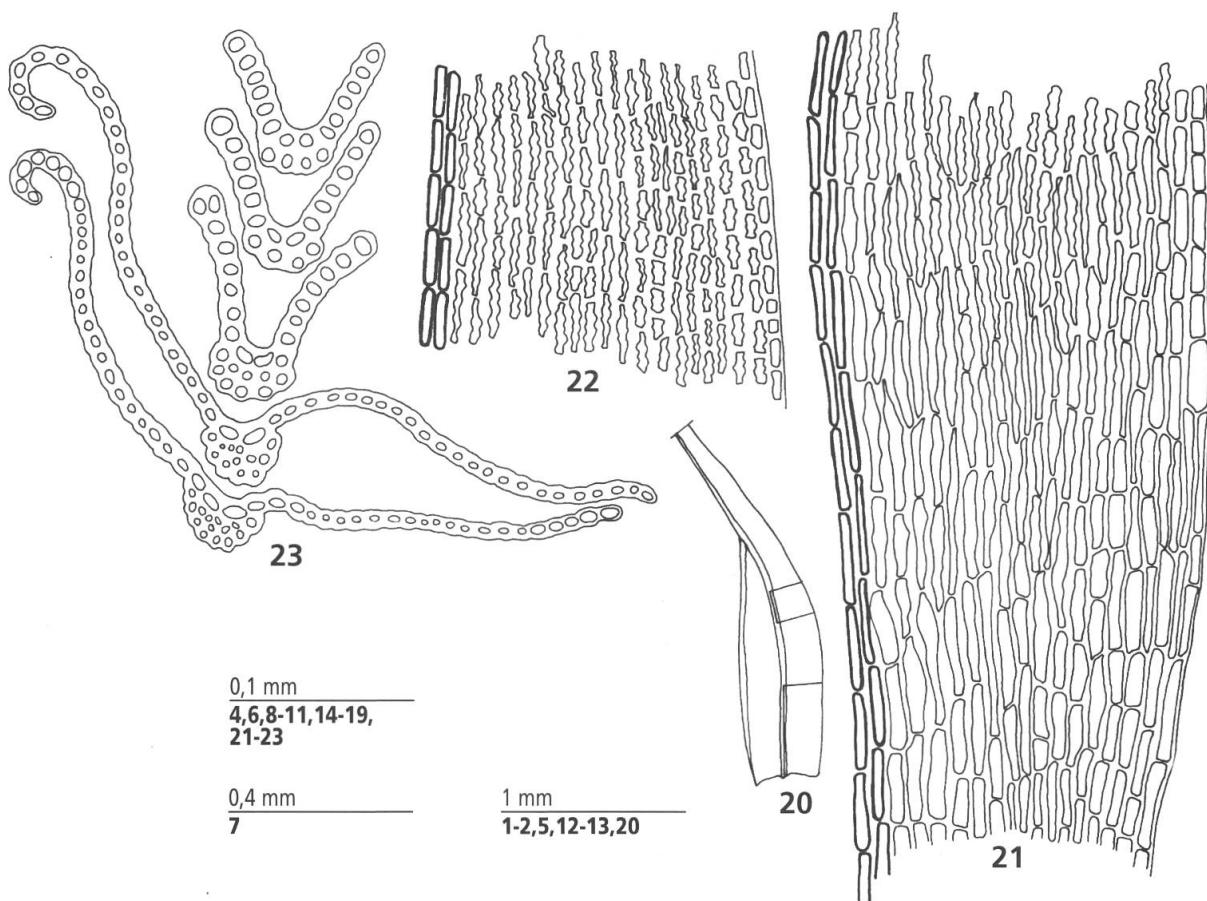


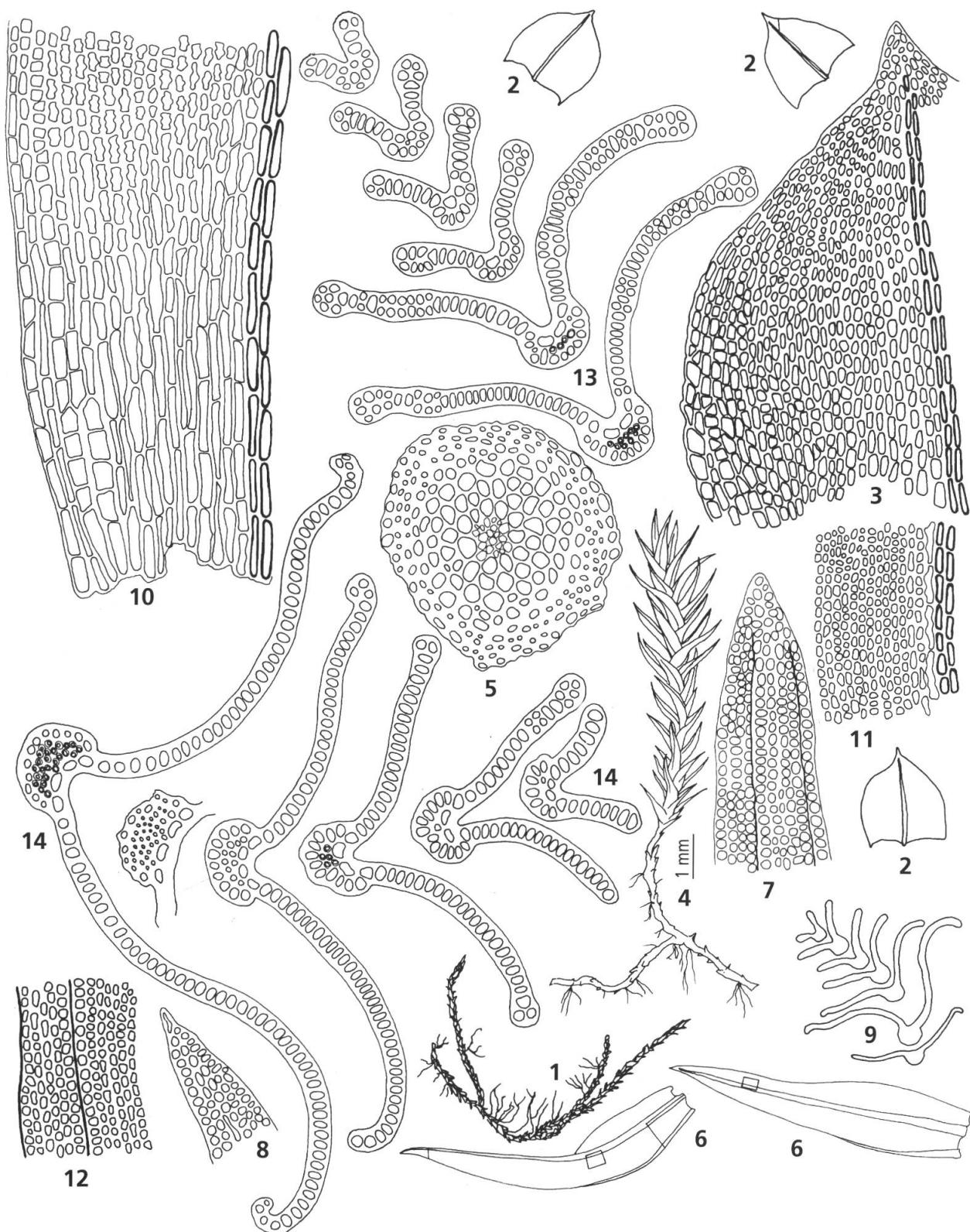
Fig. 8. – *Grimmia fuscolutea* Hook.: 1, perichaetial leaf; 2, perigonal leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaves; 6, cells at apex, hair-point; 7, outlines of transverse sections of leaf; 8, cells in leaf base; 9, transverse sections of leaf; 10, exothelial cells; 11, stoma; 12, calyptra; 13, operculum; 14, cells at margin of operculum; 15, cells of annulus; 16, peristome, outer side; 17, longitudinal section of peristome tooth; 18, cells in leaf base; 19, transverse sections of leaf; 20, leaf; 21, cells in leaf base; 22, cells in mid-leaf; 23, transverse sections of leaf.

[1-2, 4-7, 15, Long 16837; 3, Maier 7764; 8-14, 16-17, Long 16781; 18-19, Poelt s.n.; 20-23, Humboldt 50]

Sporophyte. *Seta* arcuate (Fig. 8.3), up to 2,5 mm, vaginula 0,8 mm, ochrea small. *Capsule* emergent, horizontal or pendent, ovoid, of various size, with apophysial part, after dehiscence constricted below orifice, smooth or slightly ribbed, exothelial cells (Fig. 8.10) irregularly elongated, pentagonal, walls curvilinear, thin or thick (depending on focussing), stomata (Fig. 8.11) large, numerous at apophysis, annulus (Fig. 8.15) of three or four cell rows, detaching as spirals. *Calyptra* (Fig. 8.12) mitrate, lobed, covering operculum. *Operculum* (Fig. 8.13) conical, beak obtuse of variable length, margin (Fig. 8.14) smooth, some marginal rows of rounded or short-rectangular cells, in conical part cells rounded-rectangular, thin-walled. *Peristome* (Fig. 8.16) inserted below orifice, teeth spreading when dry, lanceolate, broad at base, perforate or slit into two branches, at dehiscence joined at base, separating subsequently, trabeculae thin, seen in longitudinal section (Fig. 8.17) between exothecium and teeth two or three cell rows, outer layer thicker than inner one, inner and upper outer side densely covered with coarse, lower outer side with prickly papillae; trabeculae scarcely protruding, in upper part distant.

Spores 10-12 μ m, granulose.

Diagnostic characters. – **Gametophyte:** lamina cells with bulging exterior walls; costa mammillose dorsally, guide cells arranged obliquely to leaf axis in laminal part. **Sporophyte:** capsule constricted below orifice after dehiscence.



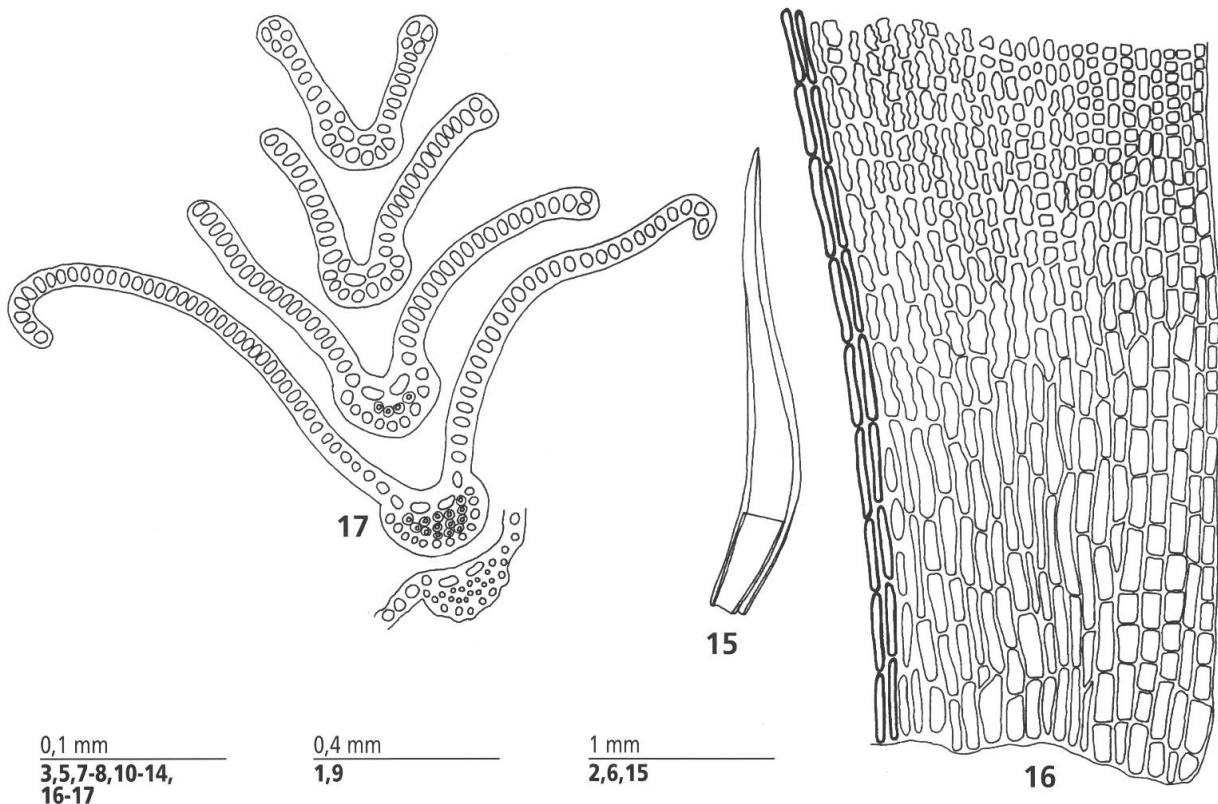


Fig. 9. – *Grimmia handelii* Broth.: 1, shoot; 2, leaflet of shoot; 3, cell pattern of leaflet of shoot; 4, plant; 5, transverse section of stem; 6, leaves; 7, apex, muticous; 8, apex with hyaline end cells; 9, outlines of transverse sections of leaf; 10, cells in leaf base; 11, cells of lamina above leaf base; 12, cells at apical part of lamina; 13-14, transverse sections of leaves; 15, leaf; 16, cells in leaf base; 17, transverse sections of leaf.

[1, 8, 13, Poelt s.n.; 2-7, 9-12, 14, Long 16783; 15-17, Handel-Mazzetti 498]

Comments. – Leaf shape and cell pattern (Fig. 8.18) may undergo transformations under extreme growing conditions, particularly at high altitudes. See also comments on *G. elatior*, *G. longirostris*, *G. ovalis*. Costal architecture, however, is not affected, transverse sections (Fig. 8.19) reveal the correct identity of the taxon.

The variability of the capsule and the shape of the beak have been documented by DEGUCHI (1979: 168, 169).

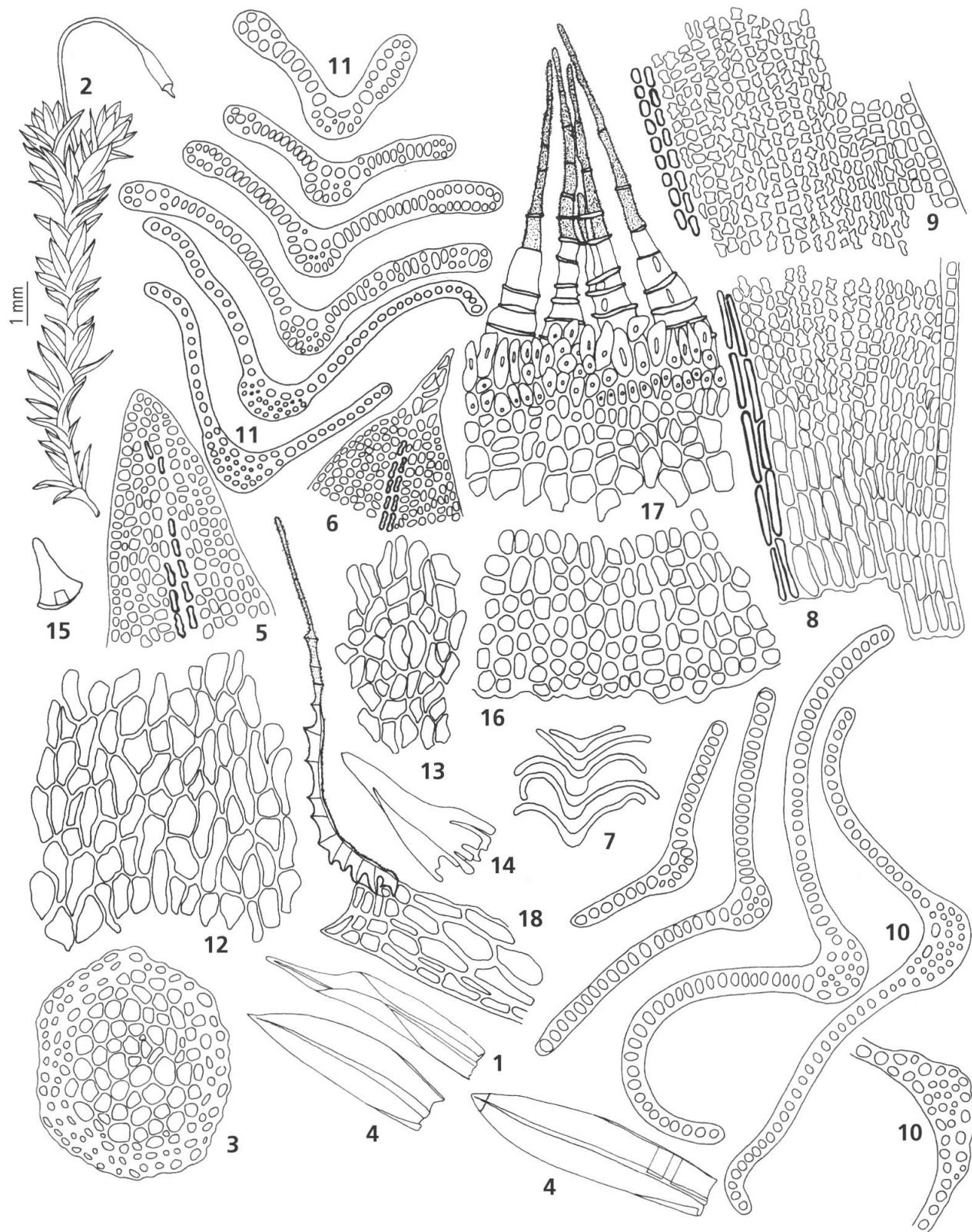
MUÑOZ (1999) proposed replacement of the name *G. apiculata* Hornsch. by the earlier name *G. fuscolutea* Hook.

Comparison of the specimens examined with the type specimen of *G. fuscolutea* shows the congruence of leaf shape (Fig. 8.20), cell pattern at the leaf base (Fig. 8.21), and in the lamina at mid-leaf (Fig. 8.22), and the costal architecture (Fig. 8.23). The type specimen is labelled as follows: H 2673, *Grimmia fuscolutea*, Musci Exot. 1: t 63, S. America, Humboldt Nr. 50 [lectotype: BM].

Provenance. – India NW Himalaya, Nepal, Sikkim.

Habitat. – On rocks, boulders, in exposed and shaded places, m., between 4000 and 5700 m.

Specimens examined. – **Forty-one**, eighteen of them from the study-area. The selected ones are: **INDIA**. “NW Himalaya, Tihri Garhwal, Kidarkanta, 12000 ft”, VI.1879, Bryotheca E. Levier, Duthie s.n. (BM). **NEPAL**. “Namdo, N. of Mustang, on rocks, 17000 ft.”, 10.VIII.1954, Stainton, Sykes & Williams 2350 (BM); “W-bank of Ghunsa Khola bet-



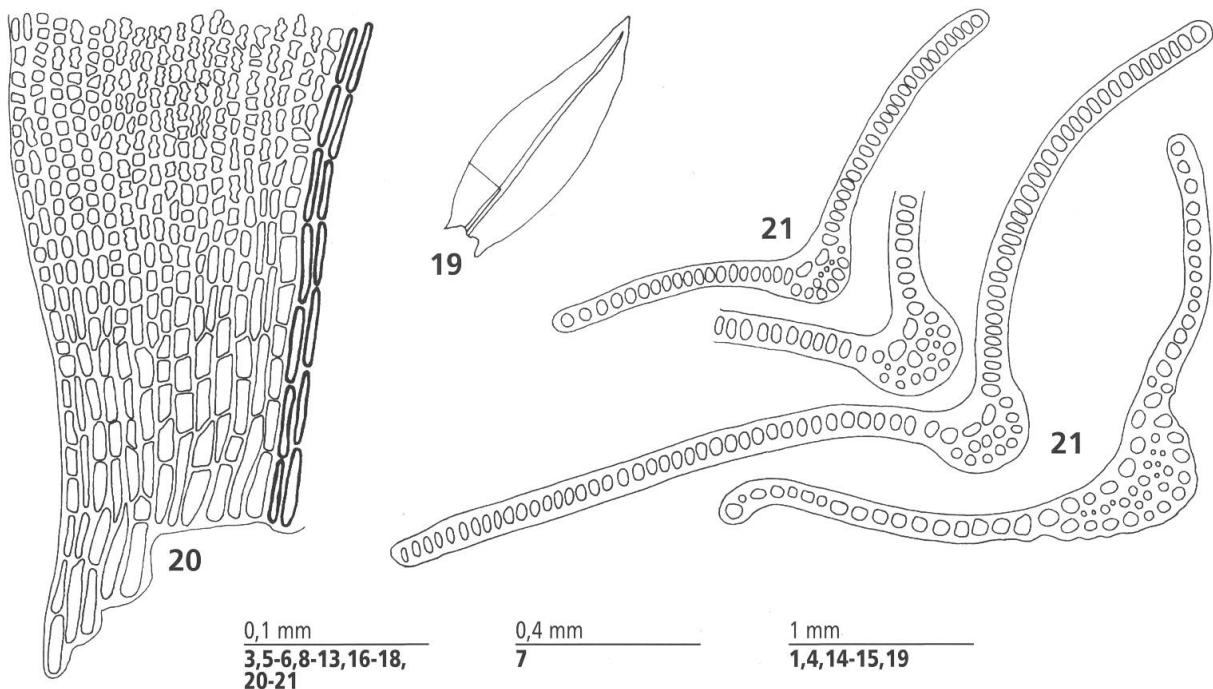


Fig. 10. – *Grimmia indica* (Dixon & P. de la Varde) Goffinet & Greven: 1, perichaetial leaf; 2, plant with sporophyte; 3, transverse section of stem; 4, leaves; 5, apex, muticous; 6, apex, apiculate; 7, outlines of transverse sections of leaf; 8, cells in leaf base; 9, cells above leaf base; 10, 11, transverse sections of leaves; 12, exothelial cells; 13, stoma; 14, calyptra; 15, operculum; 16, cells at margin of operculum; 17, peristome, outer side; 18, longitudinal section of peristome tooth; 19, leaf; 20, cells in leaf base; 21, transverse sections of leaf.

[1-18, Long 17120; 19-21, Kurz 2344]

ween Rambuk Kharka and Kambachen 27°43'N, 87°58'E; open rocky hillside; on overhanging boulder, c. 4100 m", 9.IX.1989, Long 16781 (E, G); "Lhonak to Pang Pema, Kangchenjunga Glacier 27°47'N, 88°04'E; rocky glacier valley; on large boulder, c. 4730 m", 11.IX.1989, Long 16837 (E, G); **Langtang Area**: "Slopes N above Langshisa Kharka and moraines of Shalbachun Glacier, 4400-4500 m", 16.IX.1986, Poelt s.n. (GZU); **Sankhuwasabha District**: "Upper Barun Khola valley above Mera, 27°49'N, 87°07'E; dry rocky river valley; in crevices of dry rocks; c. 4460 m", 4.X.1991, Long 20929 (E, G). **SIKKIM. West District**: "E slopes above Choktsering Chhu, Bikbari, 27°30'N, 88°08'E; unstable gully on steep slope; on boulder by stream, c. 4020 m", 13.VII.1992, Long 22572 (E, G).

Specimen selected for the description. – SWITZERLAND. Canton of Valais: "Zermatt, Hörligrat, Hirli, alpine meadow, siliceous boulder, 2890 m", 11.IX.1987, Maier 7764 (G).

9. *Grimmia handelii* Broth. in Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1 133: 567. 1924.

Gametophyte. *Supposedly dioicous*, neither archegonia nor antheridia observed. **Growth form**: cushion lax, disintegrating easily, interwoven with young, radiculose shoots (Fig. 9.1), rhizoid cell walls smooth, leaflets (Fig. 9.2, 9.3) of spade-like shape, appressed to stem, apices spreading, producing bristly aspect, plants procumbent to suberect, sparsely branched, originating from young shoots, stem (Fig. 9.4) up to 40 mm, central strand (Fig. 9.5) well developed. **Leaves** (Fig. 9.6) up to 2 mm, crowded, loosely bent towards stem, apices slightly contorted and spreading when dry, when moistened older leaves suddenly recurving, young leaves taking erectopatent position, all leaves patent when wet; from elongate-ovate leaf base lanceolate, tapering to muticous (Fig. 9.7), acute apex, leaves with few transparent cells at apex (Fig. 9.8) observed; *leaf form in situ*: (Fig. 9.9) at insertion faintly concave, in laminal part keeled, margin at leaf base on one side markedly recurved, on other side slightly so; basal leaf cells (Fig. 9.10) elongate-rec-

tangular, walls smooth or faintly nodulose, at margin 3-4 rows of rectangular cells, walls smooth, in transitional part cells short-rectangular to isodiametric, walls more or less sinuose, above leaf base cells small, thick-walled, rounded or oval (Fig. 9.11), in apical part cells rounded, costa cells of same shape (Fig. 9.12); leaf base unistratose, laminal part unistratose, in places or to a large extent bistratose, margin unistratose, in upper part some cell rows uni- to tristratose. **Costa**, seen on dorsal side, of uniform width throughout, vanishing below apex, seen in transverse section (Fig. 9.13, 9.14), on dorsal side at insertion rounded, slightly mammillose, at leaf base and upper part of leaf rounded, slightly contracted at origin of lamina, ventrally at insertion and leaf base widely channelled, in laminal part channelled, at insertion and lower part of leaf four, in upper part two guide cells, a median band of stereids or substereids, vanishing below apex, no hydroids.

Diagnostic characters. – **Gametophyte:** leafy stems originating from strongly radiculose young shoots of bristly aspect. Leaf apices muticous or with few transparent cells, no hair-point. Costa without hydroids.

Comment. – The strongly radiculose young shoots with a bristly appearance, distinguish *G. handelii* from other *Grimmia* species producing shoots and treated in this study.

Comparison of the specimens examined with the type specimen of *G. handelii* shows the congruence of leaf shape (Fig. 9.15), cell pattern at the leaf base (Fig. 9.16), and the costal architecture (Fig. 9.17). The type specimen is labelled as follows: *Grimmia handelii* Broth. n. sp. China, Prov. Setschwan austro-occid.: in montis Tschahungnyotscha supra vicum Ngaitschekou trans flumen Yalung ad septentr. oppidi Yenyüen ca. 28°15', siti regione alpina, ad rupes. Substr. schistaceo; alt. s.m. ca. 4150-4300 m, (Nr. 2667). Leg. 27.V.1914 Dr. Heinr. Frh. v. Handel-Mazzetti. (Diar. Nr. 498) [holotype: H-BR; isotype: S].

Provenance. – Nepal.

Habitat. – On schist, siliceous boulders, block scree, moraines, at altitudes between 2800 and 4500 m.

Specimens examined. – **Twelve**, two of them from the study-area. They are: **NEPAL**. “W bank of Ghunsa Khola between Rambuk Kharka and Kambachen 27°43'N, 87°58'E; large block scree on slope of valley; on large boulder, c. 4050 m”, 9.IX.1989, *Long 16783* (E, G); **Langtang Area**: “Slopes N above Langshisa Kharka and moraines of Shalbachun Glacier 4500 m”, 16.IX.1986, *Poelt s.n.* (GZU).

10. *Grimmia indica* (Dixon & P. de la Varde) Goffinet & Greven in J. Bryol. 22: 141. 2000.

- ≡ *Trigonodictyon indicum* Dixon & P. de la Varde in Ann. Cryptog. Exot. 1: 40. 1928.
- = *G. apophysata* Gangulee in Nova Hedwigia 12: 428. 1967.

Gametophyte. Dioicous. Female: innermost perichaetial leaf (Fig. 10.1) up to 2,2 mm, tubulose, sheathing up to broadest part, from above elongated base suddenly narrowing to small apical part, lower half of leaf hyaline, costa vanishing below muticous apex; **male:** perigonia not seen. **Growth form:** cushion lax, easily disintegrating, plants slender, erect, young branches originating from below perichaetia or from older stems, stem (Fig. 10.2) up to 20 mm, no central strand (Fig. 10.3). **Leaves** (Fig. 10.4) 1,1-1,8 mm, lower leaves slightly shorter than upper ones, crowded, loosely disposed on stem and slightly contorted when dry, spreading when moistened, erectopatent, rigid when wet, leaf base short, narrowed (Fig. 10.8), slightly decurrent, not reaching broadest part of leaf, laminal part lanceolate or ovate-lanceolate, muticous, apex obtuse (Fig. 10.5) or apiculate (Fig. 10.6) and translucent; **leaf form in situ:** (Fig. 10.7) keeled from leaf base up to apical part, there nearly spreading, margin on both sides recurved from leaf base to broadest part of leaf, on one side weakly so, plane in upper part; paracostal cells elongate-rectangular, thin-walled, smooth or nodulose, pellucid, at margin cells elongate-rectangular, walls smooth, conspicuously below broadest part of leaf (Fig. 10.8, 10.9) cells abruptly shortened to short-rectangular or isodiametric, lumina occasionally star-shaped, walls strongly sinuose, at upper half of leaf cells nearly isodiametric, walls thickened, lumen irregular, mostly rounded; leaf base unistratose, lamina unistratose, occasionally in upper part in places bistratose, margin unistratose or several rows of cells bistratose in upper part of leaf. **Costa**, seen on dorsal side, large at insertion, gradually attenuating up to leaf point, reaching apex not at all leaves, seen

in transverse section (**Fig. 10.10, 10.11**), costa on dorsal side rounded, on ventral side widely channelled, at insertion six to eight ventral cells, up to above short leaf base reduced to four, from mid-leaf up to apical part only two ventral cells are distinct guide cells, other costal cells small, nearly uniform, neither stereids nor hydroids, some substereids in apical part.

Sporophyte. *Seta* erect, twisted when dry, cygneous (**Fig. 10.2**) when wet, up to 5,6 mm, vaginula 0,8 mm, ochrea small. *Capsule* oblong-cylindrical, slightly asymmetric, pendent or horizontal, slightly asymmetric, smooth, in young capsules distinct apophysis, shrivelling with age, exothecial cells (**Fig. 10.12**) of various shape, mostly elongated, walls thin, curvilinear, stomata (**Fig. 10.13**) numerous, three rows in apophysis, annulus of three rows of cells, detaching as groups. *Calyptra* (**Fig. 10.14**) campanulate-cucullate, covering upper part of capsule, lobes small. *Operculum* (**Fig. 10.15**) conical, beak rostrate, long, in dry state oblique, at margin uneven (**Fig. 10.16**), some marginal rows of mostly rounded cells, in conical part short-rectangular or rectangular, lumen rounded. *Peristome* (**Fig. 10.17**) inserted below orifice, teeth elongate-lanceolate, in upper half hyaline, entire or slit to thin branches, joint at base, paired in lower part, anastomose of two or even three teeth has been observed, trabeculae broad in lower part, thin at apices, seen in longitudinal section (**Fig. 10.18**) between exothecium and teeth two rows of large cells, dorsal layer in lower part much thicker than the very thin inner one, inner and outer upper side covered with fine, prickly papillae, outer lower half smooth, trabeculae in lower part neared, strongly protruding, in upper part distant, sharply or faintly protruding.

Spores 10-12 μm , granulose.

Diagnostic characters. – **Gametophyte:** perichaetial leaf tubulose, apex muticous; leaf without hair-point, differentiation of cell shape conspicuously present below broadest part of leaf (see glossary: leaf base); costa without hydroids. **Sporophyte:** young capsules with marked apophysis; peristome teeth paired in lower part, hyaline in upper half, interconnected in places.

Comments. – Hampe, in a manuscript note (in latin) attached to the sheet of the type specimen (BM) collected by Kurz, describes the species as dioicous.

Contrary to the opinion of GREVEN & KOPONEN (1996) *G. indica* is not the only species of *Grimmiaceae* with apophysate capsules. Capsules, especially young ones, of several members of the family show the feature more or less well marked, after dehiscence the tissue shrivels. A good example is *Racomitrium aciculare* (Hedw.) Brid. (LOESKE, 1913: 198).

On the other hand, the strongly marked apophysis of *G. indica* is exceptional within the genus *Grimmia*, as well as the differentiation of cell shape conspicuously below the broadest part of leaf, the barely expressed guide cells in the lower part of leaf, the occasionally observed anastomosing of peristome teeth, the hyaline upper part of the teeth, a character observed only once in peristomes of thirty-eight species studied by the author. GANGULEE (1967), in the English version of the protologue, emphasizes apophysis and leaf shape as distinguishing characters from other species. By these peculiarities *G. indica* is marked as having a singular appearance in the genus *Grimmia*.

Arguments for the new combination and synonymy are given in GOFFINET & GREVEN (2000).

Comparison of the examined specimens with the type specimen of *G. apophysata*, housed in BM, shows congruence of leaf shape (**Fig. 10.19**), cell pattern at leaf base (**Fig. 10.20**), and costal architecture (**Fig. 10.21**). The type specimen is labelled as follows: *Grimmia apophysata* Hp., Hab. Sikkim 11.000', S. Kurz 2344 [lectotype: CAL, not seen; isotypes: BM, G].

Provenance. – Nepal, Sikkim.

Habitat. – On siliceous rocks and boulders, in clearings of *Rhododendron* forest, between 3300 and 4600 m.

Specimens examined. – **Seventeen**, nine of them from the study-area. The selected ones are: **NEPAL.** “N bank of Simbua Khola below Tseram 27°31'N, 87°56'E; Abies/Rhododendron forest; on boulder in clearing, c. 3300 m”, 21.IX.1989, Long 17120 (G, E). **SIKKIM. Sikkim Himalaya, District Darjeeling:** “Yampung, 13 720”, 12.X.1908, Ribu s.n. (H-BR).

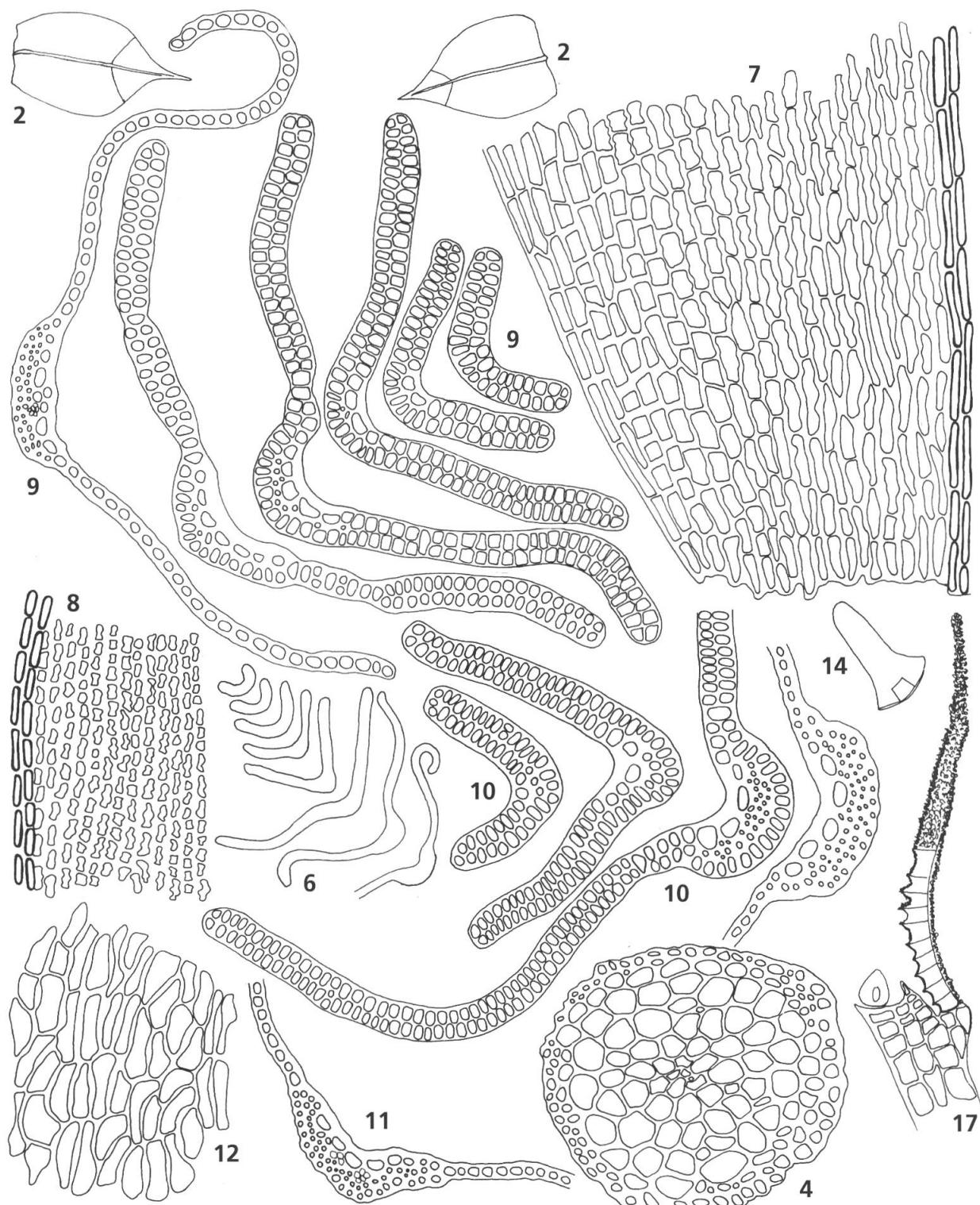
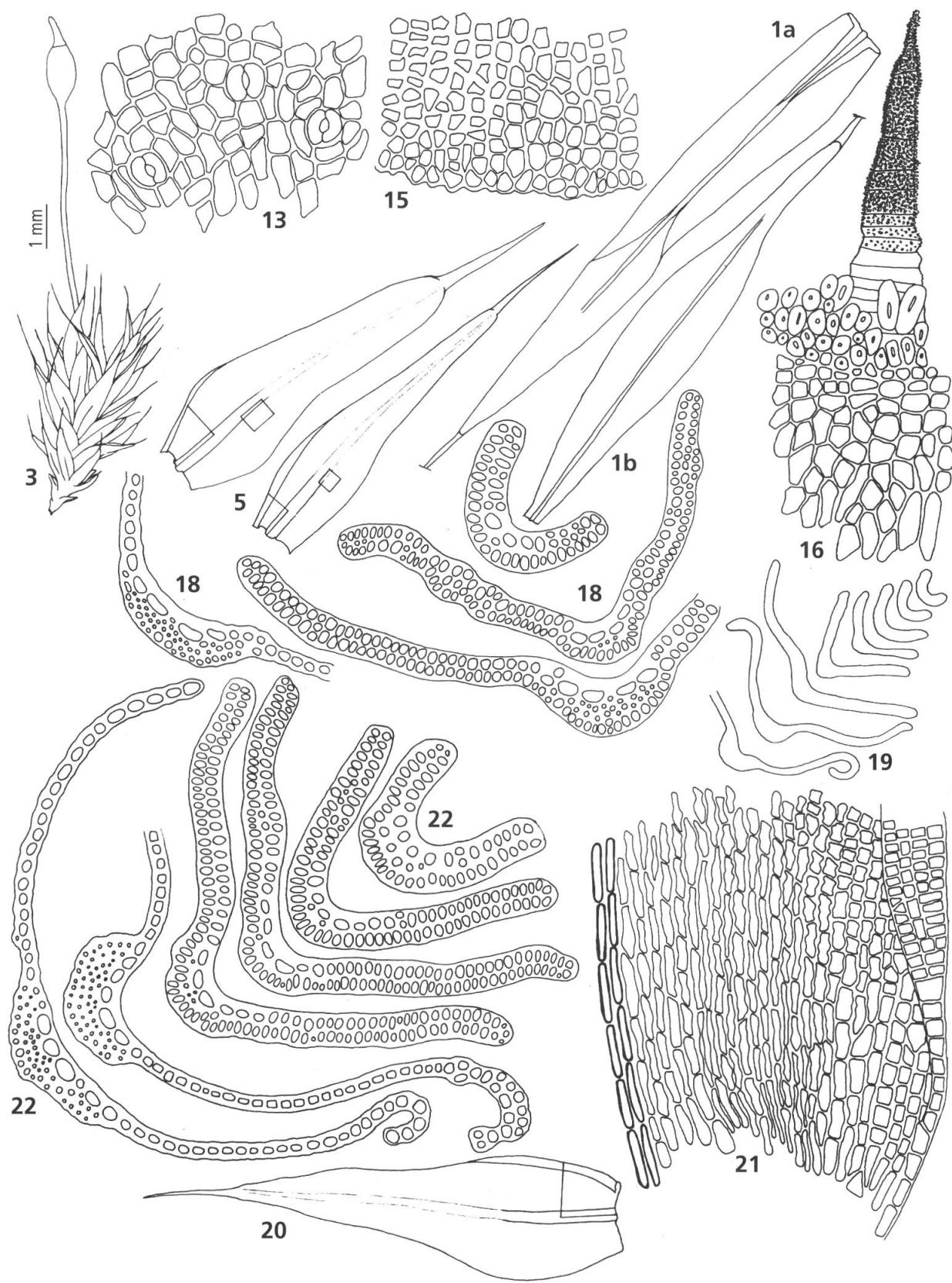


Fig. 11. – *Grimmia khasiana* Mitt.: **1**, two innermost perichaetial leaves, **a**, second inner leaf, **b**, innermost leaf; **2**, two innermost perigonal leaves; **3**, plant with sporophyte; **4**, transverse section of stem; **5**, leaves; **6**, outlines of transverse sections of leaf; **7**, cells in leaf base; **8**, lower lamina cells; **9-10**, transverse sections of leaves; **11**, costa at insertion; **12**, exothelial cells; **13**, stomata; **14**, operculum; **15**, cells at margin of operculum; **16**, peristom teeth, outer side; **17**, longitudinal section of peristome tooth; **18**, transverse sections of leaf; **19**, outlines of transverse sections of leaf; **20**, leaf; **21**, cells in leaf base; **22**, transverse sections of leaf.

[**1, 3**, Long 18927; **2**, s. coll. 1029, ALTA; **4-9, 12-17**, Handel-Mazzetti 1905; **10-11**, Giraldi 877; **18-19**, Hooker & Thomson 279, BM; **20-22**, Hooker & Thomson 279, NY]



0,1 mm
4,7-13,15-18,
21-22

0,4 mm
6,19

1 mm
1-2,5,14,20

11. *Grimmia khasiana* Mitt. in J. Proc. Linn. Soc. Bot. Suppl. 1: 45. 1859.

Gametophyte. Dioicous. Female: second inner perichaetal leaf (**Fig. 11.1a**) up to 5 mm, sheathing up to 2/3 of leaf length, tubulose, lower third and some marginal cell rows hyaline, costa excurrent, indistinct in upper part, hair-point elongated, bluntly denticulate, innermost perichaetal leaf (**Fig. 11.1b**) up to 3,5 mm, not sheathing, narrowed at insertion, up to half of leaf length hyaline, costa and hair-point as in tubulose leaf; **male:** perigonium as multifoliate bud terminal on short branches, innermost perigonial leaf (**Fig. 11.2**) up to 1,2 mm, sheathing up to broadest part, broad-ovate, concave, acuminate, muticous or with hyaline terminal cell, hyaline except in apical part, costa vanishing below apex, antheridia up to 0,8 mm, numerous, crowded, paraphysia rare. **Growth form:** cushion lax, plants originating from older stem parts, erect, branched, stem (**Fig. 11.3**) up to 30 mm, weakly radiculose at base, central strand (**Fig. 11.4**) more or less well developed or lacking. **Leaves** (**Fig. 11.5**) up to 3 mm, becoming longer at tip of stem, imbricate, lower part of leaf appressed to stem, upper part erectopatent when dry, when moistened bending backwards, spreading or erect-spreading when wet; from ovate leaf base narrowed to lingulate or broad-lanceolate laminal part, thus forming smoothly rounded shoulder, tapering to acute or rounded apex, hair-point of variable length, bluntly denticulate; **leaf form in situ:** (**Fig. 11.6**) at insertion and leaf base slightly concave or concave, in lower laminal part widely keeled or keeled, in upper laminal part concave, margin on one side from insertion up to broadest part of leaf revolute or recurved, on other side occasionally faintly so, in laminal part plane; basal paracostal cells (**Fig. 11.7**) elongate-rectangular, walls more or less nodulose, towards margin short-rectangular to quadrate, walls smooth, thickened, at margin some cell rows elongate-rectangular, hyaline, vanishing below widest part of leaf, lower lamina cells (**Fig. 11.8**) rectangular, walls sinuose, from mid-leaf up to apex gradually modified to markedly small, rounded cells; lamina at leaf base unistratose, above leaf base unistratose or at places bistratose, in upper laminal part bistratose, occasionally with tristratose patches, margin in lower leaf part unistratose, in upper part bistratose. **Costa**, seen on dorsal side, broad at leaf base, from above broadest part of leaf to apex indistinct, due to scarcely rounded costa and similarity of costa cells to lamina cells, costa percurrent, best seen on ventral side of leaf, seen in transverse section (**Fig. 11.9, 11.10**), costa on dorsal side at insertion, leaf base and lower laminal part flat, scarcely rounded, at mid-leaf slightly rounded or rounded, in upper part indistinct, on ventral side from leaf base up to mid-leaf widely channelled, in upper part channelled, at insertion and leaf base eight, sometimes seven, ventral cells, most of them guide cells, in some cases appear supplementary basal subcostal cells (**Fig. 11.11**), increasing number of ventral cells, in lower laminal part guide cells reduced to five or six, in upper laminal part to four, in apical part to two, a median band of substereids, in lower half of leaf a central group, or occasionally three small groups of hydroids.

Sporophyte. Seta 5-8 mm (**Fig. 11.3**), straight, vaginula 1,7 mm. **Capsule** erect, obloid or cylindrical, smooth, exothelial cells (**Fig. 11.12**) elongated, of varied shape, walls curvilinear, thickened, stomata (**Fig. 11.13**) numerous in neck, annulus of three rows of cells, detaching spirally in groups. **Calyptra** not seen. **Operculum** (**Fig. 11.14**) conical, beak oblique, half as long as capsule, margin (**Fig. 11.15**) uneven, cells small, angulate, of variable shape, walls thickened. **Peristome** (**Fig. 11.16**) inserted below orifice, teeth lanceolate, entire or perforate or in upper part slit to two or three branches, trabeculae thin, seen in longitudinal section (**Fig. 11.17**) two cell rows between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side densely covered with coarse, rounded papillae, lower outer side smooth, trabeculae neared, sharply protruding in lower half.

Spores 11-15(17) μm , papillose.

Diagnostic characters. – **Gametophyte:** leaf in apical part concave; margin at leaf base recurved on one side; costa indistinct dorsally in laminal part. **Sporophyte:** seta up to 8 mm; operculum with long, oblique beak; peristome teeth with coarse, rounded papillae; spores up to 17 μm .

Comments. – *Grimmia khasiana* shares the character of a dorsally indistinct costa with *G. laevigata*, *G. ovalis* and *G. unicolor*. Therefore *G. khasiana* should be placed in the group *Litoneurum* Hagen (HAGEN, 1909). Following LOESKE (1930: 79, 89) this character is correlated with a tendency of the leaf to form, in the transitional part, a smoothly rounded shoulder which is the case in the four species cited above.

GANGULEE (1972) published a description of *G. khasiana*, based on the Hooker & Thomson specimen n° 279 housed in Mitten's herbarium at NY. But unhappily he cited the specimen as n° 297 (the true n° 297 is an *Orthotrichum* species, cited in MITTEN & WILSON, 1857. A specimen is housed in GOET !). Following an annotation label accompanying the specimen n° 279 at NY, Gangulee did see the correct type specimen of *G. khasiana* but the drawing of a leaf of *G. khasiana* in GANGULEE (1972: 810, Fig. 387 L) erroneously shows recurved margins on both sides of leaf base. *Grimmia khasiana* however, has recurved margin only on one side, a strong character to distinguish the species from *G. ovalis* (Hedw.) Lindb. with both margins plane.

MITTEN (1859) described *G. khasiana*, based on a sterile specimen collected by Hooker and Thomson under No. 279, housed at BM and NY. Later on, plants collected by Handel-Mazzetti in 1916 were named by Brotherus as *G. longipes*, a name he never published. Afterwards he re-identified these plants as *G. commutata* Hueb. (CAO & VITT, 1986) (= *G. ovalis* (Hedw.) Lindb.). The present study however, shows the conspecificity of *G. longipes* Broth. with *G. khasiana* Mitt., based on the similarity of costal architecture (Fig. 11.18), and particularly in the concave apical part of the leaf and the recurved margin on one side of the leaf base (Fig. 11.19).

MÜLLER (1896) described *G. dimorphula*, based on a Chinese specimen collected by Giraldi under No. 877, housed at G, S, and, according to CAO & VITT (1986), at BM and H, and according to DEGUCHI (1980) also in FI and PC. The taxon has been recognized by DEGUCHI (1980), based on the lectotype housed in FI, as conspecific with *G. khasiana* Mitt. This statement is confirmed in this study by the similarity of transverse sections of *G. dimorphula* (Fig. 11.10) to those of the type of *G. khasiana* (Fig. 11.18). (Note: a specimen labelled Giraldi 877, housed at NY, turned out to be *G. pilifera* P. Beauv.).

CAO & VITT (1986), not aware of Deguchi's paper, based their description of *G. ovalis* (Hedw.) Lindb. partly on an isotype of *G. dimorphula* and partly on a specimen collected by Handel-Mazzetti, No. 6634, housed in H. This specimen had been labelled as *G. longipes*, the drawings 23, I, P, Q, (CAO & VITT, 1986) show correspondence with characters of this taxon. "Later Brotherus corrected them (i.e. the names *G. longipes* and *G. setschwanica*) to *G. commutata* Hueb. (= *G. ovalis* (Hedw. Lindb.))", following CAO & VITT (1986). The synonymy of *G. dimorphula* with *G. ovalis* cannot be maintained considering Deguchi's statement and the results of the present study.

Comparison of the specimens examined with the type specimen of *G. khasiana* shows congruence of leaf shape (Fig. 11.20), cell pattern at leaf base (Fig. 11.21), and costal architecture (Fig. 11.22). The type specimen is labelled (following THIERS, 1992): *Grimmia khasiana* Mitt. [Khasia Mountains,] Kollong Rock [J. D. Hooker & T. Thomson] 279 [holotype: NY; isotype: BM].

Provenance. – Bhutan, India NW Himalaya, Nepal.

Habitat. – On siliceous boulders, at altitudes between 1900 and 3200 m.

Specimens examined. – **Thirty**, four of them from the study-area. The selected ones are: **BHUTAN**. "Kunga Rab-deng Dzong, 18 km S of Tongsa, Changra village 1900 m", 22.VI.1972, *Würmli* 49 (G). **INDIA**. "NW Himalaya, Kumaon, Kali Valley", 15.IX.1900, *Inayat* s.n. (H-BR). **NEPAL. Langtang Area**: "Slopes N above Thangsep (Thogsep), pasture, big rocks, ≈ 3200 m", 4.IX.1986, *Poelt* s.n. (GZU).

Specimens selected for the description. – **CHINA**. [Dates in Chinese] "1700 m", 17.IX.1982, 1029 (ALTA). **Prov. Schen-si sept**: "In monte prope In-Kia-po", 27.VI.1894, *Giraldi* 877 (G, S). **Prov. Yunnan**: "Yulong Shan: below Ma Huang Ba, above Shu Song village. Open grazed hillside; on large siliceous boulder 2790 m", 8.X.1990, [from the same locality as Handel-Mazzetti 1905 (D. G. Long, in litt.)], *Long* 18927 (E, G); "In regionis temperate prope vicum Ngu-lukö ad urbem Lidjiang ("Likiang"), saxis. Substr. diabasico; c. 3000 m", 5.X.1916, *Handel-Mazzetti* 1905 (G, E, S).

12. *Grimmia laevigata* (Brid.) Brid., Bryol. Univ. 1: 183. 1826.

≡ *Campylopus laevigatus* Brid., Muscol. Recent. Suppl. 4: 76. 1819.

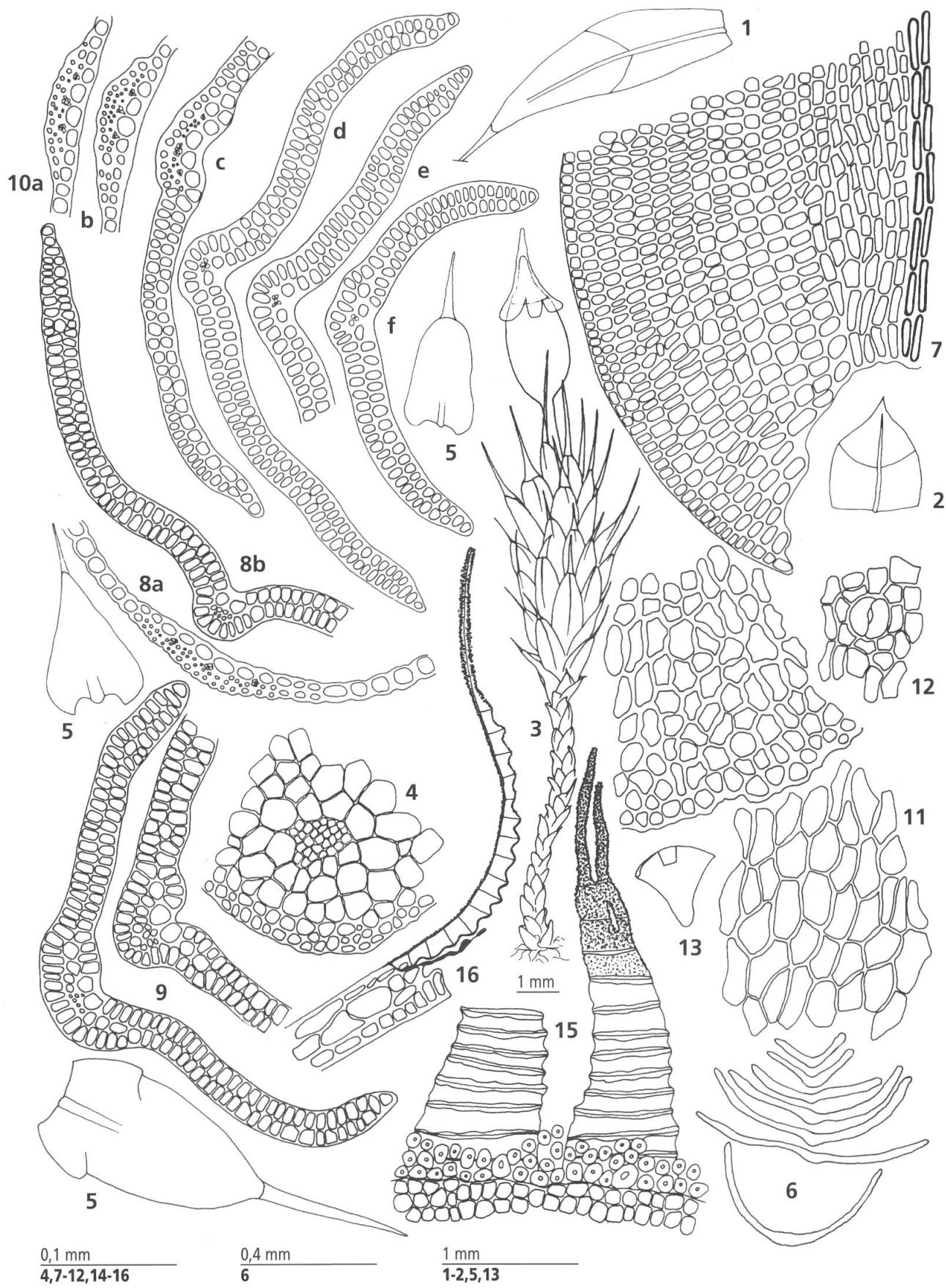
Gametophyte. Dioicous. Female: innermost perichaetal leaf (Fig. 12.1) up to 2 mm, sheathing up to broadest part of leaf, narrowed at leaf base, ovate to broad-ovate, lower half hyaline or only some rows of hyaline cells at margin, vanishing at mid-leaf, costa obscure in apical part, excruding to long, denticulate hair-point; **male:** perigonia as multifoliate buds at tips of branches, innermost perigonial leaf (Fig. 12.2) up to 1 mm, sheathing, broad-ovate, suddenly narrowed to acute apex with hyaline cell, hyaline in lower part, costa vanishing below apex, paraphysis short, numerous. **Growth form:** cushion lax, young shoots mostly present, originating from rotten plants, with scale-like leaflets appressed to stem, costa vanishing below acute apex, with sharply pointed hyaline cell or short hair-point; plants erect (Fig. 12.3), scarcely branched, slightly radiculose at base, stem up to 20 mm, central strand well developed (Fig. 12.4). **Leaves** in lower part of stem scale-like, becoming gradually longer to tip of stem (Fig. 12.5), 1.2-1.8 mm, rarely up to 3 mm, imbricate, appressed to stem when dry, older leaves bending backwards when moistened, younger leaves moving slightly, erect or spreading when wet, from short (\approx 1/5 of leaf length), rounded, half-sheathing, slightly decurrent leaf base lingulate or broad-lanceolate, tapering to obtuse or rounded, even acute apex, hair-point roughly denticulate, occasionally nearly smooth; **leaf form in situ:** (Fig. 12.6) widely concave or concave throughout, margin plane; some rows of basal paracostal cells (Fig. 12.7) rectangular, walls smooth or faintly nodulose, towards margin in sheathing part cells isodiametric or transversely rectangular or oval, transverse walls thicker than longitudinal walls, in laminal part cells homogeneous, rounded, walls thick; leaf base unistratose, in transitional part bistratose in places, in laminal part bi- to tristratose, at margin from insertion up to apical part one or more cell rows unistratose, in apical part at least one side unistratose, at apex bistratose. **Costa**, seen on dorsal side, at leaf base wide, from above widest part of leaf up to apex indistinct, excruding, in laminal part dorsal cells not different from lamina cells, seen in transverse section (Fig. 12.8-10), on dorsal side at insertion and lower part of leaf flat, weakly convex, in upper part slightly rounded, on ventral side at leaf base widely channelled, in upper part narrowly so, at insertion and leaf base from seven to eleven ventral cells, most of them guide cells, a small median band of substereids, interrupted by three groups or one large central group of hydroids, substereids and hydroids vanishing in apical part, in transitional part number of guide cells reduced to four, in laminal part to two guide cells, sunken into narrow channel (Fig. 12.8b, 12.10c-f), their adaxial cell walls strongly thickened.

Sporophyte. Seta up to 3 mm (Fig. 12.3), straight, vaginula 1 mm. **Capsule** emergent, obloid, smooth, exothelial cells (Fig. 12.11) elongated, of variable shape, slightly curvilinear, stomata (Fig. 12.12) in short neck, annulus of three rows of cells, detaching spirally in groups. **Calyptra** (Fig. 12.3) mitrate, in upper part brownish, lobed, covering upper part of capsule. **Operculum** (Fig. 12.13) conical, straight, blunt, margin (Fig. 12.14) uneven or crenulate, one or two marginal rows of rounded cells, in conical part irregular, walls thickened, curvilinear, faintly nodulose. **Peristome** (Fig. 12.15) inserted below orifice, teeth erect when dry, broad at base, slit half way down to two or three branches or perforate, trabeculae broad, at upper third thin, seen in longitudinal section (Fig. 12.16) two cell rows between exothecium and teeth, outer layer thicker than inner one, inner side and upper outer side covered with rounded papillae, lower outer side smooth, trabeculae distant, protruding, occasionally short prostome.

Spores 12-16 μm , smooth.

Fig. 12. – *Grimmia laevigata* (Brid.) Brid.: 1, perichaetal leaf; 2, perigonial leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaves; 6, outlines of transverse sections of leaf; 7, cells in leaf base; 8-10, transverse sections of leaves, 8a, at insertion, 8b, in laminal part, 10a, at insertion, 10b, in leaf base, 10c, in transitional part, 10d, e, in mid-leaf, 10f, in apical part; 11, exothelial cells; 12, stoma; 13, operculum; 14, cells at margin of operculum; 15, peristome, outer side; 16, longitudinal section of peristome tooth.

[1, 11-16, Maier 11339; 2, Maier 9070; 3, Maier 7811; 4-8, Shelp 32/6, BM; 9-10, Stewart 13725]



Diagnostic characters. – **Gametophyte:** scale-like leaflets from young shoots and from lower part of stem with short hair-points or at least with a sharp hyaline end cell; leaf base of stem leaf short, rounded, half-sheathing; margin unistratose from leaf base up to below apex; costa with hydroids, in upper leaf part with two guide cells sunken into narrow channel, their adaxial cell walls strongly thickened (Fig. 12.8b, 12.10c-f), a specific character of *G. laevigata*. **Sporophyte:** peristome teeth slit or perforated.

Comments. – The form and length of leaves are very variable (Fig. 12.5), the hair-point is short or elongated, sharply and densely denticulate, rarely nearly smooth.

The lamina is bistratose, in places with tri- to quadistratose patches. In rare cases the costa may be overlaid ventrally by supplementary cells on both sides of the leaf axis, thus covering the guide cells (Fig. 12.9).

Immature setae may be curved.

The confusion about the specimens, on which GANGULEE (1972) based his description of *G. laevigata* is noted under *G. mammosa* (see under this name).

Provenance. – India Punjab, Kashmir, Nepal.

Habitat. – On exposed siliceous boulders, at altitudes between 1200 and 2500 m.

Specimens examined. – Fifteen, six of them from the study-area. The selected ones are: **INDIA. Punjab, Kulu:** “Common on exposed schist boulder faces, N-aspect 4000”, 1.VI.1952, *Shelpe* 32/6 (BM). **Punjab, N. W. F. Province:** “Abbottabad 4-4500 ft.”, c. IV.1934, *Stewart* 13725 (E, NY). **KASHMIR.** “Jakut-i-Suliman, Srinagar 5-6000 ft”, VIII.1923, *Lillie* 790 (BM). **NEPAL.** “Jumla, alt. 10.000 [?], growing on boulders and rocks in south aspect”, 8.VIII.1952, *Polunin, Sykes & Williams* 389 (BM). **PAKISTAN. Hazara:** “Mansehra to Oghi, top of pass at Susal Gali; on rocks”, 7.VI.1958, *Burtt B* 726 (E).

Specimens selected for the description. – **SWITZERLAND. Canton of Valais:** “Fully 560 m, exposed siliceous boulder”, 1.II.1993, *Maier* 7811 (G); “Münster 1460 m, alpine meadow, exposed siliceous boulder”, 21.IX.1994, *Maier* 9070 (G); “Vernayaz 640 m, siliceous boulder, arid grassland”, 18.III.1998, *Maier* 11339 (G).

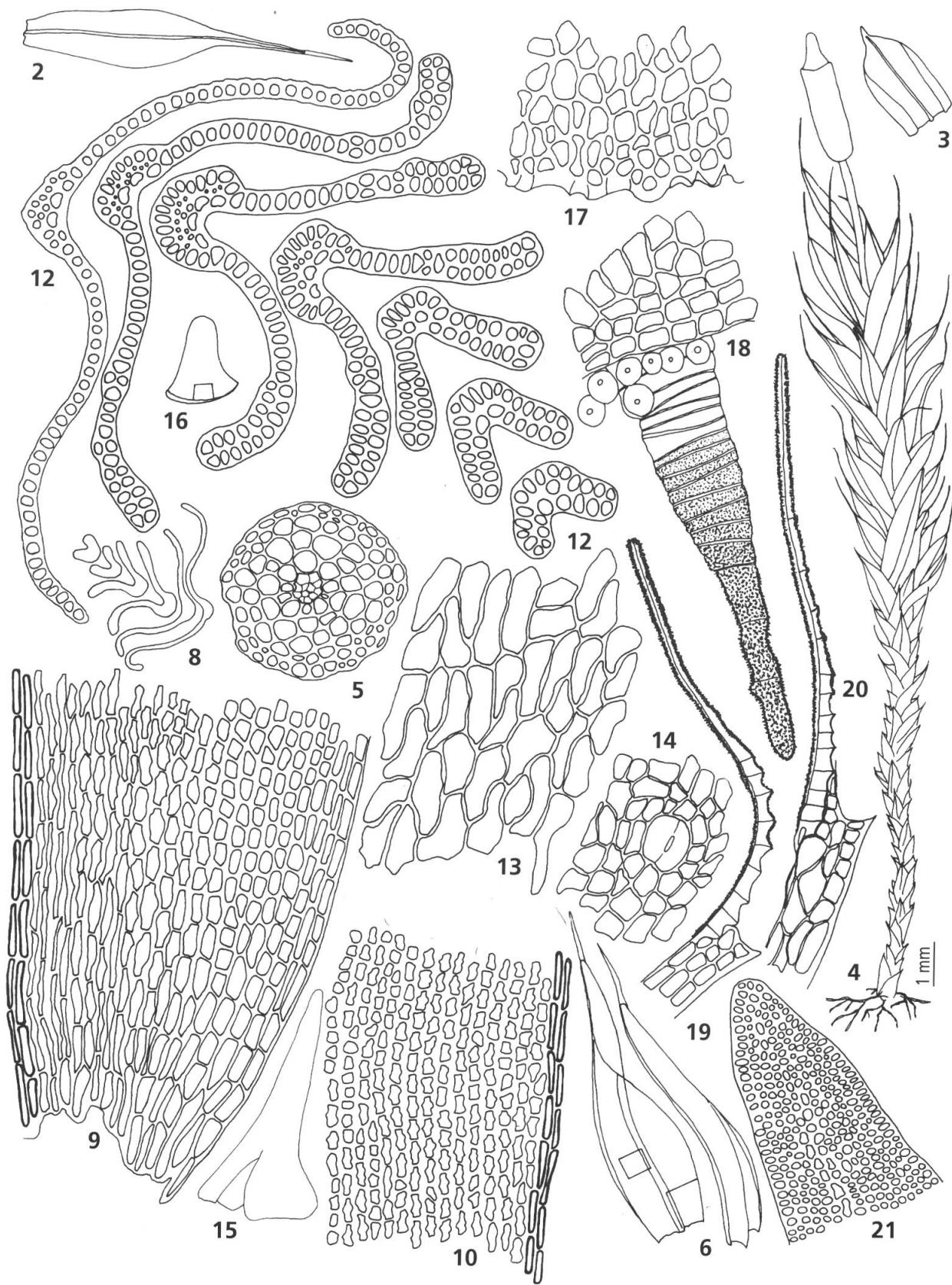
13. *Grimmia longirostris* Hook., Musc. Exot. 1: 62. 1818.

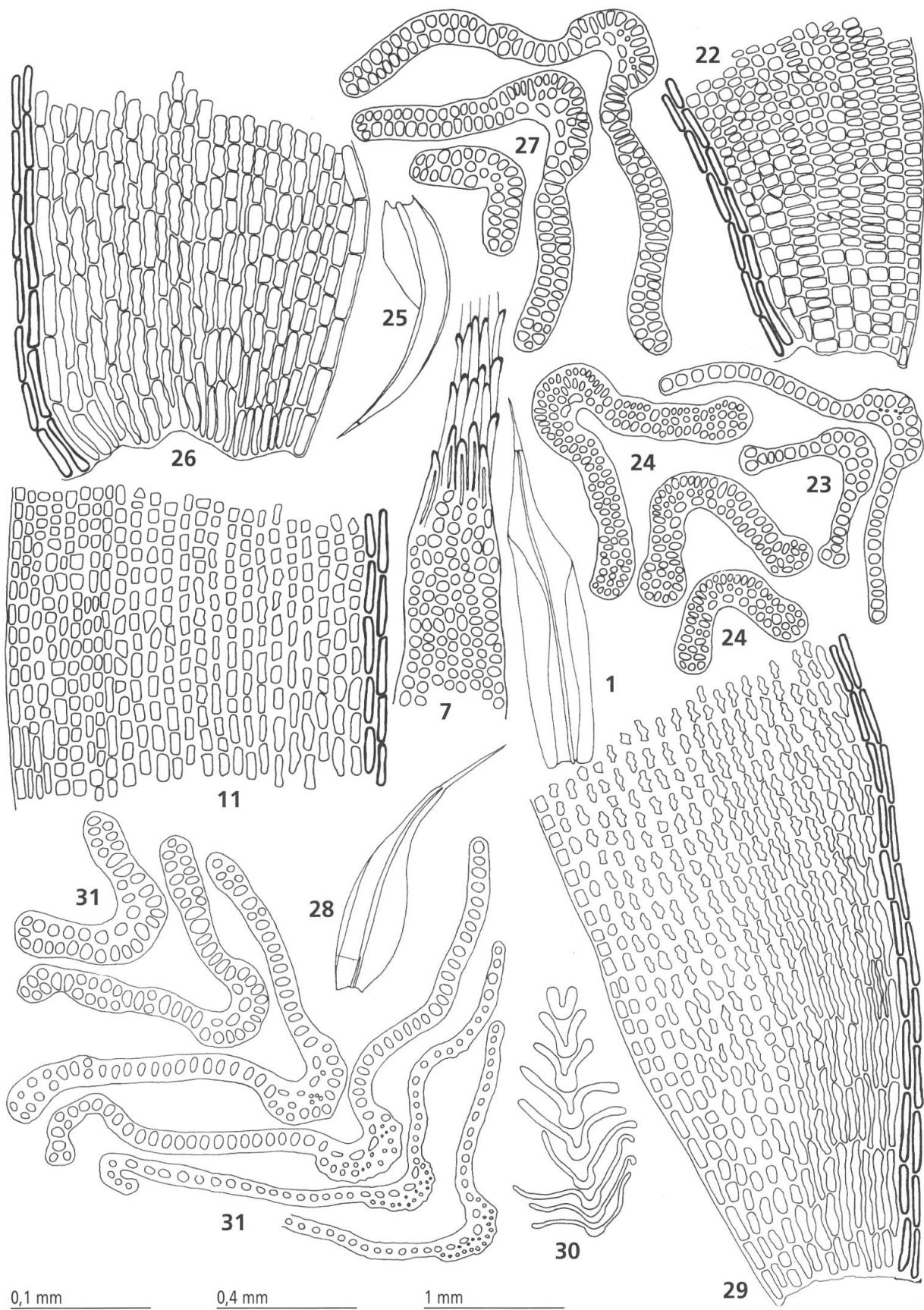
= *G. somervellii* Dixon in J. Bot. 63: 221. 1925.

Gametophyte. Mostly monoicous. Female: innermost perichaetial leaf (Fig. 13.1) up to 3,5 mm, sheathing up to 2/3 of leaf length, leaf base elongated, in broadest part suddenly narrowed to subulate apical part, at margin from insertion up to broadest part of leaf a broad band of hyaline cells, vanishing gradually, other cells chlorophyllose, below and above broadest part of leaf marginal cells with slightly protruding joint thickenings, costa excurring to denticulate hair-point, occasionally present a narrower, shorter, not sheathing leaf (Fig. 13.2); **male:** perigonia as multifoliate buds on short stalks at branchings or in leaf axils, several in a plant, innermost perigonial leaf (Fig. 13.3) 0,8 mm, sheathing up to broadest part of leaf, concave, broad-ovate, in apical part tapering to apiculate apex, costa vanishing below apex, lower 2/3 of leaf hyaline, at margin one or two rows of elongate-rectangular thin-walled hyaline cells, vanishing in broadest part, costa vanishing below apiculate apex, paraphysis few, present in younger perigonia. **Growth form:** in dense cushions, adherent to substrate with rhizoids, from them originating young shoots with scale-like leaflets, apices patent, muticous, acute, plants erect, branched, radiculose at base, stem (Fig. 13.4) up to 30 mm, central strand (Fig. 13.5) well developed. Lower

Fig. 13. – *Grimmia longirostris* Hook.: 1, perichaetial leaf; 2, perichaetial leaf, small; 3, perigonial leaf; 4, plant with sporophyte; 5, transverse section of stem; 6, leaves; 7, cells at apex, hair-point; 8, outlines of transverse sections of leaf; 9, cells in leaf base; 10-11, cells in transitional part of leaves; 12, transverse sections of leaf; 13, exothecial cells; 14, stoma; 15, calyptra; 16, operculum; 17, cells at margin of operculum; 18, peristome, outer side; 19-20, longitudinal sections of peristome teeth; 21, apex, muticous; 22, cells in leaf base; 23-24, transverse sections of leaves; 25, leaf; 26, cells in leaf base; 27, transverse sections of leaf; 28, leaf; 29, cells in leaf base; 30, outlines of transverse sections of leaf; 31, transverse sections of leaf.

[1-3, *Maier* 8204; 4, *Maier* 4285; 5-10, 12-19, *Long* 16680; 11, *Hooker* 328; 20, *Long* 16836; 21, *Long* 26855; 22-23, *Henry* 508; 24, *Long* 16787; 25-27, *Somervell* 1001; 28-31, *Humboldt* 76]





0,1 mm

5,7,9-14,17-24,
26-27,29,31

0,4 mm

8,30

1 mm

1-3,6,15-16,25,28

29

leaves scale-like, upper stem leaves (**Fig. 13.6**) up to 3 mm, loosely disposed on stem, apices may be contorted, imbricate when dry, bending backwards when moistened, erectopatent when wet, from ovate base gradually narrowed to lanceolate lamina, tapering to acute apex, hair-point (**Fig. 13.7**) 1/4 to one length of lamina, faintly to strongly denticulate; *leaf form in situ*: (**Fig. 13.8**) leaf base concave, one side plicate, in laminal part keeled, narrowly so below apex, margin on larger side from insertion up to mid-leaf recurved or revolute, other side mostly plane; basal paracostal cells (**Fig. 13.9**) elongate-rectangular, walls nodulose, thickened, transverse walls thin, often oblique, cells near margin quadrate to rectangular, walls smooth, transverse walls thickened, in some specimens hyaline up to broadest part of leaf, in transitional part paracostal cells (**Fig. 13.10**) short-rectangular, walls thickened, nodulose or smooth (**Fig. 13.11**), upper lamina cells rounded-quadrangular, walls thickened, faintly sinuose; basal cells unistratose, in transitional and lower laminal part uni- to bistratose, in upper part bistratose, at margin several rows of cells bistratose except at leaf base. **Costa**, seen on dorsal side, of nearly uniform breadth, slightly smaller at insertion, obscure in keeled part, percurrent, seen in transverse section (**Fig. 13.12**), costa on dorsal side at insertion and leaf base widely rounded, in lower laminal part unevenly rounded, somewhat angulate, and slightly contracted at origin of lamina, becoming indistinct in upper laminal and keeled part, on ventral side at insertion and leaf base widely channelled, in laminal part channelled, at insertion and leaf base six guide cells, rarely only four, in upper part five or four, in indistinct part two guide cells, from insertion up to indistinct part a central band of stereids or substereids, occasionally a central group of hydroids, vanishing in upper part of leaf.

Sporophyte. **Seta** (**Fig. 13.4**) straight, 1-5 mm, vaginula 0.9-1.2 mm, with ochrea. **Capsule** exserted, emergent or immersed, erect, cylindrical, oblong-ovoid, with short neck, narrowed at orifice, smooth, in immature state shrivelled, exothelial cells (**Fig. 13.13**) multiform, elongated, walls curvilinear, stomata (**Fig. 13.14**) at transition above neck and at base of capsule, annulus of three or four rows of cells, detaching as spirals. **Calyptra** (**Fig. 13.15**) mitrate, mostly with a single slit, covering upper third of capsule. **Operculum** (**Fig. 13.4, 13.16**) rostellate, beak straight or slightly oblique, margin (**Fig. 13.17**) crenulate, one or two rows of rounded marginal cells, in upper part rhombic, rounded-rectangular, thick-walled. **Peristome** (**Fig. 13.18**) inserted below orifice, erect when dry, teeth lanceolate, entire or slit to two or three branches, trabeculae small in lower part, thin in upper part, seen in longitudinal section (**Fig. 13.19, 13.20**) one row of cells between exothecium and teeth, their outer layer thicker than inner one, inner and outer upper side densely covered with conspicuous papillae, lower outer third with fine papillae, near insertion smooth, trabeculae in lower half neared, protruding, in upper half distant, indistinct, prostome lacks.

Spores 10-12 µm, smooth.

Diagnostic characters. – **Gametophyte:** leaf in apical part keeled, margin recurved on larger side; costa in lower part of lamina unevenly rounded, somewhat angulate. **Sporophyte:** peristome characters.

Comments. – Occasionally, cushions of male plants, with perigonia in leaf axils, mostly several on a stem can be found. A specimen, collected by J. D. Hooker in East Nepal [labelled “Sikkim”], Wallanchoon, at 12.000', is annotated by Deguchi: “Autoicous condition was not observed”, and in another one from India Orientalis, Momay (Sikkim) also collected by Hooker, at 15.000', he could not observe the autoicous conditions; both specimens are housed in NY. MÜLLER (1853) described a dioicous taxon as *G. neilgherriensis* (not seen). MUÑOZ (1998a) however, placed it in synonymy of *G. longirostris*. LOESKE (1930: 130) doubted the exclusively autoicous state of the taxon. IGNATOV & CAO (1994) explain the dioicous state as a result of decomposition of the lower parts of fruiting stems, leaving male branches isolated.

Hair-point length and denticulation depend on growing conditions. Thus plants collected at higher altitudes on dry rocks and boulders, show reduced hair-points or even muticous apices (**Fig. 13.21**). Plants growing under the same conditions have shorter cells with smooth thickened walls, not only at the leaf base but also above the transitional part of leaf (**Fig. 13.22**),

suggesting *G. alpestris*. However, costal structure (Fig. 13.23) shows the identity of the taxon. See comments to *G. fuscolutea*, *G. elatior* and *G. ovalis*.

The stratosity of the lamina varies from bi- to partly quadristratose (Fig. 13.24), and unistratose (Fig. 13.23) leaves may also be seen.

Seta length varies from 2-7 mm. Plants with immersed capsules, often erroneously identified as *G. pilifera*, are numerous. Brotherus noted a specimen (n° 2658), collected in China by Handel-Mazzetti with very short setae as “*G. subimmersa*” (E). Dixon (n° 913) noted a specimen with short seta from Zanskar Valley as “*G. himalaica*” (BM). Neither name is cited in the “Index Muscorum” (WIJK & al., 1962). They are considered as *nomina nuda*.

The variability of capsule shape has been documented in detail by CAO & VITT (1986).

MUÑOZ (1998a) proposed the replacement of the name *G. affinis* Hornsch. by the earlier name *G. longirostris*.

Comparaison of the specimens examined with the type specimen of *G. longirostris* shows the congruence of leaf shape (Fig. 13.28), cell pattern at leaf base (Fig. 13.29), and costal architecture (Fig. 13.30, 13.31). The type specimen (from Ecuador) is labelled as follows: H 2669 No 76. drawn, *Grimmia longirostris* [lectotype: BM].

Arguments for synonymy. – Based on specimens collected by J. H. Somervell during the Mt. Everest Expedition 1924 [Tibet], Rongbuk Valley, at altitudes between 16-17.000 ft., DIXON (1925) described *G. somervellii*. Leaves (Fig. 13.25) at base on one side plicate, margin on larger side recurved or revolute from insertion up to mid-leaf, in upper laminal part keeled; basal paracostal cells (Fig. 13.26) elongate-rectangular, walls nodulose, towards margin rectangular, walls smooth, at margin some rows hyaline. Costa in lower part of leaf rounded, in apical part indistinct, seen in transverse section (Fig. 13.27), costa in lower laminal part dorsally unevenly rounded, somewhat angulate. These characters correspond to those of *G. longirostris*. The type specimen, housed in BM, is labelled as follows: Ref. No. 1001. *Grimmia Somervellii* Dixon sp. nov. Journ. of Bot., 1925, p. 221. Rongbuk Valley, Mt. Everest; 16-17.000 ft. Coll. J. H. Somervell; Mt. Everest Expedition 1924 [paratype: BM].

MUÑOZ & PANDO (2000) as well proposed the synonymy of *G. somervellii* with *G. longirostris*.

Provenance. – Bhutan, India NW Himalaya, Kashmir, Nepal, Pakistan, Punjab, Sikkim, Tibet.

Habitat. – On siliceous rocks and boulders, in exposed or shaded places, from 2000-5960 m, most frequent between 3000 and 5000 m.

Specimens examined. – **Two hundred and forty-nine**, ninety-one of them from the study-area. The selected ones are: **BHUTAN. Thimphu District**: “above Jange Tsho, 27°31'26"N, 89°31'36"E. Rhododendron aeruginosum scrub; on rock, c. 4080 m”, 29.IX.1999, *Long* 28879 (E). **INDIA. NW Himalaya**: “On stones, Zanskar Valley, Zanskar, 13,500”, 26.VIII.1928, *Badhwar* 913 (BM). **KASHMIR. Astor**: “Astor Valley, 7-9000 ft.”, 15.VIII.1892, *Duthie* 12843 (BM). **NEPAL**. “Ghunsa Khola between Kyapra and Pheri 27°38'N, 87°55'E; Abies/Tsuga/Quercus/Rhododendron forest; on boulder on open slope, ca. 2850 m”, 7.IX.1989, *Long* 16680 (E, G); “W bank of Ghunsa Khola between Rambuc Kharka and Kambachen, 27°43'N, 87°58'E; large block scree on slope of valley; on large boulder, ca. 4050 m”, 9.IX.1989, *Long* 16787 (E, G); “Lhonak to Pan Pema, Kangchenjunga Glacier, 27°47'N, 88°04'E; rocky slope of glacier valley; on large boulder, ca. 4730 m”, 11.IX.1989, *Long* 16836 (E, G). **PAKISTAN. Northern Areas, Baltistan**: “Deosai National Park. Near junction of Ali Malik and Shatung Rivers. Lat 35°03'N Long 75°28'E, 3990 m. NW-facing granite and gabbro cliffs”, 6.VIII.1998, *Hedderson* 12641 (BOL). **PUNJAB. Kulu Distr.**: “Dibibokri Nel, 12,800', locally abundant on sheltered boulder faces in boulder heap (old moraine?)”, 24.VI.1952, *Schelpe* 3374 (BM). **SIKKIM Himalaya**. “Lachoong [= Lachung], 15 000”, Herb. Ind. Or. Hook. fil. & Thomson, *Hooker* 328 (BM). **TIBET**. “Himalaya, Everest-(Chomo-longma-)Gruppe, zentraler Rongbuk-Gletscher, orographisch rechte Flanke, 5960 m”, 24.IX.1984, *Miehe* s.n. (GZU).

Specimens selected for the description. – **CHINA. Qinghai Province, Maqin County**: “Jiang Ran Valley N of Dawu, 34°30'58"N, 100°13'14"E; open grazed valley; on boulder in small gully, ca. 3740 m”, 7.VII.1997, *Long* 26855 (E, G); *Henry* 508 (Herb. Mitten) (NY). **SWITZERLAND. Canton of Valais**: “Fully, 1280 m, mountain forest, siliceous boulder”, 19.X.1990, *Maier* 4285 (G); “Salvan, 780 m, mountain forest, siliceous boulder”, 16.VI.1993, *Maier* 8204 (G).

14. *Grimmia macrotheca* Mitt. in J. Linn. Soc. Bot. Suppl. 1: 44. 1859.

= *G. longicapsula* C. H. Gao & T. Cao in Acta Bot. Yunnan. 3: 395. 1981.

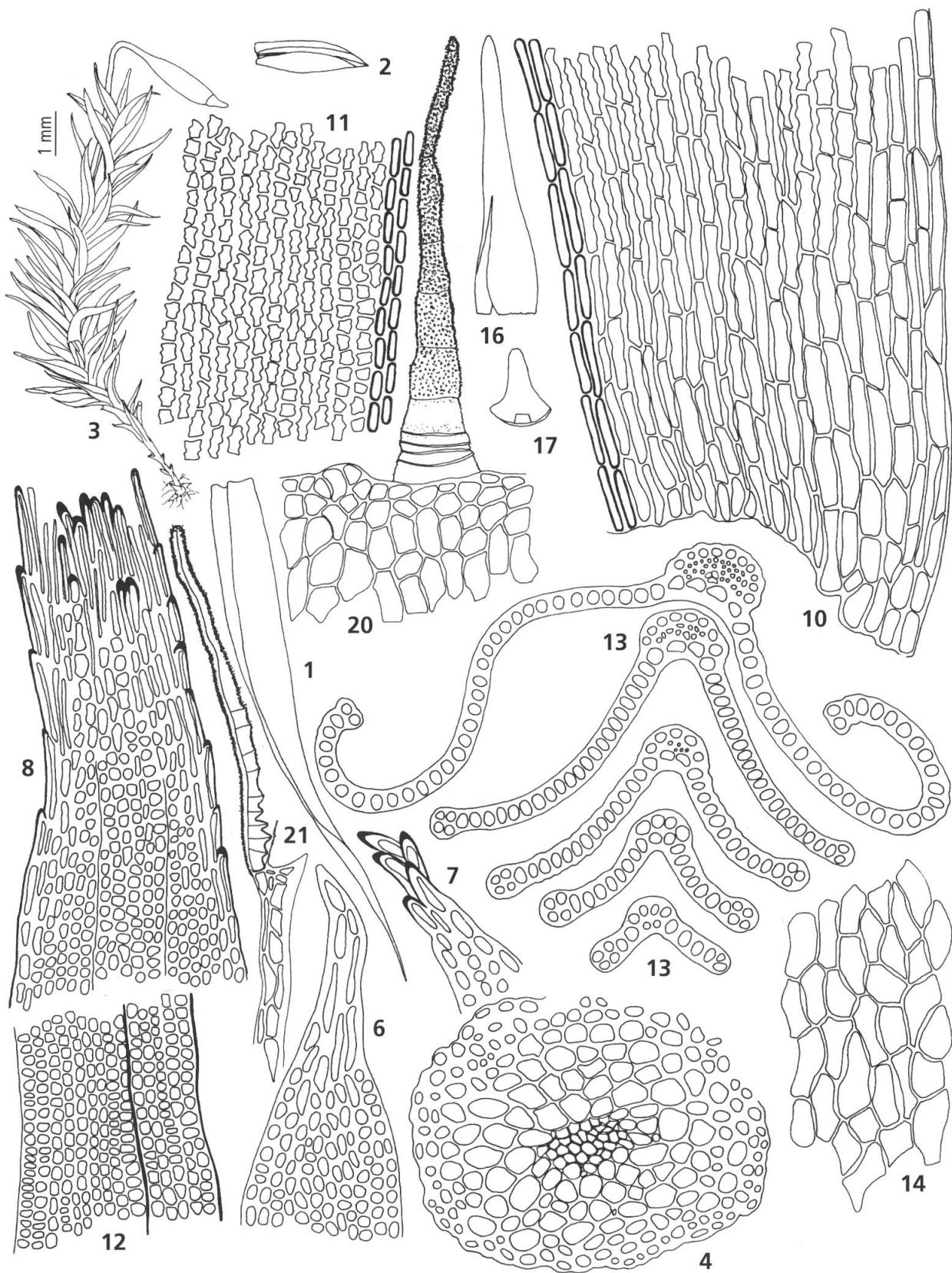
Gametophyte. *Monoicous.* **Female:** inner perichaetal leaf (Fig. 14.1) 2,2-2,5 mm, sheathing up to 2/3 of leaf length, lanceolate, cells hyaline in lower third, costa excurring to smoothly denticulate hair-point; **male:** perigonia on stem below subfloral innovation, hidden in two perigonial leaves (Fig. 14.2), up to 0,8 mm, sheathing, ovate, apex acute, costa weak, percurrent, with paraphysia. **Growth form:** cushion lax, plants erect (Fig. 14.3), branched, stem up to 20 mm, central strand (Fig. 14.4) well developed. **Leaves** (Fig. 14.5) 2,2-3,2 mm, imbricate, appressed to stem, lower part contorted, upper part flexuose when dry, squarrose when moistened, patent when wet, from broad, slightly decurrent leaf base lanceolate to broadly lanceolate, tapering to acute, apiculate apex, or to short (Fig. 14.6), hyaline, greenish or brownish tinged hair-point, or to bluntly denticulate (Fig. 14.7), or to elongated hair-point appearing twisted by somewhat obliquely arranged cells, decurrent in apical part (Fig. 14.8) as border of two rows of elongate-rectangular thick-walled cells, distally bluntly protruding, lumina distinct in all forms of hair-points; *leaf form in situ:* (Fig. 14.9) at leaf base concave, in upper part keeled, in extreme apical part widely so, margin on one side from insertion up to mid-leaf revolute, on other side from above leaf base up to mid-leaf revolute or recurved; basal leaf cells (Fig. 14.10) elongate-rectangular, walls more or less nodulose, towards margin walls smooth, some rows hyaline, lamina cells above leaf base (Fig. 14.11) rectangular, walls strongly sinuose, thick-walled, in upper part irregular (Fig. 14.12), short-rectangular to isodiametric, walls sinuose or smooth, thick-walled; leaf base and lamina unistratose, at margin one or two cell rows unistratose or bistratose. **Costa**, seen on dorsal side, of uniform width, vanishing at apex, seen in transverse section (Fig. 14.13), costa on dorsal side rounded throughout, on ventral side in lower part of leaf widely channelled, in upper part channelled, at insertion and leaf base four guide cells, reduced to two in upper third of leaf, at leaf base a median band of substereids and a small group of hydroids, gradually vanishing up to below apex.

Sporophyte. **Seta** (Fig. 14.3) 5-8 mm, twisted, nearly erect when dry, arcuate when wet, vaginula 1,2 mm. **Capsule** emergent, erect when dry, horizontal, cylindrical, slightly curved when wet, seta enlarged to short apophysis, shrivelling with age, capsule wall smooth, exothecial cells (Fig. 14.14) of variable shape, walls curvilinear, thin, stomata (Fig. 14.15) numerous at apophysis, annulus (Fig. 14.19) of three or four cell rows, detaching spirally as groups. **Calyptra** (Fig. 14.16) cucullate. **Operculum** conical (Fig. 14.17), beak straight or oblique, blunt, margin (Fig. 14.18) crenulate, in conical part cells irregular, walls slightly thickened. **Peristome** (Fig. 14.20) inserted at orifice or slightly below it, seen in one and the same capsule, teeth spreading, their apices inflexed when dry, elongate-lanceolate, entire, trabeculae in lowest plates more or less broad at teeth of one and the same capsule, in upper part thin, seen in longitudinal section (Fig. 14.21) one more or less developed cell row between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side covered with fine papillae, lower outer plates smooth, trabeculae on lowest plates neared, sharply protruding, in upper part distant, scarcely marked.

Spores 10-12 μm , smooth.

Diagnostic characters. – **Gametophyte:** perigonia borne on stem below a subfloral sympodial innovation; leaf margins revolute on both sides or on one side only, and recurved on other side; costa at insertion and leaf base in with four guide cells, with hydroids. **Sporophyte:** capsule elongated, horizontal; peristome inserted at orifice.

Comments. – Hair-points may be strongly variable in one and the same plant. Besides muticous leaves, some with some hyaline cells (Fig. 14.6) only, or very short hair-points (Fig. 14.7), or even elongated ones are present. The hair-points, often twisted, decurrent (Fig. 14.8) in apical part with a bluntly denticulate border of two rows of elongated cells (Fig. 14.8) (GANGULEE, 1972, Fig. 389, LA), and the cylindrical, freely produced capsules characterise *G. macrotheca*.



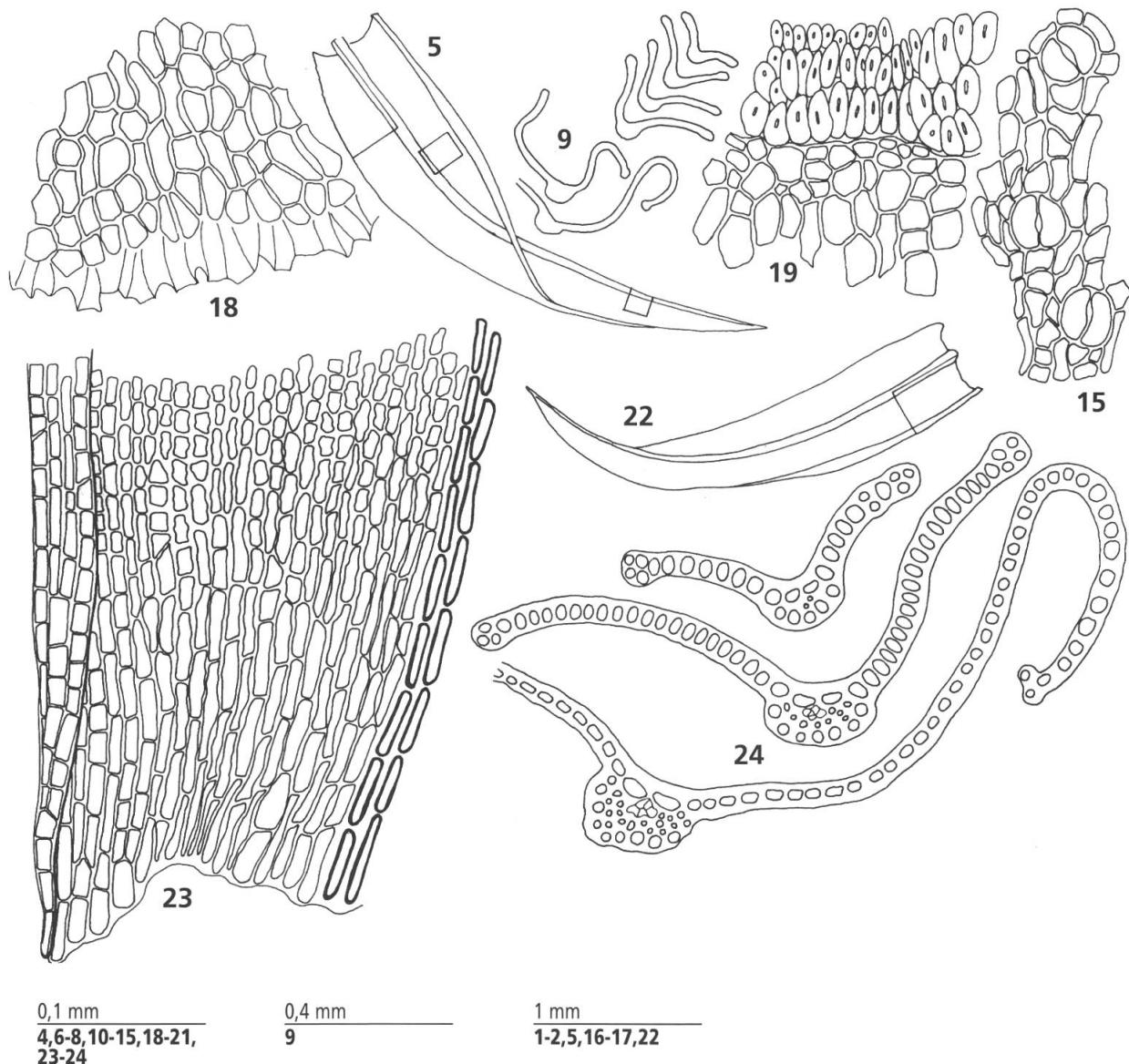


Fig. 14. – *Grimmia macrotheca* Mitt.: 1, perichaetial leaf; 2, perigonal leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaf; 6-8, cells at apex from one and the same plant, 6, with hyaline cells, 7, with short hair-point, 8, with elongated hair-point; 9, outlines of transverse sections of leaf; 10, cells in leaf base; 11, lamina cells above leaf base; 12, cells in upper part of lamina; 13, transverse sections of leaf; 14, exothecial cells; 15, stomata; 16, calyptra; 17, operculum; 18, cells at margin of operculum; 19, annulus; 20, peristome, outer side; 21, longitudinal section of peristome tooth; 22, leaf; 23, cells in leaf base; 24, transverse sections of leaf.

[1-21, Poelt s.n.; 22-24, Hooker 316]

The synonymy of *G. longicapsula* [sphalm. *longicapusula*] with *G. macrotheca* has been established by CAO & VITT (1986).

Comparison of the specimens examined with the type specimen of *G. macrotheca* shows congruence of leaf shape (Fig. 14.22), cell pattern at leaf base (Fig. 14.23), and costal architecture (Fig. 14.24). The type specimen is labelled (following THIERS, 1992): Grimmia macrotheca Mitt. [Sikkim,] Jongri, 12.000 ft, J. D. Hooker 316 [holotype: NY].

Provenance. – Nepal, Sikkim, Tibet.

Habitat. – On boulders and rocks, in coniferous forest, at ^a 4000 m.

Specimens examined. – Nine, three of them from the study-area. The selected ones are: TIBET. “Yadong County [= Chumbi Valley]. Ji-Neou, on rock”, 28.V.1975, Zang Mu 39 (NY). NEPAL. Langtang Area: “Slopes N of Kyangjin, moraines of Langtang Lirung Glacier, ≈ 4000 m”, 9.IX.1986, Poelt s.n. (GZU).

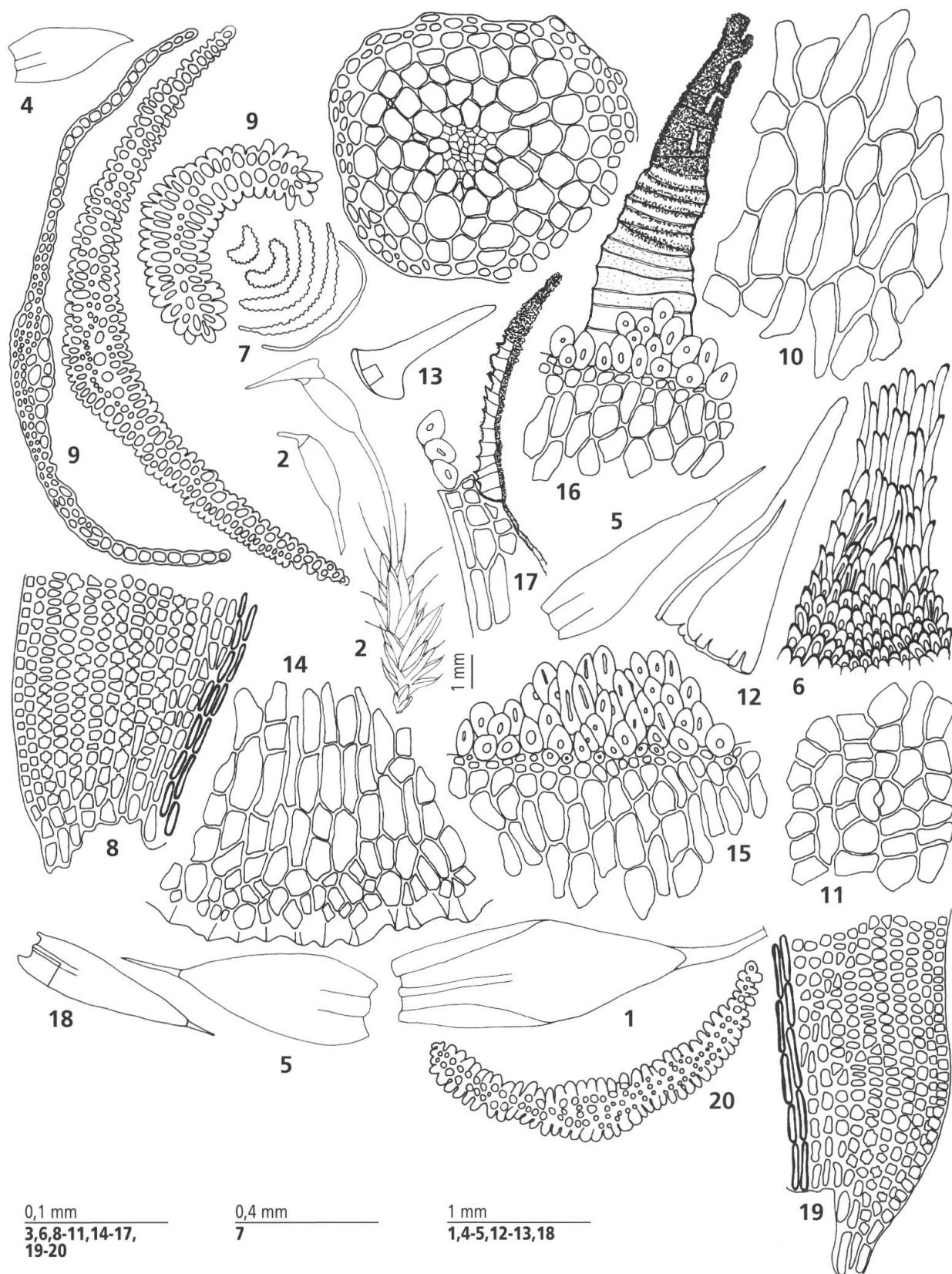
15. *Grimmia mammosa* C. H. Gao & T. Cao in Acta Bot. Yunnan. 3: 394. 1981.

Gametophyte. *Supposedly dioicous. Female:* perichaetial leaves (Fig. 15.1) 2,5-3 mm, slightly sheathing up to mid-leaf, shape as of stem leaves, hair-point elongated, smoothly denticulate; *male:* perigonia not seen. **Growth form:** cushion compact, young shoots originating from rotten plant parts, with scale-like, muticous leaflets, firmly appressed to stem, plants erect, stiff, branched, stem (Fig. 15.2) up to 15 mm, central strand (Fig. 15.3) well developed. **Leaves** in lower part of stem short (Fig. 15.4), muticous, gradually longer (Fig. 15.5) at tip of stem, 1,5-1,7 mm, imbricate, appressed to stem when dry, older leaves slightly spreading, younger leaves scarcely altered when moistened, erectopatent when wet, from short, slightly sheathing, rounded, decurrent leaf base broad-lanceolate or lanceolate, tapering to obtuse apex, hair-point short or elongated (Fig. 15.6), bluntly denticulate; *leaf form in situ:* (Fig. 15.7) throughout concave, margin plane; except some rows of rectangular smooth-walled paracostal cells, basal cells (Fig. 15.8) rounded-quadrangular or transversely oval or rectangular with thickened walls or corner thickenings, at margin quadrate, lamina cells rounded, mammillose, due to bulging distal cell walls; leaf base at insertion unistratose or bistratose in places, laminal part bistratose, some marginal rows unistratose. **Costa**, seen on dorsal side, at insertion broad, distinct, on both sides enlarged by bistratose paracostal cells, from widest part of leaf up to apex indistinct, completely covered by mammillose lamina cells, seen in transverse section (Fig. 15.9), costa on dorsal side at insertion and leaf base flat, weakly convex, in upper part dorsally and ventrally indistinct, at insertion eleven to fourteen ventral cells, most of them guide-cells, a small band of substereids, interrupted by small groups of hydroids, in laminal part median cells with rounded lumina, a row of substereids, vanishing below apex, no guide cells.

Sporophyte. *Seta* up to 4,5 mm (Fig. 15.2), straight, erect. *Capsule* emergent, erect, cylindrical, smooth, exothelial cells (Fig. 15.10) elongated, walls curvilinear, thin, stomata numerous (Fig. 15.11) on short neck, annulus (Fig. 15.15) of three or four cell rows, with difficulty detaching in groups. *Calyptra* cucullate (Fig. 15.12), covering operculum and margin of capsule. *Operculum* (Fig. 15.13) conical, subulate, beak oblique, margin (Fig. 15.14) crenulate, two or three marginal rows of small, irregular mostly rhombic cells, in conical part elongate-rectangular or -hexagonal cells, walls thin. *Peristome* (Fig. 15.16) inserted below orifice, teeth broad at base, lanceolate, entire or perforate or at upper half slit to two irregular branches, trabeculae small, seen in longitudinal section (Fig. 15.17) one cell row between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer half densely covered with rough

Fig. 15. – *Grimmia mammosa* C. H. Gao & T. Cao: 1, perichaetial leaf; 2, plant with sporophyte; 3, transverse section of stem; 4, lower leaf; 5, upper leaves; 6, cells at apex, hair-point; 7, outlines of transverse sections of leaf; 8, cells in leaf base; 9, transverse sections of leaf; 10, exothelial cells; 11, stoma; 12, calyptra; 13, operculum; 14, cells at margin of operculum; 15, annulus; 16, peristome, outer side; 17, longitudinal section of peristome tooth; 18, leaf; 19, cells in leaf base; 20, transverse section of leaf.

[1-5, 7, 9-17, Long 16698; 6, 8, Long 8296; 18-20, Zang Mu 71]



papillae, sparsely so in middle part, in lower third finely papillose to smooth, trabeculae neared, sharply protruding.

Spores 10-11 μm , smooth.

Diagnostic characters. – **Gametophyte:** lamina appears to be strongly mammillose due to the bulging distal cell walls; costa broad at insertion, completely indistinct in laminal part on dorsal and ventral side, clearly defined guide cells are lacking.

Comments. – The sporophyte description is based on a single specimen with only two fruiting plants, thus the variability of sporophyte characters is unknown.

Except for the denticulate hair-point and numerous ventral cells at leaf base, other gametophytic characters of *Grimmia* species are missing, e.g. nodulose or sinuose cell walls, and clearly expressed ventral guide cells. However, the architecture of the peristome teeth (Fig. 15.16, 15.17) proves the membership of the species to the *Grimmiinae* (VITT, 1984) and within them, to the genus *Grimmia*.

The sterile specimen (No. 296) in Herb. Ind. Or. Hook. fil. & Thomson, collected by Hooker and Thomson in India, Mont. Khasia, labelled as *G. leucophaea* Grev., and, on a second label as “*G. subfusca* Wilson MSS. “, has been considered by MITTEN (1859) to be *G. leucophaea* (= *G. laevigata*), to be *G. laevigata* by JONES (in GROUT, 1933), and also by GANGULEE (1972). However, the specimen turns out to be *G. mammosa*. A manuscript note attached to the specimen No. 296, housed in NY, states that it had been loaned to Gangulee, who used it for his description of *G. laevigata*. The drawing Fig. 381, LA (GANGULEE, 1972: 800) shows the base of the densely denticulate hair-point of *G. mammosa*. Another specimen with fruiting plants, collected by Griffith at Otipore in Afghanistan under No. 67 was also loaned to Gangulee; it is labelled on a manuscript note attached to the packet as follows: New York Botanical Garden “(on the same sheet as No. 296-) (over) packet: Otiporo Griffith 67 *G. campestris* Burch. (*G. leucophaea*). Loaned to Dr. Gangulee 1/31/63”. Therefore, Fig. 381, PD (GANGULEE, 1972: 800) shows a capsule-bearing plant correctly identified as *G. laevigata*.

On the sheet bearing No. 284, collected by Hooker in Sikkim, and housed in BM, are glued three separate specimens. Two of them are *G. longirostris* (= *G. ovata* F. Weber & D. Mohr), the third one turned out to be *G. mammosa*. A specimen housed in NY under the same number is *G. longirostris* Hook. (= *G. ovata*) as noted on the label.

Comparison of the specimens examined with the type specimen of *G. mammosa* shows congruence of leaf shape (Fig. 15.18), cell pattern at leaf base (Fig. 15.19), and costal architecture (Fig. 15.20). The type specimen is labelled as follows: *Grimmia mammosa* Gao & Cao sp. nov., China: Tibet, Yadong County [= Chumbi Valley]. Chun-Pei-River, on rock. alt. 2900 m Zang Mu 29.V.'75. 71 [isotype: NY].

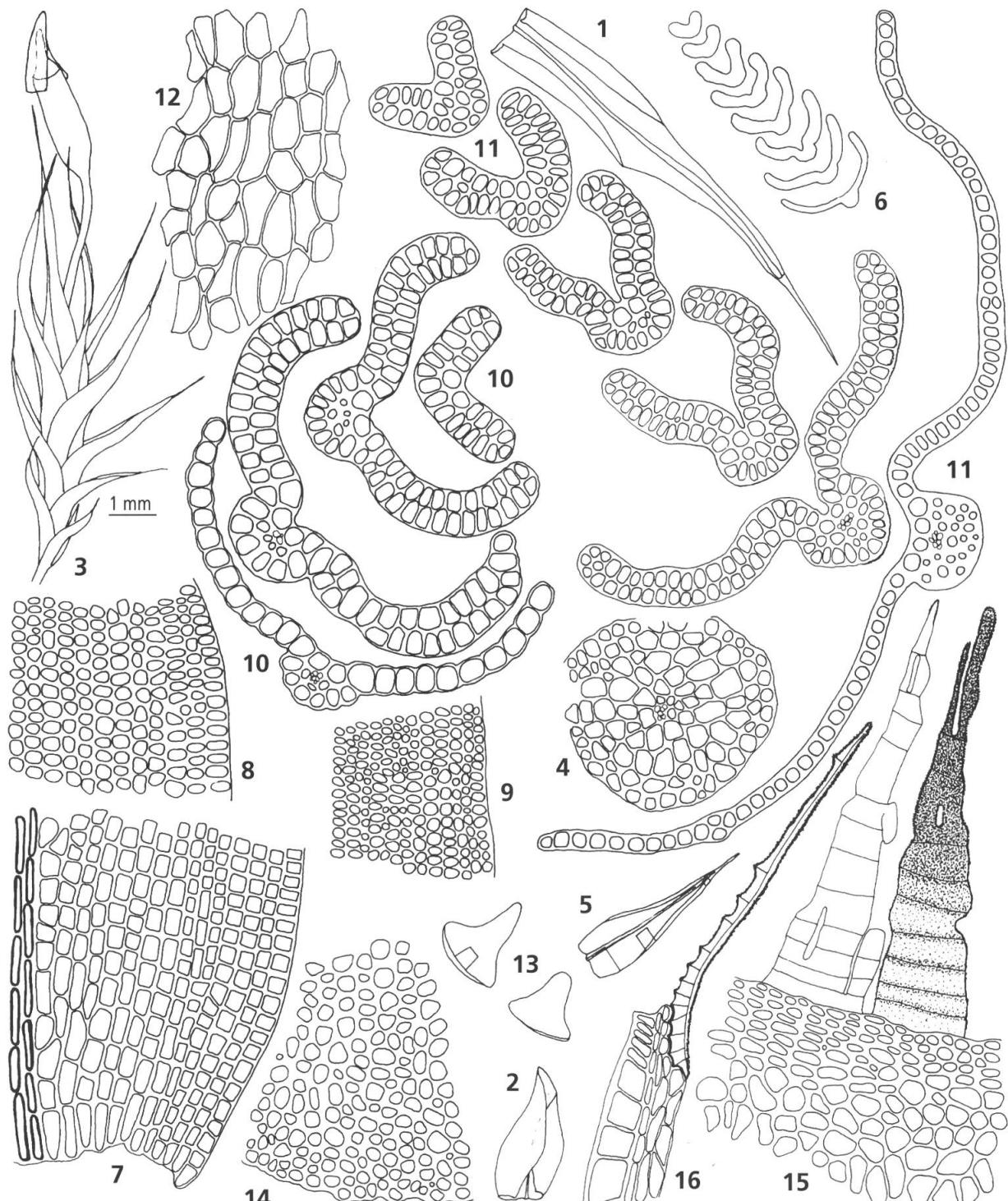
Provenance. – Bhutan, India Mont. Khasia, Nepal, Sikkim.

Habitat. – On siliceous boulders, rocks, in open and slightly shady places at altitudes between 1700 and 4000 m.

Specimens examined. – **Fifteen**, seven of them from the study-area. The selected ones are: **BHUTAN**. “Side valley 2 km N of Byakar Dzong Bumtang Chu, 27°34'N, 90°44'E; open valley with scattered pines. Dry boulder in scrub, c. 2780 m”, 10.VI.1979, Long 08296 (E, G). **INDIA**. “Kollong, Regio temp., Mont. Khasia, alt. 5.000 ped.”, Herb. Ind. Or. Hook. fil. & Thomson, Hooker & Thomson 296 (BM, NY). **NEPAL**. “Ghunsa Khola between Pheri and Ghunsa 27°39'N, 87°56'E; open Juniperus/Rhododendron woodland; on boulder, c. 3330 m”, 7.IX.1989, Long 16698 (E, G). **SIKKIM**. “Himalaya, Kankola, alt. 12000”, Herb. Ind. Or. Hook. fil. & Thomson, Hooker 284 (BM).

Fig. 16. – *Grimmia montana* Bruch & Schimp.: 1, perichaetial leaf; 2, perigonial leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaf; 6, outlines of transverse sections of leaf; 7, cells in leaf base; 8, marginal cells above shoulder of leaf; 9, upper lamina cells; 10-11, transverse sections of leaves; 12, exothelial cells; 13, opercula; 14, cells at margin of operculum; 15, peristome, outer side; 16, longitudinal section of peristome tooth.

[1, 12-16, Maier 9935; 2, Maier 9080; 3, Maier 8188; 11, Winkler s.n.; 4-10, Borelli s.n.]



0,1 mm
4,7-12,14-16

0,4 mm
6

1 mm
1-2,5,13

16. *Grimmia montana* Bruch & Schimp. in Bruch & al., Bryol. Eur. 25-28: 26. 1845.

Gametophyte. Dioicous. Female: innermost perichaetal leaf (**Fig. 16.1**) 2,7-3,5 mm, sheathing up to broadest part, at lower third of leaf cells transparent, some rows of hyaline marginal cells vanishing at broadest part, costa small at leaf base, stout in upper part, excurring to elongated, denticulate hair-point; **male** plants in separate cushions, perigonia as multifoliate buds terminal or in leaf axils, often several in one plant, innermost perigonial leaf (**Fig. 16.2**) 1 mm, strongly sheathing, concave, apex acute or blunt, costa percurrent, paraphysia numerous. **Growth form:** cushion compact, young shoots originating from rhizoids or older stems, leaflets appressed to stem, apices slightly patent, plant erect (**Fig. 16.3**), radiculose at base, stem up to 20 mm, central strand (**Fig. 16.4**) developed. Lower **leaves** small, muticous, suddenly longer (**Fig. 16.5**), 1,8-2,5 mm, lower part appressed to stem, apical part of longer leaves slightly twisted when dry, bending backwards when moistened, erectopatent when wet, from ovate leaf base abruptly lanceolate, thus forming shoulder, tapering to acuminate apex, hair-point of variable length, bluntly denticulate; **leaf form in situ:** (**Fig. 16.6**) concave from leaf base up to upper part of leaf, upper third keeled, margins from leaf base up to apex gradually stronger incurved; basal cells (**Fig. 16.7**) near costa rectangular, towards margin short-rectangular or quadrate, walls smooth, transverse walls markedly thicker than longitudinal walls, at margin some rows of hyaline cells, above shoulder at margin a longitudinal row of transversely oval cells (**Fig. 16.8**), lamina cells (**Fig. 16.9**) small, more or less isodiametric, lumina rounded, seen in transverse section (**Fig. 16.10, 16.11**) lamina cells short-rectangular, exterior cell walls smooth; leaf base unistratose, in transitional part lamina bistratose in places, in upper part bistratose, occasionally unistratose near costa, margin unistratose at leaf base, in laminal part bistratose, below apex occasionally tri- to quadistratose. **Costa**, seen on dorsal side, small at leaf base, enlarged, prominent in laminal part, excurrent, seen in transverse section (**Fig. 16.10, 16.11**), costa on dorsal side at leaf base rounded, in lower laminal part prominent, slightly angulate, in upper laminal part rounded, on ventral side at insertion widely channelled, in laminal part channelled or narrowly channelled, at insertion and leaf base four guide cells, in laminal part reduced to two, from insertion up to mid-leaf a central median group of hydroids, transformed to substereids in upper part, vanishing in apical part.

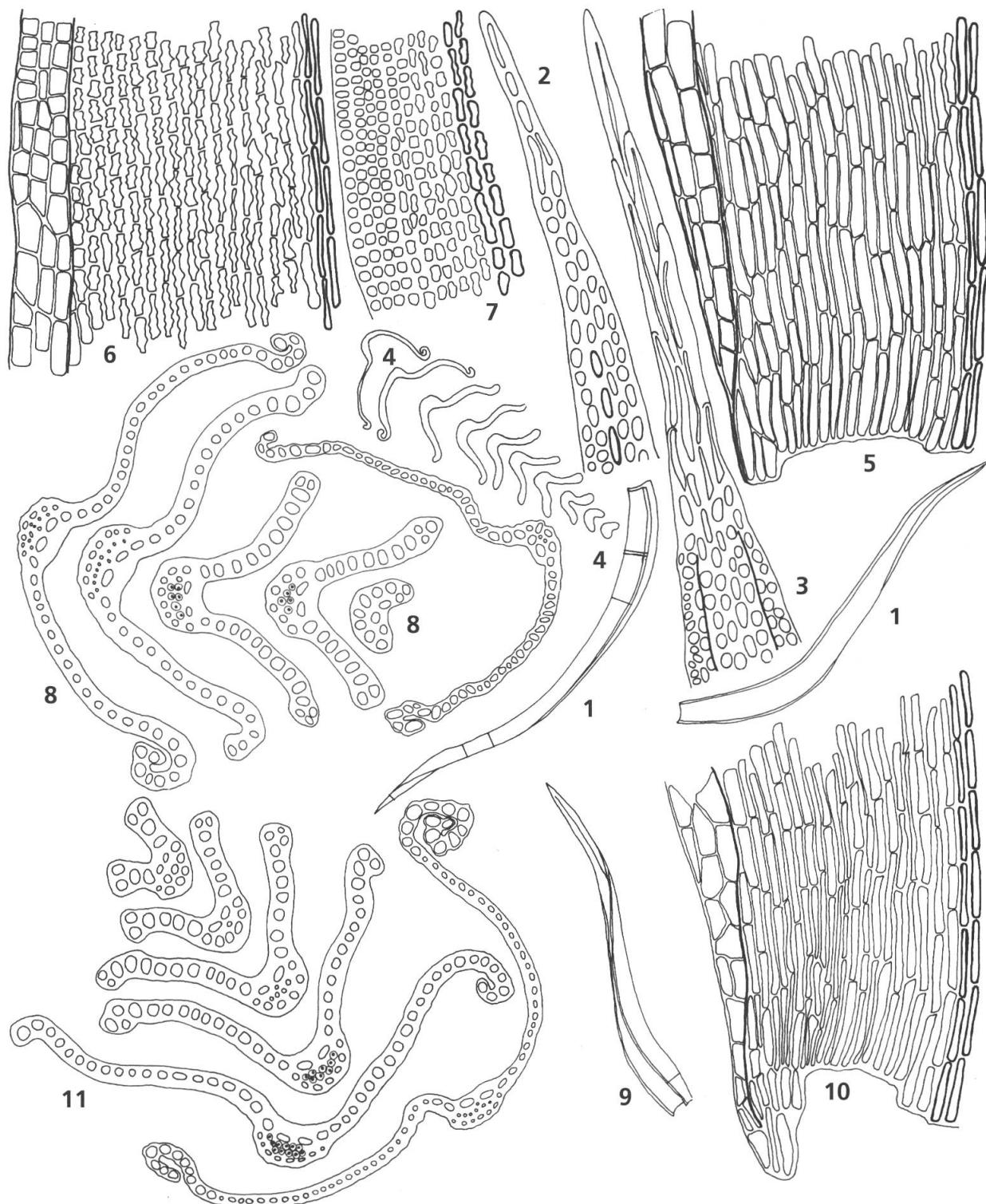
Sporophyte. Seta up to 3,5 mm (**Fig. 16.3**), straight, vaginula 0,8 mm. **Capsule** emergent, erect, obloid, smooth, exothelial cells (**Fig. 16.12**) mostly elongated, some pentagonal, walls thin, curvilinear, no stomata, at orifice several rows of transversely rectangular cells, the upper two rows suggesting a persistent annulus. **Calyptra** cucullate (**Fig. 16.3**), covering part of capsule. **Operculum** conical (**Fig. 16.13**), rostrate or rostellate, beak straight or oblique, blunt, margin (**Fig. 16.14**) uneven, some rows of small, rounded marginal cells, in conical part larger oval or rounded cells. **Peristome** (**Fig. 16.15**) deeply inserted below orifice, teeth erect when dry, lanceolate, irregularly perforate or slit to two unequal branches, trabeculae thin; seen in longitudinal section (**Fig. 16.16**) two rows of small rectangular cells between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side densely covered with fine papillae, middle part sparsely so, lower part smooth, trabeculae in lower part neared, in upper part distant, slightly protruding.

Spores 10-12 μm , smooth.

Diagnostic characters. – **Gametophyte:** cells of margin of leaf base short-rectangular to quadrate, with transverse walls strongly thickened; above shoulder at margin with a row of transversely oval cells; in transverse section lamina cells are short-rectangular, with exterior cell walls smooth. **Sporophyte:** peristome deeply inserted, teeth finely papillose.

Fig. 17. – *Grimmia nepalensis* Mitt.: **1**, leaves; **2**, cells at apex; **3**, cells at apex, hair-point; **4**, outlines of transverse sections of leaf; **5**, cells in leaf base; **6**, lamina cells above leaf base; **7**, cells at margin in upper part of lamina; **8**, transverse sections of leaf; **9**, leaf; **10**, cells in leaf base; **11**, transverse sections of leaf.

[**1-8**, Hooker 248, holotype of *G. nepalensis*; **9-11**, Hooker 248, holotype of *G. inflectens*]



0,1 mm
2-3,5-8,10-11

0,4 mm
4

1 mm
1,9

Comment. – The strongly thickened transverse walls of marginal cells at the leaf base (“Leiterzellreihen”, LOESKE, 1930: 111) and a row of transversely oval cells on the margin above the shoulder (**Fig. 16.8**) distinguish *G. montana* from *G. alpestris* and *G. sessitana*. In transverse section the short-rectangular lamina cells, with their exterior walls smooth, differ from the isodiametric, quadrate cells with slightly bulging exterior walls of *G. alpestris*.

Provenance. – Kashmir, Pakistan.

Habitat. – On rocks, in open places, at altitudes between 2400 and 4200 m.

Specimens examined. – **Fourteen**, nine of them from the study-area. The selected ones are: **KASHMIR**. “In valle Jurin, Zalinot-Jurin (?), 2400-3200 m”, 29.V.1913, Borelli s.n. (H-BR). **PAKISTAN. Baltistan**: “Basna valley, Steppe, Gneis, 2850 m”, 13.VII.1999, Gruber 2106 (Herb. Gruber); “Rupal valley, Kulturland, Felsrasen, Alm, Glimmerschiefer, 2980-3400 m”, 7-8.VII.1999, Gruber 2090, 2096, 2102 (Herb. Gruber); “Deosai National Park. Valley of the Shatung River, Bari La area, along road to Matyal. Lat 35°01'N Long 75°34'E, 4200 m, steep S-facing cliffs of basalt, gabbro and granite”, 3.VIII.1998, Hedderson 12497 (BOL).

Specimens selected for the description. – **GERMANY. [Westphalia]**: “Sauerland”, VIII.1883, Winkler s.n. (G). **SWITZERLAND. Canton of Valais**: “Bellwald, 1400 m, clearing, mountain meadow, siliceous boulders”, 22.IX.1994, Maier 9080 (G); “Finhaut, 1320 m, exposed siliceous boulders”, 15.VI.1993, Maier 8188 (G); “Naters, 2140 m, siliceous boulder, shady”, 6.VII.1994, Maier 9935 (G).

17. *Grimmia nepalensis* Mitt. in J. Linn. Soc. Bot. Suppl. 1: 46. 1859.

= *G. inflectens* Mitt. in J. Linn. Soc. Bot. Suppl. 1: 43. 1859.

Gametophyte. Monoicous. Female: perichaetial leaves with broad base, convolute, sheathing, apex hyaline; **male**: perigonium as bud at base of perichaetium. **Growth form:** cushion lax, plant erect, branched, stem up to 20 mm. **Leaves** (**Fig. 17.1**) 2,0-2,8 mm, crowded in upper part of stem, loosely disposed, somewhat contorted, incurved when dry, from ovate leaf base elongate-lanceolate, tapering to acuminate apex with some hyaline cells (**Fig. 17.2**) or short, nearly smooth hair-point (**Fig. 17.3**); **leaf form in situ**: (**Fig. 17.4**) leaf base on one side plicate, other side concave, in laminal part keeled, margin up to above leaf base on one side revolute, on other side recurved up to laminal part; basal cells (**Fig. 17.5**) from costa to margin elongate-rectangular, walls smooth or faintly nodulose, lower lamina cells (**Fig. 17.6**) rectangular, walls strongly sinuose, in upper part up to below apex at margin some rows (**Fig. 17.7**) of quadrate thick-walled cells, markedly differentiated from short-rectangular, sinuose lamina cells, at apex cells nearly isodiametric, lumina rounded; leaf base and lamina unistratose, margin on one side unistratose, on other side from leaf base up to apical part one cell row bistratose. **Costa**, seen on dorsal side, of even width, percurrent, seen in transverse section (**Fig. 17.8**), costa on dorsal side prominent, rounded, on ventral side channelled, at insertion and leaf base four guide cells, a band of substereids or stereids, in laminal part two guide cells, a median group of stereids, vanishing below apex, no hydroids seen.

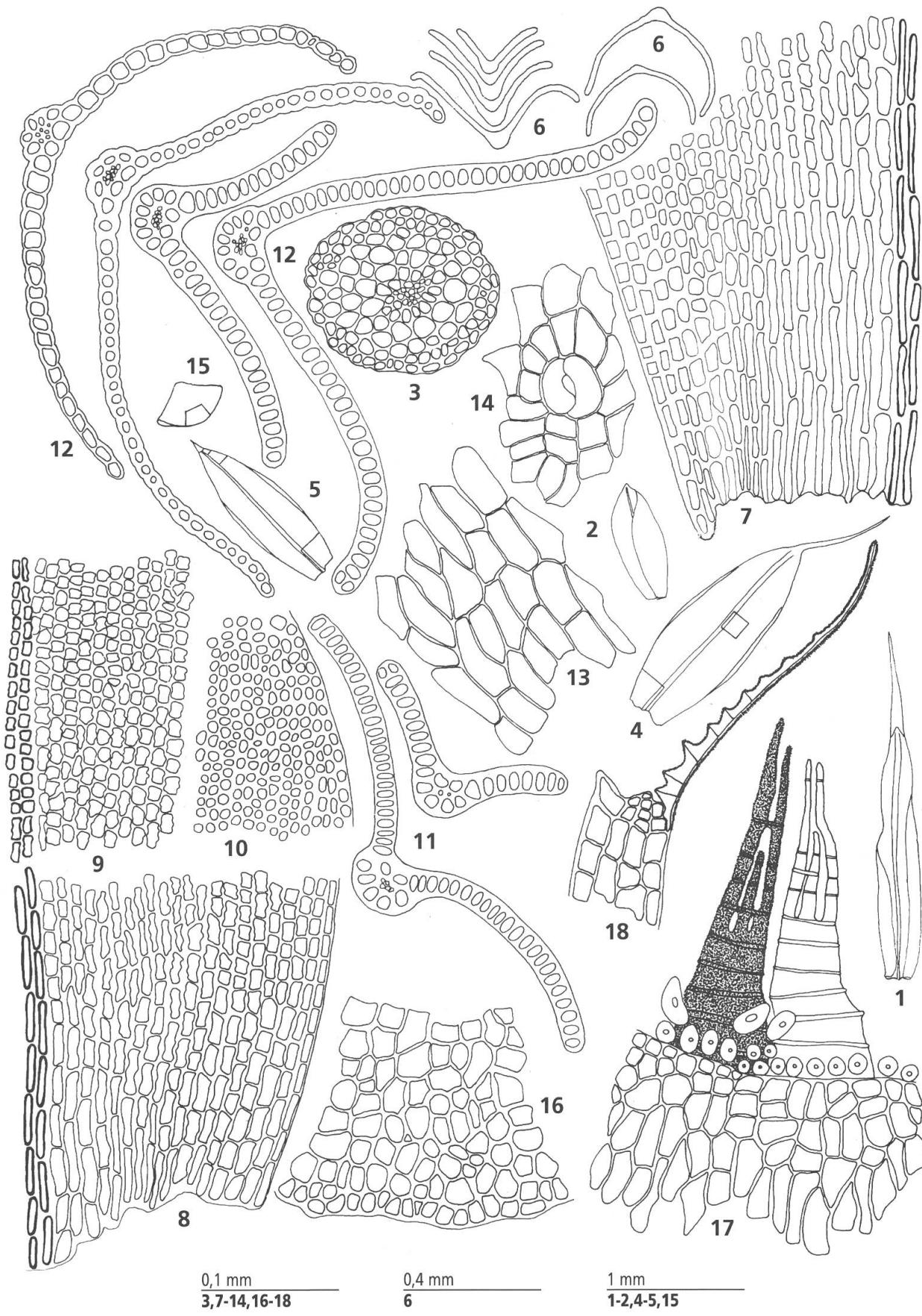
Sporophyte. Seta erect when dry, twisted. **Capsule** emergent, small, ovoid, smooth. **Operculum** conical, beak short, straight. **Peristome** teeth entire.

Comments. – As no material other than type specimens of *G. nepalensis* (**Fig. 17.1-8**) and *G. inflectens* (**Fig. 17.9-11**) (parts of the same collection number) are available, the above description is based on MITTEN’s original descriptions (1859), and some leaves removed from the type specimens. Because of the scanty information the species is excluded from the identification key.

On the sheet of the type specimen housed in NY is noted “loaned to Dr. G. Roth for drawing for the Aussereuropäischen Laubmoose”. A drawing shows a cygneous seta, probably

Fig. 18. – *Grimmia orbicularis* Wilson: **1**, perichaetial leaf; **2**, perigonial leaf; **3**, transverse section of stem; **4-5**, leaves; **6**, outlines of transverse sections of leaf; **7-8**, cells in leaf bases; **9**, lamina cells in mid-leaf; **10**, cells in upper part of lamina; **11-12**, transverse sections of leaves; **13**, exothelial cells; **14**, stoma; **15**, operculum; **16**, cells at margin of operculum; **17**, peristome, outer side; **18**, longitudinal section of peristome tooth.

[**1-4, 6-7, 9, 12**, Maier 6705; **5, 8, 10-11**, Thomson 287; **13-18**, Maier G0034]



in a wet state. It seems to be a general phenomenon that curved setae become erect and twisted when dry.

The synonymy of *G. inflectens* with *G. nepalensis* has been established by CAO & CHURCHILL (1995).

The type specimen is labelled as follows: (THIERS, 1992): *Grimmia nepalensis* Mitt. Nepal, 14.500 ft, [J. D. Hooker] 248 [in part] [holotype: NY]. *Grimmia inflectens* Mitt. Nepal, 14.500 ft, [J. D. Hooker] 248 [in part] [holotype: NY; isotype: BM].

Provenance. – Nepal. 14.500 ft.

18. *Grimmia orbicularis* Wilson, Engl. Bot. Suppl. 4: tab. 2888. 1844.

Gametophyte. *Monoicous.* **Female:** innermost perichaetial leaf (Fig. 18.1) 1,8-2 mm, sheathing up to 1/2 or 2/3 of leaf length, concave, sheathing part transparent, costa stout in upper part, excurring to broad, nearly smooth hair-point; **male:** perigonia in branches far below perichaetium as multifoliate buds on short stalks, the concave, hyaline lower part of innermost perigonial leaf (Fig. 18.2) sheathing, suddenly narrowing to acute apical part, costa vanishing below apex, paraphysia. **Growth form:** cushion dense, compact, strongly attached to substratum, stolons originating from mostly present tomentum, leaflets scale-like, appressed to stem, apices patent, plants erect, branched, stem up to 30 mm, central strand (Fig. 18.3) developed. **Leaves** (Fig. 18.4) 1-1,5 mm, crowded, appressed to stem when dry, bending backwards when moistened, erectopatent when wet, from ovate leaf base lanceolate or elongate-lanceolate, broadest at mid-leaf, tapering to obtuse apex, hair-point very short (Fig. 18.5) or elongated, nearly smooth; *leaf form in situ:* (Fig. 18.6) leaf base concave, laminal part keeled, margins on both sides from below to above mid-leaf recurved, rarely so on one side only; basal paracostal cells (Fig. 18.7, 18.8) elongate-rectangular, walls nodulose, at margin some cell rows rectangular to quadrate, transverse walls thickened, smooth, above leaf base (Fig. 18.9) cells short-rectangular, sinuose, in upper part (Fig. 18.10) isodiametric, lumen rounded; leaf base and lamina unistratose throughout, margin unistratose except occasionally one bistratose cell row on one side near apex. **Costa**, seen on dorsal side, narrowed at leaf base, gradually enlarging up to laminal part, excurring to hair-point, seen in transverse section (Fig. 18.11, 18.12), costa on dorsal side rounded, on ventral side in basal part widely channelled, in laminal part channelled, at insertion and leaf base four guide cells, in laminal part two guide cells, a median group of hydroids, vanishing below apical part.

Sporophyte. *Seta* up to 2-3 mm, arcuate, vaginula 0,8 mm, with ochrea. **Capsule** exserted, pendulous, ovoid, finely ribbed, exothecial cells (Fig. 18.13) elongated, thin-walled, stomata (Fig. 18.14) large at base of capsule, annulus of two or three rows of cells, detaching easily as groups or singly. **Calyptra** cucullate (LIMPRICHT, 1888-1889). **Operculum** (Fig. 18.15) conical, mammillate, margin (Fig. 18.16) smooth, a marginal row of nearly isodiametric cells, in conical part cells irregular, walls thin. **Peristome** (Fig. 18.17) inserted at orifice, teeth erect, spreading when dry, broadly lanceolate, in upper half slit to two to four branches, in places interconnected by anastomosis, trabeculae small, seen in longitudinal section (Fig. 18.18) two or three cell rows between exothecium and teeth, their outer layer thicker than inner one, both sides densely covered with fine papillae, trabeculae distant, in lower third sharply protruding.

Spores 10-13 μm , smooth.

Diagnostic characters. – **Gametophyte:** leaf broadest at mid-leaf; margins recurved on both sides at mid-leaf, unistratose except at apex. **Sporophyte:** seta curved; operculum conical, mammillate.

Comments. – Leaves of plants growing in exposed places, or buried in decaying substratum may lack hair-point development (named as *G. orbicularis* var. *persica* Schiffn.); they show strongly nodulose cell walls at the leaf base, and joint thickenings of lamina cells. Under harsh growing conditions hydroids may be partly transformed to stereids.

The specimen *Dixon M. 58* (BM) is labelled: “*Grimmia coscinodontoides* Dix. & Herz. sp. nov.” [*nomen nudum*].

Provenance. – Afghanistan, Pakistan, Tibet.

Habitat. – 2000 m. No further information on labels.

Specimens examined. – **Twenty-three**, eight of them from the study-area. The selected ones are: **AFGHANISTAN**. “Pur-i-dhurrah”, Herbarium Mitten, *Griffith* 67 (E, NY). **PAKISTAN**. **West-Chitral**. “Burnboret-Tal, Deutsch Hindukusch Exped.”, 2.X.35, *Dixon M. 58* (BM). **TIBET**. “Rondu, 6.000 ped.”, Herb. Ind. Or. Hook. fil. & Thomson, *Thomson* 287 (BM).

Specimens selected for the description. – **SWITZERLAND**. **Canton of Geneva**: “Confignon 430 m, limestone, sunny”, 27.III.1997, *Maier G0034* (G). **Canton of Vaud**: “Epesses 470 m, concrete wall, shady”, 8.IV.1992, *Maier 6705* (G).

19. *Grimmia ovalis* (Hedw.) Lindb. in *Acta Soc. Sci. Fenn.* 10: 75. 1871.

≡ *Dicranum ovale* Hedw., *Sp. Musc. Frond.*: 140. 1801.

Gametophyte. Dioicous. Female: innermost perichaetial leaf (Fig. 19.1) up to 4,2 mm, sheathing up to broadest part of leaf, at margin some cell rows hyaline, vanishing in broadest part, costa stout, indistinct in apical part, hair-point elongated, denticulate; **male:** perigonia as multifoliate buds on short stalks, terminal and in leaf axils, innermost perigonial leaf (Fig. 19.2) 1 mm, sheathing, concave, broad-ovate, tapering to acute apex, hyaline up to upper third, costa vanishing below apex, paraphysia. **Growth form:** cushion lax, mostly young shoots present, originating from rhizoids, leaflets scale-like, apex muticous, acute, plants decumbent or erect, branched, stem (Fig. 19.3) up to 40 mm, central strand (Fig. 19.4) developed. **Leaves** minute in lower part of stem with muticous, acute apices, becoming gradually longer (Fig. 19.5), up to 3,5 mm, with some hyaline cells in lower leaves, with elongated, denticulate hair-point at upper leaves, sheathing part appressed to stem, laminal part loosely or slightly flexuose disposed when dry, bending backwards when moistened, erectopatent when wet, from ovate or elongated sheathing base narrowed to lanceolate laminal part, thus forming rounded shoulder, tapering to rounded apex, hair-point short to elongated, denticulate; *leaf form in situ*: (Fig. 19.7) leaf base widely concave, in mid-leaf concave, at apex tubulose, margin plane, slightly inflexed at least in upper third of leaf; basal paracostal cells (Fig. 19.8) elongate-rectangular, walls nodulose, towards margin several rows of elongate-rectangular, rectangular, or quadrate cells, walls smooth, thickened, at margin some rows of hyaline cells, vanishing in broadest part of leaf, in transitional part rectangular cells, walls sinuose, towards margin isodiametric, lumen rounded, walls smooth, in laminal (Fig. 19.9) and apical part (Fig. 19.10) cells rounded; leaf base unistratose, lamina in transitional part bistratose in places, laminal part bistratose, margin at insertion, leaf base and transitional part unistratose, bistratose in upper part of leaf. **Costa**, seen on dorsal side, broadest at insertion and leaf base, from above broadest part of leaf up to apex indistinct, dorsal costal cells identical with lamina cells, seen in transverse section (Fig. 19.11), costa on dorsal side convex at lower half of leaf, rounded in upper half, in apical part indistinct, on ventral side at insertion and leaf base slightly concave, in laminal part widely channelled, at apex channelled, at insertion six to eight, sometimes eleven, ventral cells, in leaf base five or six guide cells, in laminal part four, in apical part two guide cells, a median group of hydroids at least at insertion and leaf base.

Sporophyte. Seta (Fig. 19.3) 3-5 mm, straight, enlarged to short neck, vaginula 1 mm, with ochrea. **Capsule** exserted, erect or slightly inclined, obloid, pachydermous, smooth, exothelial cells (Fig. 19.12) elongated penta- and hexagonal, thick-walled, stomata (Fig. 19.13) at short neck, annulus of three or four rows of cells detaching singly. **Calyptra** (Fig. 19.14) cucullate, covering upper half of capsule. **Operculum** (Fig. 19.15) conical, beak long, oblique, margin (Fig. 19.16) smooth, some marginal rows of rounded cells, in conical part cells oval, thick-walled. **Peristome** (Fig. 19.17) inserted below orifice, teeth erect-spreading when dry, broad at base, lanceolate, in upper half perforate or slit to two or three branches, trabeculae neared, small to broad throughout; seen in longitudinal section (Fig. 19.18, 19.20) two or three rows of cells

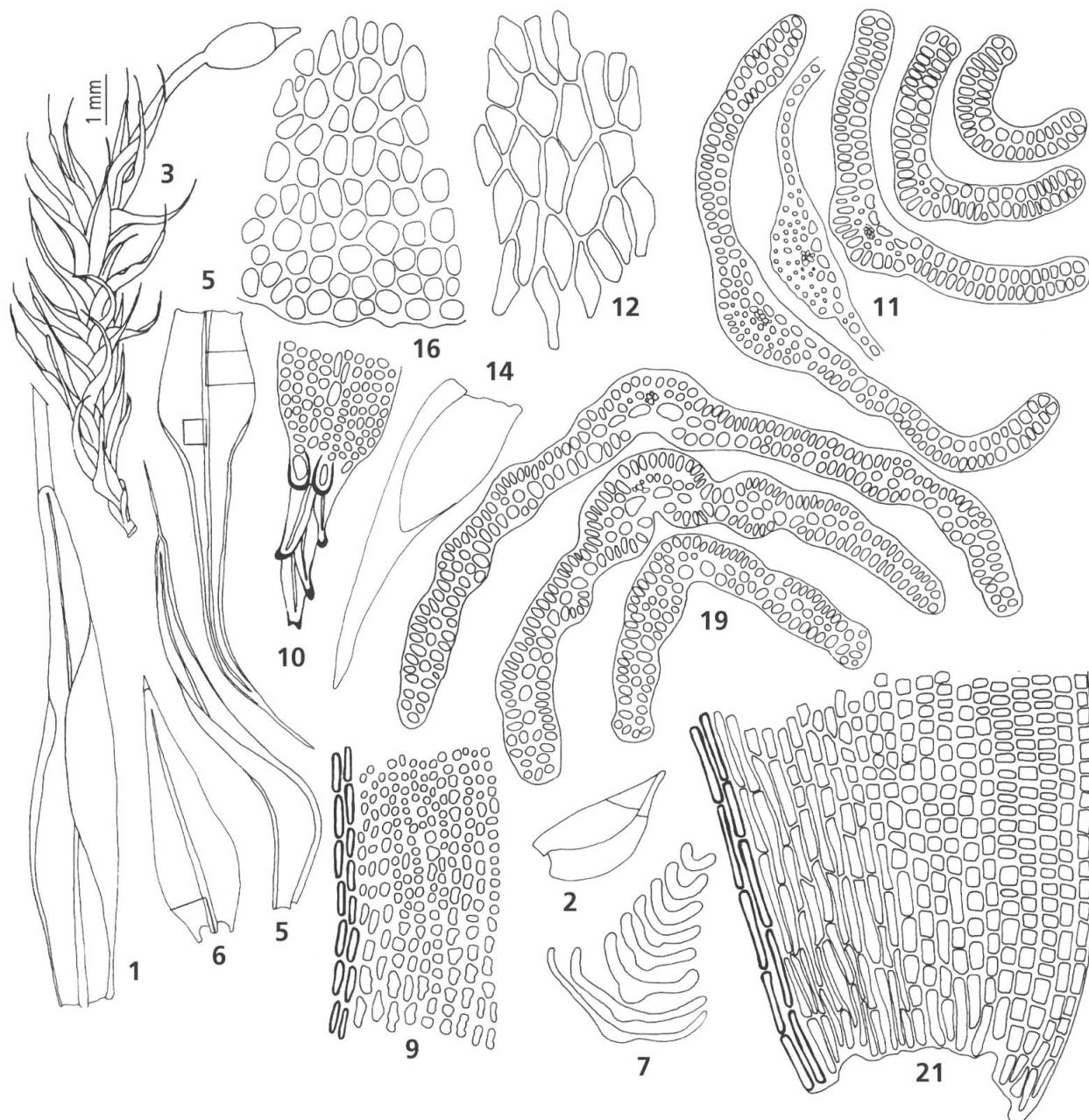
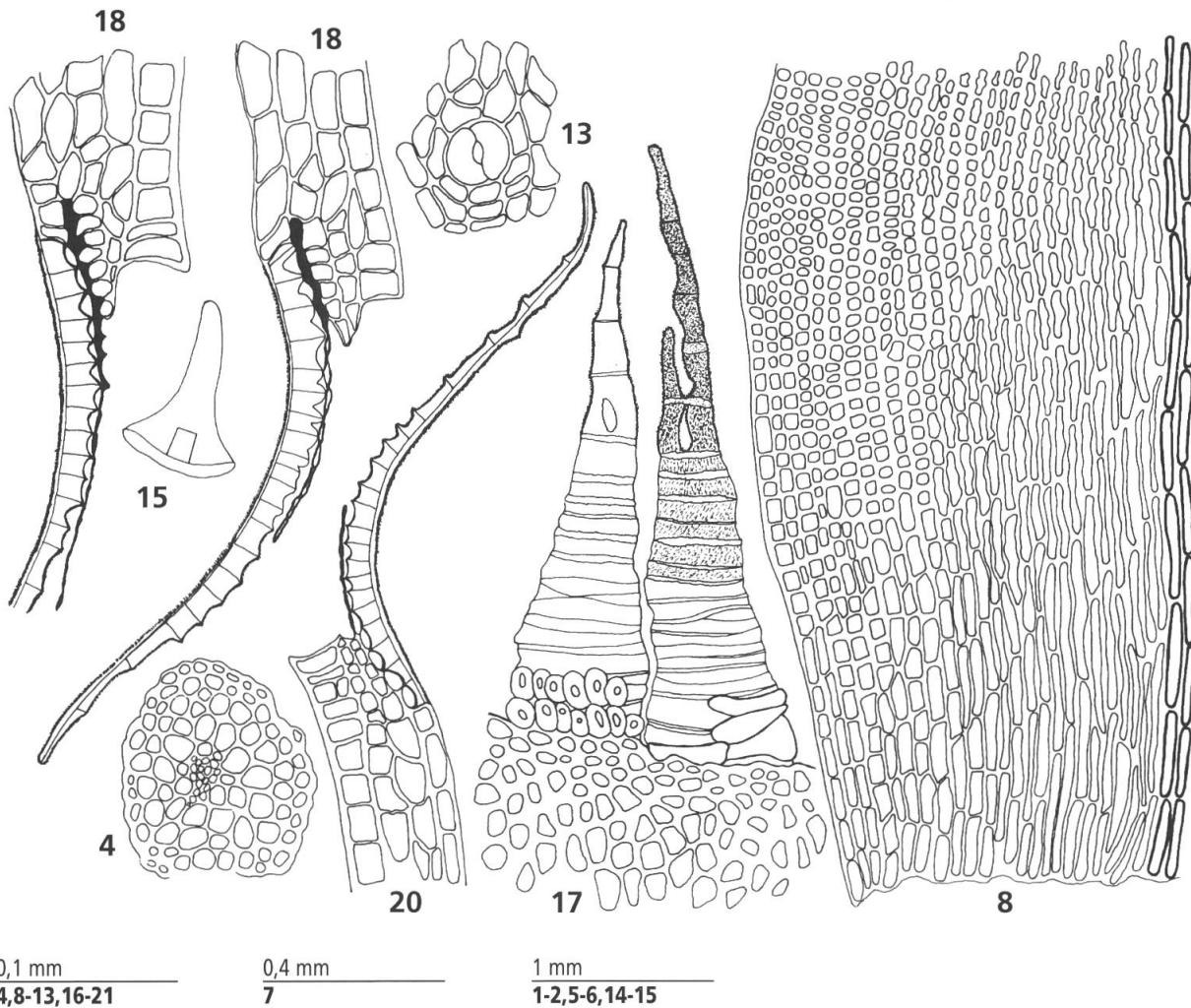


Fig. 19. – *Grimmia ovalis* (Hedw.) Lindb.: 1, perichaetial leaf; 2, perigonal leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaves; 6, leaf; 7, outlines of transverse sections of leaf; 8, cells in leaf base; 9, lamina cells in mid-leaf; 10, cells at apex, hair-point short; 11, transverse sections of leaf; 12, exothelial cells; 13, stoma; 14, calyptra; 15, operculum; 16, cells at margin of operculum; 17, peristome, outer side; 18, longitudinal sections of peristome teeth; 19, transverse sections of leaf; 20, longitudinal section of peristome tooth; 21, cells in leaf base.

[1, 3, 14-16, Maier 7920; 2, Maier 9271; 4-5, 7-9, 11, Thomson 319; 6, 10, 19, Long 16807; 12-13, Maier 10372; 17-18, Maier 8008; 20, Maier 10373; 21, Long 26550]



between exothecium and teeth, their outer layer much thicker than inner one, inner side and upper half of outer side densely covered with fine papillae, lower outer part smooth, trabeculae neared, protruding, prostome of different development (Fig. 19.18, 19.20).

Spores 9-11 μm , smooth.

Diagnostic characters. – **Gametophyte:** leaflets of young shoots muticous; leaf margin plane throughout, bistratose at least above transitional part; costa indistinct above broadest part of leaf, with one group of hydroids at least at insertion and leaf base. **Sporophyte:** peristome with prostome of different development.

Comments. – The leaf shape is variable, in well-developed plants leaves (Fig. 19.5) have a shoulder, formed by the narrowed lanceolate part above the leaf base. Leaves from plants from high altitudes are shortened (Fig. 19.6), with the shoulder less developed.

Hair-point length is variable, from very short (Fig. 19.10) to elongated; plants with muticous leaves may also be found.

The leaf stratosity varies from a bi- to quadristratose lamina. The costa ventrally may be overlaid by supplementary cells on both sides or on only one side of leaf axis, thus covering the guide cells (Fig. 19.19). This modification is not always present in all plants of a specimen. Plants from high altitudes seem to be more affected by this phenomenon, the causes of which are

unknown. Capsule-bearing plants collected in the Swiss Alps at 1315 m and showing the same modification, were used to compare peristome characters (Fig. 19.20): these are identical with those seen in specimens corresponding to the type. Plants collected at high altitudes show short-rectangular, quadrate, and transversely rectangular thick-walled cells at the leaf base towards the margin. This transition to shorter cells (Fig. 19.21) seems to be a general response to harsh growing conditions. See also comments under *G. fuscolutea*, *G. elatior*, and *G. longirostris*. On the erroneous description of *G. ovalis* in CAO & VITT (1986) see comments under *G. khasiana*.

Provenance. – India (Mid- and NW-Himalaya), Kashmir, Nepal, Pakistan, Punjab, Sikkim, Tibet.

Habitat. – On dry acid rocks, boulders, at altitudes between 1500 and 4500 m.

Specimens examined. – **One hundred and thirty-two**, sixty-three of them from the study-area. The selected ones are: **KASHMIR**. “Regio temp., 8,000 pd.”, Herb. Ind. Or. Hook. fil. & Thomson, *Thomson* 319 (BM, NY). **NEPAL**. “Kambachen to Ramtang, upper Ghunsa Khola, 27°44'N, 88°00'E; open rocky valley; on boulder, c. 4120 m”, 10.IX.1989, *Long* 16807 (E, G). **PAKISTAN. Baltistan**: “Rupal valley, Tarishing S, Chhichi gol (valley), *Pinus wallichiana* und *Picea smithiana* Bestände, Alm, Glimmerschiefer, 2980 bis 3200 m”, 8.VII.1999, *Gruber* 2097 (Herb. Gruber); “Deosai National Park, Canyon of Sadpara Stream on road between Deosai Top and Skardu. Lat 35°07'N Long 75°36'E, 3000 m; cliffs along river, with granite and schist outcrops”, 30.VII.1998, *Hedderson* 12414 (BOL). **PUNJAB. N.W.I. Province**: “Abbottabad, 4-4500 ft”, 1.IV.1934, *Stewart* 13725 (BM). **Kulu Distr.**: “Manali, 6 500', common on exposed boulder faces”, 25.V.1952, *Schelpe* 3181 (BM). **SIKKIM. North District**: “Lasha Chhu valley, below Phaklung, 27°52'22"N, 88°35'08"E; flat marshy valley floor; on boulder by ox-bow lake, c. 4440 m”, 19.VII.1996, *Long* 26550 (E). **TIBET**. “Rondu, Regio temp., alt. 6000 pd.”, Herb. Ind. Or. Hook. fil. & Thomson, *Thomson* 317 (BM).

Specimens selected for the description. – **SWITZERLAND. Canton of Ticino**: “Someo 370 m, siliceous boulder, sunny”, 26.III.1993, *Maier* 7920 (G). **Canton of Valais**: “Bovernier, sur les Frêtes, 1100 m, siliceous boulders, mixed forest, clearing”, 16.V.1994, *Maier* 9271 (G); “Finhaut 1320 m, siliceous rocks, sunny”, 24.V.1993, *Maier* 8008 (G); “Finhaut 1315 m, siliceous boulders”, 27.IV.1999, *Maier* 10373 (G); “Fully 740 m, siliceous boulder, mixed forest”, 15.V.1996, *Maier* 10372 (G).

20. *Grimmia percarinata* (Dixon & Sakurai) Deguchi in J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 16: 198. 1979.

≡ *Didymodon percarinatus* Dixon & Sakurai in Bot. Mag. (Tokyo) 50: 516. 1936.

Gametophyte. Supposedly dioicous. **Female**: perichaetal leaves markedly longer than stem leaves, innermost (Fig. 20.1) up to 2,5-2,8 mm, sheathing up to broadest part of leaf, from elongated leaf base suddenly narrowing to lanceolate upper part, at margin two or three cell rows hyaline, vanishing in broadest part of leaf, cell pattern as in stem leaves, costa excurring to short or elongated denticulate hair-point; **male**: perigonia not seen. **Growth form**: cushion dense, compact, of decomposed stems originating numerous young shoots, leaflets lanceolate, appressed to stem, costa stout, reaching apex, plants erect, of more or less marked zonate appearance, often with tomentum, branched, stem (Fig. 20.2) up to 25 mm, central strand (Fig. 20.3) developed. **Leaves (Fig. 20.4)** 1,6-2,0 mm, crowded, slightly contorted, loosely disposed on stem when dry, scarcely moving when moistened, stiff, erect or erectopatent when wet; from elongate-ovate leaf base lanceolate, tapering to acute apex, hair-point short (Fig. 20.5), denticulate; *leaf form in situ*: (Fig. 20.6) leaf base concave, laminal part keeled, margin on one side from insertion up to mid-leaf slightly recurved; basal paracostal cells (Fig. 20.7) elongate-rectangular, towards margin shorter, at margin rectangular, two or three rows hyaline, vanishing in broadest part of leaf, cells smooth, lower lamina cells (Fig. 20.8) rectangular, walls sinuose, near margin isodiametric, walls smooth, apical cells (Fig. 20.5) rounded, thick-walled; leaf base unistratose, lamina irregularly bistratose by doubled longitudinal cell rows (Fig. 20.9), appearing on surface view as irregular ridges on lamina, exterior walls of lamina cells markedly mammillose, margin unistratose at leaf base, two- to quadristratose in laminal part. **Costa**, seen on dorsal side, small at leaf base, enlarged in laminal part, excurrent, seen in transverse section (Fig. 20.10, 20.14), on dorsal side prominent, rounded, mammillose, on ventral side channelled at insertion and leaf base, in laminal part narrowly channelled, at insertion four guide cells, reduced to two at apex, costa cells homogeneous except some substereids at leaf base, with or without hydroids.

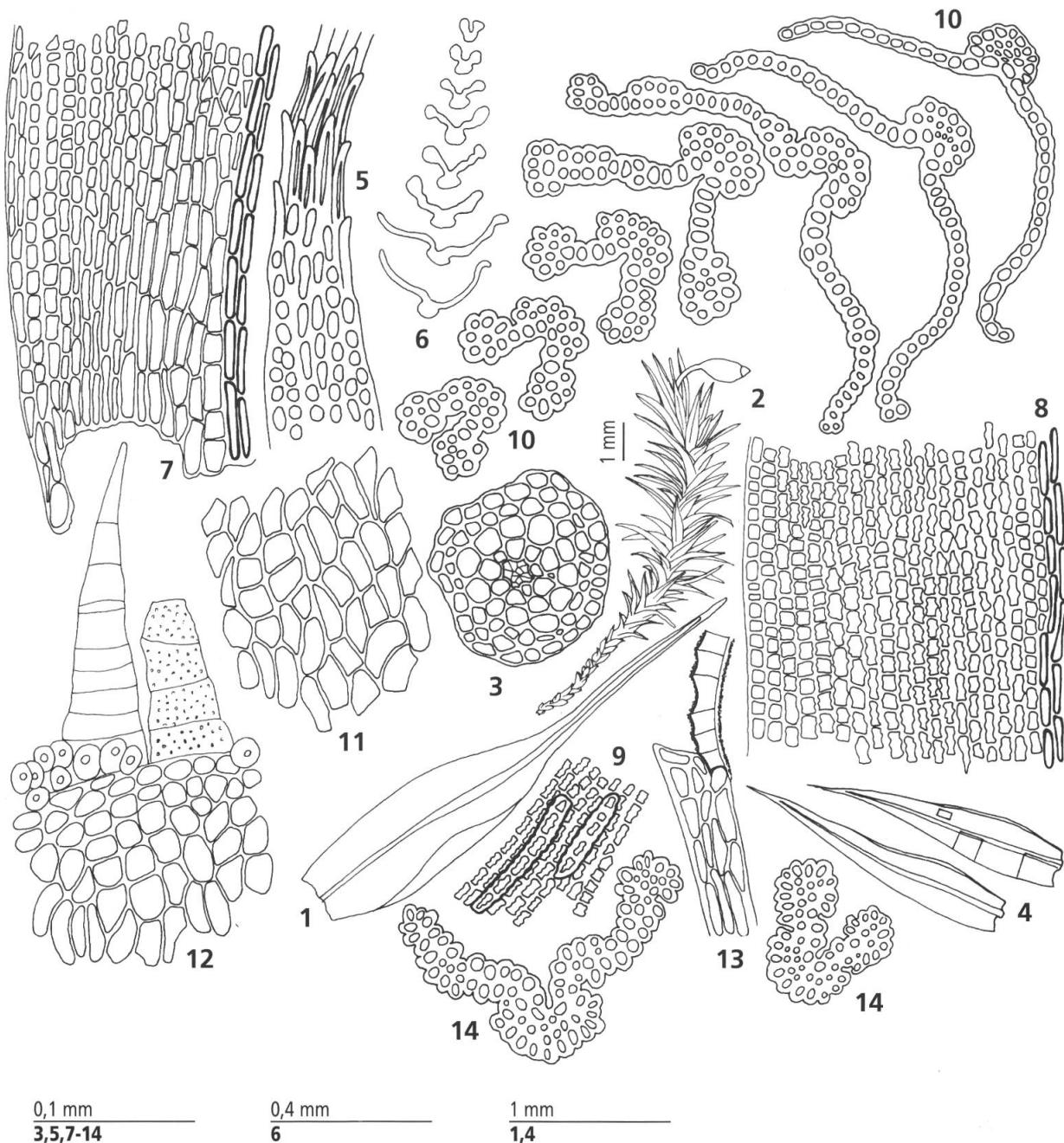


Fig. 20. – *Grimmia percarinata* (Dixon & Sakurai) Deguchi: 1, perichaetal leaf; 2, plant with sporophyte; 3, transverse section of stem; 4, leaves; 5, cells at apex, hair-point; 6, outlines of transverse sections of leaf; 7, cells in leaf base; 8, lower lamina cells; 9, lamina cells with applied cell rows; 10, transverse sections of leaf; 11, exothecial cells; 12, peristome, outer side; 13, longitudinal section of lower part of peristome tooth; 14, transverse sections of leaf.

[1-2, 11-13, Polunin M146; 3-10, Long 10896; 14, Hooker 285]

Sporophyte. *Seta* (Fig. 20.2) up to 2,5 mm, straight when dry, slightly arcuate when wet. **Capsule** exserted, horizontal, ovoid, exothelial cells (Fig. 20.11) irregular, walls thickened, stomata numerous at short neck, annulus of two or three rows of cells, detaching singly. *Calyptra* probably cucullate (immature state). **Operculum** conical, blunt. **Peristome** (Fig. 20.12) inserted just below orifice, teeth lanceolate, trabeculae thin, seen in longitudinal section (Fig. 20.13) one cell row between exothecium and teeth, their outer layer thicker than inner one, both sides papillose, trabeculae in lower part distant, slightly protruding.

Spores 12-16 μm , granulose.

Diagnostic characters. – **Gametophyte:** lamina with bistratose cell rows, appearing on surface view as ridges; lamina cells mammillose; costa without hydroids.

Comment. – As no mature material was available, drawings of sporophyte characters are based on an incompletely mature capsule, therefore the description should be used with caution. Papillosity on the dorsal side of the teeth seems to be imperfectly developed, perhaps also for the trabeculae.

Provenance. – Bhutan, Nepal, Sikkim.

Habitat. – On boulders in shady and damp places, at altitudes between 3200 and 4800 m.

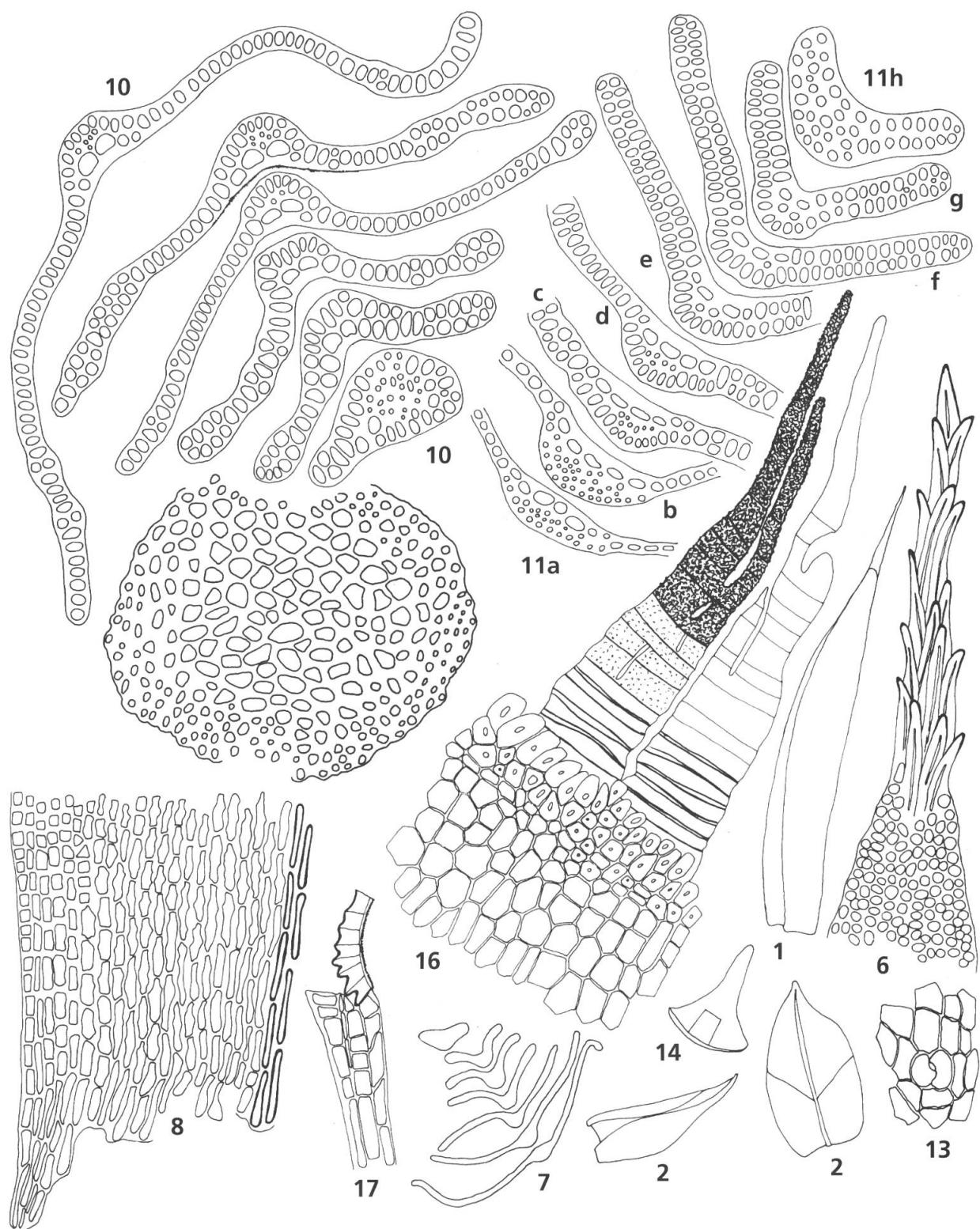
Specimens examined. – **Twenty-four**, thirteen of them from the study-area. The selected ones are: **BHUTAN.** **Thimphu district:** “Above Pajoding monasteries, Thimphu, 27°29' 89°34', rocky scree with dwarf Juniper/Rhododendron; on soil on boulder, c. 3900 m”, 16.IV.1982, *Long* 10896 (E, G). **NEPAL.** “Chilime Khola, from damp rocks, c. 14,500 ft.”, 1949, *Polunin M146* (BM). **Sankhuwasabha District:** “Pemathang Kharka, S side of Barun Khola, 27°44'N, 87°12'E, bouldery river bank, on boulder, c. 3400 m”, 28.IX.1991, *Long* 20720 (E, G). **SIKKIM.** “Lachen, Sikkim Himalaya, Regio temp., 10,000 pd.”, Herb. Ind. Or. Hook. fil. & Thomson, *Hooker* 285 (BM, NY). **West District:** “Bikbari, Choktseling Chhu valley, 27°30'53"N, 88°08'28"E, valley floor with scrub; on side of large boulder, c. 3910 m”, 12.VII.1992, *Long* 22545 (E, G). **North District:** “Tembawa Chhu valley, E of Yume Samdong, 27°54'N, 88°44'E, bouldery hollow in side valley; on boulders, 4765 m”, 24.VII.1996, *Long* 26623 (E).

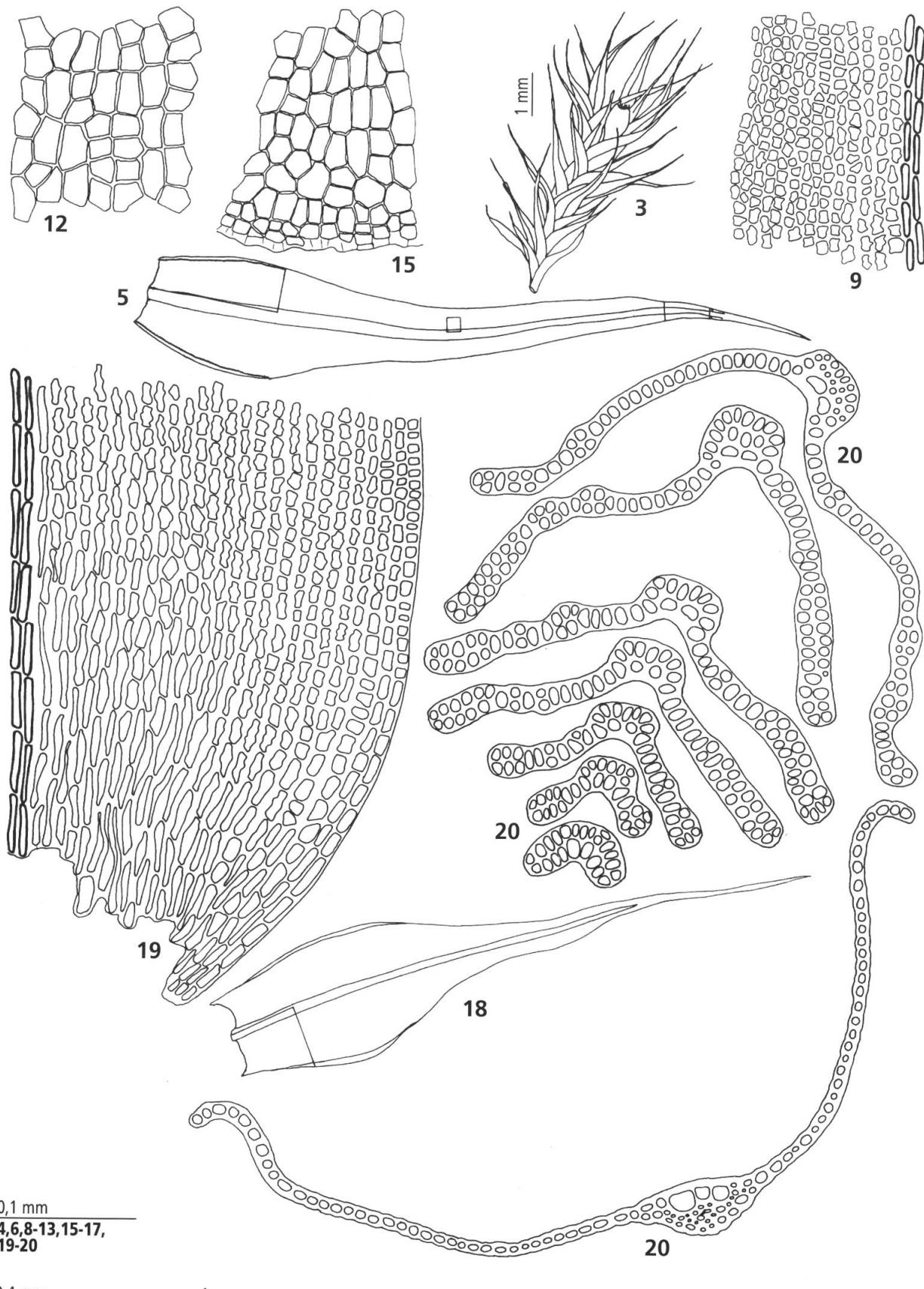
21. *Grimmia pilifera* P. Beauv., Prodr. Aethéogam.: 58. 1805.

Gametophyte. *Dioicous. Female:* innermost perichaetial leaf (Fig. 21.1) up to 3 mm, slightly sheathing up to narrowed apical part, at margin from insertion up to mid-leaf some rows of hyaline cells, costa excurring to stout, long, denticulate hair-point; *male:* perigonia as multifoliate buds on short stalks, terminal and in leaf axils, innermost perigonial leaf (Fig. 21.2) 1,2 mm, sheathing up to broadest part of leaf, concave, broad-ovate, tapering to muticous apex, hyaline in lower part, costa percurrent, paraphysia few. *Growth form:* cushion lax, disintegrating easily, plants erect or ascending, branched, stem (Fig. 21.3) up to 40 mm, epidermis and inner tissue reddish-brown, central strand (Fig. 21.4) not or only faintly developed. *Leaves* (Fig. 21.5) up to 4 mm, small in lower part of stem, becoming gradually longer, sheathing part appressed to stem, laminal part loosely disposed, scarcely contorted when dry, rapidly bending backwards when moistened, spreading to patent when wet, from broad, ovate leaf base narrowed to lanceolate laminal part, thus forming more or less strongly expressed shoulder, tapering to rounded apex, hair-point (Fig. 21.6) short to elongated, occasionally brownish, sharply denticulate; *leaf form in situ:* (Fig. 21.7) at insertion and leaf base slightly concave or concave, in laminal part widely keeled or keeled, mostly narrowly so in apical part, margin from leaf base up to broadest part of leaf on both sides recurved, occasionally one side only slightly so; basal cells (Fig. 21.8) elongate-rectangular, walls thickened, nodulose, near margin at extreme base some cell rows rectangular, becoming quadrate up to broadest part of leaf, walls thickened, smooth, cells in transi-

Fig. 21. – *Grimmia pilifera* P. Beauv.: 1, perichaetial leaf; 2, perigonial leaves; 3, plant with sporophyte; 4, transverse section of stem; 5, leaf; 6, cells at apex, hair-point; 7, outlines of transverse sections of leaf; 8, cells in leaf base; 9, cells in upper part of lamina; 10, transverse sections of leaf; 11, transverse sections of leaf, a, in leaf base, b, in broadest part of leaf, c, above broadest part of leaf, d-e, in half of leaf length, f, in upper part of leaf, g-h, in apical part; 12, exothelial cells; 13, stoma; 14, operculum; 15, cells at margin of operculum; 16, peristome, outer side; 17, longitudinal section of lower part of peristome tooth; 18, leaf; 19, cells in leaf base; 20, transverse sections of leaf.

[1, 3, 12-17, Sullivant Icon.; 2, s.coll. 1186, 5355a, ALTA; 4-10, Grierson & Long 92; 11, Handel-Mazzetti 180; 18-20, Austin 143]





0,1 mm
4,6,8-13,15-17,
19-20

0,4 mm
7

1 mm
1-2,5,14,18

tional and lower part of lamina rectangular, strongly sinuose, in upper part (Fig. 21.9) short-rectangular, walls sinuose, at apex (Fig. 21.6) isodiametric, lumen rounded; leaf base unistratose, lamina bistratose in places or completely bistratose, margin in leaf base unistratose, in laminal part in two or more cell rows bistratose, occasionally even tri- to quadristratose. *Costa*, seen on dorsal side, stout, of uniform width, excurrent, seen in transverse section (Fig. 21.10, 21.11), costa on dorsal side in leaf base and lower part of lamina rounded, in upper laminal part angulate, on ventral side channelled, at insertion widely so, at insertion six, rarely eight ventral cells, mostly guide cells, in leaf base five to six guide cells, in broadest part of leaf four, in lower half of lamina four to two, in upper laminal part up to apex two guide cells, at insertion and leaf base a more or less broad band of stereids or substereids, reduced to a median group of substereids above broadest part of leaf, apex occasionally subulate, then cells uniform, no hydroids.

Sporophyte. *Seta* 0.5 mm, straight. *Capsule* immersed, erect, ovoid, smooth, exothelial cells (Fig. 21.12) irregular, walls thin, straight, stomata (Fig. 21.13) at base of capsule, numerous, annulus of two or three rows of cells, detaching as groups. *Calyptra* mitrate (DEGUCHI, 1979). *Oberculum* (Fig. 21.14) rostrate, margin (Fig. 21.15) uneven, two marginal rows of small, isodiametric cells, in conical part rectangular, penta- or hexagonal, above elongate-rectangular, thin-walled. *Peristome* (Fig. 21.16) inserted just below orifice, teeth recurved when dry (CRUM & ANDERSON, 1981), broad at insertion, elongate-lanceolate, in upper part slit in two branches, below perforate, trabeculae of four lowest plates small, plates smooth, above trabeculae thin, intermediate plates with scattered papillae, upper half densely covered with confluent papillae; seen in longitudinal section of lowest plates (section over full length unsuccessful) (Fig. 21.17) two rows of cells between exothecium and teeth, their outer layer much thicker than inner one, inner side finely papillose, outer side smooth, trabeculae neared, protruding, less so above.

Spores 13-18 μm , nearly smooth.

Diagnostic characters. – **Gametophyte:** margin at leaf base on both sides recurved, occasionally only weakly so on one side; costa dorsally clearly delimited, without hydroids. **Sporophyte:** seta short, capsule immersed, calyptra mitrate.

Comments. – The stratosity of the margin varies, from bistratose to quadristratose.

As no further capsule bearing plants were available, the description of peristome characters is based on a single capsule; it was not possible to obtain a full longitudinal section.

Recent authors supposed the holotype of *G. pilifera* to be housed in G, but it could not be found there, neither in the general nor in the Delessert herbarium. In “Index Herbariorum” (VEGTER, 1983), besides G, P-JU and GL are cited as holding collections of P. de Beauvois. However, neither in P-JU nor in GL was the search for the type specimen of *G. pilifera* successful.

BRIDEL (1826) synonymised *G. pensylvanica* Schwaegr. with *G. pilifera*. Given this situation, comparison of the specimens examined is based on a specimen of *Grimmia pensylvanica*, designated as lectotype by T. Cao and cited in CAO & VITT (1986). The specimens examined show congruence of leaf shape (Fig. 21.18), cell pattern at the leaf base (Fig. 21.19), and costal architecture (Fig. 21.20).

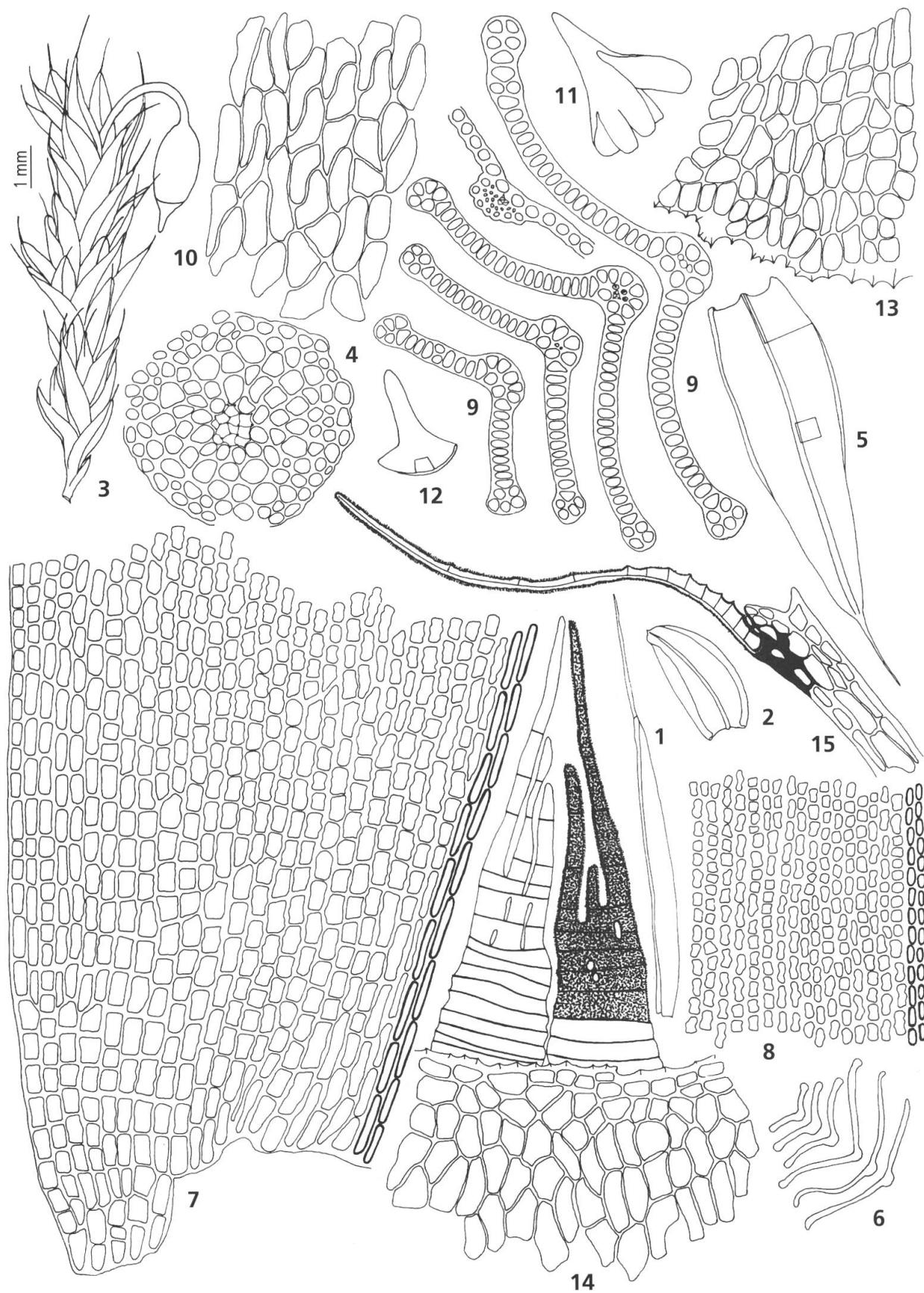
The type specimen is labelled as follows: *Grimmia Pensylvanica*. mihi (i.e. Schwaegr.) [illegible] rupestris v. H. fil. e Pensylvania [lectotype: G].

Provenance. – Bhutan, India.

Habitat. – On rocks and boulders, at 2450 and 4000 m.

Specimens examined. – **Twenty-seven**, three of them from the study-area: **BHUTAN**. “Thimphu, 27°28'N, 89°38'E. Hillside above Thimphu Public School on rock, c. 2450 m”, 8.VI.1975, *Grierson & Long* 92 (E); “Thimphu, Serbithang, open slope with *Pinus wallichiana*, on dry rocks, 2560 m”, 23.IX.1999, *Long* 28756 (E). **INDIA**. “Near source of R. Jammu, c. 12,000 ft.”, X.1868, *Bell* 139 (E).

Specimens selected for the description. – **CHINA**. [Labelled in Chinese] 14.X.1976, 1186, 5355a (ALTA); **Prov. Yünnan**: “Ab urbe Yünnanfu septentr. versus ad viam parvam directam Huili ducentem, in regione calide temperata ad saxa inter Djiaohsi et Dschenmindi ubique, substr. arenaceo, ca. 1700-2400 m”, 18.III.1914, *Handel-Mazzetti* 180 (W, WU). **USA**. “Austin Musci Appal:chiani 143, Sulliv. Icon. Musc. p. 68, t. 43. Hab. A. on dry rocks, common; B. rocks in streams, Northern New Jersey, scarce”, *Austin* 143 (G).



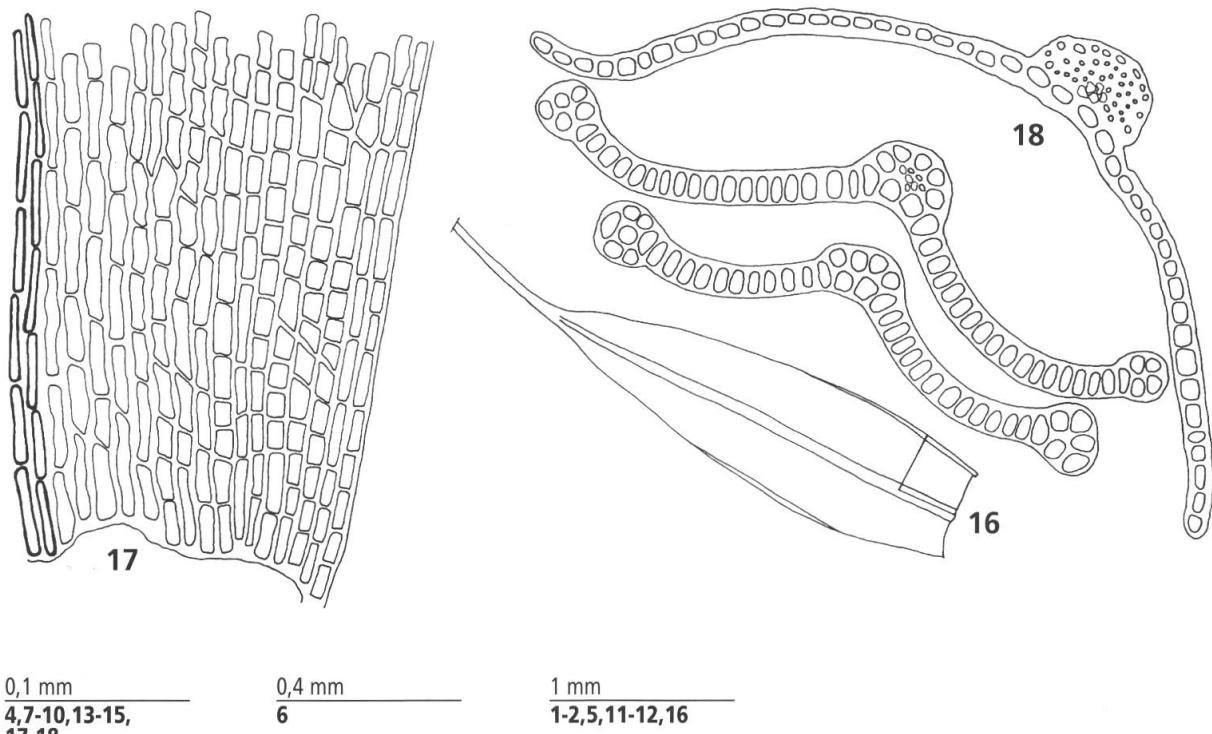


Fig. 22. – *Grimmia pulvinata* (Hedw.) Sm.: 1, perichaetal leaf; 2, perigonial leaf; 3, plant with sporophyte; 4, transverse section of stem; 5, leaf; 6, outlines of transverse sections of leaf; 7, cells in leaf base and above leaf base; 8, lamina cells in mid-leaf; 9, transverse sections of leaf; 10, exothelial cells; 11, calyptra; 12, operculum; 13, cells at margin of operculum; 14, peristome, outer side; 15, longitudinal section of peristome tooth; 16, leaf; 17, cells at leaf base; 18, transverse sections of leaf.

[1-2, 10-15, Maier 6748/1; 3, Maier 5456; 4-9, Duthie s.n.; 16-18, Rogers s.n.]

22. *Grimmia pulvinata* (Hedw.) Sm., Engl. Bot. 24: 1728. 1807.

≡ *Fissidens pulvinatus* Hedw., Sp. Musc. Frond.: 158. 1801.

Gametophyte. Monoicous. Female: innermost perichaetal leaf (Fig. 22.1) 2,2-2,5 mm, sheathing up to apical part, tubulose, costa excurrent to long, denticulate hair-point, hyaline in lower part of leaf; **male:** perigonium as bud of four or five leaves on short stalk in leaf axil on stem of fruiting plant more or less approached to perichaetium, innermost perigonial leaf (Fig. 22.2) 1 mm, sheathing up to apex, concave, ovate, apex acute or mucronate, costa vanishing below apex, hyaline except at apex, paraphysia few. **Growth form:** cushion dense, lax, young shoots originating from detritus, leaflets with hair-point, plants radiculose at base, erect, branched in upper part, stem (Fig. 22.3) up to 15 mm, central strand (Fig. 22.4) developed. **Leaves (Fig. 22.5)** in lower part of stem small, with hair-point, becoming gradually longer, up to 2,5 mm, crowded, loosely disposed on stem, upper part of leaf slightly flexuose when dry, apical part quickly bending backwards when moistened, erectopatent when wet, from short, ovate leaf base broad-lanceolate or lanceolate, apex obtuse, hair-point denticulate; **leaf form in situ:** (Fig. 22.6) leaf base widely concave or concave, laminal part widely keeled, margins recurved, on one side from insertion or leaf base, on other side from above leaf base, on both sides up to above mid-leaf; at leaf base (Fig. 22.7) some paracostal cell rows of slightly elongate-rectangular cells, towards margin rectangular or short-rectangular, at margin some rows of nearly quadrate cells, transverse walls thickened, smooth, in transitional part cells (Fig. 22.7) rectangular, walls sinuose, in laminal part mostly isodiametric (Fig. 22.8), walls somewhat sinuose, thickened, at apex cells isodiametric, lumen rounded; lamina unistratose, occasionally a bistratose cell row, margin at insertion and leaf base unistratose, in laminal part some marginal cell rows bi- or

tristratose. **Costa**, seen on dorsal side, of nearly uniform width, faintly smaller in leaf base, percurrent, seen in transverse section (**Fig. 22.9**), on dorsal side rounded, on ventral side at insertion and leaf base slightly concave, in laminal part above widest part of leaf widely channelled, at insertion and leaf base four guide cells, in laminal part reduced to two, at insertion and leaf base a small band of substereids or stereids and a median group of hydroids, gradually vanishing up to apical part.

Sporophyte. **Seta** (**Fig. 22.3**) up to 4,5 mm, erect, twisted when old and dry, cygneous in immature and mature state when wet, vaginula 0,8 mm. **Capsule** erect when old, in immature and mature state pendent and hidden in cushion, obloid, in mature state with eight to ten ribs, exothelial cells (**Fig. 22.10**) elongated, walls curvilinear, thin, stomata numerous in short apophysis, annulus of three or four cell rows, detaching as spirals. **Calyptra** (**Fig. 22.11**) mitrate, lobed, covering upper part of capsule. **Operculum** (**Fig. 22.12**) rostrate, beak straight, of variable length, margin crenulate, a marginal row (**Fig. 22.13**) of oval cells, upper cells mostly elongated of different shape. **Peristome** (**Fig. 22.14**) inserted at orifice, deeply anchored by strongly thickened walls of capsule wall cells, teeth erect-spreading when dry, broad at base, elongate-lanceolate, in upper half slit to two or three branches, trabeculae thin; seen in longitudinal section (**Fig. 22.15**) one or two cell rows between exothecium and teeth, their outer layer thicker than inner one, inner and outer side densely covered with fine papillae, except some smooth outer plates near insertion, trabeculae neared, slightly protruding.

Spores 8-11 μm , granulose.

Diagnostic characters. – **Gametophyte:** margins recurved, on one side from leaf base, on other side from above leaf base up to above broadest part of leaf, in laminal part some marginal cell rows two- to tristratose; costa with stereids and hydroids. **Sporophyte:** seta cygneous; mature capsule ribbed.

Comments. – The leaf shape is variable; plants with leaves short ovate-lanceolate to elongated ovate-lanceolate can be found, leaves with hair-points longer than leaf, or leaves without hair-point at all may be found; at the leaf base nodulose cell walls may be observed, especially in plants from sunny situations. Similar conditions cause partial or complete transformation of costal hydroids to stereids. Plants in general develop capsules freely.

Provenance. – India NW-Himalaya, Punjab.

Habitat. – At altitudes between 1000 and 1800 m. No further information on labels.

Specimens examined. – **Seventeen**, eight of them from the study-area. The selected ones are: **INDIA. NW Himalaya:** “Jaunsar, Teni, 3000 ft.”, V.1891, Rogers s.n. (BM). **District Tehri-Garhwal:** “Tons Valley 3-4000 ft.”, 5.V.1898, Duthie s.n. (BM). **PUNJAB. Northwestern India:** “Banjar, Kulu, Kangra, 5500 ft.”, 30.XI.1933, Koelz 7544 (ALTA, NY).

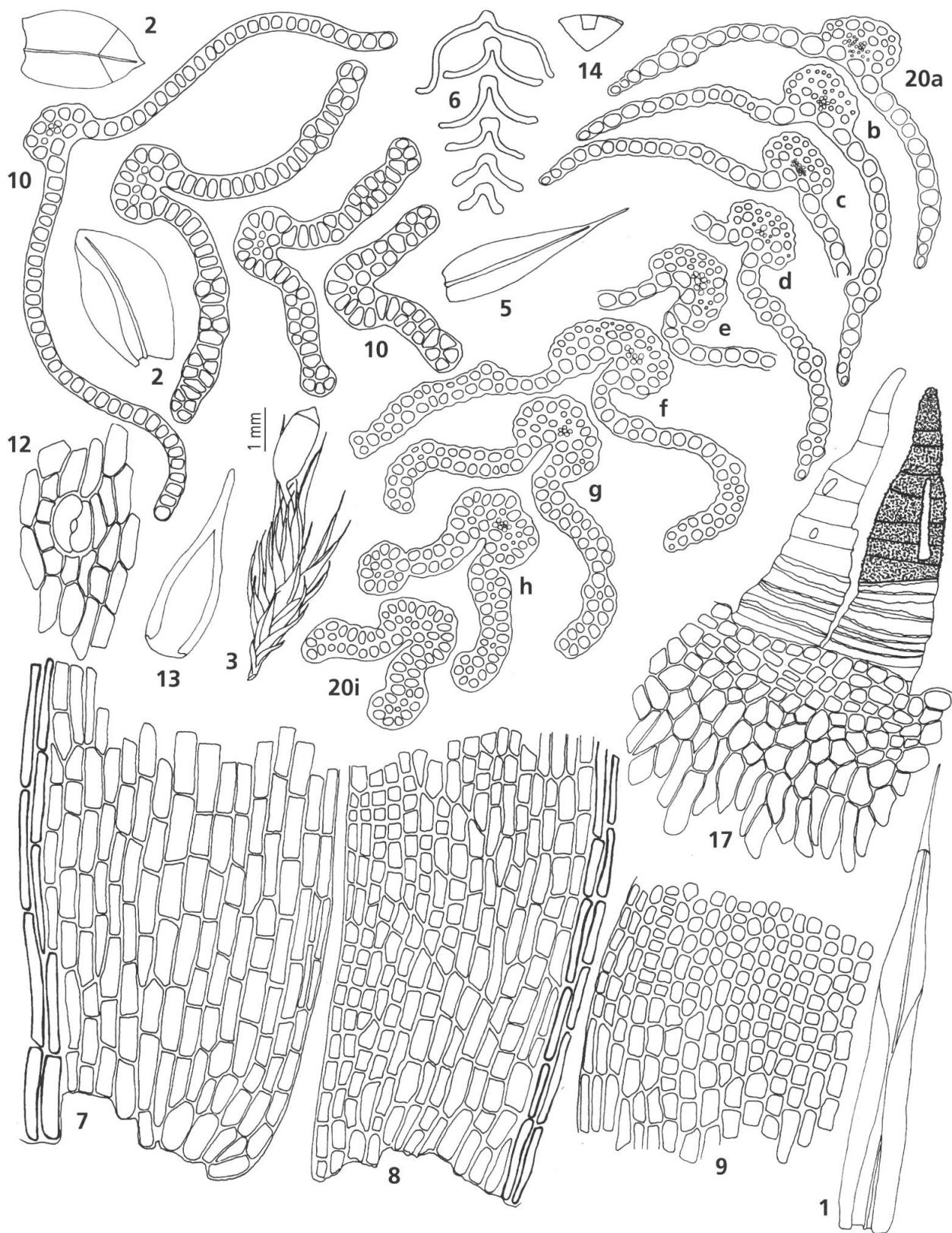
Specimens selected for the description. – **SWITZERLAND. Canton of Valais:** “Sion, Mt. d’Orge 610 m, wall, concrete”, 12.IV.1992, Maier 6748/1 (G). **Canton of Vaud:** “Rivaz, lake shore 375 m, boulders, limestone”, 31.V.1991, Maier 5456 (G).

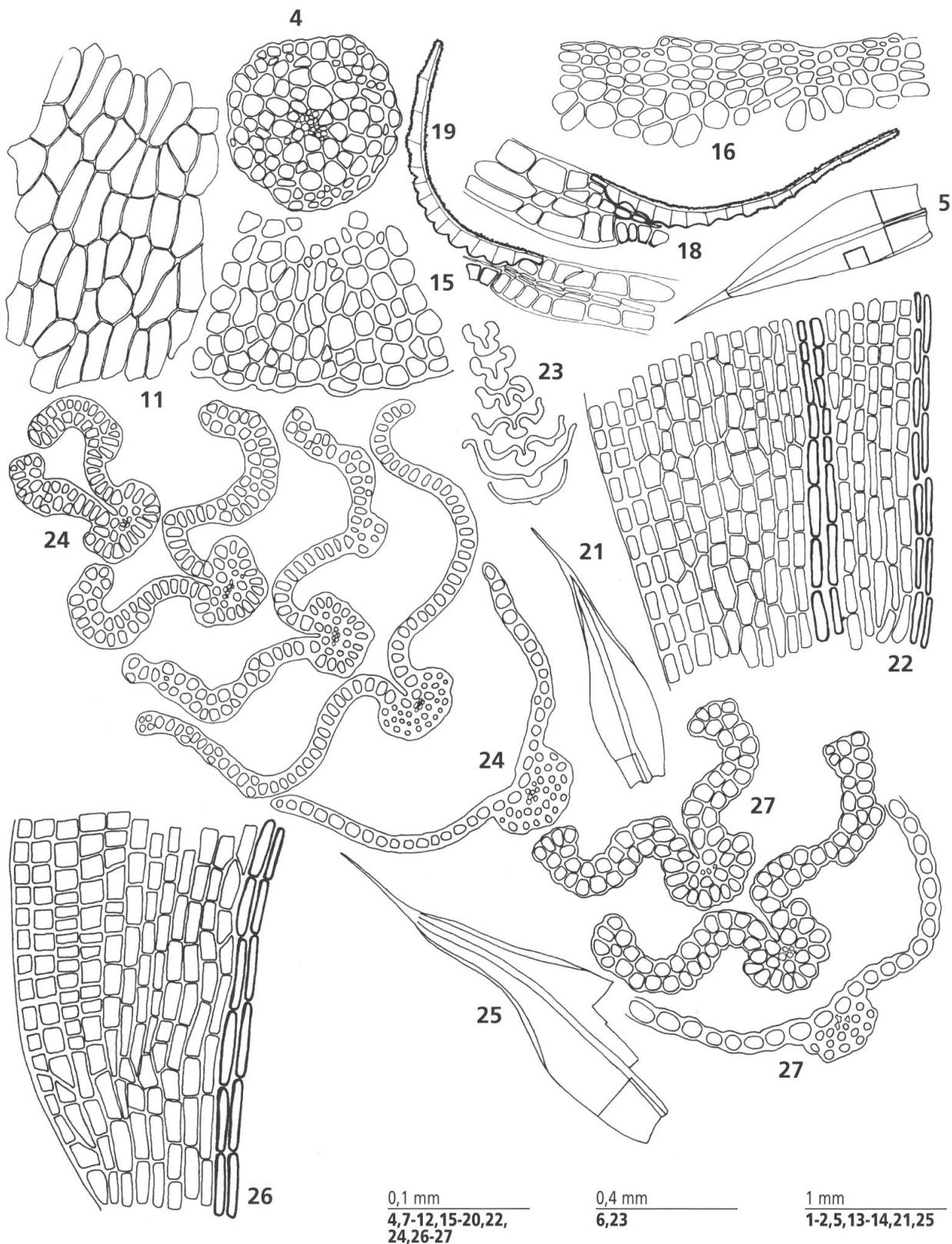
23. *Grimmia sessitana* De Not. in Atti Reale Univ. Genova 1: 704. 1869.

Gametophyte. Monoicous. Female: innermost perichaetial leaf (**Fig. 23.1**) 2,6-2,8 mm, sheathing up to 2/3 of leaf length, concave, hyaline in lower half, costa in upper part of leaf

Fig. 23. – *Grimmia sessitana* De Not.: **1**, perichaetial leaf; **2**, perigonial leaves; **3**, plant with sporophyte; **4**, transverse sections of stem; **5**, leaves; **6**, outlines of transverse sections; **7**, cells in leaf base of upper leaf; **8**, cells in leaf base of lower leaf; **9**, cells above leaf base of upper leaf; **10**, transverse sections of leaf; **11**, exothelial cells; **12**, stoma; **13**, calyptra; **14**, operculum; **15**, cells at margin of operculum; **16**, cells at orifice; **17**, peristome, outer side; **18-19**, longitudinal sections of peristome teeth; **20**, transverse sections of leaf, **a**, at insertion, **b**, in leaf base, **c**, above leaf base, **d**, in broadest part of leaf, **e-g**, in lower part of lamina, **h-i**, in upper part of lamina; **21**, leaf; **22**, cells in leaf base; **23**, outlines of transverse sections of leaf; **24**, transverse sections of leaf; **25**, leaf; **26**, cells in base of an upper leaf of a plant with capsule; **27**, transverse sections of leaf.

[**1, 11-18**, Maier 5751; **2, 19-20**, Maier 2948; **3, 9**, Maier 8323; **4-6, 10**, Schmid 10080; **7-8**, Pilous s.n.; **21-24**, Pöppig s.n.; **25-27**, Lange s.n.]





enlarged, excurring to long, slightly denticulate hair-point; **male**: perigonia as buds on short stalks on branches of female plant, terminal or in leaf axils, several in one plant, innermost perigonial leaf (**Fig. 23.2**) 1 mm, sheathing up to above mid-leaf, concave, ovate, hyaline up to 1/2 or 2/3 of leaf length, costa percurrent, apex blunt or mucronate, paraphysia few. **Growth form**: cushion dense, compact, adherent to substrate by rhizoids, plants erect, radiculose at base, strongly branched, stem (**Fig. 23.3**) up to 20 mm, central strand (**Fig. 23.4**) developed. **Leaves** (**Fig. 23.5**) crowded, in lower part of stem up to 1,2 mm, muticous or hair-point short, leaves becoming gradually longer, 1,8-2,4 mm, loosely disposed on stem, apices flexuose when dry, rapidly bending backwards when moistened, quickly moving to erect or erectopatent position when wet, from nearly rectangular or ovate leaf base lanceolate, tapering to acute apex, hair-point nearly smooth; *leaf form in situ*: (**Fig. 23.6**) at insertion and leaf base concave, narrowly keeled in laminal part, margin recurved on one side from insertion up to broadest part of leaf or plane on both sides; on upper stem leaves basal paracostal cells elongate-rectangular, walls thin, smooth, cells at margin (**Fig. 23.7**) elongate-rectangular, nearly of same length as paracostal cells, transverse walls thickened, on lower stem leaves (**Fig. 23.8**) paracostal cells elongate-rectangular, towards margin some rows short-rectangular or quadrate, transverse walls thickened, smooth, all leaves with some hyaline marginal cell rows, vanishing in broadest part of leaf, above broadest part of leaf (**Fig. 23.9**) cells short rectangular to quadrate, lumen rounded, walls smooth or slightly sinuose, in apical part isodiametric, lumen rounded, walls thickened; leaf base unistratose, laminal part unistratose, bistratose in places or completely bistratose, on surface view seen as striae. **Costa**, seen on dorsal side, enlarged from above broadest part of leaf to apex, excurrent, seen in transverse section (**Fig. 23.10**), costa dorsally rounded, ventrally at insertion and leaf base channelled, in laminal part narrowly or very narrowly so, at insertion and leaf base four guide cells, in laminal part two guide cells, a median group of hydroids, in upper part of leaf transformed to substereids.

Sporophyte. Seta (**Fig. 23.3**) up to 4 mm, straight or slightly inclined, vaginula elongate-cylindrical, 0,6 mm. **Capsule** exserted, erect, perichaetial leaves reaching capsule, oblong-ovoid, smooth, exothecial cells (**Fig. 23.11**) mostly hexagonal, elongated, walls thin, stomata (**Fig. 23.12**) at base of capsule, numerous or few, annulus of three or four rows of persistent cells, which may detach singly, seen on surface view (**Fig. 23.16**) quadrate to transversely rectangular, lumen large. **Calyptra** (**Fig. 23.13**) cucullate. **Operculum** (**Fig. 23.14**) conical, blunt, margin (**Fig. 23.15**) uneven, two rows of small, nearly isodiametric marginal cells, in conical part irregular, rectangular, isodiametric, lumen rounded. **Peristome** (**Fig. 23.17**) inserted below orifice, teeth erect or spreading when dry, lanceolate, entire or perforate, trabeculae in lower part small, neared, in upper part thin, distant, seen in longitudinal section (**Fig. 23.18, 23.19**), exothecium at orifice constricted, one or two cell rows between exothecium and teeth, their outer layer thicker than inner one, inner and upper outer side covered with rough papillae, lower outer side smooth, trabeculae neared, slightly protruding, prostome more or less markedly developed.

Spores 8-9 μm , smooth.

Diagnostic characters. – **Gametophyte**: in the leaf base of upper stem leaves marginal cells are elongated, nearly of same length as the paracostal cells; in the leaf base of lower stem leaves towards margin, cells are short-rectangular to quadrate; all leaves have smooth, thickened transverse walls, some cell rows are hyaline, vanishing above leaf base. The costa is enlarged from above the broadest part of the leaf up to the apex. **Sporophyte**: on surface view cells of the nearly persistent annulus are quadrate to transversely rectangular with a large lumen; the exothecium is constricted at the orifice.

Comments. – The monoicous sexual condition is best seen in plants with immature capsules, as perigonia, once mature, are subject to disintegration within a short time.

Plants with muticous leaves are occasionally found.

The stratosity of the lamina varies from unistratose to partly or totally bistratose. The nearly completely bistratose laminae (**Fig. 23.20**) of plants named *G. subsulcata* Limpr. are a variation of the more or less unistratose laminae of typical *G. sessitana*. The drawing of a longitudinal sec-

tion of a peristome tooth (**Fig. 23.18**) of a unistratose-leaved plant shows the same characters as the tooth of a bistratose-leaved plant (**Fig. 23.19**). Leaves of such plants have erect or somewhat incurved margins at least on one side, and a spreading lamina on one or both sides of the costa, but only in the lower half of the lamina (**Fig. 23.20e-g**). In these cases the costa is prominent and recessed in a furrow (**Fig. 23.20g-i**). Seen in transverse section the lamina cells bulge slightly and have a rounded lumen. These features may suggest *G. alpestris*. However, the cell patterns described for the leaf base of the stem leaves should make it possible to recognize *G. sessitana*. These characters also distinguish *G. sessitana* from *G. donniana* (see comments on *G. donniana*).

MUÑOZ (1998b) proposed the name *G. reflexidens* Müll. Hal. (1849) as the earliest available name for *G. sessitana*. The description of characters in MÜLLER's protologue (1849), and the drawings given in MUÑOZ (1998b) (partly) and in MUÑOZ (1999) give arise to uncertainty about the synonymy of *G. sessitana* with *G. reflexidens*. To clarify the problem a study of the material of *G. reflexidens* used by Muñoz for the synonymy was attempted. This material had been collected by Pöppig in Chile (Hb. Hampe) and is housed in BM. In his works MUÑOZ (1998b, 1999) cites a lectotype. On the herbarium sheets he annotated a specimen as "isotypus" and another as "isolectotypus". No designated "lectotype", however could be detected in BM. L. Ellis, curator of BM, states (in litt.) that only one collection of '*Grimmia reflexidens*, Chile, Poeppig' had been sent to J. Muñoz and that he has not seen any other material of this collection (Chile, Poeppig) from BM. Thus all material used by J. Muñoz for the synonymy of *G. sessitana* with *G. reflexidens* was available for the present study. The specimens of *G. reflexidens* housed in BM, as well as an isolectotypus housed in NY, turned out to be a *Coscinodon* species. (**Fig. 23.21-24**), recognizable by the plications of the leaf running down to the insertion, and the transverse sections. The taxon is not clearly identifiable using the key given in HASTINGS (1996). The name *G. reflexidens* cannot replace the name *G. sessitana*. The specimen annotated by Muñoz as isotypus is labelled as follows: Herb. Hampe 1881. *Grimmia reflexidens* inter *Dryptodon consobrinus* Kze. Chile leg. Pöppig. The specimen (p.p.) designated as isolectotypus is labelled as follows: Chile, Pöppig, *Grimmia consobrina* Kze., nsp.

The next possible earlier name for *G. sessitana* listed in MUÑOZ (1998b) is *Guembelia lamellosa* Müll. Hal. The description given in the protologue (MÜLLER, 1854) does not clearly correspond to *G. sessitana*. *Guembelia lamellosa* is described as "dioicous,... the margin lamellate, thickened, all cells soft, hexagonal,... near the thick, green, obscure, somewhat lamellate costa, on both sides with longitudinal striae which are narrow, lamellate, furrowed... Considering the appearance, the species has its place between *Guembelia alpestris* and *caespiticia*... by analogy probably belongs to the *Guembelias*" (translation EM). The type specimen of *Guembelia lamellosa*, housed in H (H-SOL), designated by Muñoz as isolectotype, turned out to be the dioicous *Grimmia alpestris*, as the characters demonstrate (**Fig. 23.25-27**) (see also **Fig. 1.5, 1.7, 1.10**), thus confirming the opinion of Müll. Hal. about the systematic position of *Guembelia lamellosa*. The specimen of *Guembelia lamellosa*, designated by DEGUCHI (1979) as lectotype, and cited by MUÑOZ (1998b), housed in PC, is not available at present, and, following a personal communication by the curator (IX-2000), it could not be found in the herbarium. DEGUCHI (1979), however, notes that "the plicae on leaves... were... confirmed on the material in both herbaria" (i.e. PC and H (H-SOL)). A slide, prepared by Deguchi and joined to the type material in H-SOL shows the characteristic transverse sections of *G. alpestris*, agreeing with **Fig. 23.25-27**. These observations are in contradiction to DEGUCHI's statement (1979) that he has seen an autoicous sexual condition in the specimen in PC but not in that in H-SOL. In addition, LIMPRICHT (1888-1889) treats *Guembelia* Hampe (HAMPE, 1846) as a subgenus within the genus *Grimmia*, and recognized *Guembelia lamellosa* as a synonym of *Grimmia alpestris*. Based on these statements, and until it becomes possible to examine the type specimen in PC to resolve the contradiction of the sexual conditions, and to establish the correctness or not of the synonymy proposed by Muñoz, the name *Guembelia lamellosa* cannot be considered as a replacement for the name *Grimmia sessitana*. The specimen of *Guembelia lamellosa*, designated by Deguchi as isolectotype and housed in H-SOL, is labelled as follows (handwritten on the inner packet): *Guembelia lamellosa* C. M. c.fr. Lai Espingo (Pyren.) Aug. 1851 Joh. Lange.

Provenance. – India NW Himalaya, Pakistan.

Habitat. – On boulders, at altitudes between 2950 and 4750 m.

Specimens examined. – **Thirty**, twenty-three of them from the study-area. The selected ones are: **INDIA. NW Himalaya**: “Doyan, Wermuthstaudensteppe, Gneisfelsen 2500 m”, V.1937, *Troll* 63 (BM). **PAKISTAN. Northern Areas, Baltistan**: “Deosai National Park. Valley of the Shatung River, Bari La area, along road to Matiyal. Lat 35°01'N Long 75°34'E, 4760 m, top of pass”, 3.VIII.1998, *Hedderson* 12539 (BOL); “Rupal valley, Tarishing village, Moränenwall, Schotterrasen, Blockschutt, Moräne, 2950 bis 3100 m”, 8.VII.1999, *Gruber* 2103 (Herb. Gruber); “Rupal valley, Shashing mountain, SW-Rücken und NW-Exposition, Geröll, Blockschutt, Gneis, 3625 bis 3870 m”, 9.VII.1999, *Gruber* 2108 (Herb. Gruber); “Deosai plains, Bunji Lungma, Chlala pani NNW 2 km, Gebirgssteppe und alpine Kobresia Rasen, Schneetälchen, tektonische Breccie, verschiefert, 4250 m”, 17.VII.1999, *Gruber* 2107 (Herb. Gruber); **Cashmire**: “Chit-takhata Sar, fentes de rochers 4500 m”, 21.-24.VIII.1953, *Schmid* 10080 (G).

Specimens selected for the description. – **AUSTRIA. Tirol**: “Vent, Breslauer Hütte 2610 m, R2-H13, siliceous boulders near river”, 1.IX.1993, *Maier* 8323 (G). **SLOVAKIA**: “Cervene Kopce, Srinica-Gebirge 1830 m, on boulder”, VII.1951, *Pilous s.n.* (G). **SWITZERLAND. Canton of Grisons**: “Lavin 1540 m, siliceous boulders”, 6.VII.1989, *Maier* 2948 (G); “La Punt 2180 m, boulder in alpine meadow”, 30.VI.1991, *Maier* 5751 (G).

24. *Grimmia tergestina* Bruch & Schimp. in Bruch & al., Bryol. Eur. 25-28: 24. 1845.

- = *G. limprichtii* Kern in Revue Bryol. 24: 56. 1897, **syn. nov.**
- = *G. limprichtii* f. *epilosa* Limpr. in P. G. Richt. & al., Rabenh. Krypt.-Fl. ed. 2, 4(1): 740. 1889, **syn. nov.**
- = *G. obtusifolia* C. H. Gao & T. Cao in Acta Bot. Yunnan. 3: 394. 1981, **syn. nov.**

Gametophyte. Dioicous. Female: innermost perichaetal leaf (**Fig. 24.1**) 1,8-2 mm, sheathing high up, concave, ovate, hyaline to different extent, at least at apex some chlorophyllose cells, at margin from insertion up to broadest part of leaf a row of rhombic or rhomboid cells, in broadest part cells hyaline, rhombic, costa excurring to denticulate hair-point; **male**: perigonia as multifoliate buds terminal or above branching of young shoots, innermost perigonial leaf (**Fig. 24.2**) up to 1,0 mm, sheathing up to apical part, ovate or broad-ovate, 2/3 of leaf hyaline, at margin one or two rows of mostly rhombic or rhomboid cells, vanishing below apical part, costa weak, vanishing below rounded, muticous apex, in apical part chlorophyllose cells (**Fig. 24.3**) irregularly angular, triangular, rectangular, rhomboid, lumina angulate, walls straight, smooth, paraphysia few. **Growth form**: cushion adherent to substrate, easily disintegrating, young shoots originating from stem and rhizoids, leaflets mostly muticous, plants erect, radiculose at base, scarcely branched, stem (**Fig. 24.4**) up to 20 mm, central strand (**Fig. 24.5**) developed. **Leaves** in lower part of stem small, mostly muticous, becoming longer at stem tip, up to 2,8 mm, developing hair-point, loosely disposed on stem, erect when dry, older leaves rapidly bending backwards, younger leaves moving slightly from stem when moistened, erectopatent when wet, (**Fig. 24.6, 24.7**) from broad-ovate leaf base lingulate with rounded apex, or lanceolate with acute apex, hair-point (**Fig. 24.8**) slightly denticulate, rarely strongly denticulate; **leaf form in situ**: (**Fig. 24.9**) leaf base widely concave, in laminal part concave, margin plane; basal (**Fig. 24.10**) paracostal cells elongate-rectangular, walls slightly nodulose or smooth, towards margin cells shorter, at margin above insertion some rows rectangular or quadrate, walls smooth, in transitional part cells quadrate, in laminal part isodiametric, lumen rounded; leaf base unistratose, in transitional part bistratose in places, in laminal part bistratose or tristratose in places, margin unistratose at leaf base, bistratose in laminal part, in apical part occasionally tristratose. **Costa**, seen on dorsal side, broadest at insertion, becoming smaller in leaf base and lower laminal part, indistinct in upper laminal part, seen in transverse section (**Fig. 24.11, 24.39**), costa at insertion and leaf base on dorsal side convex, rounded in laminal part, indistinct in upper laminal part, on ventral side at insertion nearly plane, from leaf base up to apex wide-channelled, at insertion six to eight ventral cells, number not clearly limited due to bistratose paracostal cell rows on one or both sides of leaf axis, at leaf base six guide cells, in transitional part reduced to three or four, in laminal part up to apical part two guide cells, hardly distinct or indistinct due to similarity with lamina cells, better seen on ventral side of leaf, a median central group of

hydroids from insertion up to apex gradually diminishing, probably reaching hair-point, hydroids occasionally transformed to substereids.

Sporophyte. *Seta* straight or curved, up to 0,6 mm; vaginula 0,1 mm, with ochrea. *Capsule* immersed, upright or inclined, obloid and symmetric or ovoid and ventricose, pachidermous, smooth, exothelial cells (Fig. 24.12) irregular, elongate-rectangular, rounded or pentagonal, walls thickened (Fig. 24.13), to be seen by focussing on exothecium, stomata (Fig. 24.14) numerous at base of capsule, annulus of two or three rows of cells, detaching of mature capsule as spirals. *Calyptra* (Fig. 24.15) mitrate, lobed, completely covering operculum. *Operculum* (Fig. 24.16) rostrate or rostellate, beak straight, margin smooth (Fig. 24.17) or crenulate, one or two rows of marginal tile-like cells, in conical part cells penta- or hexagonal, walls thin. *Peristome* (Fig. 24.18, 24.19) inserted at outermost margin of orifice, teeth spreading when dry, lanceolate, perforate or irregularly slit to small branches nearly down to insertion, often mutilate, trabeculae thin, distant, seen in longitudinal section (Fig. 24.20, 24.21) three rows of cells between exothecium and teeth, tooth base anchored to orifice by thickened walls of capsule wall cells, outer layer of tooth of nearly same thickness as inner one, except two lowest outer plates which are thicker, inner and outer side densely covered with fine papillae, except two lowest outer plates which are smooth, trabeculae distant, scarcely protuding, only the two lowest markedly so.

Spores 10-12 μm , granulose.

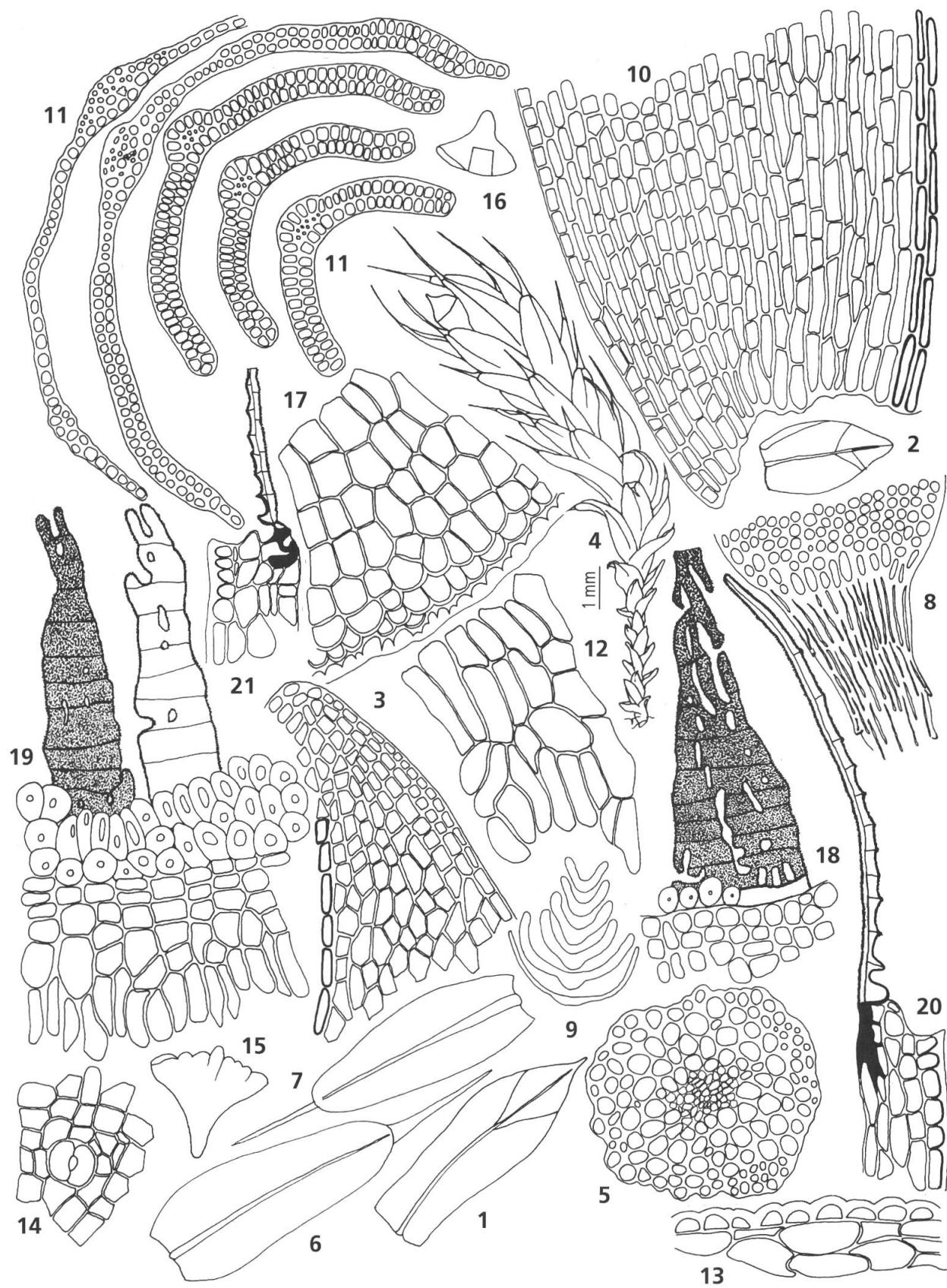
Diagnostic characters. – **Gametophyte:** marginal bistratosity of lamina not correlated to lamina stratosity; even nearly unistratose leaves present at least one or two marginal bistratose cell rows; guide cells of laminal part of costa (Fig. 24.11, 24.39) hardly distinct or even indistinct from lamina cells, due to their similarity, a unique feature in the *Grimmia* species treated in this study. **Sporophyte:** peristome teeth inserted at the outermost margin of the orifice, anchored by thickened walls of cells of capsule wall, inner and outer plates of teeth of nearly the same thickness, except for the two lowest outer plates which are slightly thicker.

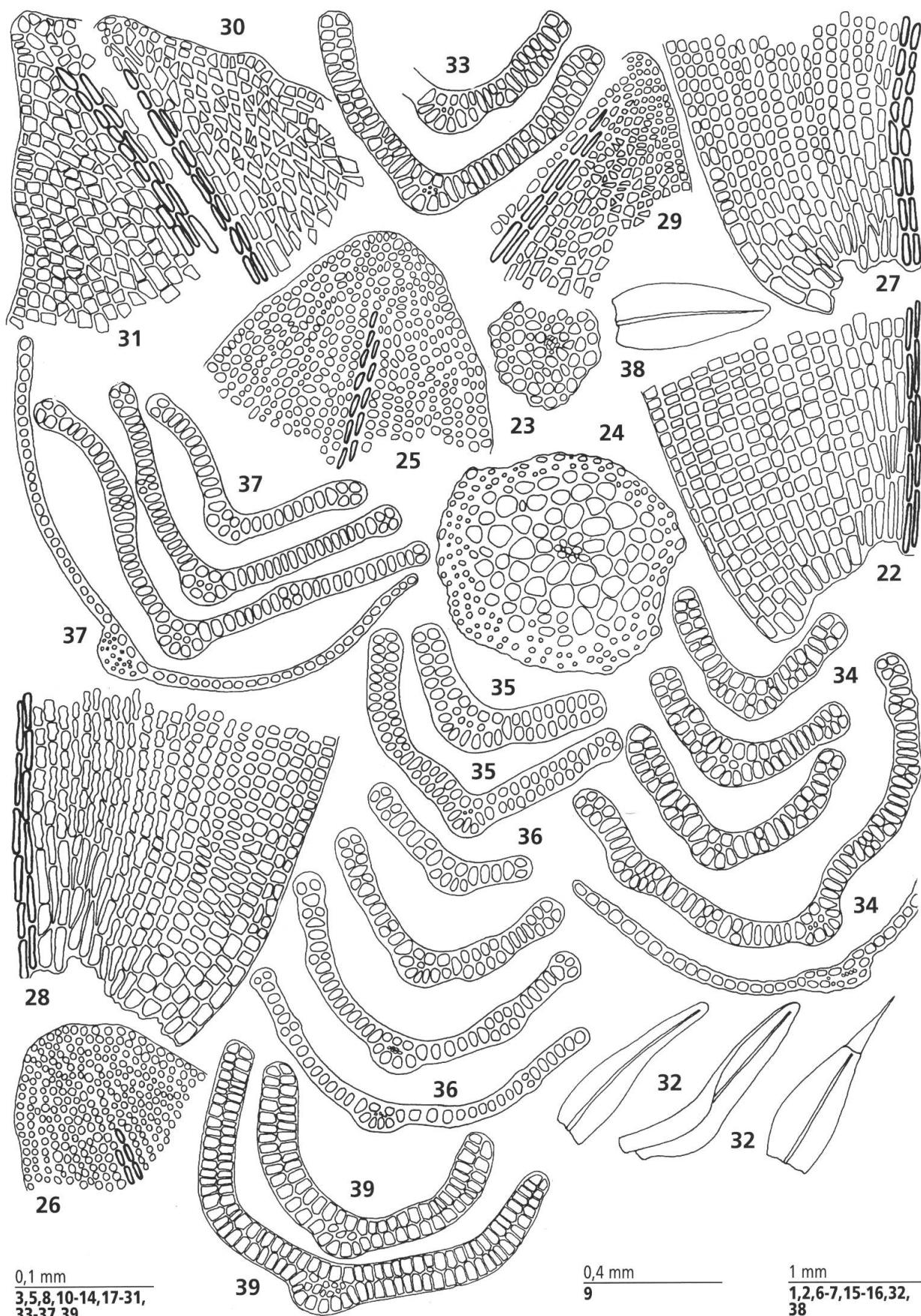
Comments. – The leaf shape is variable; lingulate as well as narrowly lanceolate forms may be seen; the apices are rounded or acute, hair-points are nearly smooth to roughly dentate, elongated or short, reduced to some hyaline cells or not developed at all, the apex may then be cucullate. The cells at the leaf base (Fig. 24.22) may be quadrate or even transversely rectangular with thickened walls, except for some rows of elongate-rectangular paracostal cells; the stratosity varies, particularly in the upper laminal part, from nearly unistratose to nearly or completely bistratose in plants with muticous leaves, and from bi- to partly tristratose in the laminal part, in plants with hair-pointed leaves.

The setae appear either straight (capsules then symmetric) or curved (capsules then asymmetric, ventricose). Gastrocarpy, however, has been overemphasized for taxonomic reasons (LOESKE, 1930: 16); plants with asymmetric capsules and curved setae show the same peristome characters (Fig. 24.20) as those with symmetric capsules and straight setae (Fig. 24.21). Occasionally peristomes are not developed at all (named *G. tergestinoides* f. *gymnostoma* Culm. (NOWAK & POELT, 1979)) or are mutilated or incompletely developed; then fragments of teeth or diaphanous structures are to be found in the operculum or at the orifice of the capsule. Deep

Fig. 24. – *Grimmia tergestina* Bruch & Schimp.: 1, perichaetial leaf; 2, perigonial leaf; 3, perigonial leaf, cells at apex; 4, plant with sporophyte; 5, transverse section of stem; 6-7, leaves; 8, cells at apex, hair-point; 9, outlines of transverse sections of leaf; 10, cells in leaf base; 11, transverse sections of leaf; 12, exothelial cells; 13, transverse section of exothecium in middle of capsule; 14, stoma; 15, calyptra; 16, operculum; 17, cells at margin of operculum; 18-19, peristomes, outer side, from ventricose capsules on curved seta; 20, longitudinal section of peristome tooth of capsule on curved seta; 21, longitudinal section of peristome tooth of capsule on straight seta; 22, cells in leaf base; 23-24, transverse sections of stems; 25-26, leaves, cells at apex; 27-28, cells in leaf bases; 29-31, perigonial leaves, cells at apex; 32, leaves of the same plant with and without hair-point; 33-37, transverse sections of leaves; 38, leaf; 39, transverse sections of leaf.

[1, 4, 6, 12-18, Maier 4994; 2-3, 8, Maier G0013; 5, 7, 9-11, Gruber 2105; 19-20, Maier 3127; 21, Maier G0041; 22, Thomson 311; 23, 27, 36, 38, Kern s.n.; 24-25, 29, 37, Gander s.n.; 26, 34, Lang Kai-Yong 1232; 28, 33, Lang Kai-Yong 1347; 30, 35, Meylan s.n.; 31, Greven 9726; 32, Merton 21; 39, Thomson 281]





0,1 mm
3,5,8,10-14,17-31,
33-37,39

0,4 mm
9

1 mm
1,2,6-7,15-16,32,
38

slitting and strong perforation of teeth, as well as their insertion at the outermost margin of the orifice may be the reasons for the fragility of the peristomes. However, the characteristic structure at the insertion is maintained. Plants affected by incomplete development of sporophytic characters have been named *G. poecilostoma* Card. & Séb., or *G. tergestinoides* Culm. In CORLEY & al. (1981) they are treated as synonyms of *G. tergestina*. As peristome modifications, mostly due to unfavourable ecological conditions, are not correlated with gametophytic characters, identification of those forms in the vegetative state is not possible.

Arguments for synonymies. – Based on plants with muticous leaves, KERN (1897) described *G. limprichtii* and GAO & CAO (1981) *G. obtusifolia*. Both grow on limestone, occasionally buried in decaying substrate, in sheltered, often poikilohydrous, or open, sunny places in alpine regions, in dense tufts. The stems are erect, dichotomously branched, with a central strand (Fig. 24.23, 24.24), and not without a central strand as noted by LIMPRICHT (1901-1903: 719), and LOESKE (1913: 52). The leaves are imbricate, concave, appressed to the stem when dry, erect when wet, the apex (Fig. 24.25, 24.26, 24.38) is obtuse, muticous, often cucullate; the costa is distinct, weak, vanishing below apex; the basal paracostal cells (Fig. 24.27) are elongate-rectangular or rectangular, the walls are smooth or nodulose (Fig. 24.28), towards the margin they become quadrate, with smooth walls, the lamina cells are incrassate, with rounded lumen, the lamina in the lower part is unistratose with bistratose patches, and nearly bistratose in the apical part. Most of the ten specimens with muticous leaves examined are male plants. That male plants of *G. tergestina* show a different appearance was also stated by GREVEN (1995: 11). The cell pattern of their innermost perigonial leaf (Fig. 24.29-31), however, corresponds to that of *G. tergestina* (Fig. 24.3); in some specimens plants are found both with leaves with and without hair-points (Fig. 24.32). In the upper third of the leaf, nearly bistratose laminae are present in the type specimen of *G. obtusifolia* (Lang Kai-Yong 1347, isotype: ALTA seen) (Fig. 24.33) (or even completely bistratose as seen in CAO & VITT, 1985: Fig. 5), in the paratype *Lang Kai-Yong 1232* (Fig. 24.34), and *Meylan s.n.* (G) (Fig. 24.35); in the type specimen of *G. limprichtii* in the same place the lamina is partially bistratose (Fig. 24.36), in the type specimen of *G. tergestina* f. *epilosa* Limpr. (LIMPRICHT, 1888-1889: 740) the lamina is unistratose with bistratose patches (Fig. 24.37). The costa at leaf insertion rarely has six, mostly four guide cells, four or three in the leaf base, in the laminal part two guide cells, which are characteristically not distinct from the laminal cells in the nearly bistratose apical part, but are distinct in the nearly unistratose laminae. The cell pattern, structural characters of the costa and characters of the perigonial leaves, as well as the occasional presence of both muticous and hair-pointed leaves in one and the same plant are evidence for conspecificity of forms with muticous leaves (*G. limprichtii*, *G. obtusifolia*, and *G. tergestina* f. *epilosa*) with *G. tergestina*.

LIMPRICHT (1888-1889: 740), first described *G. tergestina* with leaves without hair-points as *G. tergestina* f. *epilosa* (holotype: BP). Some years later, KERN (1897) described plants found in 1896 (not 1876 as noted in LIMPRICHT, 1901-1903: 719, and LOESKE, 1913: 51) as *G. limprichtii*, considered by LIMPRICHT (1901-1903: 719) as near to *Hydrogrimmia mollis*, but by LOESKE (1913: 51) as related to *G. anodon*. LOESKE (1930: 74) proposed that ecological factors influenced the growth form of Kern's *G. limprichtii* and repeated his opinion that the form is related to *G. anodon*. In "Index Muscorum" (WIJK & al., 1962) *G. limprichtii* is also considered to be a form of *G. anodon* (fide MÖNKEMEYER, 1927: 345). As CORLEY & al. (1981: 610) excluded taxa below species rank from their list, the systematic position of *G. limprichtii* was not considered. GREVEN (1995: 87) took up the discussion and stated that *G. limprichtii* and *G. anodon* are two different taxa. Comparison of the costa of *G. anodon* (see under *G. anodon* in this study) and of *G. limprichtii* confirms the erroneous attribution to *G. anodon*. This fact and the conspecificity of *G. limprichtii* with *G. tergestina* f. *epilosa*, and with *G. tergestina* demonstrated above, are arguments for placing *G. limprichtii* in synonymy of *G. tergestina*.

In a paper concerning *G. limprichtii*, GREVEN & SOTIAUX (1995) report that a study of *G. obtusifolia* showed its conspecificity with *G. limprichtii* and that this conclusion had been

accepted by Cao in a personal communication. This is further evidence that *G. obtusifolia* is synonymous with *G. tergestina*.

Provenance. – India, Pakistan, Tibet.

Habitat. – 2000–3000 m, muticous form between 3000 and 4850 m.

Specimens examined. – **Fifty-one**, ten of them from the study-area. The selected ones are: **TIBET.** “4850 m, (Lang Kaiyong)”, 13.VII.1978, *Lang Kai-Yong* 1347 (ALTA); “4800 m, (Lang Kaiyong)”, 5.VI.1976, *Lang Kai-Yong* 1232 (ALTA); “Rondu, Regio temp., 6,000””, Herb. Ind. Or. Hook. fil. & Thomson, *Thomson* 281 (BM). **INDIA. Chenab Himalaya:** “Kishtwar, Regio temp., 6,000””, Herb. Ind. Or. Hook. fil. & Thomson, *Thomson* 311 (BM). **PAKISTAN. Northern Areas, Baltistan:** “Deosai National Park, ca. 10 km S of Skardu at Park checkpoint in Sadpara Nullah. Lat. 35°10'N Long 75°37'E, 2980 m, steep slopes with outcropping crystalline rocks and open steppe vegetation with numerous bare soil patches”, 19.VII.1998, *Hedderson* 12182 (BOL); “NW Gudar 2875 m, Artemisia-Halbwüste, Granit, Alluvionen”, 10.VII.1999, *Gruber* 2105 (Herb. Gruber).

Specimens selected for the description. – **AUSTRIA. Tirol:** “Innervillgraten, von senkrechten Kalkwänden in “Kalkstein”, c. 5600””, 22.V.1890, *Gander* s.n. (BP). **FRANCE. Alpes-de-Haute-Provence:** “4 km NE of St. Paul, Le Châtelet R.nes, sunny, open, E-facing slanting limestone below the ruins of a small castle 1625 m”, 7.VII.1997, *Grevé* 9726 (G). **IRAN.** “Saghrish near Tehran 1450 m, on wet soil, rocks by a seep”, 18.III.58, *Merton* 21 (E). **ITALY. Dolomiten:** “Palagruppe: überhängende Felsen oberhalb des Rollepasses 2100 m”, 29.VII.1896, *Kern* s.n. (Z+ZT). **SWITZERLAND. Canton of Grisons:** “Parc National Suisse, Val de Munschaun 2400 m, rochers ensoleillés, sur le versant”, VIII.1924, *Meylan* s.n. (G). **Canton of Valais:** “Ausserberg 950 m, steppe, limestone”, 25.V.1996, *Maier* G0013 (G); “Dorénaz 460 m, Rosel, siliceous boulder, near river”, 11.III.1999, *Maier* G0041 (G); “Fully 460 m, Branson, Rhone bridge, concrete”, 1.IV.1990, *Maier* 3127 (G); “Fully 500 m, les Follatères, rocks, on loess”, 12.III.1991, *Maier* 4994 (G).

25. *Grimmia unicolor* Hook. in Grev., Scott. Crypt. Fl. 3: 123. 1825.

Gametophyte. Dioicous. Female: innermost perichaetial leaf (**Fig. 25.1**) up to 2,4 mm, sheathing up to 3/4 of leaf length, from elongate-ovate leaf base lingulate, apex muticous, leaf base hyaline, at margin some rows of thin-walled rhombic cells vanishing with sheathing part, costa percurrent; **male:** perigonia not seen. **Growth form:** cushion compact, adherent to substrate with rhizoids, young shoots originating from older stem parts, leaflets scale-like, appressed to stem, plants decumbent, branched, stem (**Fig. 25.2**) up to 40 mm, central strand (**Fig. 25.3**) developed. **Leaves** (**Fig. 25.4, 25.5**) bottle-green, glossy, in lower part of stem small, appressed to stem, apices slightly spreading, in upper part becoming gradually longer, up to 2 mm, crowded, imbricate, loosely disposed on stem, slightly inflexed when dry, when moistened older leaves bending backwards, younger ones moving only slightly, when wet sheathing leaf base appressed to stem, laminal part stiff, erectopatent or patent, from elongated or scarcely ovate, slightly decurrent leaf base linear-lanceolate, apex (**Fig. 25.6**) rounded, muticous, often cucullate; **leaf form in situ:** (**Fig. 25.7, 25.8**) at insertion and leaf base widely concave or concave, in laminal part up to apex concave, margin plane; basal paracostal cells (**Fig. 25.9**) elongate-rectangular, towards margin rectangular, at margin two or three rows hyaline, particularly in younger leaves, cell walls smooth, in laminal part cells isodiametric, lumen rounded; leaf base unistratose, in transitional part lamina bistratose in places, up to apex becoming tri- to multistratose, stratosity of margin indistinct from lamina stratosity. **Costa**, seen on dorsal side, broad from insertion up to lower laminal part, becoming indistinct up to apex, seen in transverse section (**Fig. 25.10**), costa at insertion and leaf base on dorsal side rounded, in laminal part slightly convex, on ventral side widely channelled throughout, at insertion eight guide cells, occasionally ten ventral cells, in leaf base six to eight guide cells, in laminal part up to apical part diminishing to two guide cells, at apex cells homogeneous, neither stereids nor hydroids.

Sporophyte. Seta (**Fig. 25.2**) up to 4 mm, straight, vaginula 0,8–1 mm. **Capsule** exserted, upright, ovate or elongate-ovate, smooth, exothelial cells (**Fig. 25.11**) irregular, thick-walled, stomata numerous in short neck, annulus of three or four rows of cells, detaching as groups. **Calyptra** (**Fig. 25.12**) mitrate, lobed, fugacious before capsule maturity. **Operculum** (**Fig. 25.13**) conical, beak short or elongated, straight, margin (**Fig. 25.14**) smooth, some marginal rows of irregularly shaped, slightly smaller cells than in conical part. **Peristome** (**Fig. 25.15**) deeply inserted below orifice, teeth broad at base, lanceolate, perforate in upper half, imperfect at apex, broken off cell plates remained in operculum, trabeculae thin, closely neared, seen in longitudinal section (**Fig. 25.16**) three rows of cells between exothecium and teeth, their outer layer much

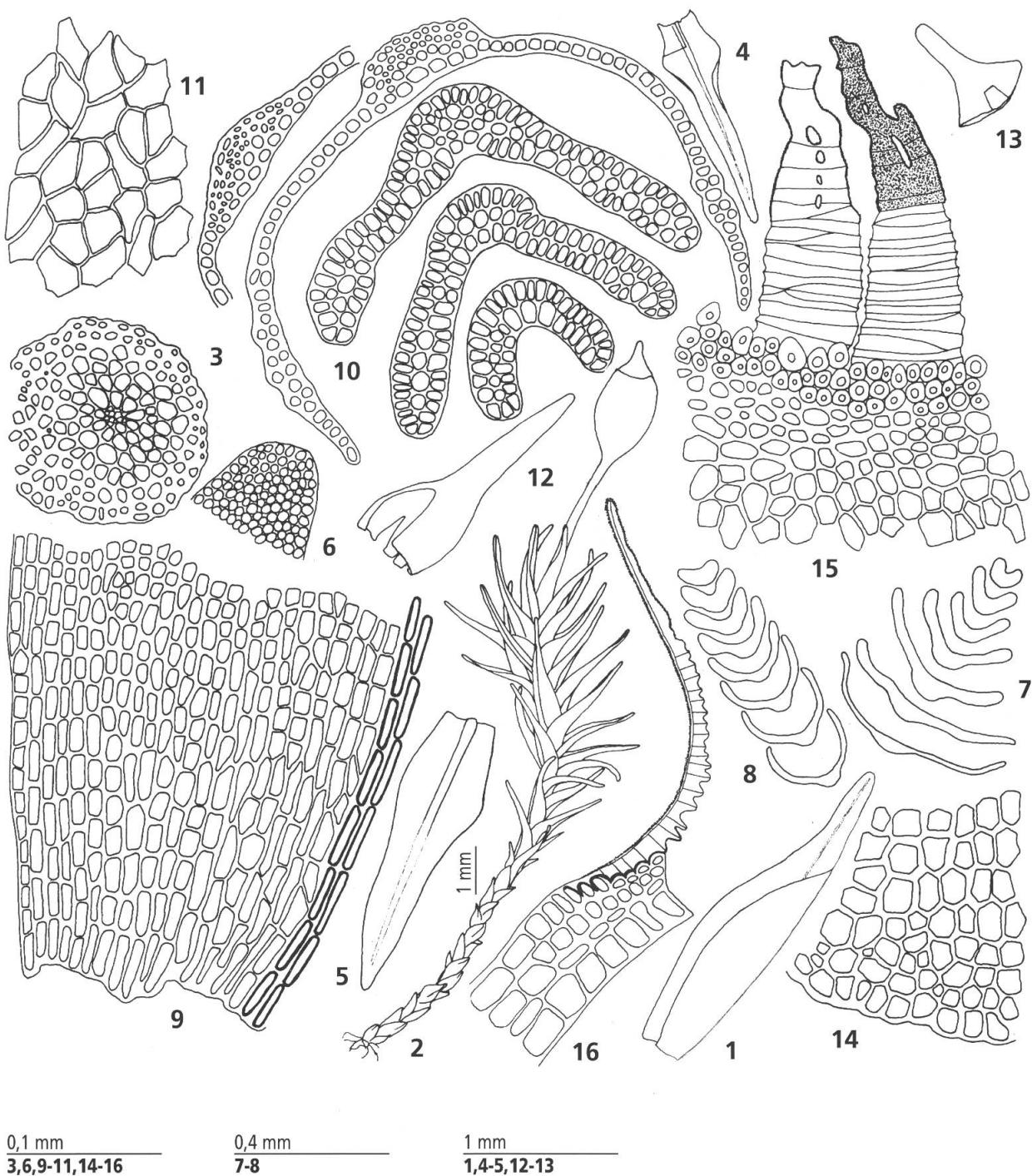


Fig. 25. – *Grimmia unicolor* Hook.: **1**, perichaetial leaf; **2**, plant with sporophyte; **3**, transverse section of stem; **4-5**, leaves; **6**, cells at apex; **7-8**, outlines of transverse sections of leaves; **9**, cells in leaf base; **10**, transverse sections of leaf; **11**, exothelial cells; **12**, calyptra; **13**, operculum; **14**, cells at margin of operculum; **15**, peristome, outer side; **16**, longitudinal section of peristome tooth.

[**1-2, 5, 8**, Maier 8625; **3-4, 6-7, 9-10**, Garrit & Lillie 2443; **11-15**, s.coll. s.n., G; **16**, Schimper s.n.]

thicker than inner one, inner side and upper outer side densely covered with fine papillae, lower outer side smooth, trabeculae closely neared, strongly protruding.

Spores 10-13 μm , smooth.

Diagnostic characters. – **Gametophyte:** leaf apex rounded, muticous; lamina in upper part multistratose. Costa, seen on dorsal side, above lower laminal part indistinct, without hydroids and stereids. **Sporophyte:** peristome deeply inserted.

Provenance. – India, Kashmir.

Habitat. – 2300-4300 m. No further information on labels.

Specimens examined. – **Four**, two of them from the study-area: **INDIA. Kashmir:** “Lidar and Sind Valley, 7000-13000 ft.”, VIII.1931, *Garrit & Lillie* 2443 (BM); “Kashmir, 8000”, *Thomson* 319, Herbarium Mitten (NY).

Specimens selected for the description. – **AUSTRIA. [Salzburg]:** “Alp. Salisb.”, *Schimper* s.n. (G). **FRANCE. Haute-Savoie:** “Contamines am Mt. Blanc über Notre Dame de la Gorge, an nassen Felsen”, 17.VII.1855, *s. coll. s.n.* (G). **SWITZERLAND. Canton of Obwalden:** “Engelberg, Stäfeli, 1380 m, alpine meadow, siliceous boulder”, 30.VII.1993, *Maier* 8625 (G).

Taxon for which the type specimen was not available

Grimmia pilifera P. Beauv., *Prodr. Aethéogam.*: 58. 1805.

Nomina nuda

Grimmia badia Dixon, in scheda ad *Troll* 63 (= **G. sessitana** De Not.).

Grimmia coscinodontoides Dixon & Herzog, in scheda ad *Dixon M.* 58 (= **G. orbicularis** Wilson).

Grimmia himalaica Dixon, in scheda ad *Badhwar* 913 (= **G. longirostris** Hook.).

Grimmia incana Wilson, in scheda ad *Thomson* 281 & in Hooker's J. Bot. Kew Gard. Misc. 9: 323. 1857 (= **G. tergestina** Bruch & Schimp.).

Grimmia longii Broth., in scheda ad *Ribu* s.n. (= **G. indica** (Dixon & P. de la Varde) Goffinet & Greven).

Grimmia longipes Broth., in scheda ad *Handel-Mazzetti* 1905 & in *Ann. Naturhist. Mus. Wien* 40: 147. 1926 (= **G. khasiana** Mitt.).

Grimmia oblonga Wilson, in scheda ad *Hooker* 316 & in Hooker's J. Bot. Kew Gard. Misc. 9: 323. 1857 (= **G. macrotheca** Mitt.).

Grimmia orientalis Wilson, in scheda ad *Hooker* 293 & in Hooker's J. Bot. Kew Gard. Misc. 9: 323. 1857 (= **G. elongata** Kaulf.).

Grimmia pulvericola Müll. Hal., in scheda ad *Rogers* s.n. & in *Rec. Bot. Surv. India* 13(1): 123. 1931 (= **G. pulvinata** (Hedw.) Sm.).

Grimmia subanodon Müll. Hal., in scheda ad *Kurz* s.n. (= **G. anodon** Bruch & Schimp.).

Grimmia subfusca Wilson, in scheda ad *Hooker & Thomson* 296 & in Hooker's J. Bot. Kew Gard. Misc. 9: 323. 1857 (= **G. mammosa** C. H. Gao & T. Cao).

Grimmia subimmersa Broth., in scheda ad *Handel-Mazzetti* 498 (= **G. longirostris** Hook.).

Grimmia subnuda Müll. Hal., in scheda ad *Kurz* s.n. (= **G. anodon** Bruch & Schimp.).

Doubtful taxon

Grimmia reflexidens Müll. Hal., *Syn. Musc. Frond.* 1: 795. 1849.

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Appendix

1. <i>G. alpestris</i>	10. <i>G. indica</i>	19. <i>G. ovalis</i>
2. <i>G. anodon</i>	11. <i>G. khasiana</i>	20. <i>G. percarinata</i>
3. <i>G. atrata</i>	12. <i>G. laevigata</i>	21. <i>G. pilifera</i>
4. <i>G. crinata</i>	13. <i>G. longirostris</i>	22. <i>G. pulvinata</i>
5. <i>G. donniana</i>	14. <i>G. macrotheca</i>	23. <i>G. sessitana</i>
6. <i>G. elatior</i>	15. <i>G. mammosa</i>	24. <i>G. tergestina</i>
7. <i>G. elongata</i>	16. <i>G. montana</i>	25. <i>G. unicolor</i>
8. <i>G. fuscolutea</i>	17. <i>G. nepalensis</i>	
9. <i>G. handelii</i>	18. <i>G. orbicularis</i>	

1. List of *Grimmia* specimens provided by David G. Long, Edinburgh (UK)

8296	15	BHUTAN	Byakar Dzong	10.VI.1979	20720	20	NEPAL	Sankhuwasabha	28.IX.1991
8787	15	BHUTAN	Thimphu	19.VII.1979	20720	20	NEPAL	Sankhuwasabha	28.IX.1991
10883	13	BHUTAN	Thimphu	16.IV.1982	20851	13	NEPAL	Sankhuwasabha	02.X.1991
10896	20	BHUTAN	Thimphu	16.IV.1982	20929	8	NEPAL	Sankhuwasabha	04.X.1991
10900	13	BHUTAN	Thimphu	16.IV.1982	20931	13	NEPAL	Sankhuwasabha	04.X.1991
16680	13	NEPAL	Kyapra	07.IX.1989	20936	3	NEPAL	Sankhuwasabha	04.X.1991
16698	15	NEPAL	Pheri	07.IX.1989	20944	5	NEPAL	Sankhuwasabha	04.X.1991
16744	13	NEPAL	Ghunsa	08.IX.1989	20945	8	NEPAL	Sankhuwasabha	04.X.1991
16781	8	NEPAL	Rambuk Kharka	09.IX.1989	20947	3	NEPAL	Sankhuwasabha	04.X.1991
16783	9	NEPAL	Rambuk Kharka	09.IX.1989	20957	5	NEPAL	Sankhuwasabha	05.X.1991
16787	13	NEPAL	Rambuk Kharka	09.IX.1989	20963	7	NEPAL	Sankhuwasabha	05.X.1991
16807	19	NEPAL	Kambachen	10.IX.1989	21041	8	NEPAL	Sankhuwasabha	09.X.1991
16836	13	NEPAL	Lhonak	11.IX.1989	21387	7	NEPAL	Sankhuwasabha	19.X.1991
16837	8	NEPAL	Lhonak	11.IX.1989	21451	7	NEPAL	Taplejung	21.X.1991
16843	13	NEPAL	Lhonak	11.IX.1989	21457	10	NEPAL	Taplejung	22.X.1991
16861	3	NEPAL	Lhonak	12.IX.1989	22093	13	NEPAL	Rasuwa Distr.	26.IV.1992
17014	7	NEPAL	Mirgin La	16.IX.1989	22545	20	SIKKIM	West District	12.VII.1992
17059	13	NEPAL	Lapsang	19.IX.1989	22551	10	SIKKIM	West District	12.VII.1992
17105	7	NEPAL	Yalung	20.IX.1989	22553	13	SIKKIM	West District	12.VII.1992
17120	10	NEPAL	Tseram	21.IX.1989	22560	13	SIKKIM	West District	13.VII.1992
18556	14	CHINA	Yunnan	26.IX.1990	22572	8	SIKKIM	West District	13.VII.1992
18572	13	CHINA	Yunnan	26.IX.1990	22585	13	SIKKIM	West District	14.VII.1992
18674	13	CHINA	Yunnan	29.IX.1990	22611	3	SIKKIM	West District	15.VII.1992
18675	13	CHINA	Yunnan	29.IX.1990	22612	7	SIKKIM	West District	15.VII.1992
18755	11	CHINA	Yunnan	02.X.1990	22761	8	SIKKIM	West District	20.VII.1992
18927	11	CHINA	Yunnan	08.X.1990	22830	8	SIKKIM	West District	23.VII.1992
18928	15	CHINA	Yunnan	08.X.1990	23724	13	CHINA	Yunnan	27.V.1993
18930	9	CHINA	Yunnan	08.X.1990	23814	13	CHINA	Yunnan	29.V.1993
18944	10	CHINA	Yunnan	08.X.1990	23820	13	CHINA	Yunnan	29.V.1993
19048	8	CHINA	Yunnan	10.X.1990	23991	24	CHINA	Yunnan	03.VI.1993

23998	24	CHINA	Yunnan	03.VI.1993	26864	24	CHINA	Qinghai	07.VII.1997
24007	13	CHINA	Yunnan	04.VI.1993	26865	2	CHINA	Qinghai	07.VII.1997
24065	8	CHINA	Yunnan	05.VI.1993	26868	24	CHINA	Qinghai	07.VII.1997
24137	11	CHINA	Yunnan	08.VI.1993	26885	13	CHINA	Qinghai	08.VII.1997
24225	24	CHINA	Sichuan	11.VI.1993	26925	24	CHINA	Qinghai	09.VII.1997
24548	13	CHINA	Yunnan	19.VI.1993	26930	13	CHINA	Qinhgai	10.VII.1997
26308	7	SIKKIM	East District	08.VII.1996	26934	24	CHINA	Qinghai	10.VII.1997
26429	20	SIKKIM	Lachung	14.VII.1996	26971	24	CHINA	Qinghai	12.VII.1997
26457	20	SIKKIM	Lachung	15.VII.1996	26972	24	CHINA	Qinghai	12.VII.1992
26519	20	SIKKIM	Chhoptha	17.VII.1996	26987	24	CHINA	Qinghai	14.VII.1997
26533	8	SIKKIM	Dambochi	18.VII.1996	26998	24	CHINA	Qinghai	15.VII.1997
26535	8	SIKKIM	Dambochi	18.VII.1996	27017	2	CHINA	Qinghai	15.VII.1997
26537	13	SIKKIM	Dambochi	18.VII.1996	27030	24	CHINA	Qinghai	15.VII.1997
26540	5	SIKKIM	Phaklung	19.VII.1996	27050	24	CHINA	Qinghai	16.VII.1997
26550	19	SIKKIM	North District	19.VII.1996	27063	24	CHINA	Qinghai	18.VII.1997
26581	5	SIKKIM	Lasha Chhu	21.VII.1996	27127	24	CHINA	Qinghai	19.VII.1997
26584	7	SIKKIM	Lasha Chhu	21.VII.1996	27131	24	CHINA	Qinghai	20.VII.1997
26592	5	SIKKIM	Lasha Chhu	22.VII.1996	27132	24	CHINA	Qinghai	20.VII.1997
26622	13	SIKKIM	Yume Samdong	24.VII.1996	27135	24	CHINA	Qinghai	21.VII.1997
26623	20	SIKKIM	North District	24.VII.1996	27280	24	CHINA	Qinghai	25.VII.1997
26782	24	CHINA	Qinghai	30.VI.1997	27281	24	CHINA	Qinghai	25.VII.1997
26795	24	CHINA	Qinghai	02.VII.1997	28577	15	BHUTAN	Thimphu	08.IX.1999
26813	2	CHINA	Qinghai	03.VII.1997	28724	13	BHUTAN	Haa	19.IX.1999
26814	24	CHINA	Qinghai	03.VII.1997	28732	20	BHUTAN	Haa	19.IX.1999
26842	2	CHINA	Qinghai	05.VII.1997	28756	21	BHUTAN	Thimphu	23.IX.1999
26850	24	CHINA	Qinghai	07.VII.1997	28761	11	BHUTAN	Thimphu	24.IX.1999
26855	13	CHINA	Qinghai	07.VII.1997	28846	20	BHUTAN	Thimphu	28.IX.1999
26857	24	CHINA	Qinghai	07.VII.1997	28879	13	BHUTAN	Thimphu	29.IX.1999

2. Identification list of the selected specimens

<i>Amann s.n.</i>	6	<i>Garrit & Lillie 2443</i>	25	<i>Gruber 2105</i>	24
<i>Austin 143</i>	21	<i>Giraldi 877</i>	11	<i>Gruber 2106</i>	16
<i>Badhwar 913</i>	13	<i>Greter 7846</i>	5	<i>Gruber 2107</i>	23
<i>Badhwar 951</i>	1	<i>Greven 9726</i>	24	<i>Gruber 2108</i>	23
<i>Bor, N. L. 451</i>	1	<i>Grierson & Long 92</i>	21	<i>Handel-Mazzetti 180</i>	21
<i>Borelli s.n.</i>	16	<i>Griffith 67</i>	18	<i>Handel-Mazzetti 1905</i>	11
<i>Burtt B 726</i>	12	<i>Gruber 1934</i>	4	<i>Hartmann M 35</i>	2
<i>Dickoré F 2</i>	4	<i>Gruber 2090</i>	16	<i>Hartmann s.n.</i>	4
<i>Dixon M. 58</i>	18	<i>Gruber 2096</i>	16	<i>Hedderson 12182</i>	24
<i>Duthie 12843</i>	13	<i>Gruber 2097</i>	19	<i>Hedderson 12265</i>	6
<i>Duthie s.n.</i>	22	<i>Gruber 2098</i>	6	<i>Hedderson 12285</i>	1
<i>Duthie s.n.</i>	8	<i>Gruber 2102</i>	16	<i>Hedderson 12414</i>	19
<i>Gander s.n.</i>	24	<i>Gruber 2103</i>	23	<i>Hedderson 12486</i>	2

<i>Hedderson</i> 12497	16	<i>Maier</i> 8625	25	<i>Thomson</i> 287 (BM, NY)	2
<i>Hedderson</i> 12539	23	<i>Maier</i> 8680	1	<i>Thomson</i> 290	2
<i>Hedderson</i> 12641	13	<i>Maier</i> 9070	12	<i>Thomson</i> 311	24
<i>Henry</i> 508	13	<i>Maier</i> 9080	16	<i>Thomson</i> 317	19
<i>Hooker</i> 284	15	<i>Maier</i> 9138	7	<i>Thomson</i> 319 (BM, NY)	19
<i>Hooker</i> 285	20	<i>Maier</i> 9271	19	<i>Thomson</i> 319 (NY)	25
<i>Hooker</i> 293	7	<i>Maier</i> 9935	16	<i>Townsend</i> 87/341	1
<i>Hooker</i> 294	7	<i>Maier</i> 10372	19	<i>Townsend</i> 87/343	6
<i>Hooker</i> 299	5	<i>Maier</i> 10373	19	<i>Troll</i> 63	23
<i>Hooker</i> 328	13	<i>Maier</i> 10424	4	<i>Walker</i> 431	2
<i>Hooker & Thomson</i> 296	15	<i>Maier</i> 10459	6	<i>Winkler</i> s.n.	16
<i>Inayat Khan</i> 2864	1	<i>Maier</i> 11339	12	<i>Wraber</i> s.n.	5
<i>Inayat</i> s.n.	11	<i>Maier</i> 11371	1	<i>Würmli</i> 49	11
<i>Kern</i> s.n.	24	<i>Maier</i> 11761	6	<i>Zang Mu</i> 39	14
<i>Koelz</i> 7544	22	<i>Maier</i> G0013	24	<i>Zimmermann</i> 558	3
<i>Kurz</i> s.n.	2	<i>Maier</i> G0034	18		
<i>Lang Kai-Yong</i> 1232	24	<i>Maier</i> G0041	24		
<i>Lang Kai-Yong</i> 1347	24	<i>Merton</i> 21	24		
<i>Lillie</i> 790	12	<i>Meylan</i> s.n.	24		
<i>Maier</i> 2948	23	<i>Miehe</i> s.n.	13		
<i>Maier</i> 3127	24	<i>Molendo</i> s.n.	7		
<i>Maier</i> 3825	1	<i>Pilous</i> s.n.	23		
<i>Maier</i> 4285	13	<i>Poelt</i> s.n.	11		
<i>Maier</i> 4994	24	<i>Poelt</i> s.n.	14		
<i>Maier</i> 5456	22	<i>Poelt</i> s.n.	8		
<i>Maier</i> 5495	2	<i>Poelt</i> s.n.	9		
<i>Maier</i> 5650	1	<i>Polunin</i> M146	20		
<i>Maier</i> 5712	6	<i>Polunin, Sykes & Williams</i> 389	12		
<i>Maier</i> 5751	23	<i>Reuter</i> s.n.	7		
<i>Maier</i> 6139	3	<i>Ribu</i> s.n.	10		
<i>Maier</i> 6705	18	<i>Rogers</i> s.n.	22		
<i>Maier</i> 6748/1	22	<i>s.coll.</i> s.n.	25		
<i>Maier</i> 6860	6	<i>Sauter</i> s.n.	3		
<i>Maier</i> 7544	5	<i>Schelpe</i> 3181	19		
<i>Maier</i> 7764	8	<i>Schelpe</i> 3374	13		
<i>Maier</i> 7811	12	<i>Schimpfer</i> s.n.	25		
<i>Maier</i> 7920	19	<i>Schmid</i> 10080	23		
<i>Maier</i> 7972	4	<i>Shelpe</i> 32/6	12		
<i>Maier</i> 8008	19	<i>Stainton, Sykes & Williams</i> 2350	8		
<i>Maier</i> 8188	16	<i>Stewart</i> 13725 (E, NY)	12		
<i>Maier</i> 8204	13	<i>Stewart</i> 13725 (BM)	19		
<i>Maier</i> 8323	23	<i>Thomson</i> 281	24		
<i>Maier</i> 8444	4	<i>Thomson</i> 287 (BM)	18		
<i>Maier</i> 8585	5				