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BRYOPHYTES OF ALTAI MOUNTAINS. IV. THE FAMILY GRIMMIACEAE (MUSCI)

МОХООБРАЗНЫЕ АЛТАЯ. IV. СЕМЕЙСТВО GRIMMIACEAE (MUSCI)

MICHAEL S. IGNATOV[1] & CAO TONG[2]

М. С. ИГНАТОВ[1] и ЧАО ТОНГ[2]

Abstract

Fifteen species of *Grimmia*, 5 of *Schistidium*, 5 of *Racomitrium*, and 1 of *Coscinodon*, *Hydrogrimmia*, *Indusiella*, and *Jaffueliobryum* are reported for Altai. Brief descriptions, illustration, keys for identification, distinguishing characters and comments on species distribution are provided for all species. Seven species and two genera, *Hydrogrimmia* and *Indusiella*, are reported as new for Altai.

Резюме

Пятнадцать видов рода *Grimmia*, 5 *Schistidium*, 5 *Racomitrium* и по одному из родов *Coscinodon*, *Hydrogrimmia*, *Indusiella* и *Jaffueliobryum* выявлены в бриофлоре Алтая. Для всех видов приведены краткие описания, иллюстрации, ключи для определения, диагностические признаки и заметки об их распространении и экологической приуроченности. Семь видов и два рода, *Hydrogrimmia* и *Indusiella* указываются для Алтая впервые.

INTRODUCTION

This article belongs to a series of treatments of the bryoflora of Altai which started in this issue of *Arctoa*. As we intend, the series will describe, illustrate and discuss all the bryophyte groups present in the study area. For detailed information about the natural history of Altai, the history of its bryological investigation, as well as for an explanation of the specimen citation, please see the introductory part by Ignatov in this issue.

B. A. Keller (1914) reported 2 species of *Grimmia* in Altai Mts., P. N. Krylov (1925) - 17 species, now referable to the genera *Grimmia*, *Schistidium*, *Racomitrium*, *Coscinodon*, *Jaffueliobryum*, and L. V. Bardunov (1974) - 22 species of the same genera.

Between 1989 - 1993 the senior author collected in Altai a lot of specimens. In addition, he received abundant collections of bryophytes from the Altaian State Reserve, made mostly by N. I. Zolotukhin. These materials and also a revision of other collections in herbariums allow the present additions of two genera, *Hydrogrimmia* and *Indusiella*, and 7 species of Grimmiaceae new to Altai.

In recent years both *Grimmia* and *Schistidium* (Deguchi, 1979a; Cao Tong & Vitt, 1986), *Jaffueliobryum* (Churchill, 1987) and *Racomitrium* (Frisvoll, 1983, 1988) were carefully taxonomically revised. The purpose of this paper is to concentrate mainly on the variability of some species observed in Altai, to provide data on their ecology and distribution in Altai, as well as to discuss some neglected and underestimated taxonomic characters.

GRIMMIACEAE (description based on Altaian representatives)

Plants small to robust, in dull, dark cushions, tufts or mats, typically becoming black with age, especially in lower parts of plants. Stems erect to ascending, rare prostrate, forked or fascilulately branched, with rhizoids mostly only at base. Leaves spirally arranged, more or less erect when dry, rarely crisped, fastly reflexing when wetting, but soon afterward becoming less reflexed, spreading, lanceolate, rare to ovate, usually entire, with plane or recurved, rare incurved margins, keeled or rarer concave, with more or less developed hyaline hair-point. Costa

[1] - Main Botanical Garden of Russian Academy of Sciences, Botanicheskaya 4, Moscow 127276 Russia - Россия 127276 Москва, Ботаническая 4, Главный ботанический сад РАН.

[2] - Institute of Applied Ecology of Academy of Sinica, P. O. Box 417, Shenyang, China

single, strong, with more or less homogenous cells on cross section. Upper cells usually small, isodiametric, with thick walls, basal cells tending to rectangular. Cell walls variously thickened, straight, sinuose to nodulose. Dioicous or autoicous. Seta terminal or lateral, erect or arcuate-geniculate, long to very short. Capsulae exserted to immersed, oblong-cylindric, ovoid or subglobose, erect, rarer pendulous. Columella persistent or systylious. Annulus present or absent. Operculum conic, variously beaked to rostrate. Peristome usually present, single, consisting of 16 teeth, free or a little fused at insertion, entire to variously cleft and perforated above, often with orange-reddish coloration, usually densely papillose on inner surface, and densely papillose to smooth on outer surface. Outer plates of peristome teeth much thicker than inner plates. Calyptra mostly small, cucullate, sometimes mitriform, rarer campanulate, smooth, rarer longitudinally plicate, naked. Spores sperical, smooth to weakly papillose, mostly small, 7-19 μm. - The family includes about 10 genera, three of which are large, widespread and well-known, *Grimmia*, *Schistidium* and *Racomitrium*. Typically saxicolous plants, growing in cold to temperate climates. Many species are well adapted to xeric conditions. Most of Altaian species have wide Holarctic or nearly worldwide distribution.

KEY TO THE ALTAIAN GENERA OF GRIMMIACEAE

1. Plants very small, rigid, dull-brown; leaves with sheathing base and strongly inrolled upper margins, muticous; capsula exserted ..... *Indusiella* (p. 68)
1. Plants otherwise 2
2. Calyptra large, campanulate to mitriform, longitudinally plicate; capsulae deeply immersed; peristome cribrose to strongly cribrose; small plants 3
2. Calyptra cucullate or mitriform, smooth; capsulae immersed or exerted; peristome entire to slightly perforated and cleft above; small to robust plants 4
3. Plants in dense whitish cushions; leaves broadly ovate to suborbicular, with a hyaline margin of several rows of thin-walled cells in upper part; calyptrae covering most of the urn ... *Jaffueliobryum* (p. 70)
3. Plants in moderately dense bluish-green cushions; lower leaves lanceolate and strongly plicate, upper and perichaetial leaves plane, ovate; calyprtae mitriform...*Coscinodon* (p. 74)
4. Plants soft, leaf laxly areolated, upper leaf cells ca.20 μm .... *Hydrogrimmia* (p. 103)
4. Areolation otherwise, upper leaf cells thick-walled and small, 6-12 μm 5
5. Basal cells long linear with nodulose lateral walls; usually robust plants with numerous abbreviated branches ..... *Racomitrium* (p. 115)
5. Basal cells short or long rectangular, with straight to sinuose walls; mostly medium size, sometimes robust plants with forked branches 6
6. Opercula falling with the attached columella; calyptra covering only a part of operculum; capsulae immersed, rare emergent (*S. agassizii*); leaves mostly ovate to ovate-lanceolate, with quadrate cells reaching the base along leaf margins ...*Schistidium* (p. 106)
6. Opercula falling detached from the columella; calyptra covering operculum and a part of urn; capsulae in most species exserted (immersed in *G. anodon, G. plagiopodia, G. pilifera, G. tergestina*); leaves lanceolate to ovate-lanceolate, with quadrate cells in its upper part and rectangular at base (quadrate cells rarely reaching the base) ..... *Grimmia* (p. 76)

Indusiella Broth. et C. Muell. in Broth.

Plants very small, in dense, dark-brown, opaque cushions. Stem with central strand. Leaves muticous, from a sheating base with lanceolate upper lamina with strongly involute to inrolled margins. Upper lamina bistratose, with adaxial cells larger than abaxial cells. Basal cells quadrate or subquadrate. Costa strong, ending below the apex, not apparent in upper part of strongly inrolled leaves. Autoicous. Archegonia at stem apex, with funnel-like and strongly cuspidate mouth. Capsula exserted, small, ovoid. Peristome irregularly divided and perforated above, densely papillose. Annuli of 1 row of moderately thick-walled cells. Operculum with long beak. Calyptra campanulate, longitudinally plicate, lobed at base.

Indusiella thianschanica Broth. et C. Muell. in Broth., Bot. Centralbl. 75: 322. 1898. Fig. 1.

Stem up to 5 mm high, with a sharply differentiated cortical region of 2 layers of transversely rectangular cells. Leaves 1.0 mm long. Upper lamina cells dimorphous: cells on abaxial (dorsal) side 10-12 μm, while those on adaxial (ventral) side larger, 18 μm wide in median part, ca. 12 μm towards the margin. Basal cells at margin quadrate to very short-rectangular (1.5:1). Cells in paracostal area wider but of the same length and therefore, transversely rectangular. In uppermost and perichaetial leaves basal cells short-rectangular (2:1). Autoicous. Seta straight, ca.

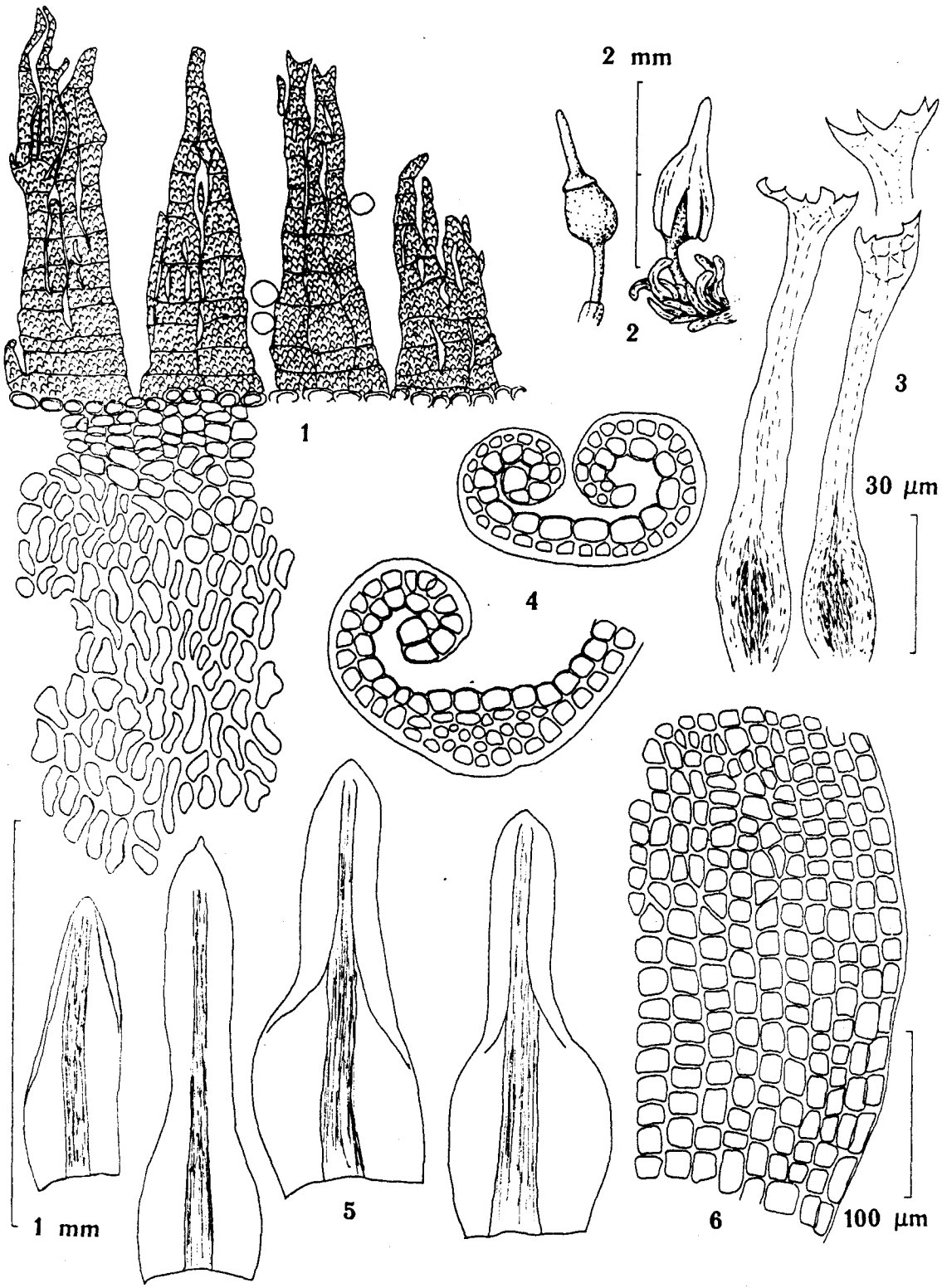


Fig. 1. *Indusiella thianschanica* Broth. et C. Muell. in Broth.. (from *Tabozhok Creek, 8 km upstream* 2100 m Ignatov 30/24): 1 - peristome teeth; 2 - capsulae; 3 - archegonia; 4 - leaf cross sections; 5 - leaves; 6 - cells of leaf base. Scale bars: 2 mm - for 2; 1mm - for 5; 100 μm - for 1, 4, 6; 30 μm - for 3.

1 mm long. Capsula 0.7 mm long, exothecial cells below the mouth transversely elongated, variously irregular below. Peristome teeth reddish, lanceolate 0.15 mm tall. Spores 9-12 μm, yellow-brown, more or less granulate.

The peculiar inrolled leaves make *Indusiella thiansshanica* an unmistakable moss. Other useful recognizing features in the field include: 1) very small plants in dense dull-brown tufts; 2) calyprta totally covering the capsulae, deeply plicate; 3) sporogones (both calyptra and capsula) are very small (smaller, probably, than in any other Altaian mosses), slightly exserted from the perichaetia. An interesting feature which we never observe in the other mosses is the funnel-like and sharply toothed mouth of arhaegonium in the present species.

Distribution: The world distribution of *Indusiella thianschanica* is discussed and mapped by Murray (1984). It includes Alaska and xeric regions of Southern Siberia (at 1200 - 2100 m), Mongolia (including Mongolian Altai), China (Nei Monggol, Xinjiang, Tibet), Tian-Shan Mountains in Middle Asia, Dagestan (the only locality in Caucasus), and Chad in Africa. Probably, South Siberia with neighboring Mongolia and North-West China represent the territoriy where *Indusiella* occurs rather regularly in all appropriate habitats. The distribution within the former USSR was mapped by Mamatkulov (1988), and in Mongolia by Abramov & Abramova (1983). In Altai *Indusiella* was found only once from Kuraiskij Mt. Range, growing on shaded rocks (red-brown clayish schists) in a narrow canyon of a small dry stream in the steppe/semi-desert zone.

Specimens examined: Tabozhok Creek, 8 km upstream 2100 m (30/24).

Jaffueliobryum Thér.

Plants small, in dense cushions. Stem with well defined central strand, julaceously foliated. Leaves broadly ovate to obovate, concave, with differentiated base consisting of thin-walled cells; margins entire or eroso-serrate in upper lamina. Costa narrow, percurrent. Hyaline hairpoint smooth, long (1/2 to 2 lamina lenth), slightly flexuose. Upper lamina cells quadrate or shortly rhombic, with the cell walls especially thick on the abaxial surface. Marginal leaf cells elongate, sometimes hyaline, forming more or less distinct border. Basal cells shortly rectangular. Autoicous. Perichaetial leaves more or less enlargened, with longer hairpoint. Seta in most species shorter than urn. Capsula broadly ovoid. Peristome teeth highly perforate, papillose. Annulus of 2-3 rows of cells. Operculum short-rostrate. Calyptra campanulate, plicate. Spores sphaerical, granulate.

Jaffueliobryum latifolium Lindb. et H. Arnell ex Thér., Rev. Bryol., n. ser, 1: 193. pl. 8, f. 3. 1928. Figs. 2-4.

Cosconodon latifolium Lindb. et H. Arnell, Kongl. Vetensk. Acad. Handl. 23: 99. 1890, nom. illeg., non (Schwaegr.) De Not., 1836.

Plants small, in dense whitish-brown cushions in several mm above the substrate. Stems 0.5-1 cm long, moderately branched, subjulaceous, with a well developed central strand. Leaves imbricate, concave, obovate-ovate, broadly acute, 0.3-0.8 mm long (without hairpoint), 0.2-0.6 mm wide. Basal portion of lamina well differentiated in areolation and being plane. Costa percurrent, more or less protruded on the abaxial leaf. Hyaline hairpoint about 0.5-0.8 of the leaf length, often decurrenting along upper lamina forming hyaline margins. Upper lamina cells quadrate to shortly rhombic, sometimes irregularly polygonal, 8-10 μm long, 6-8 μm wide, with thick lateral walls; abaxial cell walls are much thicker than adaxial walls. Cells in hyaline margins elongate, up to 5:1, narrowly triangular in cross section. Basal leaf cells both at marginal and paracostal areas are thin walled, rectangular, 20-30 μm long and 10-15(20) μm wide. Autoicous. Perichaetial leaves about 3 times larger, with upper quarter to half composed of hyaline cells. Seta straight, ca. 0.3 mm long. Capsula erect, immersed, ovoid, ca. 0.8 mm long, with rugose exothecium due to the presence of irregularly, but in general, longitudinally oriented groups of narrow cells with thick walls. Peristome teeth triangular in outline, strongly perforated, apparently composed of a number of independent and strongly papillose shoulders which do not connect with each others in the upper part (in fact hanging on the thin hyaline inner peristome layer). Annulus of 3 rows of thick-walled, rounded cells. Operculum conic, with short obtuse beak. Calyptra large, companulate, longitudinally plicate, flanked by the deep, broad lobes at base. Spores 7-9 μm, finely papillose.

Once seen, this species is impossible to be confused with any species of mosses. Even in the field it is easily recognized by the very small plants forming dense cushions and with numerous large golden calyptras. Superficially, it somewhat resembles *Bryum argenteum* which grows in the same habitat, sometimes even intermixed with it. The always present sporogones distinguish *Jaffueliobryum* at once from the *Bryum*.

The genus *Jaffueliobryum* has been given five species by Thériot (1928). Only *J. austinii* from Mexico is well differentiated by an exserted capsula. The status of the other four species remains more or less disputable. They are the

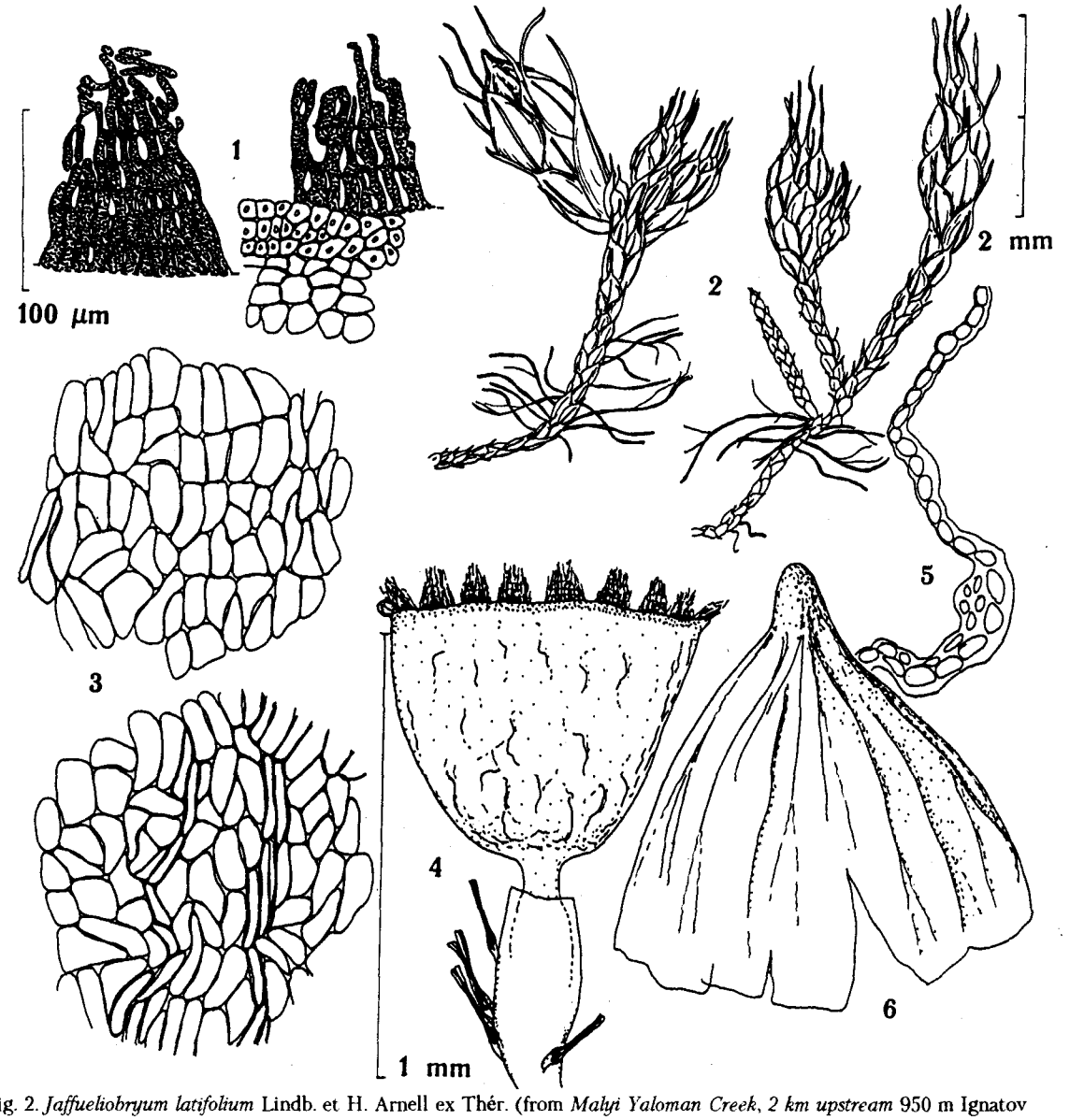


Fig. 2. *Jaffueliobryum latifolium* Lindb. et H. Arnell ex Thér. (from *Malyi Yaloman Creek, 2 km upstream* 950 m Ignatov 25/173): 1 - peristome; 2 - habitus; 3 - exothecial cells; 4- capsula; 5 - calyptra cross section; 6 - calyptra. Scale bars: 2 mm - for 2; 1 mm - for 4, 6; 100 μm - for 1, 3, 5.

North American *J. wrightii* and *J. rauii*, the Bolivian *J. marginatum*, the South Siberian+Mongolian+Chinese *J. latifolium*. In Russian bryological literature this latter species was reported as *Coscinodon latifolium* (Lindberg & Arnell, 1890; Krylov, 1925) or *Jaffueliobryum latifolium* (Savicz-Ljubitskaya & Smirnova, 1970; Bardunov, 1969, etc.). Also this name was used for the Mongolian materials (Abramov & Abramova, 1983). In China, Cao & Gao (1985) at first identified the Tibetan plants as *J. marginatum*, but later Cao & Gao (in press), following Churchill (1987) revision, attributed all Asian collections of *Jaffueliobryum* to *J. wrightii*. In his revision, Churchill (1987) had synonymized *J. latifolium* and *J. marginatum* with *J. wrightii*. Recently Murray (1992) studied again the taxonomy of *Jaffueliobryum*. She disagreed with the synonymization of *J. latifolium* and *J. marginatum* with *J. wrightii*, but admitted the identity of the two former species. However, *J. marginatum* of Bolivia known so far only from too small specimen (Murray, pers. corr.). Murray (1992) also reported a new undescribed species from Alaska. Based on the collection of Weber & Krasnoborov (B-65165), Murray (l.c.) re-

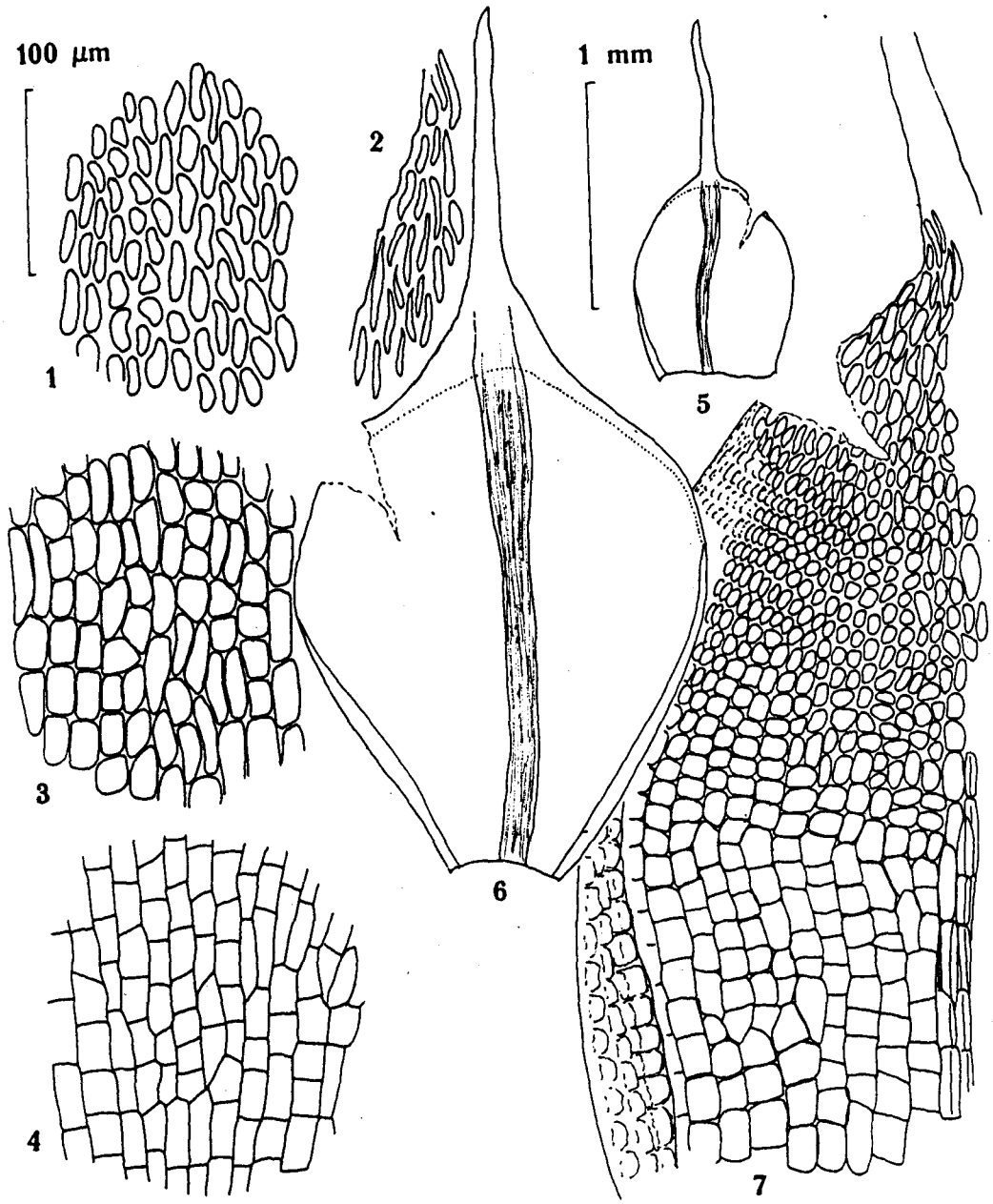
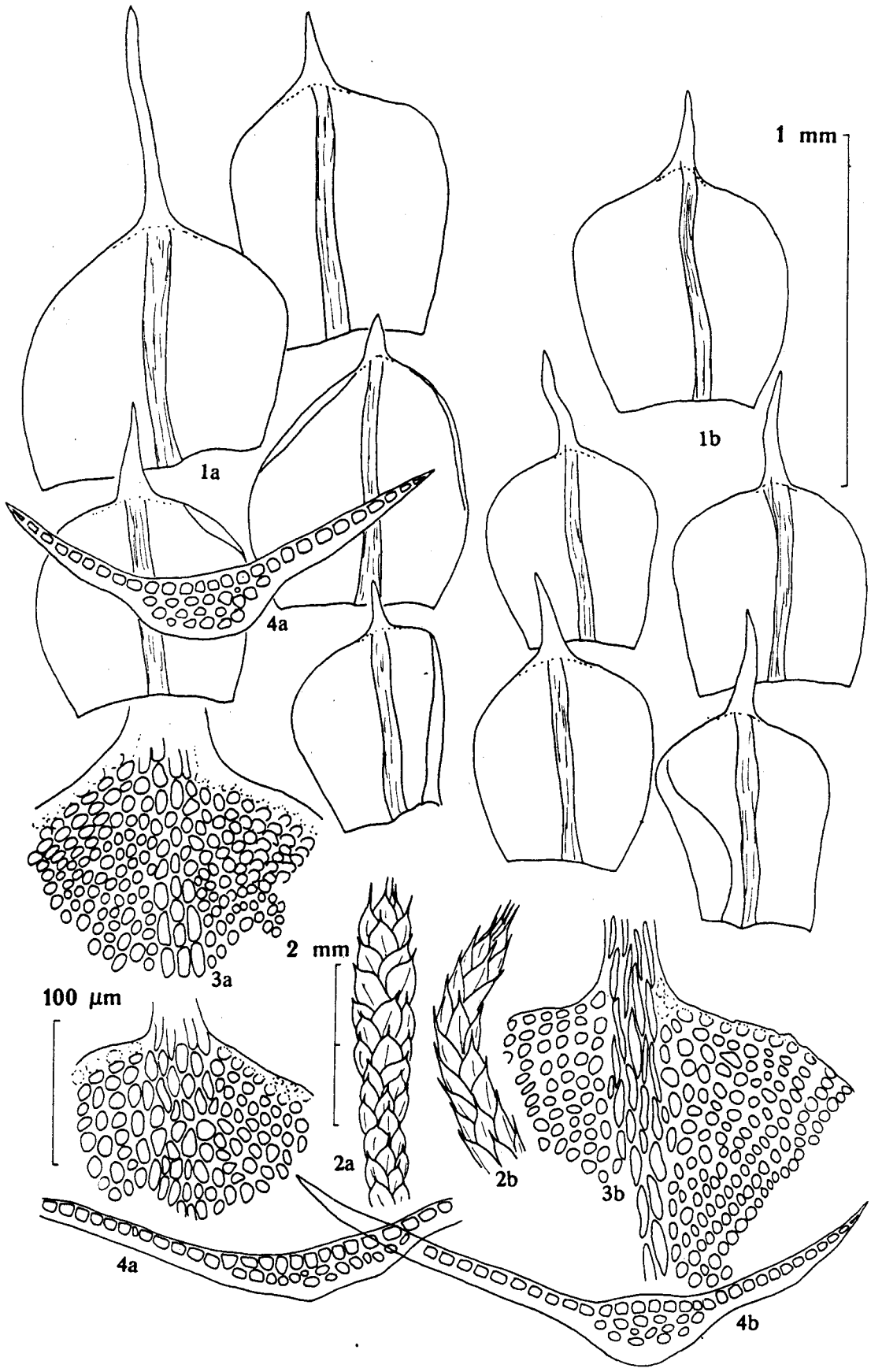


Fig. 3. *Jaffueliobryum latifolium* Lindb. et H. Arnell ex Thér. (from *Malyi Yaloman Creek, 2 km upstream* 950 m Ignatov 25/173): 1 - upper lamina cells; 2 - upper marginal cells; 3 -middle leaf cells; 4 - basal cells; 5, 7 - stem leaves; 6 - perichaetial leaf. Scale bars: 1 mm -for 5, 6; 100 µm - for 1, 2, 3, 4, 7.

Fig. 4. (right) *Jaffueliobryum latifolium* Lindb. et H. Arnell ex Thér. (*a - from Eastern Mongolia, Az-Ula, 45° 10' N, 114° 34' E, Gubanov 26.VII.1991, MHA; *b - from *Malyi Yaloman Creek, 2 km upstream* 950 m Ignatov 25/173): 1a, 1b -leaves; 2a, 2b - habitus; 3a, 3b - upper leaf cells; 4a, 4b - leaf cross sections. Scale bars: 2 mm - for 2a, 2b; 1 mm - for 1a, 1b; 100 µm - for 3a, 3b, 4a, 4b.

ported *J. wrightii* as a second species for the Altai. Authors of this paper are not in full agreement about the status of *J. latifolium*. The first author accepted its specific rank, while the second agree with Churchill (1987). Below discussion on this species reflect the former point of view.

In his study, Churchill (1987) saw only 9 Asian specimens. He stated that they are different from the North American plants in being smaller, with shorter hairpoints, more developed hyaline margins and a strongly demarcated leaf


1 mm
1a
1b
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3a
2 mm
100 μm
2a
2b
3b
4a
4b

base. Since in some North American collections could be found similar forms, Churchill concluded that these are not enough differences for a separate specific recognition. We have seen about 70 herbarium collections of Asian *Jaffueliobrium* and also field observations were made in Altai where this species is locally fairly common. Admittedly, we have not examined numerous North American collections, but what we saw originated from different states (Arizona, Texas, and Minnesota, specimens in MHA, LE). These specimens agree well with the description of American materials in the literature (Churchill, 1987; Crum & Anderson, 1981; Lawton, 1971; Flowers, 1983). We concluded that nothing similar to North American materials was observed in Asian *Jaffueliobryum*. To the characters mentioned by Churchill should be added some differences in the growth habit. In *J. latifolium*, the very dense cushions appear in herbarium packet as a number of soil pieces from which solitary shoots do not break off. In contrast, in all American materials numerous separated shoots were seen in most collections. Such character is due to the more abundant rhizoids at base of *J. latifolium* than in *J. wrightii* and also due to more extensive branching. The cushions consist of mostly very small sterile shoots among which are scattered conspicuous rosettes of perichaetial leaves which are three times bigger than stem leaves and are hyaline in upper quarter (or sometimes in upper half). In *J. wrightii*, the proportion of fertile/sterile shoots is higher and the perichaetial leaves are not so suddenly enlarged in comparison with the leaves below (cf. figs. 21 and 25 in Churchill, 1987). Leaf hairpoints on sterile shoots are also longer, making the cushions look homogenous and without at once seeing the sporogones.

Jaffueliobryum latifolium is morphologically fairly uniform in Altai and Sayan mountains, and agrees completely with the original material (Sahlberg, Krasnojarsk, 56° N, H. W. Arnell, lectotype H, not seen, isotypes LE!, NY!). Specimen of Weber & Krasnoborov B-65165 (cited by Churchill as Elias & al. B-65165) has a little longer hairpoints, but does not exceed the variation of Altaian populations. However, collections from Baikal area, Transbaikalia, and especially from the Eastern part of Mongolia, look different. They have rather short hairpoints and a more inflated (tumid) appearance of foliated stem, due to more concave leaves (better seen in wet condition, but hard to observe in two-dimentional geometry on a slide, Fig. 4). Other differences include: (1) cells of the costa in the uppermost part of the abaxial surface (in specimens from western end of the range, these leaf cells are short-rectangular, while those in the eastern end of the range are elongate; (2) hairpoint seen in western populations is longer and more widened toward the base than their eastern counterparts; (3) abaxial surface of leaf costa forming more sharp angle among individuals of western populations. However, all these differences between the two forms are connected by intermediate forms.

Distribution: The range of *Jaffueliobryum latifolium* includes China, Mongolia, and the south facing mega-slopes of mountains in Southern Siberia and extends eastward to Transbaikalia to about 120°E (map of Mongolian distribution is in Abramova & Abramov, 1983; for Siberian distribution - in Bardunov, 1992). In Mongolia, *J. latifolium* occurs in most part of the country, eastward to "External Mongolia" (115°E, Gubanov's collections in MHA), reaching mountains at 3000 m alt. In China *J. latifolium* is known from Xizang (Tibet), Xinjiang and Inner Mongolia (Cao & Gao, in press). In Altai it is very frequent in xeric parts of Central Altai and South-East Altai (450 to 2450 m). It is totally absent in the basin of Biya River. Along Katun River it reaches the mouth of Aedigan Creek, being absent further downstream where climate becoming wetter. Only one isolated population in very small quantity was found on the south-facing rock outcrops near Gorno-Altaisk. The distribution of this species could be interpreted as being restricted to the areas with annual precipitation lower than 300 mm. In wetter areas it is nearly totally absent, while very nearby is very common across a wide range of habitats (rocks outcrops, soil among rocks, and alone boulders) and always with numerous sporogones.

Specimens examined: *Aedigan* 600 m (34/134); *Aedigan Creek, 5 km upstream* 600 m (34/26); *Bijka Creek, 2 km upstream along Katun* 450 m (34/53); *Chagan-Uzun Creek* 1700 m (Bardunov 23.VII.1966 IRK!); *Chuya Riber , lower course* 800 m (Weber & Krasnoborov B-65165 MO!), *Gorno-Altaisk (SE edge)* 550 m (23/10); *Malyi Yaloman* 700 m (25/127); *Malyi Yaloman Creek, 2 km upstream* 850 m (25/43); 950 m (25/173); *Malyi Yaloman Creek, 8 km upstream* 1100 m (25/107); *Tabozhok Creek, 8 km upstream* 2000 m (30/21; 30/23); 2250 m (30/22); *Toshak Creek* 1980 m (36/114).

Coscinodon Spreng.

Plants small, in dense hoary cushions. Stem with central strand. Leaves lanceolate, keeled, strongly

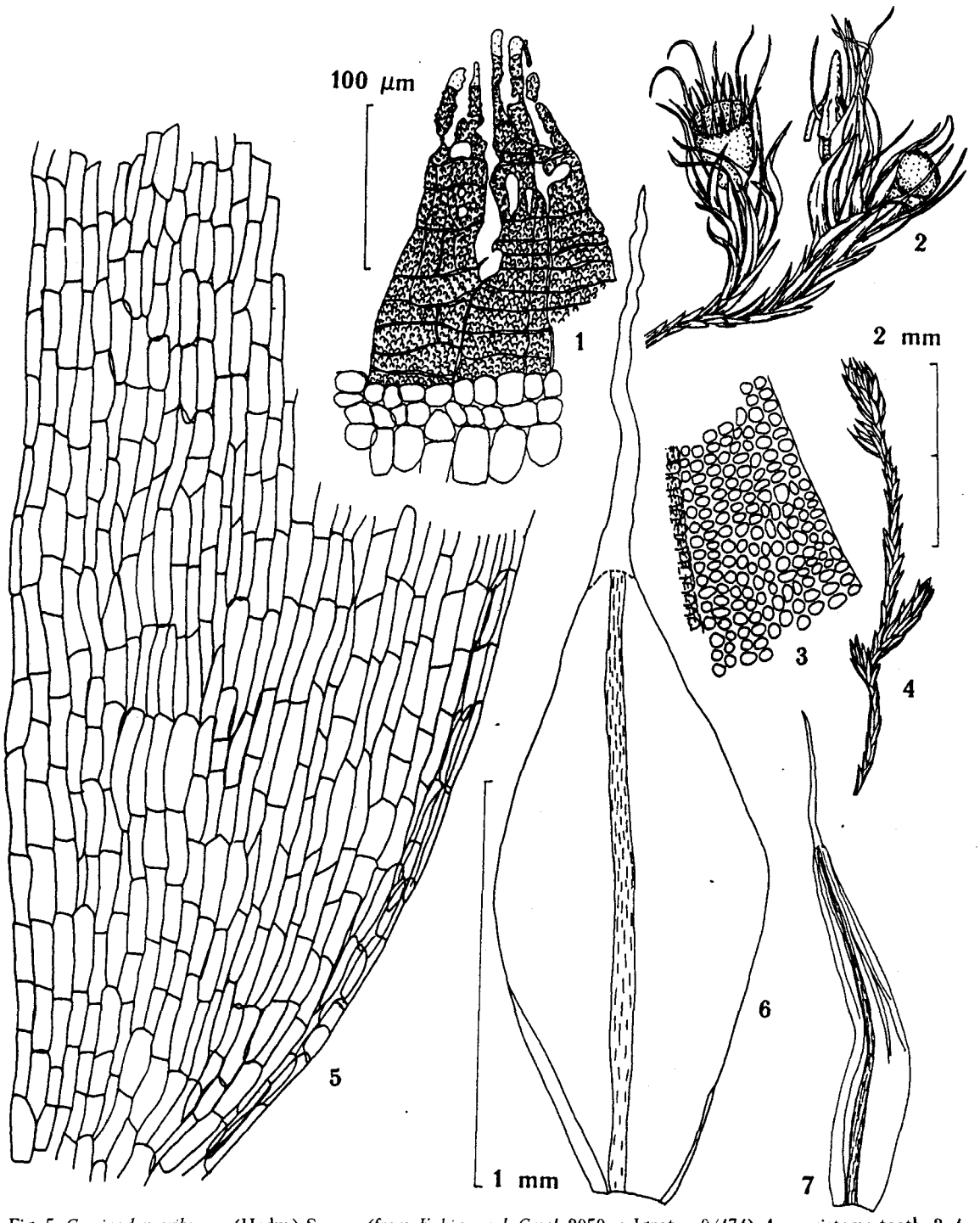


Fig. 5. *Coscinodon cribrosus* (Hedw.) Spruce (from *Kobiguayuk Creek* 2050 m Ignatov 0/474): 1 - peristome tooth; 2, 4 - habitus; 3 - upper lamina cells; 5 - basal cells of upper leaf; 6,- perichaetial leaf; 7 - stem leaf. Scale bars: 2 mm - for 2, 4; 1 mm - for 6, 7; 100 μm - for 1, 3, 5.

plicate, the plicae bistratose. Costa percurrent. Hyaline hairpoint long, narrow, smooth, somewhat flexuose. Upper lamina cells small, isodiametric. Basal cells at margin short rectangular, with incrassate transverse walls, becoming longer in paracostal area. Dioicous. Perichaetial leaves much larger, not plicate, with basal half consisting of thin-walled, rectangular cells throughout. Seta 0.5-1 mm long, straight. Capsula immersed or emergent. Peristome teeth more or less perforated. Annulus absent. Operculum rostrate. Calyptra mitrate, covered about a half of capsulae, longitudinally plicate. Spore smooth.

Coscinodon cribrosus (Hedw.) Spruce Ann. Mag. Nat. Hist. ser. 2 3: 491. 1849. Fig. 5.

Grimmia cribrosa Hedw. Sp. Musc. Frond. 76. 1801

Plants in dense cushions, bluish-green above, blackish below. Stem 0.5-1 cm. Leaves 1.0-1.5 mm long. Hyaline hairpoint in middle leaves about 1/4-1/2 of their length, in upper leaves nearly as long as the lamina. Upper lamina cells isodiametric, 6-9 μm, basal cells rectangular at paracostal position, quadrate in several rows along the margins; at the ultimate margin of larger leaves, there is 2-3 rows of elongated cells. Perichaetial leaves up to 3-4 times larger than stem leaves. Seta 0.5-1 mm long. Capsula ca. 1 mm. Peristome teeth papillose, reddish brown. Spores 12-15 μm.

The distinguishing characters of *Coscinodon cribrosus* include the specific bluish color, strongly plicate leaves on both sides of costa, rather small plant size with immersed capsulae, more or less cribrose peristome, and obviously plicate calyptra. Despite its dioicous condition, most of Altaian collections are with sporogones. Young cushion of this species, however, can be confused with *Grimmia caespiticia* which also have small plants with strongly plicate leaves. However the latter species have quadrate lamina cells reaching the base in stem leaves; the perichaetial leaves have several rows of rectangular and rather thin-walled cells at the base, but this area is much smaller than in perichaetial leaves of *C. cribrosus*. Another difference between *C. cribrosus* and *G. caespiticia* is the cortical layer of the stem (of 1-2 row in *C. cribrosus*; undifferentiated in *G. caespiticia*).

Distribution: Despite its wide distribution throughout the Holarctic, this species is probably nowhere common. A beautiful illustration of this was given by Steere (1978) who had shown on the map of North America only few dots representing the exceedingly random distribution of *C. cribrosus*. In Western Europe *C. cribrosus* is known in many countries where it is confined mostly to mountain areas. In former USSR, it was found in most mountain systems: Carpatians, Khibiny (on Kola Peninsula), Polar Urals, Caucasus, Krym (Crimea), mountains of Middle Asia, Altai, near Krasnoyarsk in Upper Yenissei, mountains of Baikal Area and also from the Beringian and Siberian (Yakutian) Arctics and mountains of Russian Far East. Also *C. cribrosus* is known from Mongolia (including the Mongolian Altai), China (Taiwan), Japan, Himalayas, and northern Africa. In Altai *C. cribrosus* was reported by Krylov from Manzherok at about 300 m alt. It was collected tree times by the senior author from subalpine zone near the tree line on highly acidic, often wet (after everyday rains) rocks in association with *Grimmia donniana, G. affinis, G, elatior, G. funalis.*

Specimens examined: Bogoyash Creek 2400 m (36/444), *Kayakkatuyarykskij Creek* 2100 m (7/109); *Kobiguayuk Creek* 2050 m (0/474).

Grimmia Hedw., Spec. Musc. Frond. 75. 1801.

Plants small to robust, green to yellowish-green above, dark-brown to black below, in dense or loose cushions or tufts. Stem with or without central strand, moderately irregularly branched. Leaves imbricate to contorted when dry, erect- spreading when moist, ovate, lanceolate to narrow-lanceolate, keeled or concave, with hyaline hairpoint or, rarer, muticous; leaf margin recurves, plane or incurved. Costa strong, percurrent, terete or at times, flattened, in cross section consisting of nearly homogeneous cells. Upper lamina cells bi- or unistratose, small, isodiametric, with more or less incrassate walls; middle leaf cells also isodiametric, with variously incrassate walls; basal cells larger, quadrate and short-rectangular with straight wall to long rectangular and narrow linear with straight or sinuose (rarely to nodulose in paracostal area) walls. Autoicous or dioicous. Perichaetial leaves more or less enlarged, with basal margins often composed of relatively thin-walled cells. Seta straight or geniculate, in latter case turning capsulae to horizontal or pendent when moist and young. Capsula ovoid, exserted, emergent or immersed, with persistent columella. Annulus developed, consisting of thick-walled cells in several rows, or undeveloped. Operculum rostrate, beaked or convex. Calyptra cucullate to mitrate. Peristome teeth 16, well-developed, red-brown, bright-red, or yellowish-red, erect or reflexed backward when dry, entire or imperfectly perforated above, papillose on both surfaces, especially in upper part, to nearly smooth below, outer plates thicker than inner ones. Spores small, 7-16 μm, smooth to granulose or finely papillose.

KEY TO ALTAIAN SPECIES OF *GRIMMIA*

1. Capsula immersed in perichaetial leaves, seta shorter than urn 2
1. Capsula exserted or emergent, seta longer than urn or plants without sporogones 5
2. Leaves narrowly lanceolate, 4 or more times longer than its width, gradually tapered, keeled above, with recurved margins ..... *G. pilifera* (p. 78)
2. Leaves broadly lanceolate, length to width ratio less than 4, concave, margins plane or incurved 3
3. Robust plant of 2-4 cm high; leaves obviously concave, at apex more or less obtuse,

most of leaves with long, nearly smooth, hyaline hairpoint; perichaetial leaves with a broad hyaline border ... *G. tergestina* (p. 96)

3. Plants low, rarely taller than 1 cm; leaves in upper part obviously keeled, at apex broadly triangular, only upper leaves with developed hyaline hairpoint which is markedly widened toward the base; middle stem leaves much smaller than perichaetial leaves and often muticous 4
4. Peristome present, leaf margin unistratose ..... *G. plagiopodia* (p. 93)
4. Peristome absent, leaf margin bistratose ..... *G. anodon* (p. 95)
5. Leaves muticous, cucullate at apex ..... *G. unicolor* (p. 103)
5. Leaves with hyaline hairpoint; some species (especially *G. incurva*) have also muticous forms under unfavorite conditions, but in these forms, the apex is filled by the broadened costa and is not obviously cucullate . 6
6. Leaves strongly longitudinally plicate, small alpine plants ..... *G. caespiticia* (p. 85)
6. Leaves plane or slightly plicate above 7
7. Leaves broad, length to width ratio less than 4:1, margins plane or incurved 8
7. Leaves lanceolate, length to width ratio more than 4:1, margins recurved or rarely, plane to incurved (*G.ovalis, G. montana* and *G. donniana*) 11
8. Lamina bistratose and not transparent above, leaves broadly rounded at apex with long hairpoint 9
8. Leaves unistatose and transparent above or bistratose only at margin, leaves obtuse to broadly acute, keeled above 10
9. Perichaetial and uppermost stem leaves with thick-walled cells reaching the margin at base, awn coarsly serrate; julaceous innovations with small, rounded leaves often present; sporogones exserted .... *G. laevigata* (p. 90)
9. Perichaetial and uppermost stem leaves with broad pale margin at base, composed of thin-walled hyaline cells; sporogones immersed ..... *G. tergestina* (p. 92)
10. Leaf margin bistratose ... *G. anodon* (p. 95)
10. Leaf margin unistratose ..... *G. plagiopodia* (p. 93)
11. Plants with thread-like young slender shoots, bearing small cymbiform and carinately muticous leaves; leaves more or less spirally twisted, often with long hairpoint ..... *G. funalis* (p. 101)
11. Plants otherwise 12
12. Robust plants, with typically arcuate stem of 2-6 cm high, and leaves 3-4 mm long, bistratose in upper lamina with a 3-5-stratose margin; costa at back and cells of upper lamina more or less papillose; seta geniculate; capsula horizontal to pendent, ribbed ..... *G. elatior* (p. 97)
12. Less robust plants, upper lamina at the margin 1-2-stratose, cells smooth 13
13. Leaves with plane margins (rarely slightly incurved) at upper part of leaf; quadrate cells of lamina reaching nearly the leaf base along the margin (or submarginal zone) 14
13. Leaves with obviously recurved margin on one or both sides, or rarely, with plane margins, but then basal cells rectangular (*G. donniana*) 17
14. Robust to medium sized plants, 1-3 cm high, central strand is well-developed; capsulae well exserted, operculum long-rostrate; widespread in all vegetational zones ..... *G. ovalis* (p. 89)
14. Small plants, 0.5-1 cm high; capsulae emergent to slightly exserted, operculum with short beak 15
15. Leaves linear-lanceolate, costa fills up most of the upper lamina, muticous or with very short hyaline hairpoint .... *G. incurva* (forma) (p. 97)
15. Leaves lanceolate to ovate-lanceolate, costa does not fill up upper lamina 16
16. Basal cells quadrate at margin and elongate in paracostal area; stem without or with a weak central strand; dioicous ..... *G. montana* (p. 88)
16. Basal cells quadrate to short rectangular, but practically uniform all across the leaf base; central strand well-developed; autoicous, often with emergent brownish capsula with obtuse beak; alpine plant ..... *G. alpestris* (p. 85)
17. Plants up to 4 cm high, with linear-lanceolate leaves, crisped and contorted when dry; cells at leaf base near the costa narrow-linear, with nodulose longitudinal walls; capsulae on arcuate-geniculate setae which are shorter than perichaetial leaves, ribbed ..... *G. incurva* (p. 97)

17. Leaves straight; basal cells rectangular to linear, with walls straight to sinouse; setae shorter or longer, but always straight 18
18. Rather robust plants with stems 2-4 cm high, leaves ca. 3mm long 19
18. Small, alpine plants, with stems 0.5-1 cm high, leaves ca. 2 mm long 20
19. Stem without central strand; dioicous; capsula immersed, seta shorter than urn ..... *G. pilifera* (p. 78)
19. Stem with a well-developed central strand; autoicous plants, often bearing capsula exserted on long setae ..... *G. affinis* (p. 78)
20. Plants usually of medium size, with stem longer than 1 cm; capsulae well exserted; operculae with long beak; leaves usually recurved at margin on both sides ..... *G. affinis* (form) (p. 78)
20. Plants usually small, with stem shorter than 1 cm; capsulae emergent to shortly exserted; operculae conic-convex, sometimes with short beak; leaves with plane margin or recurved on one side ... *G. donniana* (p. 81)

Grimmia pilifera P. Beauv., Prodr. Aetheogam. 58. 1805. Fig. 6.

Plants robust, in rather loose tufts, dark-green above, blackish below. Stem erect, up to 3 cm high, without central strand. Leaves narrowly lanceolate, 2.5-3.5 mm long, keeled, with recurved margins on both sides. Hyaline hairpoints rather short, 1/8-1/4 of lamina length. Upper lamina bistratose, at least partly, cells about 7 μm; middle lamina cells short, up to 2:1, with incrassate-sinuose walls. Basal cells at margin slightly enlarged, with thin walls; in paracostal area cells elongate with sinuose longitudinal walls. Dioicous. Seta 0.6-1.0 mm, shorter than urn. Capsula immersed, ovoid, 1.5-2 mm long. Peristome teeth erect, lanceolate, reddish-brown, irregularly cleft and perforated above, densely papillose above, sparsely papillose below. Annulus of 2-3 rows of short, thick-walled cells. Operculum with straight or slightly oblique beak. Calyptra mitrate. Spores about 9 μm, granulate.

When it is fertile, the rather robust plant with immersed capsula allows the recognition of *G. pilifera* at once. However, under sterile condition, it can be confused with *G. affinis*. Because of the enormous polymorphism of the latter species in Altai, probably the only reliable difference between the two taxa is the absence of central strand in *G. pilifera*, while it is always readily seen in *G. affinis*. In the field the robust plants with narrowly acute leaves are usually helpful in recognizing *G. pilifera*.

Distribution: This species represents an example of classical disjunction between East Asia and Eastern North America (maps: Iwatsuki, 1972; Ignatov, 1992; for China - Cao Tong & Vitt, 1986). Recently Iwatsuki (1992) excluded it from this pattern group because the species has been found in Western North America in British Columbia. However, the distributional pattern of *G. pilifera* could still be referred to this group in a broader sence as suggested by Ignatov (1993). Asian range of this species lies mostly in eastern China (especially east of hundred meridian), Japan, Korea, and southern part of Russian Far East. In other countries *G. pilifera* is rather rare. It is reported from 1 locality in India (Assam), Pakistan, two places in Mongolia (Abramov & Abramova, 1983) and several localities in Transbaikal Area of Southern Siberia (Bardunov, 1992). In Eastern North America *G. pilifera* is known from many states (southward to Texas), and in Canada, from Ontario. In Altai *G. pilifera* is rare and found so far only in two areas: (1) in high mountains of South-Eastern Altai, in tundra-steppe landscape at 2190-2300 m alt., and (2) in the middle range of Katun River, at 450-500 m alt.

Specimens examined: Bogoyash Creek, upper course 2300 m (3♀/341); *Chemal* 450 m (34/217); *Chemal, 10 km upstream along Katun* 450 m (34/215; 34/97); *Dzhulukul Lake* 2190 m (Zolotukhin 1.VIII.1989); *Kokkul Lake* 2300 m (33/11); *Kuba Creek* 500 m (Makarov 3.VI.1972).

Grimmia affinis Hoppe et Hornsch. ex Hornsch., Flora 2: 85, 443. 1819. Fig. 7.

Plants in dense tufts, yellowish-green above, brown to dark brown below. High alpine forms are totally black. Stem (0.5)1-3 cm high, with central strand. Leaves lanceolate, up to 3-3.5 mm long. Hyaline hairpoint 1/6-1/3 of lamina lenght. Upper lamina cells bistratose, 7-9 μm. Basal cells at margin rectangular, hyaline, with thin longitudinal and somewhat thicker transverse walls, becoming linear at paracostal area, with sinuose walls. Autoicous, with perigonia on separate branches. Seta erect, 2-5 mm long, yellow. Capsula ovoid to cylindric. Peristome teeth yellow-brown to red-brown, somewhat cleft above. Annulus well-developed. Operculum with long to short beak. Calyptra mitriform. Spores 9-12 μm, granulate.

Grimmia affinis in its typical expression is a medium-size plant of dull-green or yellowish-green color. Leaves in dry conditions are somewhat curved with the hairpoints differently oriented. Despite the hairpoints are of average length in the genus, cushions of *G. affinis* do not seem hoary. This character is useful to de-

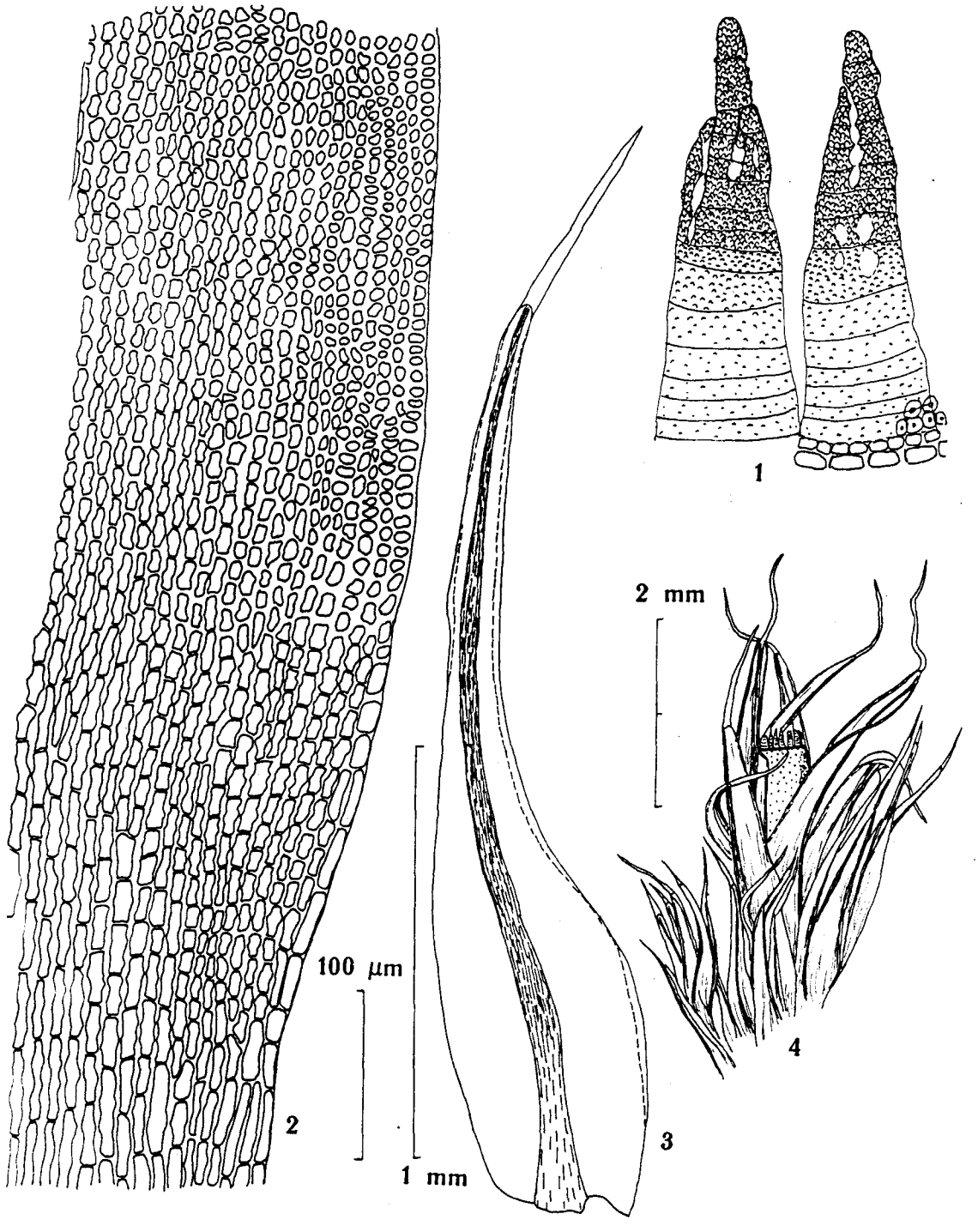


Fig. 6. *Grimmia pilifera* P. Beauv. (from *Dzhulukul Lake* 2190 m Zolotukhin 1.VIII.1989): 1 - peristome teeth; 2 - cells of leaf base; 3 - leaf; 4 - habitus. Scale bars: 2 mm - for 4; 1 mm - for 3; 100 µm - for 1, 2.

limit this species from *G. ovalis* which has leaves closely adpressed with straight, upward orientation in dry condition, making the cushions appear hoary. Leaves of *G. affinis* are sharply keeled in the upper part and recurved usually on both sides at about the middle of the leaf, becoming reflexing when wet. Microscopically *G. affinis* is characterized by a rather prominent narrow area at basal margin where cells are much longer and have thiner walls. Some-

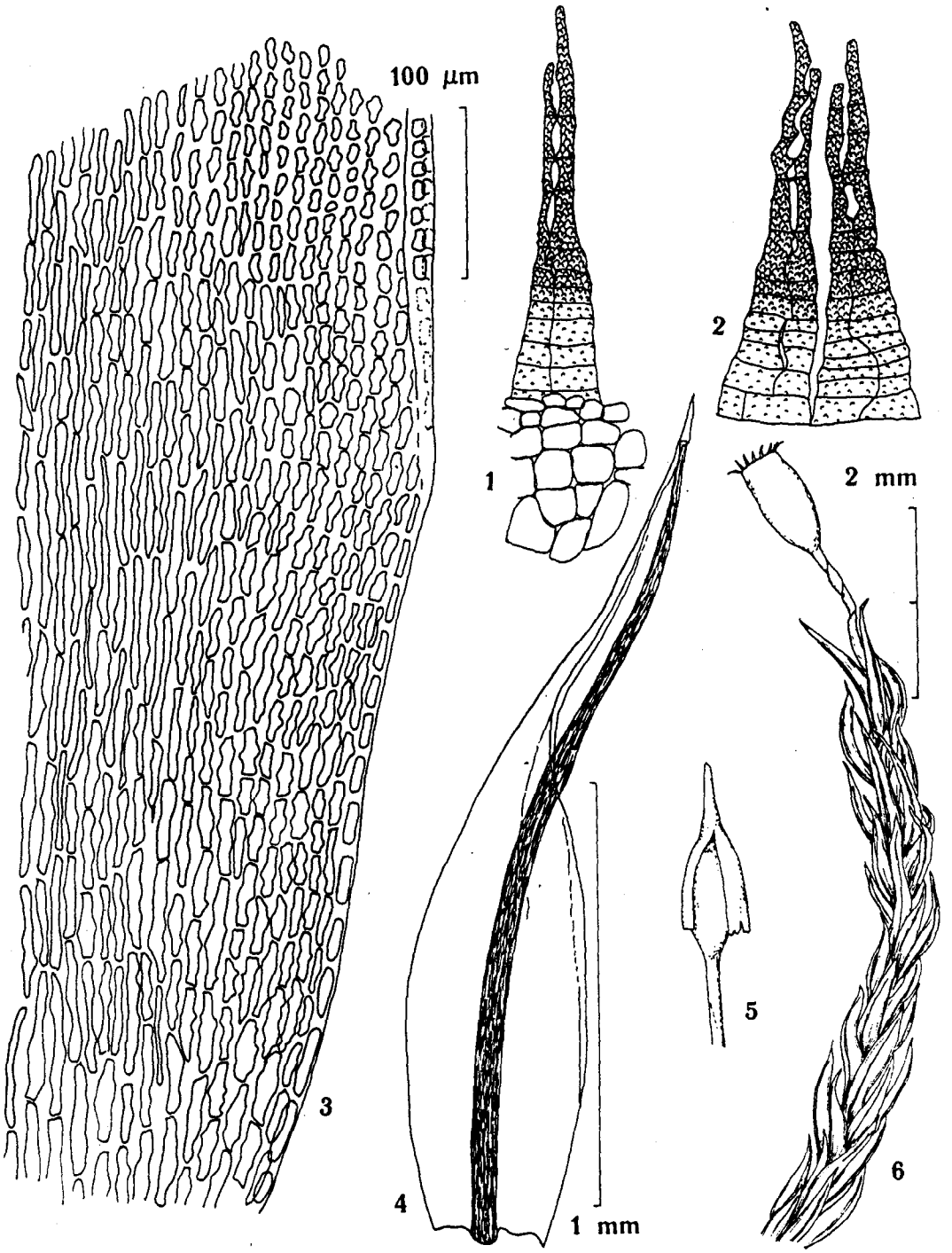


Fig. 7. *Grimmia affinis* Hoppe et Hornsch. ex Hornsch. (from *Kukol* 1750 m Ignatov 0/922): 1, 2 - peristome; 3 - basal leaf cells; 4 - leaf; 5 - capsula; 6 - habitus. Scale bars: 2 mm - for 5, 6; 1 mm - for 4; 100 µm - for 1, 2, 3.

times this area is just of one row of cells, but still it is distinct because of larger cells with relatively thin and straight cell walls. Farther from the margin there is a zone of rectangular to linear cells with thick and more or less sinuous walls which gradually merges into the paracostal zone of elongate-rectangular cells with straight walls.

Grimmia affinis is autoicous and most collection of it are with sporogones, even under

very unfavourite conditions. In alpine zone, capsulae remain juvenille untill the end of summer and therefore only in rare seasons can they become ripen. Perigoniae are situated on branches which are long and have the same appearance as the female axes (stems and some branches). In alpine conditions, however, many junctions of male and female parts of plants are buried and become decomposed, so that plants may seem like dioicous.

The variation of *G. affinis* is rather moderate in the forest and taiga zones, but become considerable above the tree line. Alpine plants are often totally black, sometimes brownish, forming very dense tufts (becoming difficult to pick up from rocks by hands) and showing a reduction of hairpoint to nearly almost muticous condition. Leaves also become smaller and with less recurved margins (the smallest plant could have plane leaf margins). Sporogones are observed in plants growing even on exposed rocks at high elevations (up to 2800 m alt.) where fruiting cushions become far less common than the sterile cushions - the latter, upon examination, consist of only female plants. The distinction of such expression from the *G. elongata* Kaulf., which is so far not seen in Altai, needs further observation. At the same time on less exposed rocks (especially when growing among rocks), *G. affinis* maintains its normal appearance up to nearly its upper distributional limit.

Distribution: Very widespread species, *Grimmia affinis* is known from most regions of the Holarctic. It is present in practically all of the boreal and temperate regions of the former USSR, except the flat lowlands of the Eastern Europe and Western Siberia. It is rather common in Mongolia, in many provinces of China (southward to Yunnan), Japan, New Guinea, Himalayas, Ceylon, Philippines. In North America the species is also widespread, penetrating southward to Guatemala, Costa Rica and Bolivia). In tropical high mountains it is known from Africa too. In Altai and other mountains in Southern Siberia, *G. affinis* is one of the most common species on granites, schists and other rocks in open places and in not very dense forests. It occurs at all altitudes, becoming somewhat rarer only in more xeric areas where *G. ovalis* becomes more common.

Specimens examined: Arsoek Creek (Koroleva 16.VIII.1986); *Artyshtu Creek* 600 m (Zolotukhin 20.IX.1989); *Askat* 1000 m (Zerov 15.VIII.1940 LB!); *Bardaky Lake* 2100 m (11/8); *Bele* 550 m (0/926); *Berekhtuyaryk* 1600 m (0/473; 0/731; 0/920); *Bogoyash Creek, at mouth* 2100 m (Zolotukhin 17.VI.1986); *Bogoyash Creek, upper course* 2350 m (36/330); *Bogoyash Lake* 2965 m (Zolotukhin 18.VI.1986); *Buguzun Creek, at mouth of Sailyugem Cr.* 2100 m (Pavlov V.N. 19.VIII.1993); *Chainary Creek, upper course* 1800 m (34/218); *Chemal* 400 m (29/41); *Chiri* 450 m (17/80); *Chulcha River, in middle course* 1000 m (9/11; 9/30);1100 m (9/166); *Kairu Creek, 8 km upstream* 1000 m (15/36); *Kairu Creek, lower course* 500 m (Zolotukhin 11.IX.1987); *Kairu-Bazhi Peak* 2100 m (13/32; 13/61);2300 m (13/122; 13/79; 13/96); *Kamga Creek, 11 km upstream* 580 m (0/933); *Karakem River, 6 km upstream* 1600 m (0/923); *Kayakkatuyarykskij Creek* 1760 m (8/18), 1800 m (8/178), 1860 m (8/275), 1900 m (8/147; 8/153; 8/284; 8/328; 8/96), 1920 m (3/273; 8/48), 1930 m (3/181; 3/182; 3/247; 3/274; 3/275; 3/290; 7/152), 1950 m (3/111; 8/154), 2000 m (3/132; 3/183; 3/39; 3/67; 8/131), 2050 m (3/100; 3/102; 3/103; 5/14; 7/32; 7/33), 2100 m (4/7; 8/66), 2150 m (4/27), 2200 m (6/15), 2250 m (6/36), 2400 m (7/82), 2450 m (7/80), 2550 m (7/79), 2750 m (7/66), 2966 m (7/55); *Kobiguayuk Creek* 2150 m (0/477), 2200 m (0/728), 2220 m (0/730), 2300 m (0/732), 2350 m (0/948), 2500 m (0/729; 0/924), 2908 m (0/186); *Kobukhtushka* 440 m (0/475); *Kokorya Creek* 2100 m (32/5), 2200 m (32/4); *Kolyushta Peak* 2050 m (Zolotukhin 27.VII.1982); *Kukol* 1750 m (0/472; 0/922; 0/928),1850 m (0/931), 1900 m (0/921),2440 m (Zolotukhin 23.VI.1989); *Kumzir* 450 m (20/11); *Malyi Yaloman* 1100 m (25/129; 25/8; 25/86); *Malyi Yaloman Creek, 4 km upstream* 900 m (25/71); *Malyi Yaloman Creek, 5 km upstream* 900 m (25/59); *Oimok* 1100 m (Zolotukhin 8.IX.1987); *Ok-Porok Creek, at mouth* 450 m (Zolotukhina 30.III.1988); *Seminskij Pass* 1850 m (s.n.; Vysozkaya LB!); *Tabozhok Creek, 12 km upstream* 2200 m (30/43); *Tabozhok Creek, 8 km upstream* 2500 m (30/9); *Tabozhok Creek, upper course* 2400 m (30/8); *Tabozhok Peak* 2200 m (31/8), 2550 m (31/6; 31/7), 2750 m (31/11), 2780 m (31/10); *Tamanel Peak* 1800 m (34/190); *Tokpak Creek, in middle course* 1950 m (36/275); *Toshkalykaya Peak* 2600 m (Zolotukhin 14.VII.1990); *Tura Creek, in middle course* 1300 m (28/12; 28/52), 1650 m (28/11); *Ulagan Pass* 2000 m (Vysozkaya 10.VII.1977 LB!); *Uzunoyuk Creek, upper course* 2400 m (Zolotukhin 9.VII.1990); *Uzuntytygem Creek, upper course* 2400 m (36/350); *Yailyu* 440 m (0/932), 450 m (1/43), 460 m (0/929); *Yakhansoru Lake* 1850 m (Zolotukhin 26.VI.1990), 1940 m (Zolotukhin 26.VI.1990), 2000 m (Zolotukhin 26.VI.1990); *Yazula* 1600 m (0/925).

Grimmia donniana Sm., Engl. Bot. 18: 1259. 1804. Figs. 8-10.

Plants in grayish-green, dense hoary cushions. Stem up to 1 cm high, with central strand. Leaves lanceolate, 1.5-2 mm long, distinctly keeled, with plane or, rarer, recurved margins. Hyaline hair point well developed, between 1/5 to 4/3 of the lamina lenth, decurrenting to the lamina forming a hyaline margin in the upper leaf. Upper lamina cells ca. 10 μm, rounded to quadrate, partly bistratose. Basal cells at margins rectangular (3:1), with thin walls, both transverse and longitudinal. Cells at paracostal area rectangular, with thin transverse and thicker and straight longitudinal walls. Autoicous. Seta yellow-brown 1.6-1.8 mm long. Capsula emergent, ovate to elliptic, yellow-brown. Peristome teeth brownish, papillose throughout, nearly entire to hardly eroded above. Annulus of quadrate, thick-walled cells. Operculum convex, shortly beaked. Calyptra mitriform. Spores 10 μm, finely granulose.

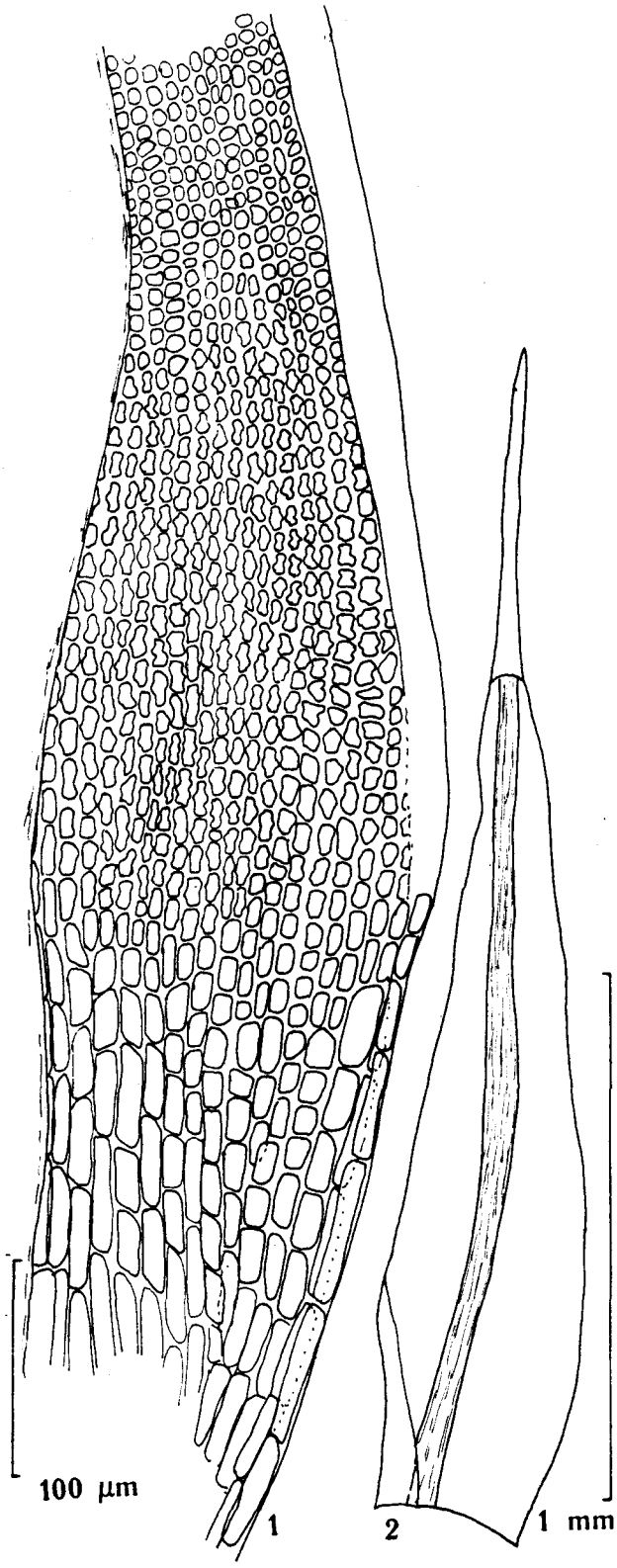


Fig. 8. *Grimmia donniana* Sm. (from Kayakkatuyarykskij Creek 2250 m Ignatov 4/26); 1 - cells of leaf base; 2 -leaf. Scale bars: 1 mm - for 2; 100 µm - for 1.

The conception of *G. donniana* is sufficiently broadened here, since its enormous variability. Plants with relatively narrow leaves, plane margins, highly sinuose cells in middle zone of leaf (as in syntype specimen of *G. donniana*: "Beddgelart, North Wales, col. Turner, BM!) are rare in Altai. Only few specimens, i. e. Ignatov 4/26 (Fig. 8) almost totally agree with the type. Most of specimens from Altai have less sinuose to nearly straight cell walls in middle of leaf, slightly recurved margins and very variable areolation of leaf base. In smaller stem leaves cells along leaf margin are short rectangular, with thicker transversal cell walls. However in larger upper leaves cells along leaf margin are pellucid forming a transparent area of cells with very thin walls; this area contrasting with paracostal cells, also rectangular, but with thicker longitudinal walls. In smaller leaves hair-point is rather short, in upper leaves longer, in ultimate case (Fig. 10) longer than lamina and decurrenting on leaf forming a border in upper lamina.

Some specimens with shorter basal cells and narrow lanceolate leaves (Fig. 9) agree with *G. sessitana*, but this species is described as having no annulus. Also all these modifications are connected by numerous transitional forms, making impossible any natural segregation.

G. donniana is growing in alpine zone, where it could be mistaken with the other species of *Grimmia*. The close relatives, *G. montana* and *G. alpestris* are differing from *G. donniana* by the areolation of the leaf base - in *G. donniana* cells along the margin at least in upper leaves are elongate without transverse thickness. Also in basal paracostal group longitudinal cell walls are thickened. Forms with shorter basal cells differ from *G. alpestris* by more narrow leaves with usually recurved margin and autoicous sexual conditions. From the *G. affinis* *G. donniana* differs by the emergent capsulae with very short beak or without it, smaller size of plants, thickened longitudinal cell walls in base along the costa and extensive hyaline area at margin of upper leaves.

In 3 collections were observed the setae arcuate when young and moist in part of plants, while in others - straight. By this feature these

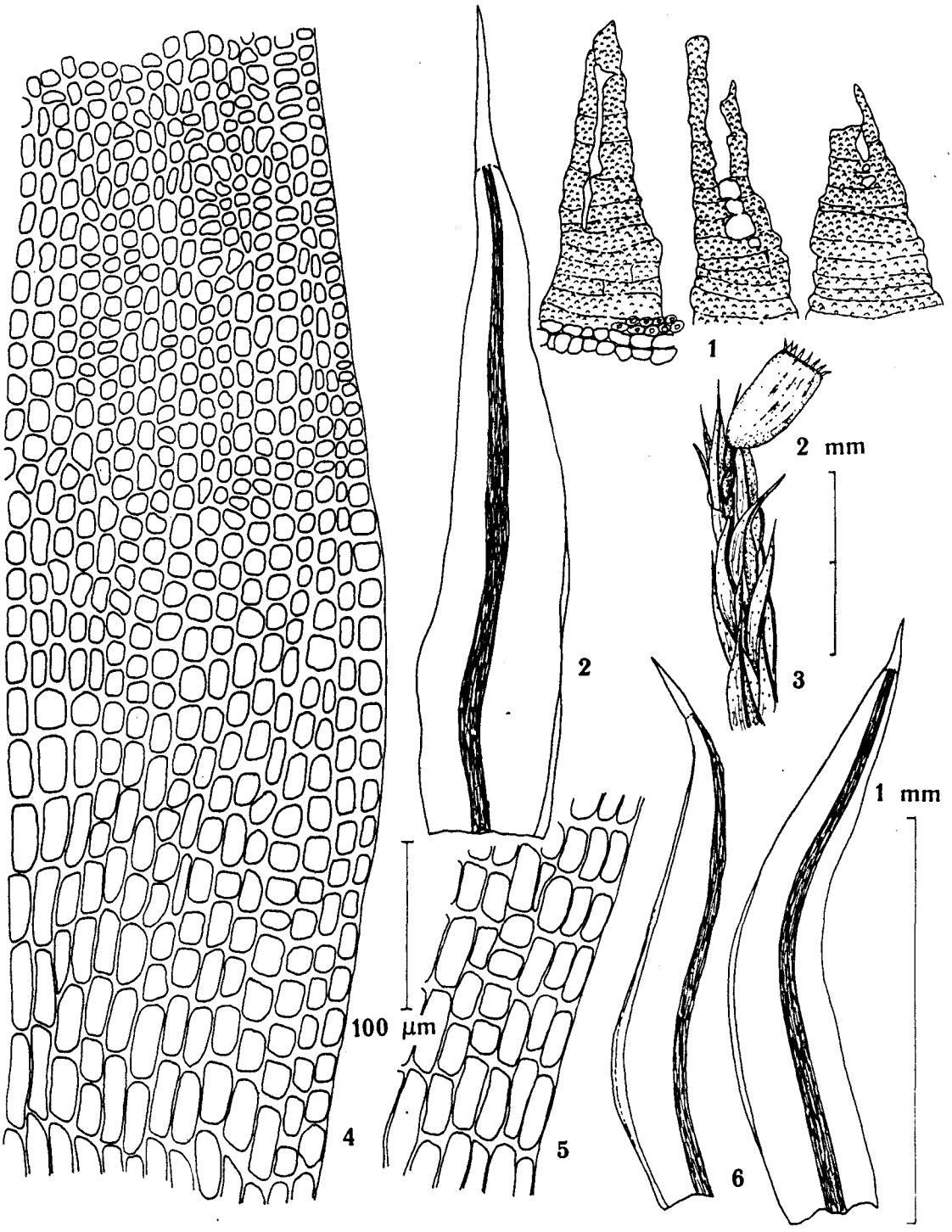
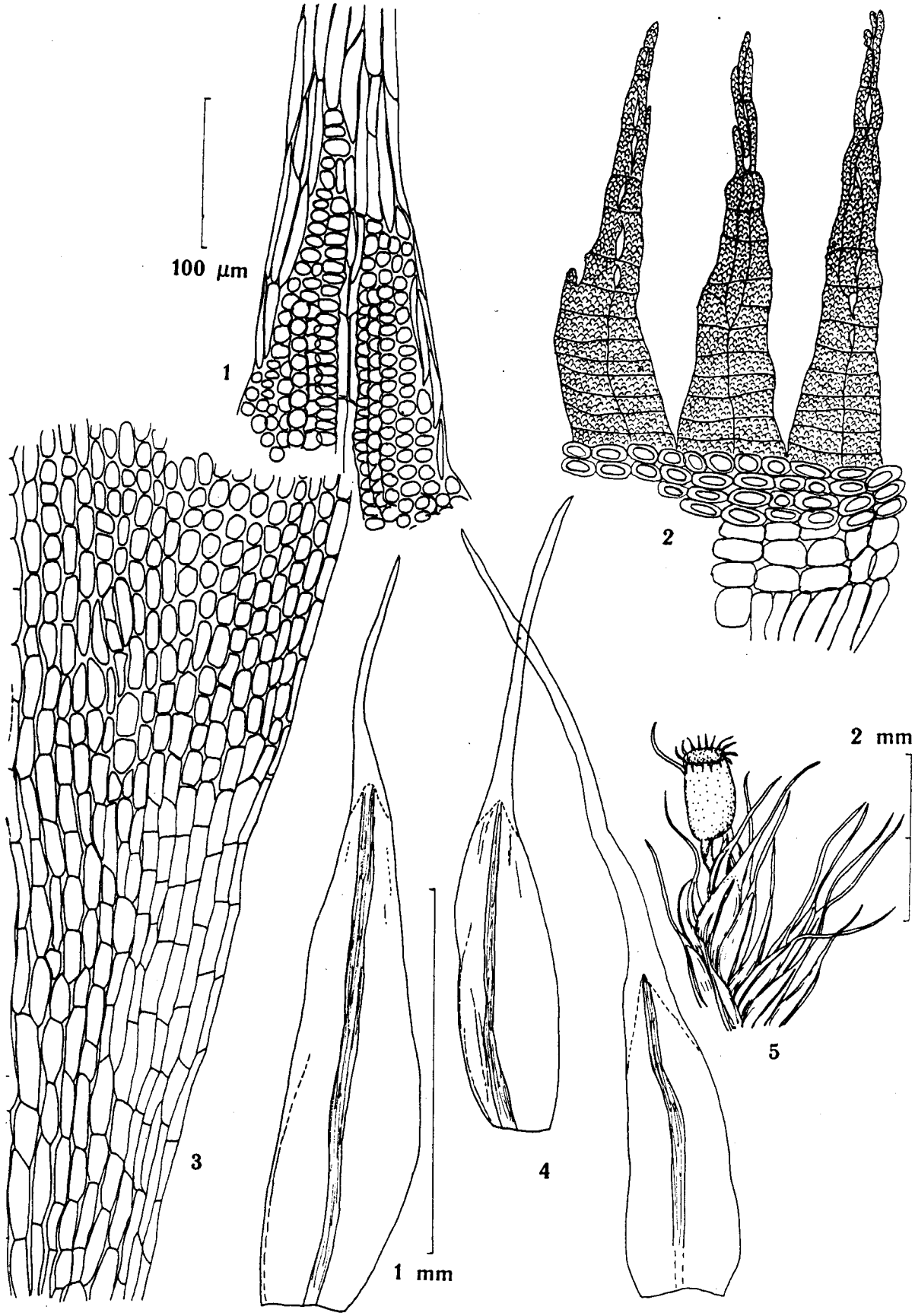


Fig. 9. *Grimmia donniana* Sm. (from *Kobiguayuk Creek* 2200 m Ignatov 0/944): 1 - peristome teeth; 2, 6 - leaves; 3 - habitus; 4 - cells of leaf base; 5 - basal cells at margin. Scale bars: 2 mm - for 3; 1 mm - for 2, 6; 100 µm - for 1, 4, 5.

plants could be referred to *G. apiculata* Hornsch., but the inflorescences of them are autoicous or female, not paroicous as in true *G. apiculata* and also cell walls in middle leaf are nearly straight, not strongly sinuose, as *G. apiculata*.

Distribution: This species has a very wide distribution in both hemispheres at low latitudes and in high mountains. In Western Europe, *G. donniana* is known from Scotland, Portugal, Norway, Sweden, Finland, Poland, and reported also from France, Brit-


100 μm
1
2
3
4
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1 mm
2 mm

ain, Italy. In the former USSR - it is present in mountains in the Arctic zone and other high mountains such as Carpatians, Caucasus, Middle Asian mountains, some ridges in Southern Siberia and in the Far East. Also it is known from Tibet in China and the neighbouring territory of Himalayas in Assam, Japan, North America (Arctic including Greenland and mountains, both Appalachians and mountains in Pacific North-West), Antarctic King George Island and also reported from South America, North and East Africa. In Altai *G. donniana* is not rare and known mostly from the upper alpine zone and also in lower alpine and subalpine zones. It grows on rocks or lithosoil, typically on exposed places.

Specimens examined: Ayulyuyuzyuk Creek 2500 m (0/476); *Bogoyash Creek, in middle course* 2400 m (36/319; 36/356); *Dvukhkarovaya Creek* 2600 m (36/351); *Karakol Mt. Range* 2000 m (Zerov 22.VIII.1940 LB!); *Kayakkatuyarykskij Creek* 1930 m (3/140), 2000 m (3/141), 2050 m (5/10), 2100 m (8/67), 2250 m (4/26; 6/14), 2450 m (7/84), 2600 m (7/49), 2650 m (7/41); *Kobiguayuk Creek* 2200 m (0/943; 0/944), 2300 m (0/939; 0/940; 0/942), 2600 m (0/478; 0/941); *Kurkurebazhi Peak* 3100 m (Zolotukhin 13.VIII.1976), 3200 m (Zolotukhin 13.VIII.1976); *Pass between Bashkaus and Pravyi Bogoyash* 2900 m (36/345); *Toshkalykaya Peak* 2600 m (Zolotukhin 14.VII.1990); *Trekhglavaya Peak* 2850 m (Zolotukhin 19.VII.1990), 3150 m (Zolotukhin 19.VII.1990); *Uzuntytygem Creek, upper course* 2400 m (36/362).

Grimmia alpestris (Web. et Mohr) Schleich. ex Nees, Bryol. Germ. 2(1): 139. 1827 Fig. 11.

Trichostomum pulvinatum var. *alpestre* Web. & Mohr, Bot. Taschenb. 110. 1807.

Plants small, in greenish-gray hoary cushions. Stem ca. 0.5 mm high, with central strand. Leaves lanceolate to broadly lanceolate, ca. 1.5 mm long, margins plane. Hyaline hairpoint 1/4-2/3 of lamina lenght. Upper lamina cells 8-10 µm, partly bistratose, with longitudinal rows of bistratose cells. Basal cells at margin and in paracostal area homogeneous, quadrate to short rectangular in stem leaves, and rectangular with a ratio of 1.5-2:1 in upper and perichaetial leaves, ca. 40 x 25 µm. Dioicous. Seta ca. 2 mm long, straight. Capsula emergent, broadly ovoid to broadly cylindrical, dark-brown. Peristome teeth red-orange, entire or eroded above. Annulus not differentiated. Operculum shortly and obtusely beaked. Spores ca. 8 µm, smooth.

Among small species of *Grimmia*, superficially similar to *G. alpestris*, there are *G. caespiticia*, *G. montana* and *G. donniana*. *G. caespiticia* is easily distinguished by its strongly plicate leaves, *G. montana* - by quadrate cells at basal margin and rectangular paracostal cells, *G. donniana* in typical expression - by long-rectangular basal cells; however some forms with short basal cells is more difficult to delimit from *G. alpestris*; the following characters are useful:

- leaves ovate-lanceolate, rigid, straight; margin plane; cells quadrate or short rectangular (1.5-2:1) to the base; dioicous, capsula dark-brown; peristome papillose above - *G. alpestris*;
- leaves lanceolate, flexuose; margin typically recurved on one side; basal cells rectangular (2-3:1); autoicous, capsula yellowish; peristome papillose throughout on inner surface - *G. donniana* (small forms).

The character of sexuality needs comments. In alpine plants in most of collections are observed only archaegoniae, even in such normally autoicous species, as *G. affinis*. So, if a collection is not very extensive (and it is usually so for small alpine species), the decision about dioicous condition is unreliable.

Distribution: The distribution of *Grimmia alpestris* needs additional verification. Plants almost identical with the Altaian *G. alpestris* have been seen from Central Europe, Caucasus, North America (California). Japanese plants referred by Deguchi (1979a) to *G. subsulcata* Limpr. (*G. alpestris* var. *subsulcata* (Limpr.) Loeske) probably are also very close to the Altaian specimens studied. In Altai, *G. alpestris* is a rather rare moss, occurring on lithosoil in lower alpine zone.

Specimens examined: Bayas Lake 2000 m (0/477); *Tuguryuk* 2200 m (Bardunov 23.VI.1966 IRK!).

Grimmia caespiticia (Brid.) Jur., Laubm.-Fl. Oesterr.-Ung. 172. 1882. Fig. 12.

Campylopus caespiticius Brid., Muscol. Recent. Suppl. 4: 77. 1819.

Plants in dense grayish hoary cushions. Stem low, 0.3-0.5 cm high, with indistinct central strand. Leaves on male plants 0.7-1 mm long, on female - up to 1.5 mm. Hyaline hairpoint 1/3-1/2 of lamina length. Upper lamina cells bistratose, 6-8 µm, with incrassate walls, toward the base in male plants the cells become quadrate at margins and short-rectangular in paracostal area; in female plants the cells at leaf base are rectangular, 40 x 15 µm. Dioicous. Sporogones unknown in Altaian collections.

This species is readily distinguished from all other *Grimmia* by the small plants with deeply sulcate leaves and very long hairpoint. Its stout plicae on both sides of the costa seem unlikely

Fig. 10. *Grimmia donniana* Sm. (from *Kobiguayuk Creek* 2200 m Ignatov 0/943): 1 - upper leaf cells; 2 - peristome teeth; 3 - cells of leaf base; 4 - leaves; 5 - habitus. Scale bars: 2 mm - for 5; 1 mm -for 4; 100 µm - for 1, 2, 3.

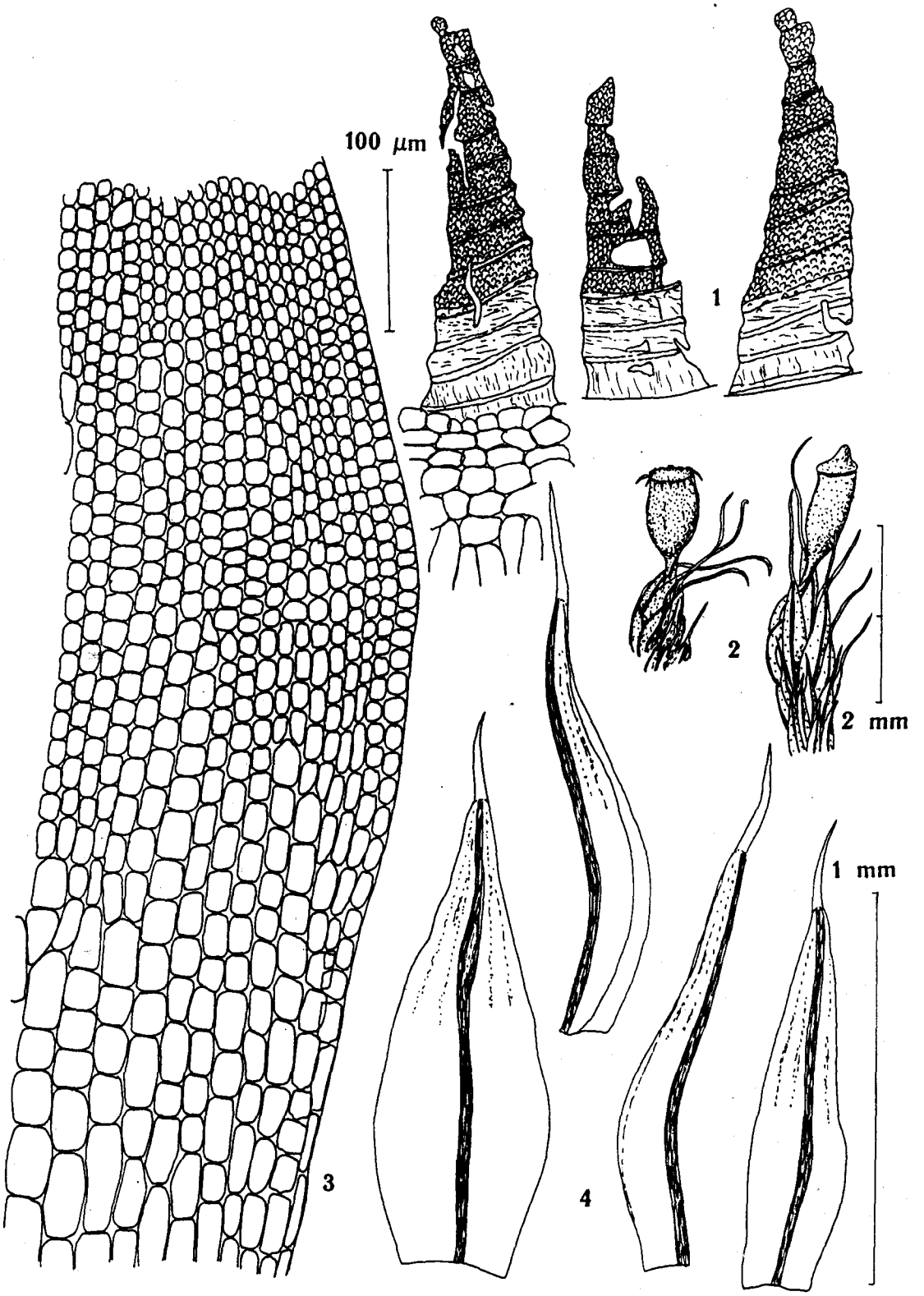


Fig. 11. *Grimmia alpestris* (Web. et Mohr) Schleich. ex Nees (from *Bayas Lake* 2000 m Ignatov 0/477): 1 - peristome teeth; 2 - habitus; 3 - cells of leaf base; 4 - leaves. Scale bars: 2 mm - for 2; 1 mm - for 4; 100 μm - for 1, 3.

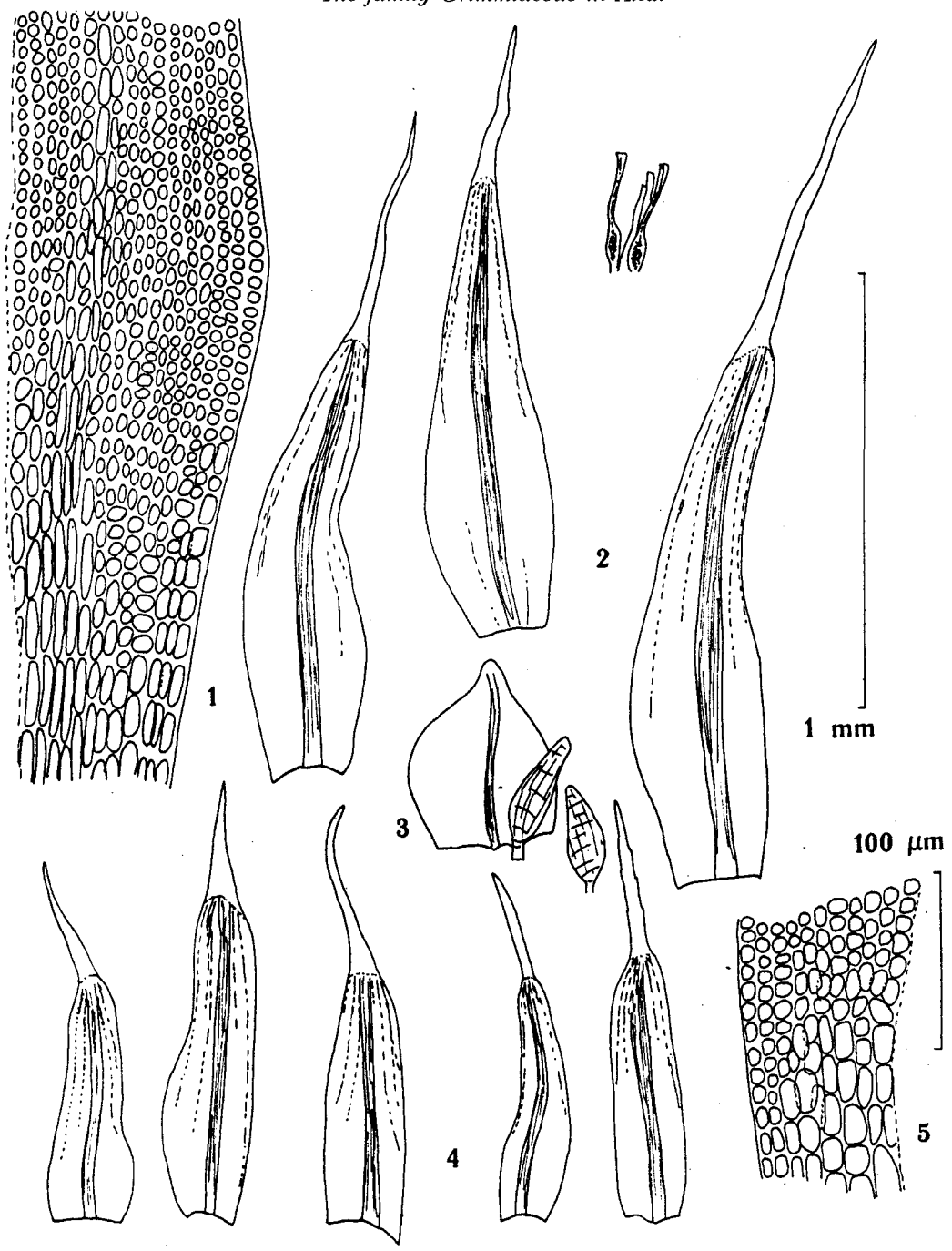


Fig. 12. *Grimmia caespiticia* (Brid.) Jur. (from *Kobiguayuk Creek* 2200 m Ignatov 0/947: 1-2 - female plants; 3-5 - male plants): 1 - basal leaf cells; 2, 4 - leaves; 3 -perigonial leaf with antheridia; 5 - basal cells at margin. Scale bars: 1 mm - for 2, 3, 4; 100 μm - 1, 5.

to be mistaken even under the stereo-microscope. In male plants it is important to note that there is a very slight differentiation of cells at the leaf base where they are almost all quadrate. The latter character readily discriminates *G. caespiticia* from *Coscinodon cribrosus* which have also sulcate leaves. In female plants of *G. caespiticia*, however, in the upper and especially perichaetial leaves there are several rows of rectangular, thin-walled cells at the leaf base, but this feature is never so developed as in the case of *Coscinodon*.

Distribution: The species is restricted to the Holarctic where it is scattered in high mountain areas of

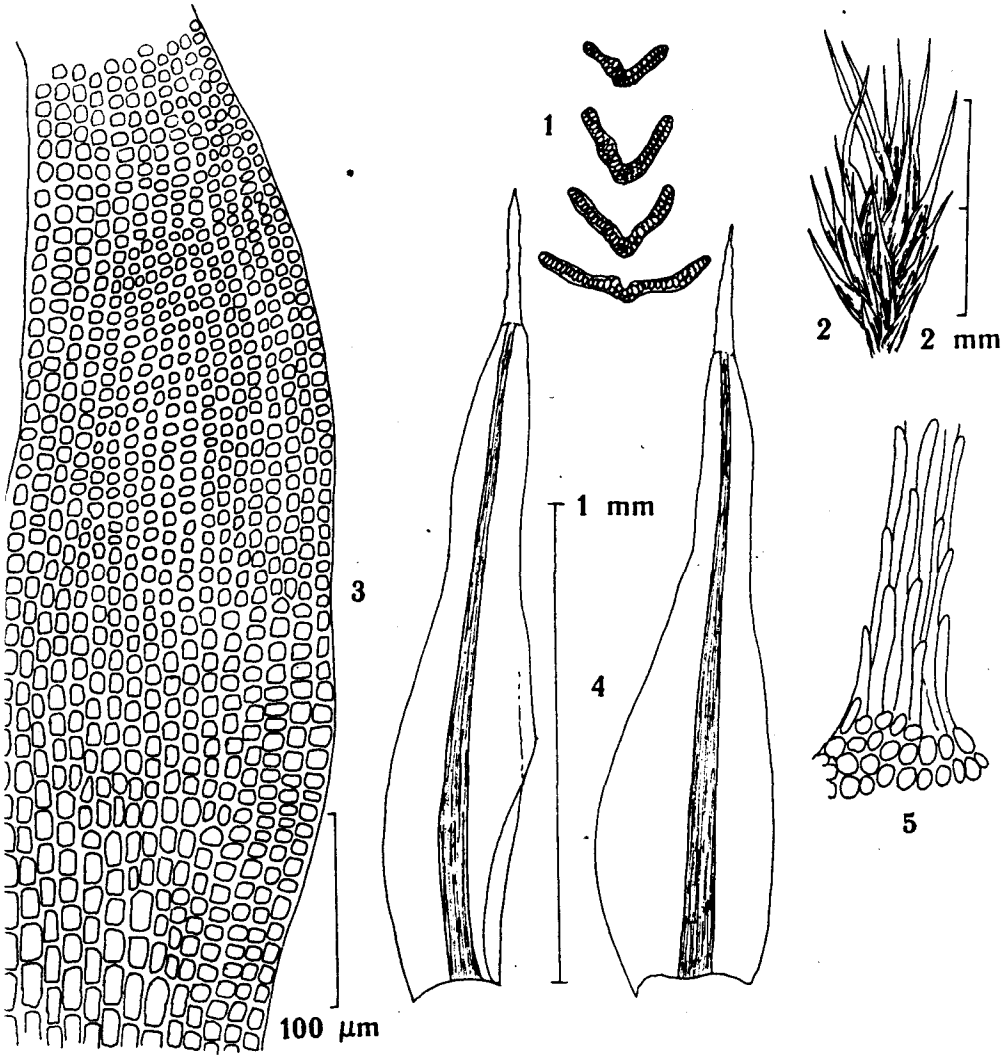


Fig. 13. *Grimmia montana* Bruch et Schimp. in B.S.G. (from *Chuya River, lower course* 800 m Bardunov 16.VII.1966 IRK): 1 - leaf sections; 2 - habitus; 3 - basal leaf cells; 4 - leaves; 5 - cells of leaf tip and hair-point. Scale bars: 2 mm - for 2; 1 mm - for 4; 100 μm - for 1, 3, 5.

Central Europe, Scandinavia, Caucasus, South and East Siberia, Middle Asia, China (Shanxi only) and Greenland. In Altai *G. caespiticia* was found in lower alpine, subalpine and upper taiga zones, on relatively xeric S-facing slopes, on rocks or lithosoil, always in restricted quantity.

Specimens examined: Altyntash Creek 2150 m (Zolotukhin 16.VI.1989); *Bogoyash Creek, in middle course* 2400 m (36/354; 36/355); *Bogoyash Creek, upper course* 2350 m (36/328); *Bolshoye Kurkure Creek, upper course* 2300 m (Galanin 9.VIII.1976); *Chulyshman against Uandu Creek mouth* 1950 m (36/300); *Kayakkatuyarykskij Creek* 1940 m (3/282; 3/286), 2100 m (7/111a; 7/112); *Kobiguayuk Creek* 2200 m (0/947); *Trekhglavaya Peak* 2200 m (Zolotukhin 18.VII.1990); *Yazula* 1600 m (0/946).

Grimmia montana Bruch et Schimp. in B.S.G., Bryol. Eur. 3: 128. pl. 250. 1845. Fig. 13.

Plants small, in dense, dark-green tufts or cushions. Stem up to 1 cm, without a central strand. Leaves lanceolate, 1.5-2.0 mm long, keeled above. Hyaline hairpoint 1/5-1/3(1/2) of lamina length. Upper lamina totally or partially bistratose, cells about 7 μm. Basal cells at margin are quadrate to short-rectangular, with transverse walls thicker than longitudinal ones; in paracostal area, cells are rectangular up to 2:1. Dioicous. Sporogones unknown in Altaian plants.

Grimmia montana is a small-sized species, superficially similar to *G. donniana* (among Altaian representatives). The diagnostic character of *G. montana* is the peculiarities of leaf base areolation, including quadrate or short-rectangular cells at the basal margin and more elongated paracostal cells (in *G. donniana* marginal cells are typically thin and much elongated, or

in its forms with short basal cells there is no or only slaight differences between marginal and para-costal cells). Also *G. donniana* grows in Altai only in alpine zone. In leaf areolation patterns *G. montana* seems to be similar with *G. ovalis*, but the leaf of *G. montana* is keeled (cf. Figs. 13, 14), the plants in *G. ovalis* is much larger and usually have in upper leaves a differentiated zone at leaf margin, composed of more thin-walled cells.

Distribution: *Grimmia montana* has a scattered Holarctic distribution in Central Europe, Great Britain and Iceland. In the former USSR it is present in mountains of Kola Peninsula, Carpatians, South Ural Mts., Caucasus, Altai, and mountains of Middle Asia. Known also from China, western North America, and Morocco. In Altai it is known from a single collection from the steppe zone of Central Altai.

Specimens examined: *Chuya River, lower course* 800 m (Bardunov 16.VII.1966 IRK!).

Grimmia ovalis (Hedw.) Lindb., Acta Soc. Sci. Fenn. 10: 75. 1872. Fig. 14.

Dicranum ovale Hedw., Sp. Musc. Frond. 140. 1801.

Grimmia cavifolia Lindb. et H. Arnell, K. Sv. Vetensk. Acad. Handl. 23(10): 103. 1890, syn. nov. (syntypes: Krasnojarsk, 56° N, 11.VI.1976, H. With. Arnell, S; seen in part).

Plants in loose tufts, dark-green above and ferruginaceous brown below, often hoary. Stem up to 3 cm high, with central strand, sparsely branched. Leaves rigid, directed upward when dry, with hyaline hairpoints crowded at stem top. Lamina lanceolate with ovate base and more narrow upper part, 2.5-3.2 mm long, margins plane to slightly incurved or rarely recurved. Hyaline hairpoint 1/5-1/2 of lamina length. Upper lamina cells bistratose, opaque, about 7 µm. Median leaf cells 2:1, with sinuose walls. Basal cells at leaf margin in middle stem leaves quadrate to short-rectangular, with thick walls. However, there are several rows of cells with thinner walls along basal margins of larger upper leaves. In perichaetial leaves all the bases are composed of thin-walled cells whereas the paracostal cells are rectangular, up to 3(4):1. Dioicous. Seta erect 4-6 mm long, yellowish. Capsula well exserted, ovoid, about 2 mm long, smooth when dry. Peristome teeth erect, lanceolate, 2-3 cleft or somewhat perforate above, papillose above and nearly smooth below. Annulus of 3-4 rows of elongate, thick-walled cells with small lumina. Operculum longly rostrate with oblique beak. Calyptra cucullate. Spores 12-14 µm, granulose.

Typical expression of *Grimmia ovalis* is easily recognized in the field by its (1) large plant size for the genus; (2) loose tufts with long hair points which are usually straight upward (as compared to *G. affinis* which has somewhat flexuose leaves in dry condition and therefore with the hairpoints differently orientated resulted in a quite different appearance); (3) the characteristic ferruginaceous brownish color below. Often *G. ovalis* is described as having concave and unkeeled leaves. Although this is true, this character is not always easy to decide (cf. the series of cross sections of concave leaf of *G. ovalis* and the keeled leaf of *G. montana*, Figs. 13, 14). In some leaves of *G. ovalis*, margin in the middle can become recurved on one side. In *G. affinis* and other species with typically recurved margins, the "keelness" of leaves is not apparent when growing in unfavourite conditions. Microscopically, *G. ovalis* is characterized by (1) the shape of leaf which is distinctly consticted above the broadly ovate base, with lanceolate upper part, while in *G. affinis* it is gradually, narrow-triangularly tapering towards the apex, and (2) the pattern of leaf base areolation, with a broad zone of quadrate cells along the leaf base margin, or in larger leaves, along the submarginal area. For its differentiation from *G. montana*, see discussion under that species.

Distribution: *Grimmia ovalis* is a very widespread species in most of the European countries and in nearly all the regions of the former USSR (except some northern areas). It is known also from China, Mongolia, Indonesia, India, Sikkim, Nepal, Pakistan, Iraq, Middle East, Canary Ils., North America, North and South Africa, South America, Australia. In Altai *G. ovalis* grows on exposed rocks and is especially abundant in forest-steppe districts of Central Altai. Also it is not rare in open xeric places in forest areas and at higher elevations in steppe/ semi-desert areas. It does not penetrate into alpine zone in wetter areas. In the most xeric areas of South-Eastern Altai, some rather poor and ill-developed plants of *G. ovalis* were found up to 2700 m alt.

Specimens examined: *Aedigan* 650 m (34/126); *Artyshtu Creek* 650 m (Zolotukhin 20.IX.1989); *Bijka Creek, 2 km upstream along Katun* 450 m (34/52); *Bijka Creek, 4 km upstream along Katun* 450 m (34/219); *Chemal* 450 m (29/68); *Chemal, 10 km upstream along Katun* 450 m (34/12); *Chemal, 4 km upstream along Katun* 450 m (34/212); *Chiri* 450 m (0/950; 17/43; 17/48; 17/54); *Chodro* 800 m (0/935); *Chulcha River, in middle course* 1000 m (9/37; 9/48); *Chulyshman River* (Shishkin 4.IX.1931); *Edikhta Creek* 1100 m (34/161); *Kairu-Bazhi Peak* 2050 m (13/170); *Kayakkatuyarykskij Creek* 1850 m (8/149), 2000 m (8/279;

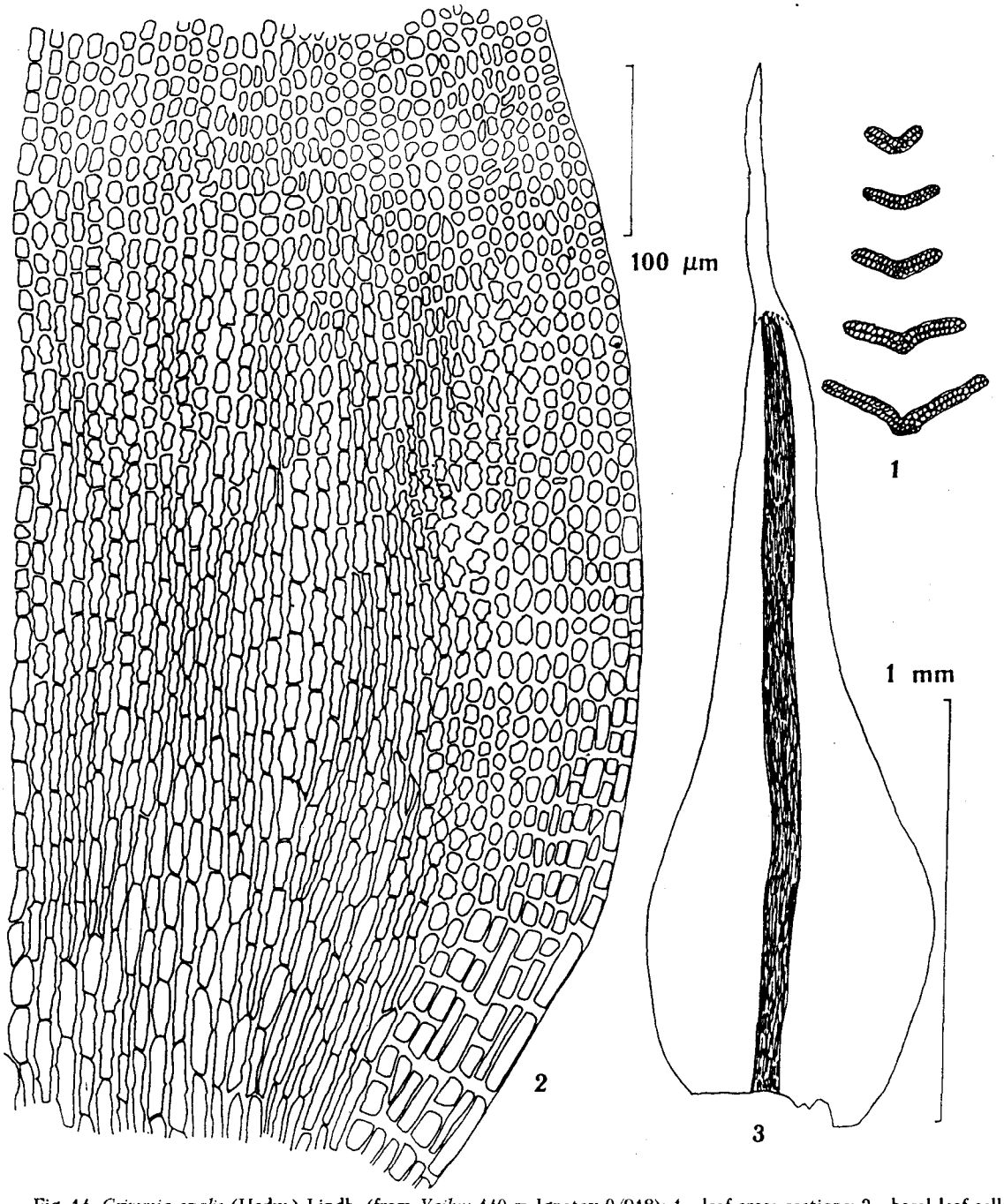


Fig. 14. *Grimmia ovalis* (Hedw.) Lindb. (from *Yailyu* 440 m Ignatov 0/918): 1 - leaf cross sections; 2 - basal leaf cells; 3 - leaf. Scale bars: 1 mm - for 3; 100 μm - for 1, 2.

8/307), 2100 m (7/136); *Kobiguayuk Creek* 2200 m (0/463); *Kukol* 1900 m (0/952); *Kyuzyulya in Inyurlya Valley* (Zerov 16.8.1940 LB!); *Malyi Yaloman* 1100 m (25/130); *Seminskij Pass* 1850 m (Vysozkaya 19.VII.1977 LB!); *Tabozhok Peak* 2450 m (31/77; 31/80), 2500 m (31/79), 2700 m (31/78); *Tamanel Peak* 2150 m (34/185); *Ulagan* 1220 m (36/103); *Ust-Sema* 380 m (24/74), 580 m (24/51), 700 m (24/61); *Yailyu* 440 m (0/918; 0/919), 450 m (0/915); *Yazula* 1550 m (0/951), 1600 m (0/916), 1650 m (0/917); *Yurga* 440 m (21/13; 21/33); *Yustyd* 2250 m (632 Vereshchagin 2.VII.1907 LE!).

Grimmia laevigata (Brid.) Brid., Bryol. Univ. 1: 183. 1826. Fig. 15.

Campylopus laevigatus Brid., Muscol. Recent. Suppl. 4: 76. 1819 [1818].

Plants in moderately dense, rigid cushions, dark-green to black. Stem 1-2 cm high, with central strand, sparsely branched, the innovations at proximal posi-

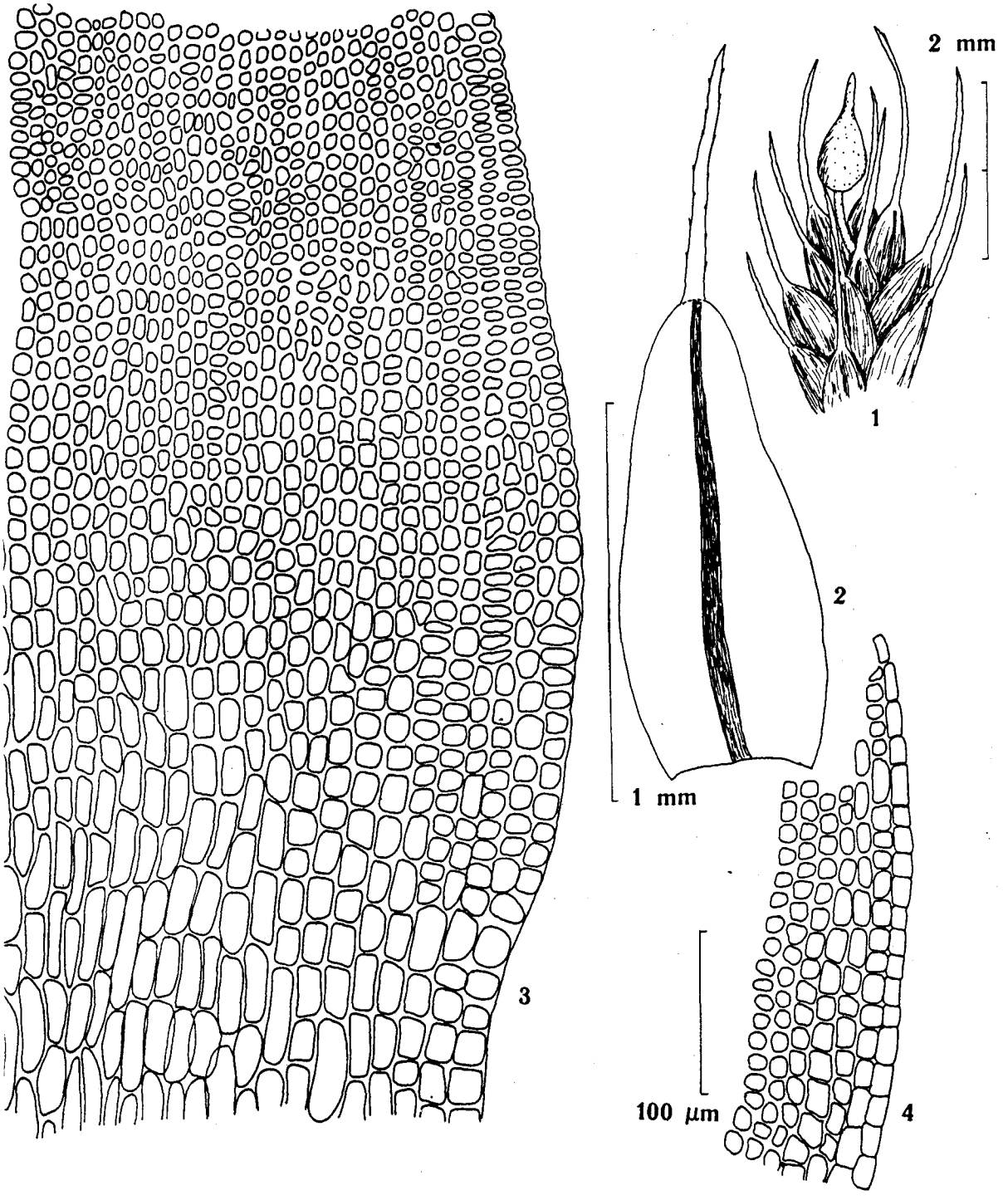


Fig. 15. *Grimmia laevigata* (Brid.) Brid. (from *Kobukhta* 550 m Ignatov 0/462): 1 - habitus; 2 - leaf; 3 - basal leaf cells; 4 - basal cells at margin of perichaetial leaf. Scale bars: 2 mm - for 1; 1 mm - for 2; 100 μm - for 3, 4.

tion julaceously foliated with small, concave, and strongly appressed leaves. Stem leaves broadly ovate to broadly lanceolate, 1.5-2.5 mm long, concave, with flattened costa. Hyaline hairpoint short in lower leaves, becoming longer upward, to as long as the lamina, finely serrulate all along. Upper lamina cells opaque, bistratose, small, 5-7 μm. Basal cells at margins quadrate to short rectangular, with thick walls, or in upper leaves with 1-2 row of relatively thin-walled cells. In paracostal area at basal leaf cells are rectangular, up to 3:1. Dioicous. Perichaetial leaves larger, similar to stem leaves. Seta up to 2 mm long,

yellow. Capsula shortly exserted or emergent. Peristome teeth erect, lanceolate, variously split or perforated above, red-brown, papillose throughout (densely above). Annulus of 2-3 row of elongated cells. Operculum with short beak. Calyptra mitrate. Spores 7-9 μm, smooth. (Since only juvenille and old capsulae were found in only one collection from Altai, the description of peristome is borrowed from Chinese collections).

Grimmia laevigata is distinguished by ovate to oblong leaves, concave, with flattened costa. Being dioicous, it rarely bears sporogones in the Altai region. By gametophyte alone the species can be mistaken for *G. tergestina*. The important difference between these two species lies in the development of a zone of very thin-walled cells along the basal leaf margin in *G. tergestina* and this character is well seen in perichaetial and upper stem leaves. In *G. laevigata* thick walled cells reach the leaf base, and only rarely in larger upper leaves one sees 1-2 rows of cells with moderately thick walls. The second species which can be confused with *G. laevigata* is *G. ovalis*. In their typical expressions, leaf shape is distinctive enough to separate the two taxa (cf. Figs. 14, 15), but forms that are difficult to interpret sometimes occur. To summarize the delimitation of the two species, the following characters can be used:

- plants usually 1.0-1.5 cm high; leaves without constriction above the base, if with constriction, then the upper portion of lamina is shorter than the basal part ..... *G. laevigata*
- plants usually 2-3 cm high; leaves with a constriction above the base; upper portion of the lamina is longer than the basal part ..... *G. ovalis*

Grimmia ovalis sometimes produces small forms in alpine zone, but within forest and steppe zones of Altai it is uniform and always markedly larger than *G. laevigata*.

Distribution: *Grimmia laevigata* is known from many xeric parts of the world. In Europe it occurs mostly in the south, penetrating northward to Scandinavia where it is rare. In the former USSR it is known from the southern half of Europaean part, Caucasus, Middle Asia, and South Siberia. Also it occurs in Mongolia, China (except the most oceanic regions), India, Sri Lanka, Pakistan, many countries of Middle East, North and South Africa, arid zone of North America (from Georgia to California), Hawaii, Australia, Tasmania and New Zealand. In Altai *G. laevigata* is scattered all over xeric rock faces from 350 to 1400 m alt.

Specimens examined: Chulcha River, in middle course 1100 m (9/163); *Gorno-Altaisk* 400 m (35/11); *Gorno-Altaisk (SE edge)* 550 m (23/13; 23/14); *Kobukhta* 550 m (0/462), 600 m (0/229); *Malyi Yaloman* 950 m (25/145); *Saratan* 1400 m (36/349); *Ust-Sema* 350 m (24/151); *Yailyu* 600 m (0/945).

Grimmia tergestina Tomm. ex B.S.G., Bryol. Eur. 3: 126. pl. 258. 1845. Fig. 16.

Plants rough, in dense, rigid tufts, green to pale-green above and black below. Stem up to 2.5 cm, with central strand. Leaves broadly-ovate to oblong-ovate, 2.0-2.5 mm long, concave, with flattened costa. Hyaline hairpoints short in lower leaves, as long as the lamina in upper leaves. Upper lamina cells bistratose, opaque, small, 5-7 μm. In upper stem and perichaetial leaves, the marginal basal cells in few to many rows, rectangular, about 25-40 x 10 μm, with very thin, hyaline walls; in paracostal area cells rectangular, up to 5:1, with straight walls. Dioicous. Seta shorter than urn, about 0.3 mm long. Calyptra mitriform. Mature capsulae unknown in Altai.

When sporogones are present *Grimmia tergestina* is easily distinguished by the immersed capsulae on a rather robust plant and the unkeeled, ovate to oblong-ovate, leaves with long awns. In sterile condition it much resembles *G. laevigata*. Their difference in gametophyte includes, in the case of *G. tergestina*, the extensive hyaline "alars" of the perichaetial or upper leaf bases where cells are strikingly thin-walled and are well contrasting with the zone of thick-walled cells in leaf base (this character is often seen in upper leaves of plants even without archegoniae). In *G. laevigata*, the zone of thick-walled cells extends up along the margin or forms 1-2 rows of marginal cells having only slightly thinner walls. Other differences include the nearly smooth hairpoint in *G. tergestina* (distinctly serrate in *G. laevigata*), and the presence of julaceously foliated innovations in *G. laevigata*. Though in many cases juvenille sporogones are present, we have never seen mature or old capsulae in our Altaian collections.

Distribution: The distribution of *G. tergestina* definitely corresponds with the xeric range of the Old World. It is known from Central (very rare) and South Europe, Northern Africa (Morocco) and Macaronesia, the former USSR - in Krym, Caucasus, East Siberia (tundro-steppe regions of Yakutia) and South Siberia, southern part of Russian Far East, Middle Asia, in Asia also in Middle East, Iraq, Afganistan, China, and Mongolia. In Altai *G. tegestina*

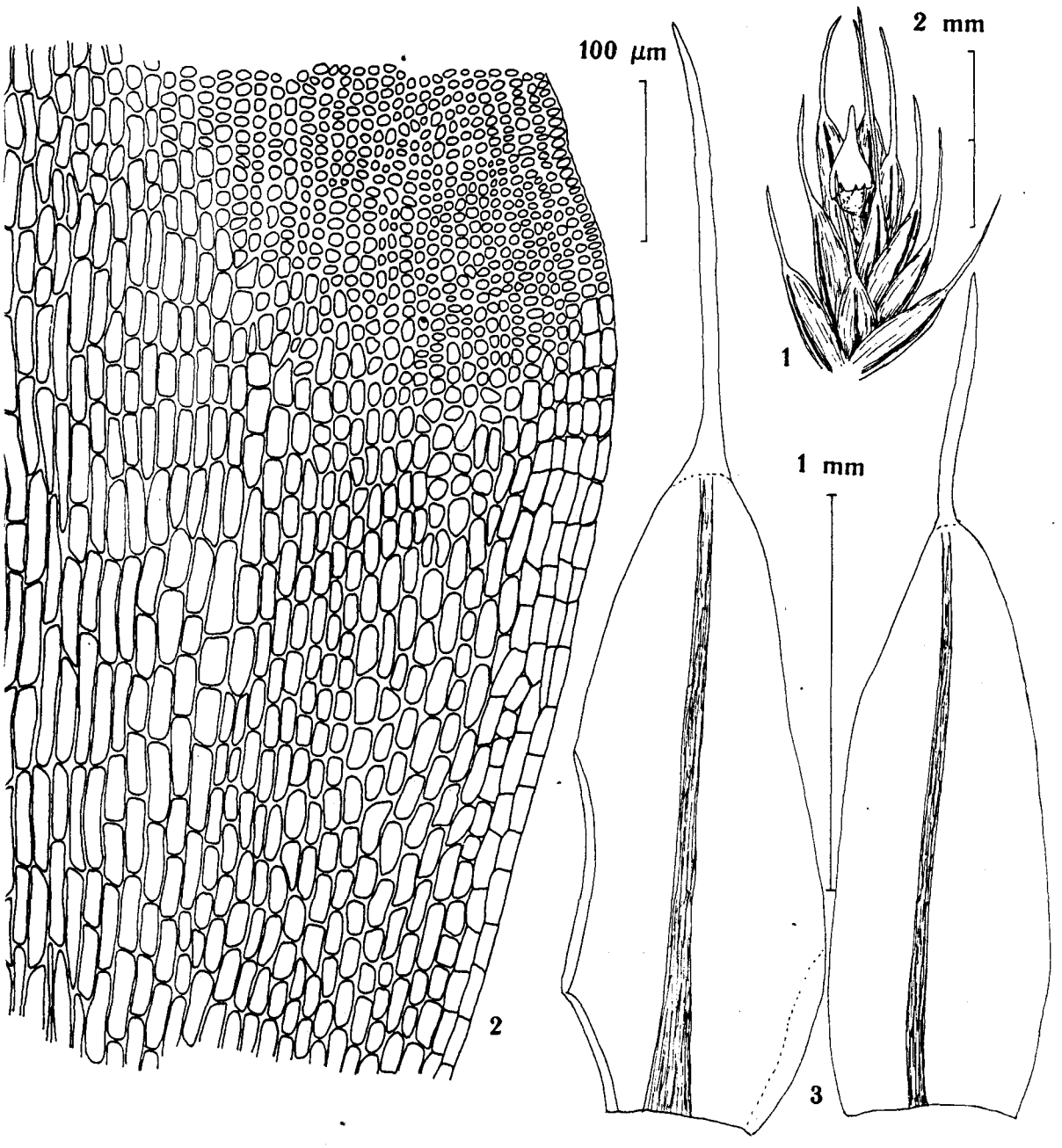


Fig. 16. *Grimmia tergestina* Tomm. ex B.S.G. (from *Derbogach* 440 m Ignatov 0/897): 1 - habitus; 2 - basal leaf cells; 3 - leaves. Scale bars: 2 mm - for 1; 1 mm - for 3; 100 µm - for 2.

is very common in forest-steppe areas of the Central Altai, in regions where *G. ovalis* and *Jaffueliobrym latifolium* are common. The species occurs also in steppe areas of South-East Altai and rare in forested part of Norhtern Altai. It strictly avoids the alpine zone (though in Mongolia it is reported from 2600-3100 m alt.).

Specimens examined: Aedigan 600 m (34/168); *Bijka Creek, 2 km upstream along Katun* 450 m (34/120); *Chagan-Uzun Creek* 1700 m (Bardunov 23.VII.1966 IRK!); *Chemal, 4 km upstream along Katun* 450 m (34/213); *Derbogach* 440 m (0/897); *Inya* 800 m (Melnichuk 19.VIII.1959 LWS! 3584); *Kokkul Lake* 2200 m (33/1), 2300 m (33/2); *Kokorya Creek* 2100 m (32/7); *Malyi Yaloman* 800 m (25/128), 950 m (25/160; 25/89); *Malyi Yaloman Creek, 2 km upstream* 850 m (25/42), 950 m (25/178; 25/181); *Malyi Yaloman Creek, 7 km upstream* 1050 m (25/26); *Tabozhok Creek, 12 km upstream* 2200 m (30/18); *Tabozhok Creek, 8 km upstream* 2000 m (30/16), 2050 m (30/15), 2250 m (30/17).

Grimmia plagiopodia Hedw., Sp. Musc. Frond. 78. pl. 15, f. 6-13. 1801. Fig. 17.

Plants small, dark-green, in dense cushions. Stem

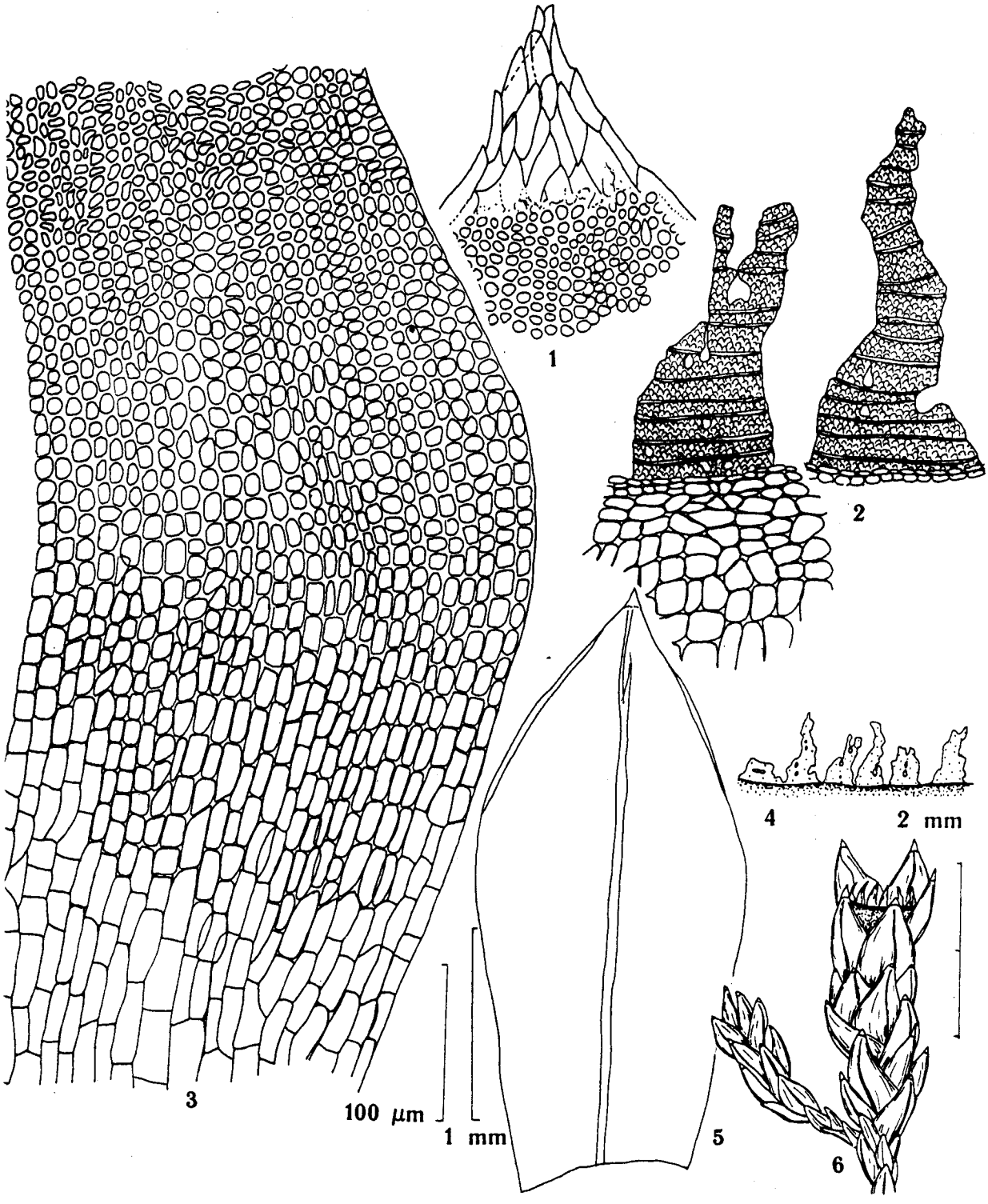


Fig. 17. *Grimmia plagiopodia* Hedw. (from: *Kobiguayuk Creek* 2200 m Ignatov 0/884): 1 - upper lamina cells; 2, 4 - peristome; 3 - basal leaf cells; 5 - leaf; 6 - habitus. Scale bars: 2 mm - for 6; 1 mm - for 4, 5; 100 μm - for 1, 2, 3.

0.5-1.0 cm high, with central strand. Leaves broadly ovate, up to 1.5 mm long, acute, keeled above. Costa thin, ending below the apex. Lower leaves muticous or with a hyaline apical cell; in upper and perichaetial leaves, hyaline hairpoints are well developed, but short, to 0.1 mm long. Upper lamina cells ca. 10 µm, unistratose, transparent, strongly and irregulaly rounded. Cells at basal margin and in paracostal area of the leaf uniformly rectangular, 3-4:1, thin-walled. Autoicous. Seta shorter than urn, 0.2-0.8 mm long, curved, excentrically attached to the capsula. Capsula deeply immersed in perichaetial leaves, 1.0-1.5 mm long, broadly ovoid or nearly hemisphaeric, not contracted below the mouth. Peristome teeth spreadig when dry, reddish, much eroded and also moderately perforate, finely papillose above, nearly smooth below. Annulus absent. Operculum nearly plane, beak short. Calyptra mitrate. Spores about 11 µm, smooth.

Grimmia plagiopodia is a small moss with immersed capsula. Superficially it is much similar to the submuticous expression of *G. anodon*, but since it is usually found with sporogones, it is easy to identify this species by the presence of a peristome. In sterile condition the most important diagnostic characrer is the unistratose margins of *G. plagiopodia* and the bistratose leaf margins of *G. anodon*. From *Schistidium* species, both *G. anodon* and *G. plagiopodia* are easily distinguished by the much enlarged area of thin-walled cells at the leaf base, an area about a quarter to a half in upper leaves.

Distribution: *Grimmia plagiopodia* has a scattered Holarctic range. It is known from southern Europe and Middle East. In the former USSR - it is reported from Ukraine, Cis-Caspean territory, South Ural, Caucasus, Middle Asia, Altai. Also it is known from Mongolia (specimen of *Grimmia elenkinae* Broth. sp. nov., nom ined.: Mongolia, lac. Kossogol. 31.VII.1902. A. A. Elenkin, LE!), and from the xeric territories of western North America where it reaches its northern range limit at 65°N. In Altai *G. plagiopodia* occurs on xeric rocks in subalpine/steppe zone of South-Eastern Altai.

Specimens examined: *Kobiguayuk Creek* 2200 m (0/884); *Yustyd* 2250 m (Vereshchagin 3.VII.1907 LE!).

Grimmia anodon Bruch et Schimp. in B.S.G., Bryol. Eur. 3: 110. f. 236 1845. Fig. 18.

Plants in dense dark-green to nearly black cushions. Stem 0.3-1.5 cm high, with central strand, more or less branched. Leaves of lower stem and branches small, less than 1 mm long, strongly concave, muticous, or similar with the upper stem leaves, larger (to 1.5 mm long) and hairpointed. Costa percurrent or ending below the apex. Hyaline hairpoint in upper leaves up to 1/3 of leaf length, but often shorter, towards its base broader and flattened, and irregularly serrate. Upper lamina cells unistratose except along the bistratose margins, 7-10 µm, with incrassate cell walls. Basal cells rectangular, up to 60 x 15-20 µm, with thin, straight walls. Autoicous. Seta 0.2-0.3 mm, curved. Capsula deeply immersed, subglobose, 0.6-0.8 mm long. Peristome and annulus absent. Operculum nearly plane, bluntly mucronate. Calyptra mitriform. Spores 8-11 µm, granulate.

Grimmia anodon is easily distinguished from all other *Grimmia* species by the absence of a peristome and the subglobose, ventricose capsula borne on distinctly curved and very short seta. These characters are practically always useful, since capsulae are present in nearly all the cushions. Sterile materials can be identified by the ovate leaves, with the hairpoint becoming broader ("decurrenting") on lamina. The only similar species is *G. plagiopodia*, which, however, differs in the lamina being unistratose throughout, while in *G. anodon*, the margins are bistratose.

The range of development of hairpoint in *G. anodon* varies greatly. Some cushions look very hoary, but some consist mostly of stems and branches with muticous leaves, with the hairpointed leaves present in the uppermost portion of fertile shoots. When totally sterile, such expressions look much alike some species of Pottiaceae.

Distribution: The species is known from many countries in Western Europe from Pyrenees to Scandinavia. In the European part of the former USSR, it occurs in Kola Peninsula and also to the south - Ukraine (both mainland and Krym) and South-East. Also it is known from Caucasus, South Siberia, Middle Asia, Chukotka Peninsula, Mongolia, Tibet in China, India, South-West Asia, Northern Africa (Aligeria, Marocco), Western North America (from California to Alaska) and Greenland. Reported also from the Great Antilles Is. The general distribution obviously seems related to more or less xeric territories, avoiding the humid East Asia and Eastern North America. In Altai *G. anodon* is not rare. Its typical habitat in the most part of Altai is dry rock outcrops where it grows in the distal corner of an overhanging cliff. The difference is, however, in xeric areas of South-Eastern Altai at the Kuraiskij Mt. Range - here *G. anodon* occurs everywhere, often forming extensive tufts on the upper surface of rocks. It probably is the most abundant epilithic moss here at 2000-2300 m alt.

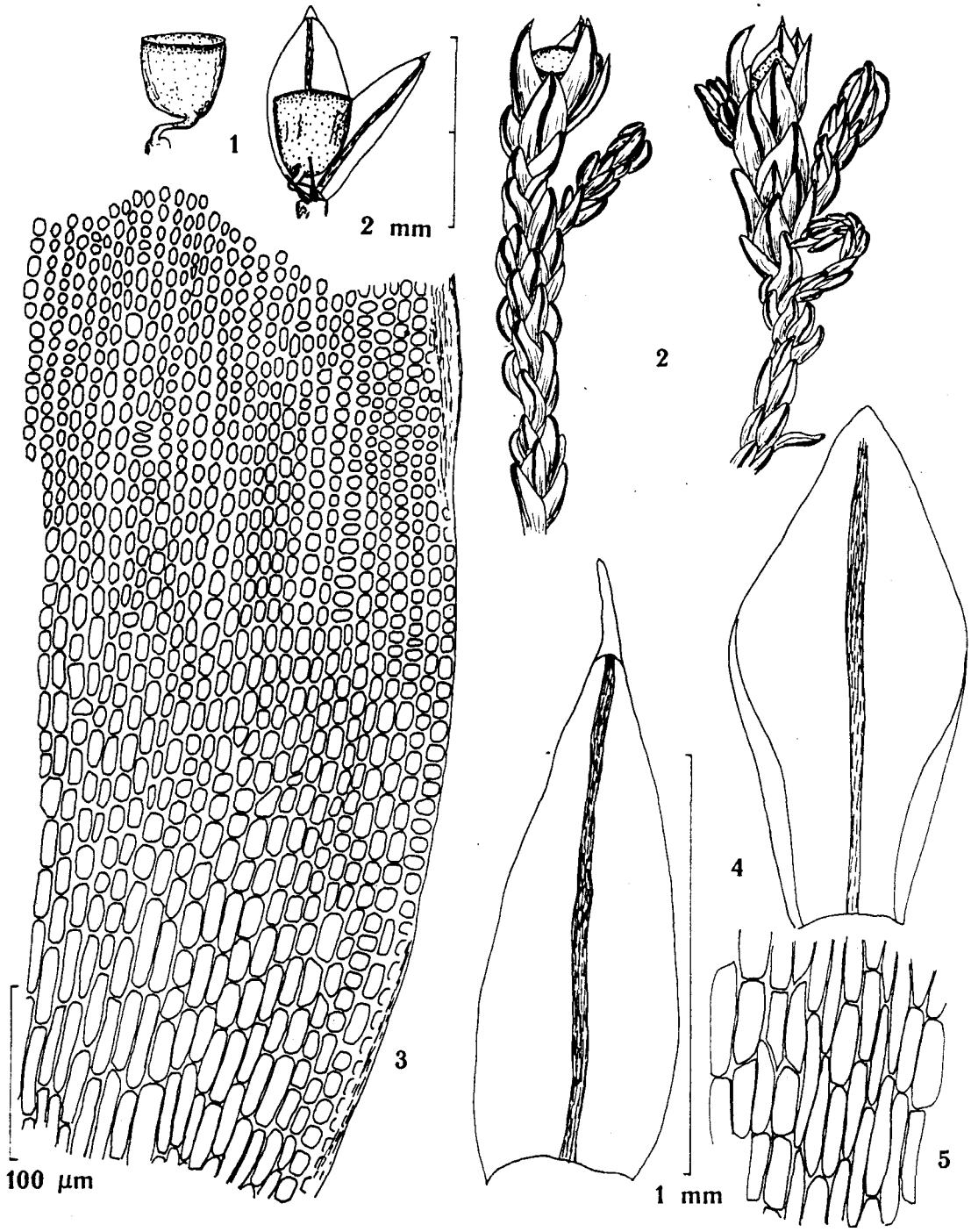


Fig. 18. *Grimmia anodon* Bruch et Schimp. in B.S.G. (from *Kukol* 2000 m Ignatov 0/723): 1 - capsulae; 2 - habitus; 3 - basal leaf cells; 4 - leaves; 5 - paracostal basal cells. Scale bars: 2 mm - for 1, 2; 1 mm - for 4; 100 µm - for 3, 5.

Specimens examined: Ak-Turu Creek 2600 m (Bardunov 19.VII.1966); *Berekhtuyaryk* 1600 m (0/478); *Bogoyash Creek, upper course* 2350 m (36/340), 2400 m (36/329), 2500 m (36/333), 2550 m (36/250); *Chulyshman against Uandu Creek mouth* 1950 m (36/301); *Kairu-bazhi Peak* 2100 m (13/31; 13/50); *Kayakkatuyarykskij Creek* 2150 m (7/113); *Kobiguayuk Creek* 2240 m (0/724), 2300 m (0/480); *Kokorya Creek* 2100 m (32/2; 32/6), 2200 m (32/17), 2400 m (32/1; 32/3); *Kukol* 1800 m (0/721), 1900 m (0/479; 0/722; 0/726; 0/727), 2000 m (0/723); *Tabozhok Creek, 12 km upstream* 2200 m (30/12; 30/13; 30/14; 30/2); *Tabozhok Creek, 8 km upstream* 2050 m (30/4), 2100 m (30/3; 30/5), 2200 m (30/6), 2250 m (30/1; 30/11; 30/7), 2500 m (30/10); *Tabozhok Peak* 2100 m (31/2), 2350 m (31/4), 2380 m (31/264), 2500 m (31/1; 31/3); *Tokpak Creek, upper course* 2400 m (36/359); *Tutuoyuk Creek* 2500 m (Zolotukhin & 15.VII.1990);

Yakhansoru Lake 1870 m (Zolotukhin 28.VI.1990); *Yazula* 1700 m (0/725).

Grimmia elatior Bruch ex Bals. et De Not., Mem. Reale Accad. Sci. Torino 40: 340. 1838. Fig. 19.

Plants robust, in loose rigid, green to yellow-green tufts. Stem up to 6 cm long, ascending, moderately branched, with central strand. Leaves imbricate when dry, reflexed soon after wetting, but then spreading, 3-4 mm long, keeled, margins recurved on both sides. Hyaline hairpoint relatively short, 1/7-1/3 of lamina lenght. Upper lamina cells bistratose with a 3-5-stratose margin, irregularly papillose, 8-12 μm, with incrassate walls. Basal cells at margin rectangular, with straight walls, in paracostal area longer, with sinuose longitudinal walls and thin transverse walls. Dioicous. Seta arcuate when wet, 2-3 mm long. Capsula horizontal to pendent, doesn't exceed perichaetial leaves, 1.5 mm long, elliptic, ribbed. Peristome teeth erect, linear-lanceolate, cribrose or irregularly 2-3-cleft above, red-brown and smooth below, yellowish and papillose in the upper, linear part. Annulus of 3-4 rows of elongated cells with minute lumina. Operculum convex with long conic beak. Calyptra mitriform. Spores 10-12 μm, finely granulose.

Because of its robust plant size, *Grimmia elatior* is difficult to be mistaken for any other *Grimmia* known in the study area, even by the naked eye. By general appearance it is more similar to *Racomitrium sudeticum*, though the elongate and strongly sinuose leaf cells in the latter distinguish them apart at once. In some uncertain cases (especially in young plants), *G. elatior* can be verified by its bistratose upper lamina, 3-5-stratose leaf margin and the obviously papillose cells. The distinctively ribbed capsulae on a curved seta is also diagnostic for *G. elatior*.

Grimmia elatior is constant in its vegetative characters. We have seen one unusual collection (8/169) of robust plants to about 10 cm high with submuticous leaves and very high papillae. It was found in abundance on a rather xeric and shrubby rock-field in subalpine zone.

Distribution: *Grimmia elatior* is known from many countries in Northern Atlantic and Central Europe; in the former USSR - in mountains of European part (Carpatians, Knibiny, Ural, rarely in lowland, and in Baltia), Caucasus, mountains of Middle Asia and throughout the Siberia and Far East, and also in the Siberian and Beringian Arctics. It is reported from Mongolia, China (southward to Fujian Province), North America (boreal mountains southward to Colorado), and Greenland. In Altai it is one of the most common epilithic mosses, occurring in all altitudes and in nearly all the climatic zones, except the most xeric zone. In forest zone it occurs in more or less open places on rocks and boulders, often covering the latter all around. Above the tree line *G. elatior* survives on open rock surfaces only in permanently wet habitats (near waterfalls, etc.). It however is one of the most common species in alpine zone, growing in the well-sheltered rocks or deep crevices between rocks up to the "depth of arm" and more. In the latter habitat, it was found with sporogones probably more often than in any other types of habitats.

Specimens examined: *Altyntash Creek* 2050 m (Zolotukhin 7.VI.1982); *Artyshtu Creek* 1100 m (Zolotukhin 8.IX.1987); *Ayulyuyuzyuk Creek* 2500 m (0/468); *Bayas Lake* 1750 m (0/467); *Bogoyash Creek, upper course* 2400 m (36/331; 36/98); *Chainary Creek, upper course* 1800 m (34/102; 34/139; 34/201); *Chemal* 450 m (29/6); *Chulcha River, in middle course* 1100 m (9/104); *Inya* 800 m (Melnichuk 19.VIII.1953 LWS! 3446; Melnichuk 20.VIII.1953 LWS! 3447; Melnichuk 19.VIII.1953 LWS! 3452; Melnichuk 20.VIII.1953 LWS! 3455); *Kairu-bazhi Peak* 2100 m (13/37); *Karagai* 500 m (Zolotukhin 10.VIII.1988); *Kayak Lake* 2280 m (7/187); *Kayakkatuyarykskij Creek* 1850 m (8/170; 8/331; 8/82), 1900 m (8/169), 2000 m (3/200; 8/324), 2050 m (3/13; 3/46; 5/17; 7/17), 2100 m (7/106), 2200 m (4/11; 7/97), 2250 m (6/25; 7/102; 7/102b), 2350 m (7/6), 2650 m (7/42); *Kobiguayuk Creek* 2150 m (0/469), 2300 m (0/904); *Kokorya Creek* 2100 m (32/8); *Malyi Yaloman* 1100 m (25/2); *Seminskij Pass* 1750 m (Makarov 15.VI.1972); *Srednij Shaltan Creek* 1000 m (0/905); *Tabozhok Creek, uppermost right branch* 2700 m (36/363a); *Tabozhok Peak* 2350 m (31/5), 2500 m (31/16), 2700 m (31/17); *Ust-Nezya* 800 m (Melnichuk 22.VIII.1953 LWS! 3448); *Yailyu* 450 m (0/903).

Grimmia incurva Schwaegr., Sp. Musc. Frond., Suppl. 1, 1: 90. 1811. Fig. 20-21.

Plants green to dark green above, brown to black below, in loose tufts or rather dense cushions. Stem up to 2-3 cm high, with poorly developed central strand. Leaves flexuose-contorted when dry, narrowly lanceolate (lenght:width ratio about 6:1), up to 3 mm long. Hyaline hairpoint short, usually less than 1/5 of lamina length. Upper lamina cells bistratose, ca. 7 μm, toward the base longer, becoming narrowly linear with nodulose longitudinal walls in paracostal area and rectangular at the leaf margin. Autoicous or dioicous. Seta arcuate, ca. 2 mm long. Capsula do not exceed parichaetial leaves, horizontal to pendent, oblong, ca. 2 mm long. Peristome teeth lanceolate, red-brown, papillose above, slightly papillose below. Annulus differentiated. Operculum with obtuse beak. Calyptra mitriform. Spores ca. 12 μm, smooth.

Grimmia incurva is distinguished from the other species of *Grimmia* by the exceptionally narrow leaves, as long as in *G. elatior*, but narrower. In dry condition leaves are more or less crisped and contorted and this character combined with hyaline hairpoint make this species

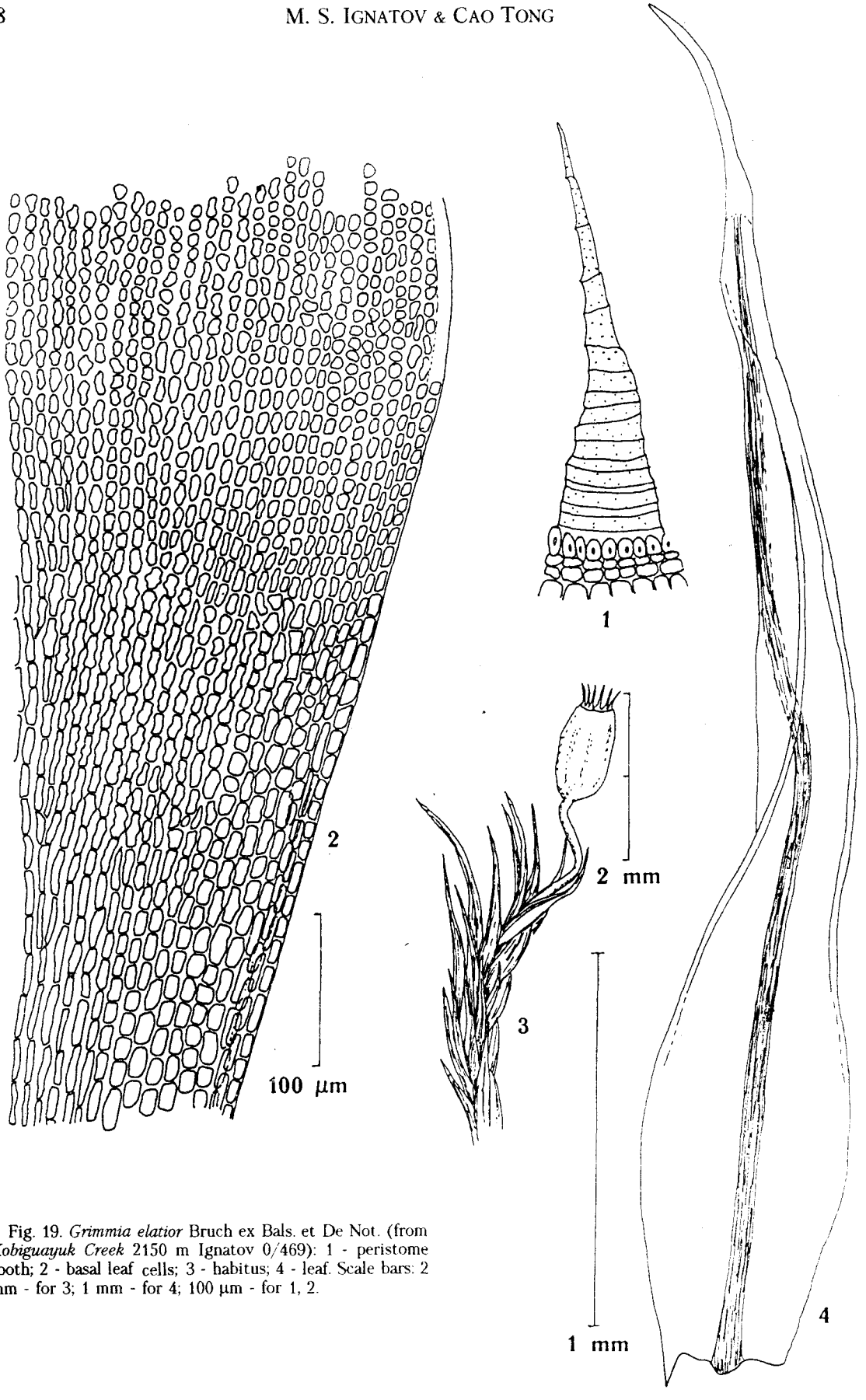


Fig. 19. *Grimmia elatior* Bruch ex Bals. et De Not. (from *Kobiguayuk Creek* 2150 m Ignatov 0/469): 1 - peristome tooth; 2 - basal leaf cells; 3 - habitus; 4 - leaf. Scale bars: 2 mm - for 3; 1 mm - for 4; 100 μm - for 1, 2.

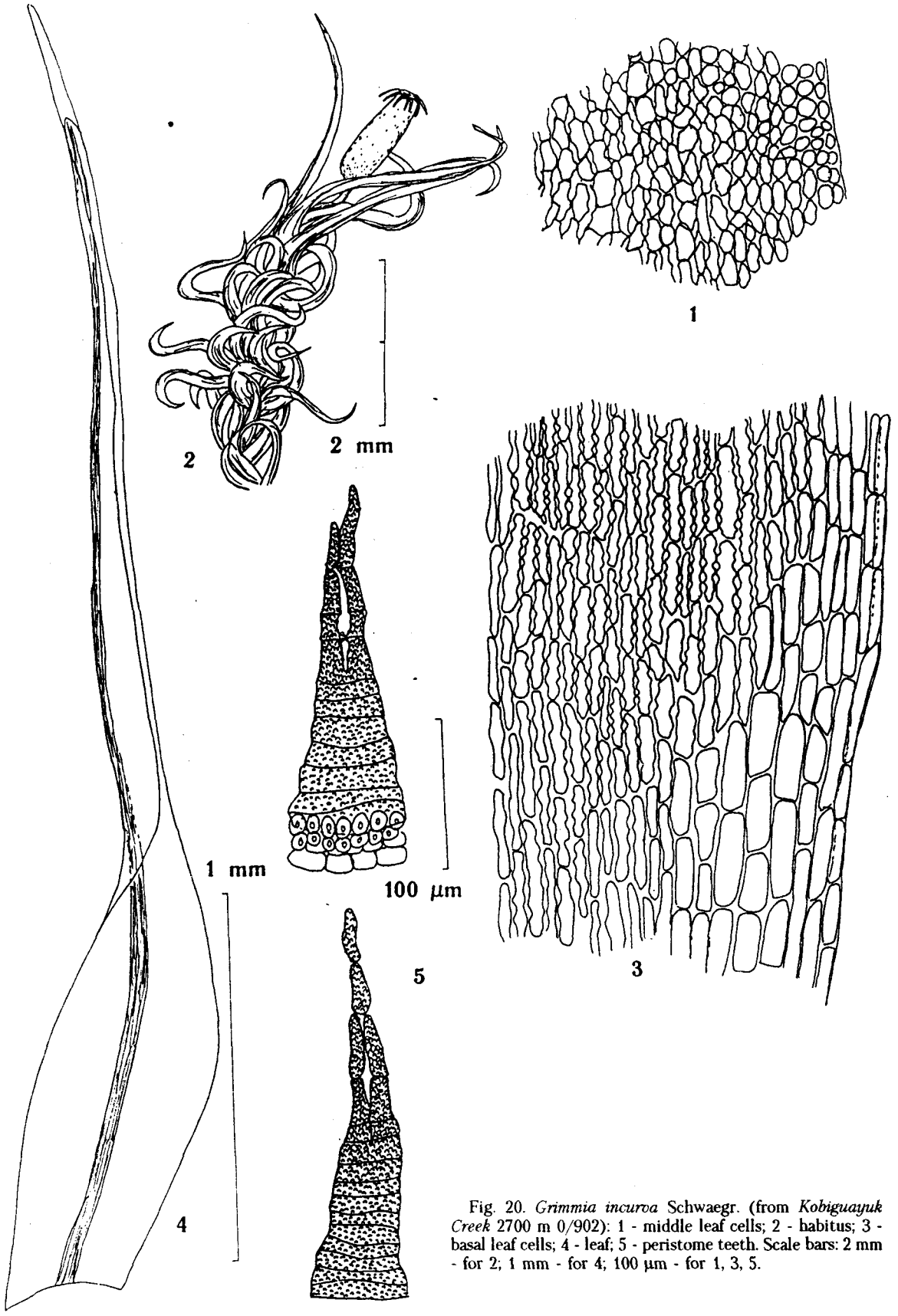


Fig. 20. *Grimmia incurva* Schwaegr. (from *Kobiguayuk Creek* 2700 m 0/902): 1 - middle leaf cells; 2 - habitus; 3 - basal leaf cells; 4 - leaf; 5 - peristome teeth. Scale bars: 2 mm - for 2; 1 mm - for 4; 100 μm - for 1, 3, 5.

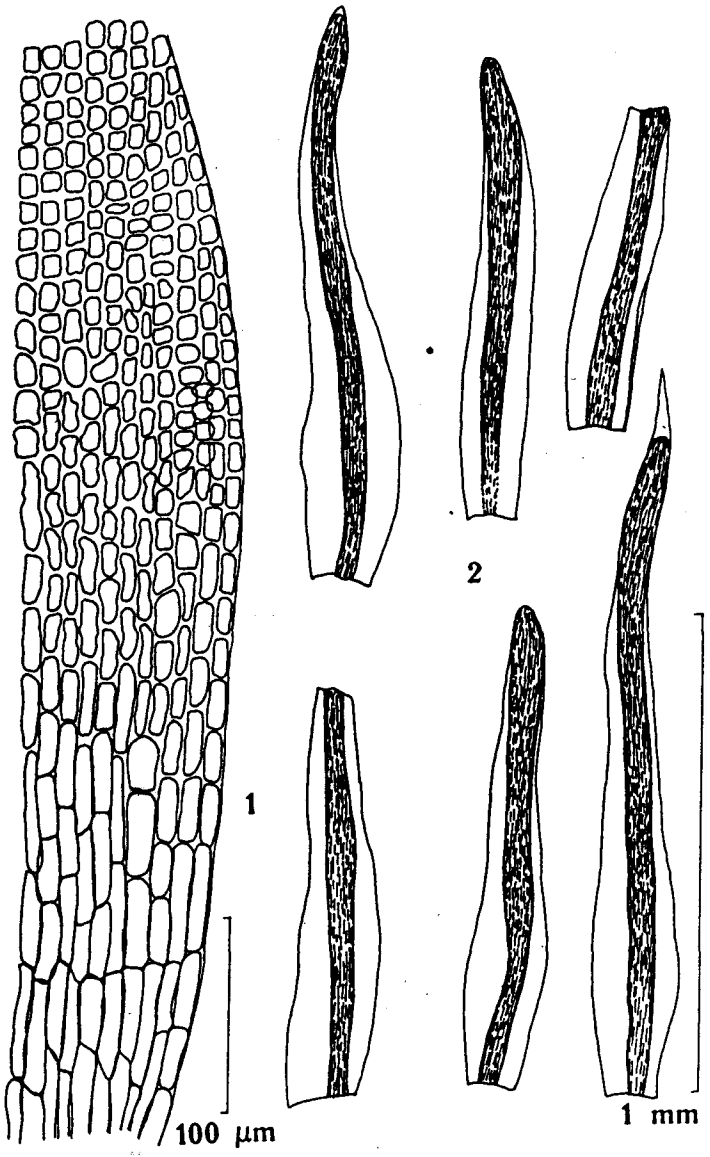


Fig. 21. *Grimmia incurva* Schwaegr. (from *Kobiguayuk Creek* 2908 m Ignatov 0/187): 1 - cells of leaf base; 2 - leaves. Scale bars: 1 mm - for 2; 100 µm - for 1.

easy recognizable in the field. The variation in *G. incurva* mostly concerns the degree of development of hairpoint. In "difficult" habitats the hairpoints can become reduced, so that only upper leaves are shortly hairpointed. Further reduction of leaf hairpoint is observed in several places in the upper alpine zone where *G. incurva* grows on soil: plants are much smaller; leaf is to only 1.5 mm long, perfectly straight, more or less fragile, muticous, costa filling the whole upper half of the leaf. The leaf basal area has the strongly elongate cells reduced to just several rows of rectangular cells (Fig. 21). This expression may become difficult to determine as *G. incurva* (or even to the family Grimmiaceae), if transitional forms with hairpoint are not present.

Distribution: The species is known from the mountains of Europe, from Pyrenees to Scandinavia and Iceland. In the former USSR, it is known from the Arctic (Novaya Zemlya, Chukotka), Kola Peninsula, Baltia, Carpatians in Ukraine, South Ural Mts., Caucasus, Mountains of South Siberia, northern part of the Russian Far East. Present also in Mongolia, China (Tibet and East China), North America (in mountains southward to California) and Greenland. In Altai *G. incurva* is a common species in subalpine and alpine zones. It is distributed from about the timber line to the highest altitudes investigated. Habitat preferences of *G. incurva* are similar to that of *G. elatior*, since both have robust plant body which

enables them to exist without more or less frequent moisturing. As a result, *G. incurva* grows between rocks in rock-field, inside cliff crevices and other sheltered places, usually avoiding exposed surfaces. However, in upper alpine zone *G. incurva* grows sometimes on exposed rocks and soil, forming the unusual expressions discussed above.

Specimens examined: Ayulyuyuzyuk Creek 2500 m (0/927); *Bogoyash Creek, upper course* 2600 m (36/99); *Booshkon Pass* 2600 m (Zolotukhin 1.VII.1990), 2700 m (Zolotukhin 5.VII.1990); *Karakol Lakes* 1950 m (28/111); *Kayakkatuyarykskij Creek* 1900 m (6/23), 1930 m (3/139; 3/260), 1950 m (8/336), 2000 m (3/264; 3/270; 3/72), 2050 m (7/38), 2350 m (7/168; 7/171; 7/4), 2600 m (7/50), 2650 m (7/78), 2850 m (7/57), 2966 m (7/56); *Kobiguayuk Creek* 2500 m (0/471), 2700 m (0/901; 0/902; 0/907), 2750 m (0/934), 2830 m (0/906), 2900 m (0/883), 2908 m (0/187; 0/361; 0/421; 0/930); *Pass between Bashkaus & Pravyi Bogoyash* 2900 m (36/346); *Pass between Kolbakaya and Saluru Creeks* 2400 m (36/71); *Tabozhok Peak* 2750 m (31/13; 31/14), 2780 m (31/12; 31/8); *Tamanel Peak* 2150 m (34/87; 34/88); *Trekhglavaya Peak* 3151 m (Zolotukhin 19.VII.1990); *Uzunkul Lake* 2050 m (Zolotukhin 23.VI.1990); *Uzunoyuk Creek, upper course* 2400 m (Zolotukhin 9.VII.1990).

Grimmia funalis (Schwaegr.) Bruch et Schimp in B.S.G., Bryol. Eur. 3: 119. pl. 247. 1845. Fig. 22.

Trichostomum funale Schwaegr., Sp. Musc. Frond., Suppl. 1, 1: 150. pl. 37. 1811.

Dioicous plants with sexual dimorphism, forming loose tuft, up to 2-3 cm high. Male cushions golden-yellow above and dark-brown to black below. Female cushions blackish and hoary. Stem straight, but slender, with central strand, producing thread-like young slender shoots, bearing small cymbiform and carinate, muticous leaves. Leaves lanceolate, keeled, appressed, spirally twisted on male and sometimes also on female stems, measuring ca. 1 mm long on male, and 1.8 mm long on female stems. Hyaline hairpoint about 0.3 of the lamina length in males, and as long as the lamina in female plant. Costa percurrent. Upper lamina cells 6-8 μm. Middle leaf cells rectangular, with rather uniformly incrassate walls so that the lumens look homogenously, ca. 14 mm in diameter. Basal cells at margin rectangular, or sometimes with 1-2 rows of more elongated cells. In paracostal area cells are elongate. Perichaetial leaves are somewhat larger. Seta arcuate on young stages of sporogone development, later slightly geniculate, thick. Capsula ovoid. Peristome teeth straight, nearly smooth below, minutely papillose above. Annulus well differentiated. Operculum convex and beaked. Calyptra mitriform. Spores ca. 15 μm.

The distingishing feature of *G. funalis* which many authors use is the spirally twisted leaves. However, according to our observation, this twisting pattern is constant only in male plants, while in female plants leaves are often just curved like that seen in *G. affinis, G. donniana,* etc. Our observation is confirmed by the comparison of Altai plants with materials from Central Europe, Scandinavia and Caucasus. We think that the reliable diagnostic features of *G. funalis* are: (1) characteristically juvenile shoots which are julaceously foliated with muticous leaves; and (2) pattern of the laminal areolation. Due to strongly and evenly thickened cell walls, cell lumens have approximately the same measurement as the cell walls and so form a specific homogenous pattern of small and relatively regular network of lumens, becoming slightly enlarged near the leaf base and slightly decreased in size towards the apex. Cell walls are usually somewhat sinuose, but under the low magnification of the microscope, the lumens seem almost ovate.

The perigonia and perichaetia were never observed in the same cushion. The male and female cushions have their rather distinctive appearance. Moreover, in the field, male and female cushions were never seen side by side. As described above, male cushions are greyish or golden-yellow above and contrastingly black below. Stem leaves are small, with hair points, and obviously twisted. Usually 3-4 perigonia are found on each stem, with approximately the same distance between them and with a geniculate curvation of stem at those places with perigonia. The neighbouring "internodes" have the different direction of twisting, clockwise/counter-clockwise. The length of hairpoint varies from moderate (in unfavoured conditions) to long. Female plants are considered conspecific with the male plants on the basis of similarity in the leaf areolation pattern and presence of thread-like shoots. Female plants form more robust cushions, because of longer leaves which are only slightly twisted. A rather constant character of female plants is the very long hairpoint which easily distinguishes *G. funalis* from *G. affinis*, a species of about the same size.

Sporogones were seen only in 2 collections from Altai: seta is short (hairpoints of perichaetial leaves exceed the capsula), rather stout, arcuate when wet in premature capsula, but only slightly curved when wet in collection with old empty capsulae. Capsulae are small (for a *Grimmia* of such height) and slaightly ribbed.

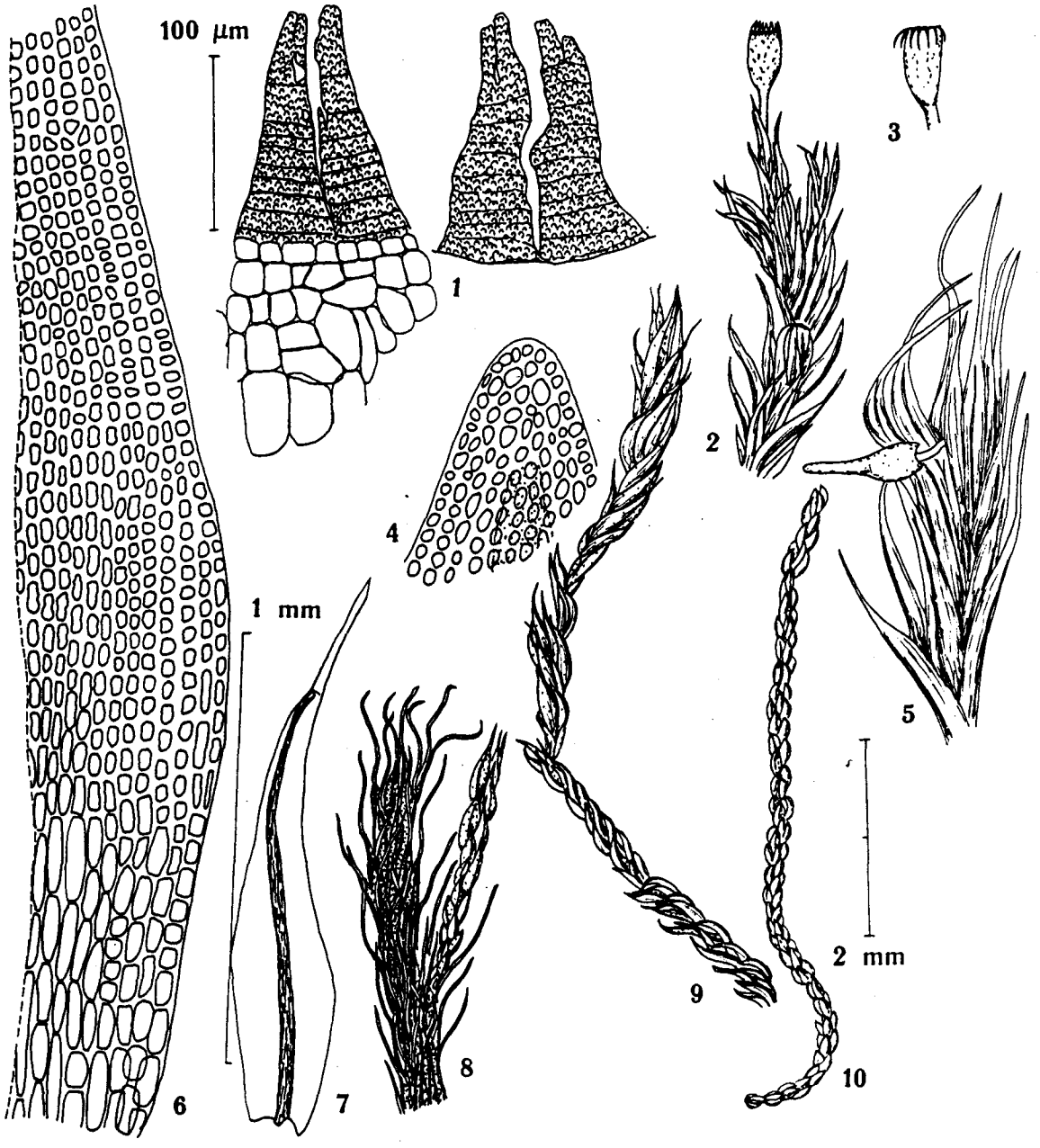


Fig. 22. *Grimmia funalis* (Schwaegr.) Bruch et Schimp in B.S.G. (from *Kobiguayuk Creek* 2150 m Ignatov 0/908): 1 - peristome; 2, 5, 8 - female plants; 9-10 - male plants; 3 -capsula; 4 - upper leaf cells; 6 - basal leaf cells; 7 - leaf. Scale bars: 2 mm - for 2, 3, 5, 8, 9, 10; 1 mm - for 7; 100 μm - for 1, 4, 6.

Distribution: The species is present in the mountains of Northern and Central Europe and reported from Canaries, Algeria, Greenland and East Nepal. In the territory of the former USSR - in Kola Peninsula (rather common there), Carpatians, Caucasus, mountains of Middle Asia and South Siberia, and also in Siberian Arctic. In Japan, it is known from only 1 locality. In the Altai, *G. funalis* is a rather common species throughout the subalpine and lower part of alpine zone, especially in more wet areas. In more xeric part of Altai, *G. funalis* usually occurs only at very high elevations where the influence of surrounding steppe and semi-deserts is minimized.

Specimens examined: Bayas Lake 1750 m (0/913); *Bogoyash Creek, upper course* 2300 m (36/135), 2400 m (36/335); *Dvukhkarovaya Creek* 2450 m (36/179); *Kairubazhi Peak* 2100 m (13/38; 13/45), 2300 m (13/133; 13/30); *Karakol Lakes* 1900 m (28/121); *Kayakkatuyarykskij Creek* 1750 m (8/10), 1950 m (3/112), 2000 m (3/165), 2050 m (3/107; 3/33; 3/52; 3/69; 7/35), 2200 m (6/18), 2280 m (7/182), 2350 m (7/5; 7/7); *Kobiguayuk Creek* 2150 m (0/469; 0/470; 0/908; 0/910), 2200 m (0/911), 2220 m (0/914), 2350 m (0/912), 2370 m (0/2350; 0/297), 2500 m (0/916);

Kokkul Lake 2300 m (33/12); *Kolyushta Peak* 2150 m (0/949); *Malaya Kokorya Creek* 2300 m (36/344); *Tabozhok Peak* 2750 m (31/76); *Trekhglavaya Peak* 2450 m (Zolotukhin 19.VII.1990).

Grimmia unicolor Hook. ex Grev., Scott. Crypt. Fl. 3: 123. 1825. Fig. 23.

Plants medium in size, in rather dense dark-green to dark-brown tufts. Stem ascending, up to 3 cm high, with central strand. Leaves lanceolate, muticous, concave, with incurved margins and narrowly obtuse cucullate apex, 2.0-2.5 mm long. Costa ends below the apex. Upper lamina cells bistratose, not translucent, rounded, ca. 6 μm. Basal cells at margin thick-walled, quadrate to short-rectangular; in larger leaves with a few rows of thin-walled, rectangular cells, 2-3:1. Laminal cells in paracostal area linear, with thick longitudinal walls. Dioicous. Seta 2-3 mm long, curved, yellow-brown. Capsula exserted, yellow-brown to brown, wrinkled-striate, 1.5 mm long, ovoid, distinctly contracted at apex and base; in empty capsula the seta attaching to urn in a depression. Peristome teeth erect, rigid, dark-red, nearly entire, slightly perforated, densely papillose above, less papillose below. Annulus of 3 rows of subquadrate, thick-walled cells. Operculum with short obtuse beak. Calyptra mitrate. Spores 8-12 μm, nearly smooth.

Muticous leaves with a rather cucullate apex allow an easy distinction of *Grimmia unicolor* from all other Altaian *Grimmia*. Some expressions of *G. affinis* and *G. incurva*, growing in unfavourite conditions, can produce muticous forms, but the two taxa never have cucullate apex, and also they form usually small and dense cushions, while under normal condition, *G. unicolor* is a rather robust plant. Contrary to the widespread report that the seta of *G. unicolor* is straight when wet, we found geniculate or curve setae in some cushions with numerous sporogones. At the same time the seta is not hygroscopic and the changing moisture does not affect the characteristics of curvation. Capsula is usually somewhat ribbed, though not always, and definitely constricted both below the mouth and at base as in *G. pulvinata*, *G. elatior*, and other members of the subgenus *Rhabdogrimmia*.

Distribution: The species is widely distributed in Northern Hemisphaere, known from Northern Europe and mountains of Atlantic and Central Europe. In the former USSR, it is known from Kola Peninsula, Polar Urals, Caucasus, mountains of Middle Asia and South Siberia. Also present in Mongolia (Khangai Mts.), China (Tibet, Shanxi, Jilin) and has been reported from India and North America (scattered in boreo-temperate regions). In Altai *G. unicolor* is not common, occurring usually on wet and relatively basic rocks (schists) mostly in subalpine zone, rarely in forest and alpine zones.

Specimens examined: Ak-Turu Creek 2600 m (Bardunov 18.VII.1966 IRK!); *Artybash* 450 m (Melnichuk 3589 LWS!); *Kairu-Bazhi Peak* 2100 m (13/162; 13/21; 13/41; 13/49); *Kayakkatuyarykskij Creek* 1900 m (3/268; 8/158; 8/163), 1920 m (3/147), 2050 m (3/12; 3/32; 3/61; 3/84), 2280 m (7/11); *Kobiguayuk Creek* 2200 m (0/464); *Pass between Kolbakaya and Saluru Creeks* 2400 m (36/347); *Tabozhok Creek, uppermost right branch* 2700 m (36/363).

Hydrogrimmia Loeske

Plants in dark green, rather soft tufts. Stem with central strand. Leaves muticous, ovate, concave and cucullate, roundly obtuse. Costa relatively weak, ending below the apex. Upper lamina cells isodiametric, thin-walled; basal cells shortly rectangular. Dioicous. Perichaetial leaves similar to stem leaves, but larger and sometimes, short-awned. Seta straight. Capsula shortly exserted, oblong-cylindric. Peristome normally developed, papillose, somewhat perforate above. Annulus absent. Operculum apiculate. Calyptra cucullate. Spores small, faintly papillose (sporophyte characteristic is based on non-Altaian material).

Hydrogrimmia mollis (Bruch et Schimp. in B.S.G.) Loeske, Stud. Morph. Syst. Laubm. 108. 1910. Fig. 24.

Grimmia mollis Bruch et Schimp. in B.S.G., Bryol. Eur. 3: 133. pl. 253. 1849.

Stem 1-2 cm high. Leaves 1.5-2.5 cm long, costa narrow, ca. 0.01 mm. Upper lamina cells ca. 20 μm; basal cells at margin and in paracostal area similar, 30-40 μm long, 20-25 μm wide. Altaian plants sterile.

As a member of Grimmiaceae, there is no problem in determining a specimen of *Hydrogrimmia mollis* because of its unusually large quadrate cells and large leaves which are broadly rounded at the apex.

Distribution: *Hydrogrimmia mollis* has a Holarctic range which was discussed in details by H. Bednarek-Ochyra & al. (1990). Probably the only region where it is common is the Northern Europe, including Scandinavia and Kola Peninsula. In Central Europe it is a rare montane moss. Specimens from the former USSR were seen from Kola Peninsula, Polar Ural, Caucasus, Chukotka, northern part of Russian Far East and Alati. Recently it was reported for Japan from a single locality (Iwatsuki & al., 1986). Also it is known from North America (rare in Yukon, Rocky Mountains, Labrador, Greenland). In Altai *H. mollis* was found well above the tree line on rocks in dry brook bed, in seepy lithosoil from melting water of snow bed, and among big rocks in the rock-field.

Specimens examined: Ayulyuyuzyuk Creek 2500 m (0/466); *Pass between Bashkaus & Pravyi Bogoyash* 2600 m

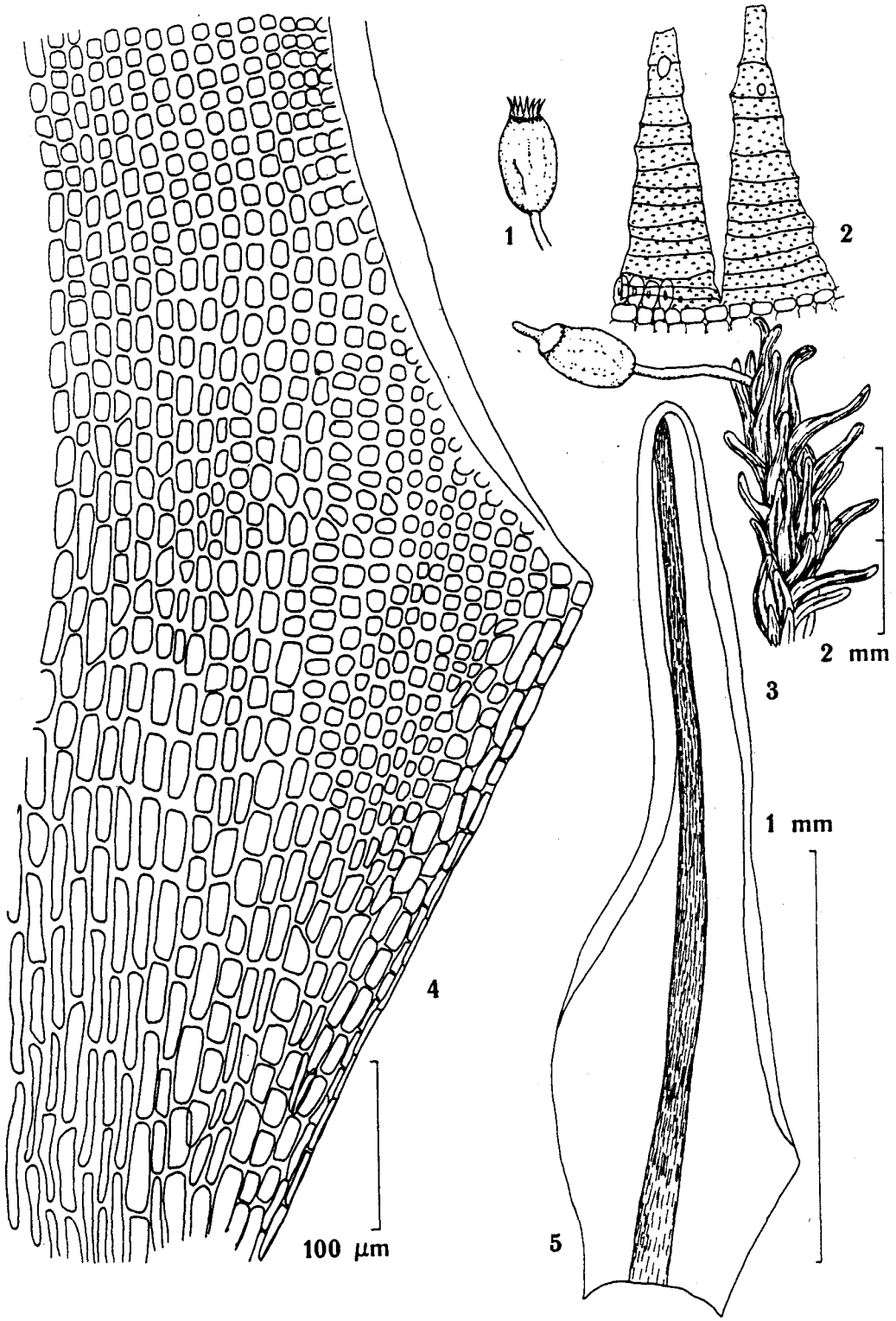


Fig. 23. *Grimmia unicolor* Hook. ex Grev. (from *Kayakkatuyarykskij Creek* 2050 m 3/84): 1 - capsula; 2 - peristome teeth; 3 - habitus; 4 - basal leaf cells; 5 - leaf. Scale bars: 2 mm - for 1, 3; 1 mm - for 5; 100 µm - for 2, 4.

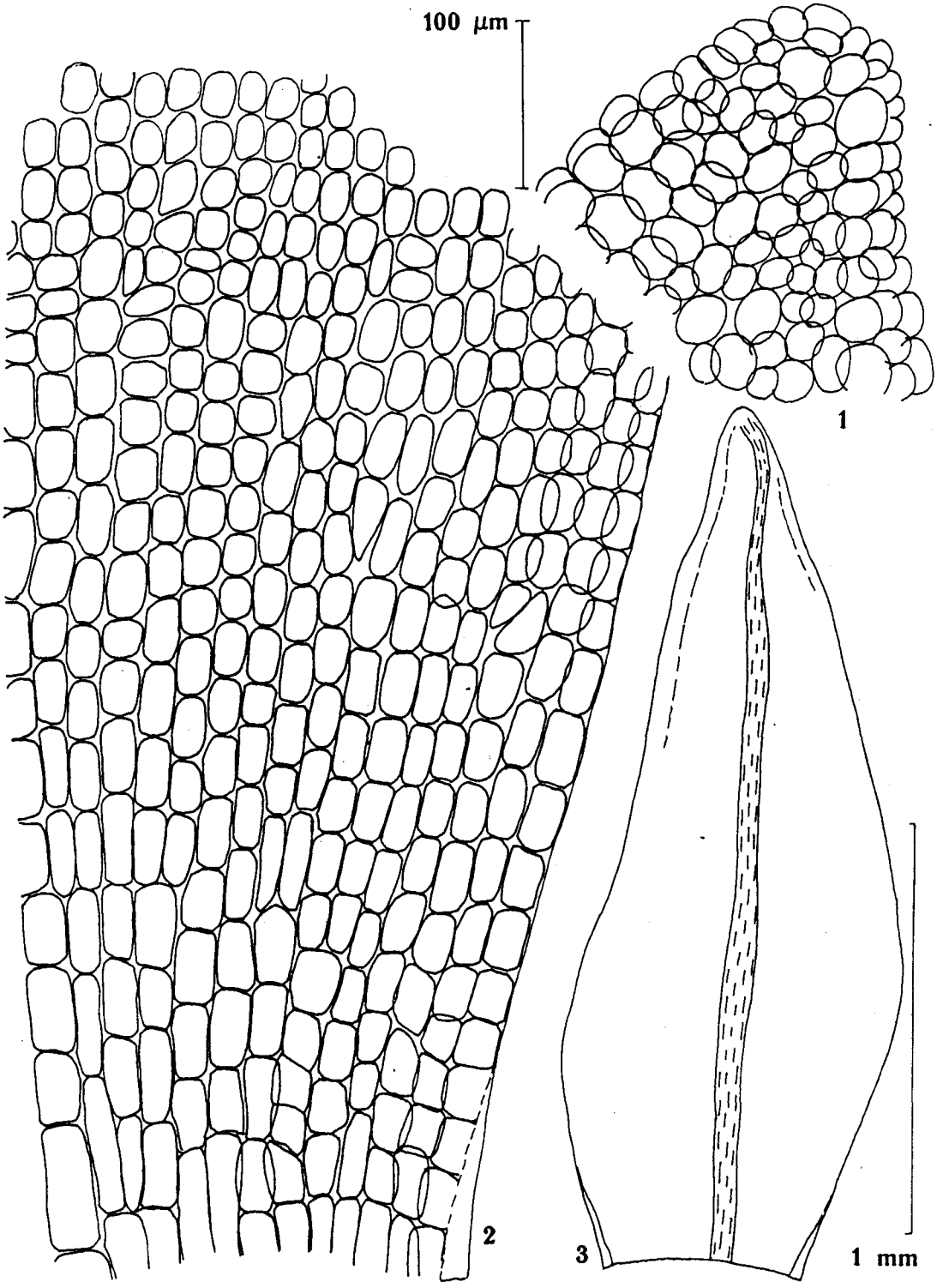


Fig. 24. *Hydrogrimmia mollis* (Bruch et Schimp. in B.S.G.) Loeske (from *Ayulyuyuzyuk Creek* 2500 m Ignatov 0/466): 1 - cells of leaf tip; 2 - basal cells; 3 - leaf. Scale bars: 1 mm - for 3; 100 µm - for 1, 2.

(36/79); *Uzunoyuk Creek, upper course* 2400 m (Zolotukhin 9.VII.1990).

Schistidium Brid.

Plants slender to robust, yellowish-green, green, reddish-brown or blackish-green tufts. Stem erect to ascending, frequently branched, with or without central strand. Leaves erect when dry and spreading when moist, lanceolate to ovate, keeled to obtusely keeled, muticous or ending in hyaline hairpoint. Margins recurved on one or both sides, uni- or bistratose, entire, or in *S. strictum*, slightly toothed above. Costa stout, terete, percurrent or subpercurrent, smooth or papillose on abaxial surface. Upper lamina cells quadrate or almost so, with thick walls. Basal cells at margins quadrate to short rectangular, in paracostal area, rectangular, with straight or slightly sinuose walls. Perichaetial leaves of the same shape, but larger and with extensive zone of thin-walled rectangular cells in its lower half. Autoicous (Altaian species). Seta straight, shorter than urn (except *G. agassizii*). Capsula erect, immersed, oblong-cylindric to hemispheric. Peristome teeth 16, well-developed (in Altaian species), bright-red to red-brown, lanceolate, entire, or little perforated, densely papillose on both inner and outer surfaces. Annulus absent. Opercula low-conic, with short oblique beak, falling with the columella attached. Calyptra cucullate, small, not extending to the urn. Spores 9 to 19 μm, smooth to papillose.

KEY TO THE ALTAIAN SPECIES OF *SCHISTIDIUM*

1. Leaves totally muticous, capsulae broadly hemispheric, spores 12-19 μm 2
1. Leaves with hairpoint or submuticous, at least with hyaline apical cells in upper leaves, capsulae oblong-cylindric, spores 9-13 μm ... 3
2. Leaves broadly ovate, bi- to tristratose along the margins, seta shorter than urn ..... *S. rivulare* (p. 109)
2. Leaves lanceolate-ovate, margins unistratose, seta as long as urn .... *S. agassizii* (p. 106)
3. Plants small, less than 1 cm in height, red-brown ..... *S. liliputanum* (p. 113)
3. Plants larger, usually more than 2 cm in height (except some low forms of *S. apocarpum*, which are dark-green to blackish in color) 4
4. Abaxial cells of costa distinctly papillose, plants typically in rather loose, red-brown tufts ..... *S. strictum* (p. 112)
4. Abaxial cells of costa smooth or nearly so, plants in compact, dark-green to blackish tufts ..... *S. apocarpum* (p. 109)

Schistidium agassizii Sull. et Lesq. in Sull., Musci Hep. U.S. (repr.) 104. 1856. Fig. 25.

Plants in dark green to nearly black tuft. Stem up to 5 cm long, ascending, or prostrate in frequently submerged populations, with central strand. Leaves lanceolate, 1-3 mm long (perichaetial leaves up to 4.5 mm), obtuse or obtusely acute, concave, muticous. Costa percurrent or ending a little below the apex. Upper lamina cells unistratose, including margins, quadrate-rounded, 9-11 μm. At leaf bases are a small groups of short-rectangular cells. Autoicous. Seta up to 1 mm long, about as long as urn. Capsula subimmersed, obconic, with broad mouth. Peristome teeth big, up to 0.6 mm long, narrow-triangular, red, papillose, more or less cribrose, irregularly cleft above, especially along median line. Operculum with oblique beak. Calyptra cucullate. Spores smooth, ca. 15 μm.

Deguchi (1979b) clarified the typification of *Grimmia alpicola*. Bremer (1980) proposed that the names *G. alpicola* and *Schistidium alpicola* be placed on the list of rejected names. In this case, the species with narrow leaves will then be named *Schistidium agassizii* or *Grimmia agassizii* (Cao & Vitt, 1986).

Schistidium agassizii is easy to recognize by its very narrow and long leaves with unistratose margins. When growing submerged, the leaves of *S. agassizii* often become decomposed and only the costae remain persistent, except in a few uppermost leaves.

Distribution: For a long time this species was known under the name *Schistidium alpicola* var. *alpicola*, while *S. rivulare* was named *S. alpicola* var. *rivulare* or *S. alpicola* var. *latifolia*. Since many publications referred only to *S. alpicola*, the actual range of *S. agassizii* is still little known. In Europe, *S. agassizii* is known in many countries from Lusitania, Spain, Italy, Bulgaria to Iceland and Scandinavia. In the former USSR, it is known from Siberian and Beringian Arctic, northern part of European Russia, penetrating southward along the coast to Baltic countries, Caucasus, mountain areas of South and East Siberia, Far East and Middle Asia. In North America *S. agassizii* is bicentric, being widespread in mountains in the West from Alaska, Yukon to California and Colorado, and in the East from Newfoundland to New York. *S. agassizii* has not been reported so far from China and Mongolia. In Altai *S. agassizii* is known only from a single creek basin, where, however, it is frequent in a number of creek tributaries in alpine and subalpine zones. Populations grow on rocks along streams and beside waterfalls occuring constantly for kilometers along banks.

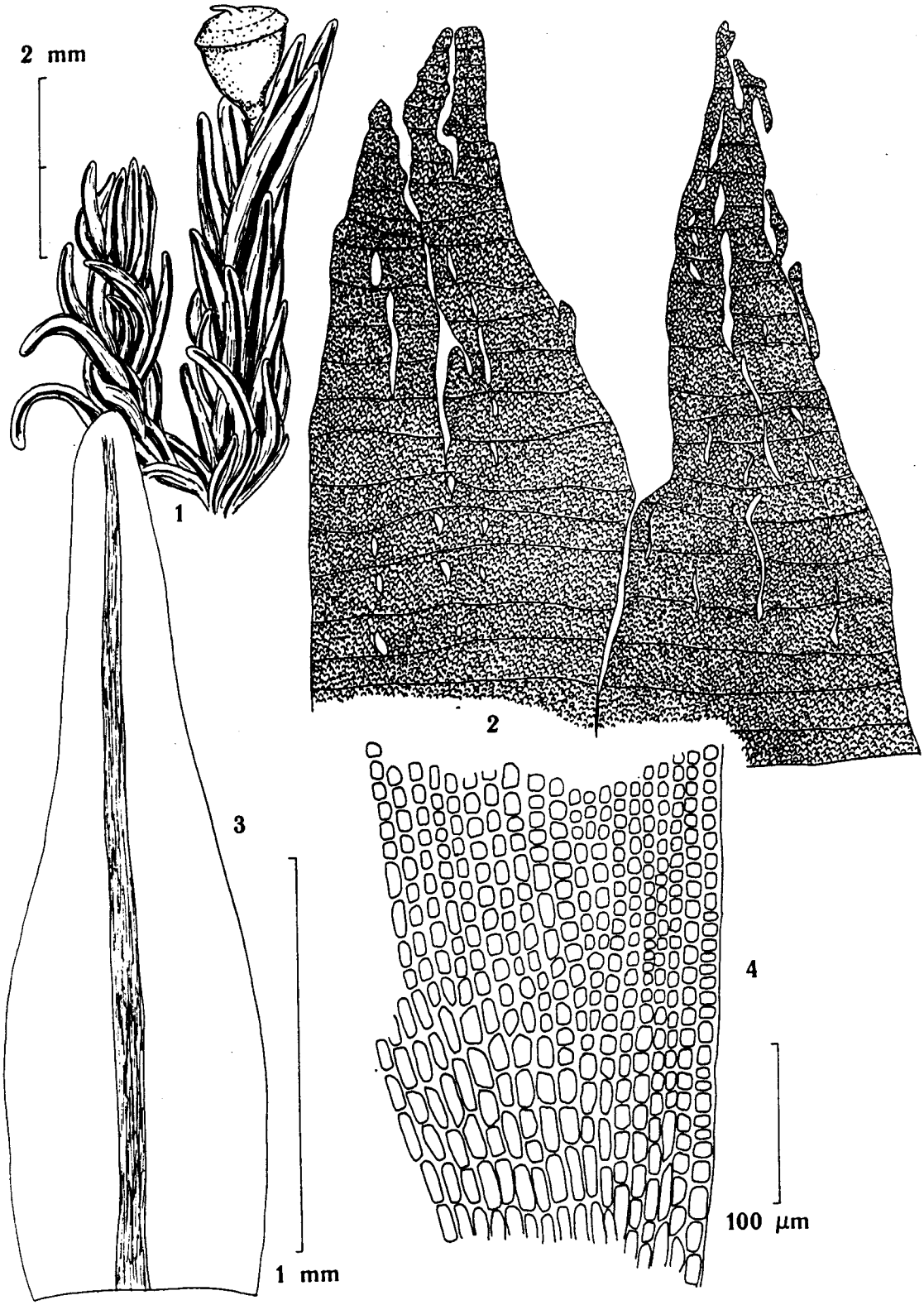
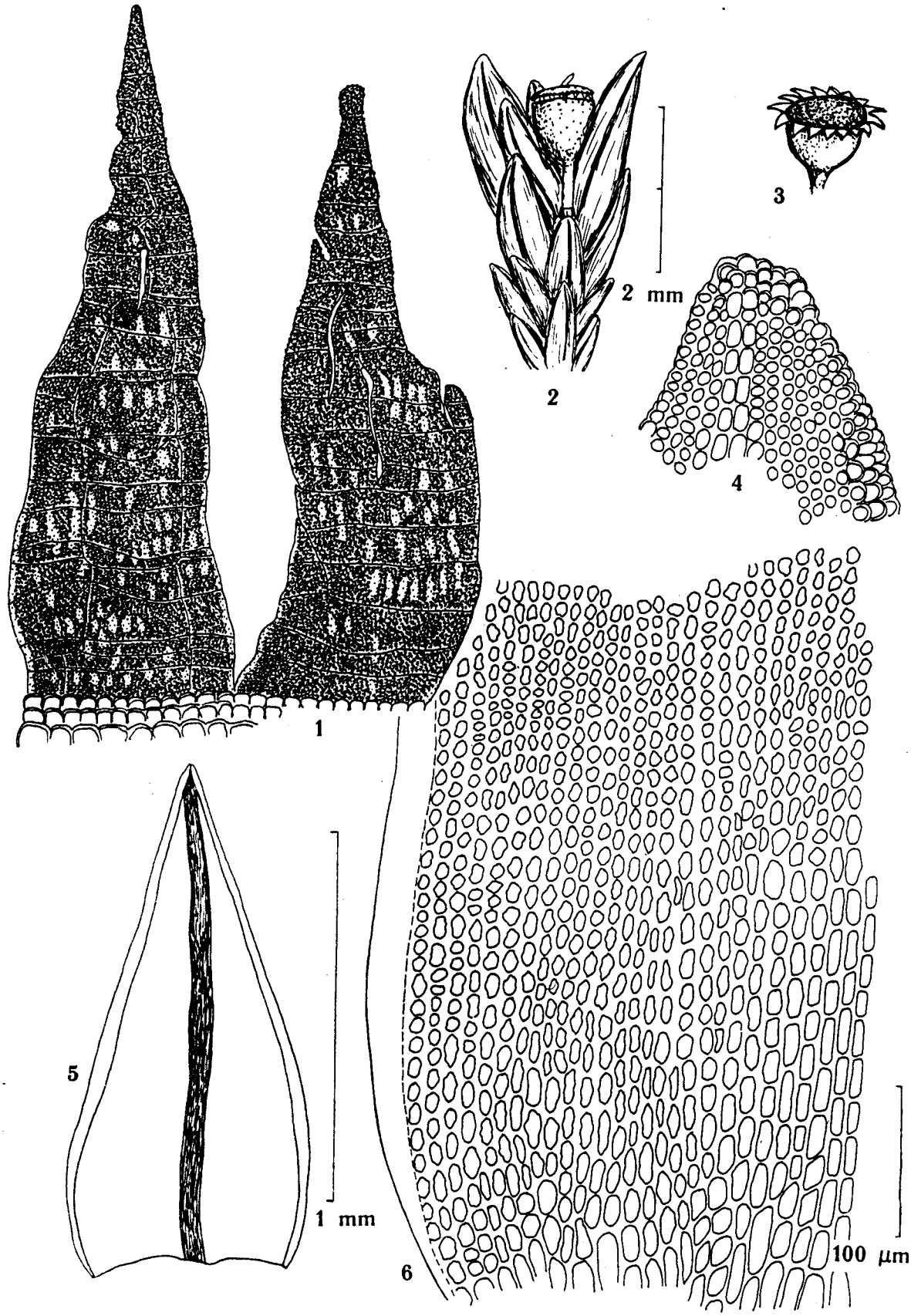


Fig. 25. *Schistidium agassizii* Sull. et Lesq. in Sull. (from *Kayakkatuyarykskij Creek* 2050 m Ignatov 7/139): 1 - habitus; 2 - peristome teeth; 3 - leaf; 4 - basal cells. Scale bars: 2 mm - for 1; 1 mm - for 3; 100 μm - for 2, 4.


1
2
2 mm
3
4
5
1 mm
6
100 µm

Specimens examined: Kayakkatuyarykskij Creek 1750 m (8/115); 1760 m (8/235); 1850 m (8/58); 2050 m (7/139; 7/15).

Schistidium rivulare (Brid.) Podp., Beih. Bot. Centralbl. 28(2): 207. 1911. Fig. 26.

Grimmia rivularis Brid., J. Bot. (Schrader) 1(2): 276. 1801.

Grimmia alpicola Hedw. var. *rivularis* (Brid.) Wahlenb., Fl. Lapp. 32. 1812.

Plants medium to robust, in loose, large tufts, dark-green above, black below. Stem up to 4 cm high, with central strand. Leaves 1.5-3.0 mm long, ovate-lanceolate to ovate and nearly triangular, acute, with broadly recurved margins, muticous. Costa thick, percurrent. Upper lamina cells rounded, ca. 10 µm in diameter, slightly mamillose, so that the margin looks denticulate. Basal cells at margin quadrate or very shortly rectangular, up to 1.5:1; in paracostal area, rectangular, up to 2.5:1. Autoicous. Seta shorter than capsula, ca. 0.5 mm long. Capsula immersed, dark-brown, semi-globose, wider than long when empty. Peristome teeth red, big, about 0.5 mm long, perforated, papillose throughout. Operculum convex, with oblique beak. Calyptra cucullate. Spores 13-17 µm.

Schistidium rivulare is a robust plant with broad muticous leaves and nearly always present hemispherical capsulae with massive bright-red peristome teeth. In some ambiguous cases it can be distidguished from *S. agassizii*, by the unistratose margins of the latter.

Distribution: Schistidium rivulare is distributed throughout the Holarctic, being however rarer or absent in the lowland. In the territory of former USSR, it occurs in nearly all regions. Outside Holarctic, it was reported from the Himalayas, Central Africa, Central America (Ecuador) and Australia. In Altai this species is distributed mostly in alpine zone, typically on wet, sometimes over-flooded rocks, rarer in other habitats on rocks (in alpine and forest zones), or on soil (in alpine zone).

Specimens examined: Ayulyuyuzyuk Creek 2500 m (0/430); *Bardaky Lake* 1950 m (0/900); *Inya* 800 m (Vysozkaya 15.VII.1977 LB! 9217); *Karakol Lakes* 1900 m (28/139); *Kayakkatuyarykskij Creek* 1900 m (8/161), 2050 m (5/16), 2100 m (8/107), 2650 m (7/71); *Kishte* 440 m (Zolotukhin 11.VII.1988); *Kobiguayuk Creek* 2400 m (0/115); *Kokkul Lake* 2300 m (33/8); *Kolbakaya Creek, upper course* 2400 m (36/78); *Kukol* 1750 m (0/898; 0/899); *Tabozhok Peak* 2350 m (31/15); *Yazula* 1650 m (0/431).

Schistidium apocarpum (Hedw.) Bruch et Schimp. in B.S.G., Bryol. Eur. 3: 99. pl. 233. 1845. Fig. 27.

Grimmia apocarpa Hedw., Sp. Musc. Frond. 76. 1801.

Plants in more or less dense tufts, green or dark-green above, black below. Stems (1)1.5-3 cm high, with central strand. Leaves lanceolate from an ovate base, 1.5-2.5 mm long (perichaetial leaves up to 3.5 mm long), keeled above, with variously developed hairpoints from only a few hyaline cells in uppermost leaves (lower leaves muticous) to about 1/5-1/3 of the entire laminal length. Upper lamina cells irregularly isodiametric to subquadrate; basal leaf cells rectangular, at margin ca 1.5-2:1, while in paracostal area 2-4:1, with nearly straight walls. Autoicous. Seta shorter than urn, ca 0.3 mm. Capsula immersed, 1.2-1.5 mm long, oblong-ovate. Peristome teeth triangular, ca. 0.3 mm long, red, entire to slightly perforated. Operculum with short straight beak. Calyptra small, cucullate. Spores 7-12 µm, smooth.

Most treatments describe *Schistidium apocarpum* as a very variable species. Altaian materials can confirm this statement. The most common expression in Altai has medium to robust plants (for the genus) forming dull-green or blackish-green tufts, with weekly developed hairpoints (sometimes present only in perichaetial leaves), and triangular (not attenuate) peristome teeth. Such plants were observed on calcareous rocks (often covered by alluvium) along Katun River and in the region of Teletzkoye Lake at lower altitudes. Other plants, especially that on xeric rocks, have a more slender appearance, almost black in its tuft coloration during mid- to late summer, and with rather developed hairpoints. This form could become very similar to the weakly papillose form of *S. strictum*. Under the circumstance, the different sizes of cells at leaf base can be used for their respective identification, since this character seems to be constant in these two species. In alpine zone, *S. apocarpum* is rare and more or less uniform in morphology, forming more lowly and denser tufts.

Distribution: Schistidium apocarpum s.l. is a species of world-wide distribution from polar to temperate zones of both hemispheres, occurring also in high mountains in low latitudes. In Europe it is known from all the countries and in the former USSR, from all regions. It is especially common in lowlands, probably because of its preference of calcareous rocks. On acidic rocks *S. apocarpum* is less common, while

Fig. 26. *Schistidium rivulare* (Brid.) Podp. (from *Ayulyuyuzyuk Creek* 2500 m Ignatov 0/430): 1 - peristome teeth; 2 - habitus; 3 - capsulla; 4 - cells of leaf tip; 5 - leaf; 6 - cells of leaf base. Scale bars: 2 mm - for 2, 3; 1 mm - for 5; 100 µm - for 1, 4, 6.

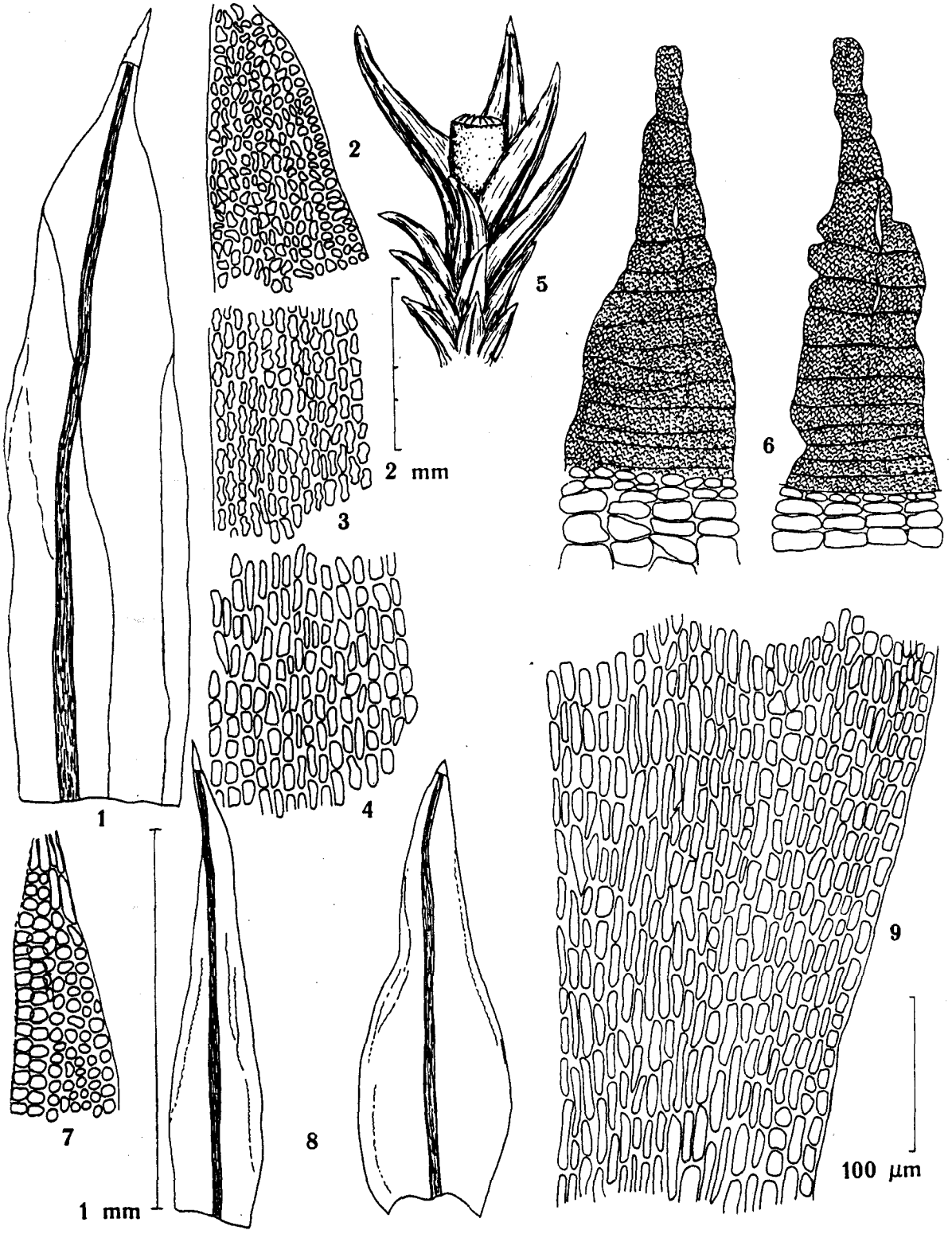


Fig. 27. *Schistidium apocarpum* (Hedw.) Bruch et Schimp. in B.S.G. (from *Kobiguayuk Creek* 2750 m Ignatov 0/885): 1, 8 - leaves; 2, 7 - cells of leaf tip; 3 - upper lamina cells; 4 - middle lamina cells; 5 - habitus; 6 - parts of peristome; 9 - cells of leaf base. Scale bars: 2 mm - for 5; 1 mm - for 1, 8; 100 µm - for 2, 3, 4, 6, 7, 9.

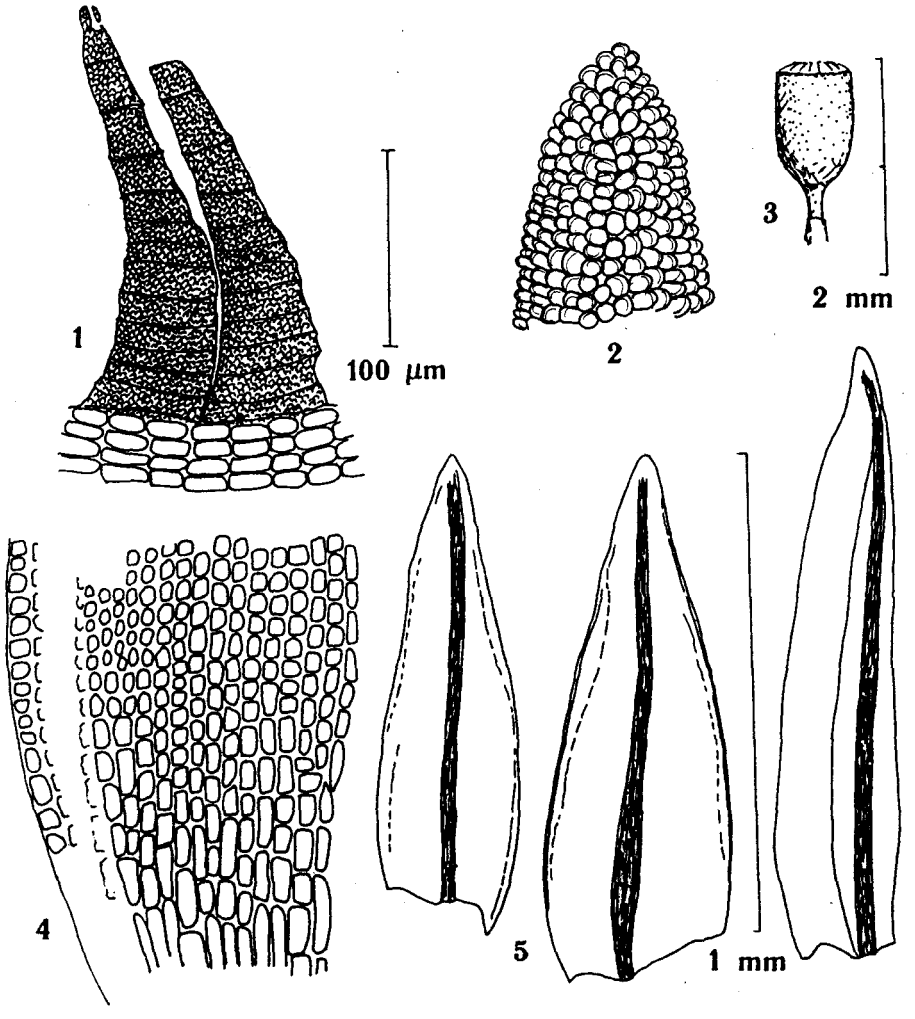


Fig. 28. *Schistidium* cf. *helveticum* (Schkuhr) Deguchi (from *Bayas Lake* 1950 m Ignatov 0/936): 1 - peristome teeth, 2 - cells of leaf tip; 3 - capsula; 4 - cells of leaf base; 5 - leaves. Scale bars: 2 mm - for 3; 1 mm - for 5; 100 µm - for 1, 2, 4.

S. strictum become more frequent. Consequently, in Altai *S. apocarpum* is rather rare, especially in comparison with the very abundant *S. strictum* (the same situation is also true in China and Japan). In the study area, most of its localities are situated in the valley of Katun River, from the Chuya mouth and downstream, at 1000 - 300 m alt. Only a few other collections are known from the northern shore of Teletzkoye Lake in the alpine zone.

Specimens examined: Bogoyash Creek, upper course 2350 m (36/370), 2400 m (36/373); *Chemal* 400 m (29/66), 420 m (29/17; 29/54); *Chike-Taman Pass* (Vysozkaya 12.VII.1977 LB!) 1600 m (Vysozkaya 12.VII.1977 LB!); *Kobiguayuk Creek* 2750 m (0/885); *Malyi Yaloman* 800 m (25/31), 950 m (25/163); *Taldura* 2200 m (Krylov 18.VII.1903 LE); *Ust-Sema* 400 m (Vysozkaya 14.VII.1977 LB! 57.77); *Yailyu* 450 m (1/75).

In one collection from subalpine zone *(Bayas Lake* 1950 m 0/936) we have found a form which was preliminary identifyed as *Schistidium helveticum* (Schkuhr) Deguchi, Rev. Bryol. Lichenol. 45: 434. 1979 - *Grimmia helvetica* Schkuhr, Deutschl. Krypt. Ges. 2(2): 48. pl.21. 1811.(Fig. 28). This is not enough clear species for us, so it is discussed briefly.

Plants in compact brownish-green tufts. Stem 2 cm high, with central strand. Leaves lanceolate, up to 2 mm long, muticous, obtusely keeled, with recurved margins. Costa percurrent. Upper lamina cells rounded, ca. 10 mm in diameter. Basal cells at margin quadrate, becoming short- rectangular in paracostal area. Autoicous. Seta ca. 0.3 mm long. Capsula immersed, oblong-cylindric. Peristome teeth lanceolate, rather short, 0.25 mm long, papillose, yellowish above, red below. Operculum obtusely beaked. cucullate. ca 12 mm, nearly smooth.

From *S. agassizii* and *S. rivulare*, this species differs in having oblong-cylindric capsulae, a

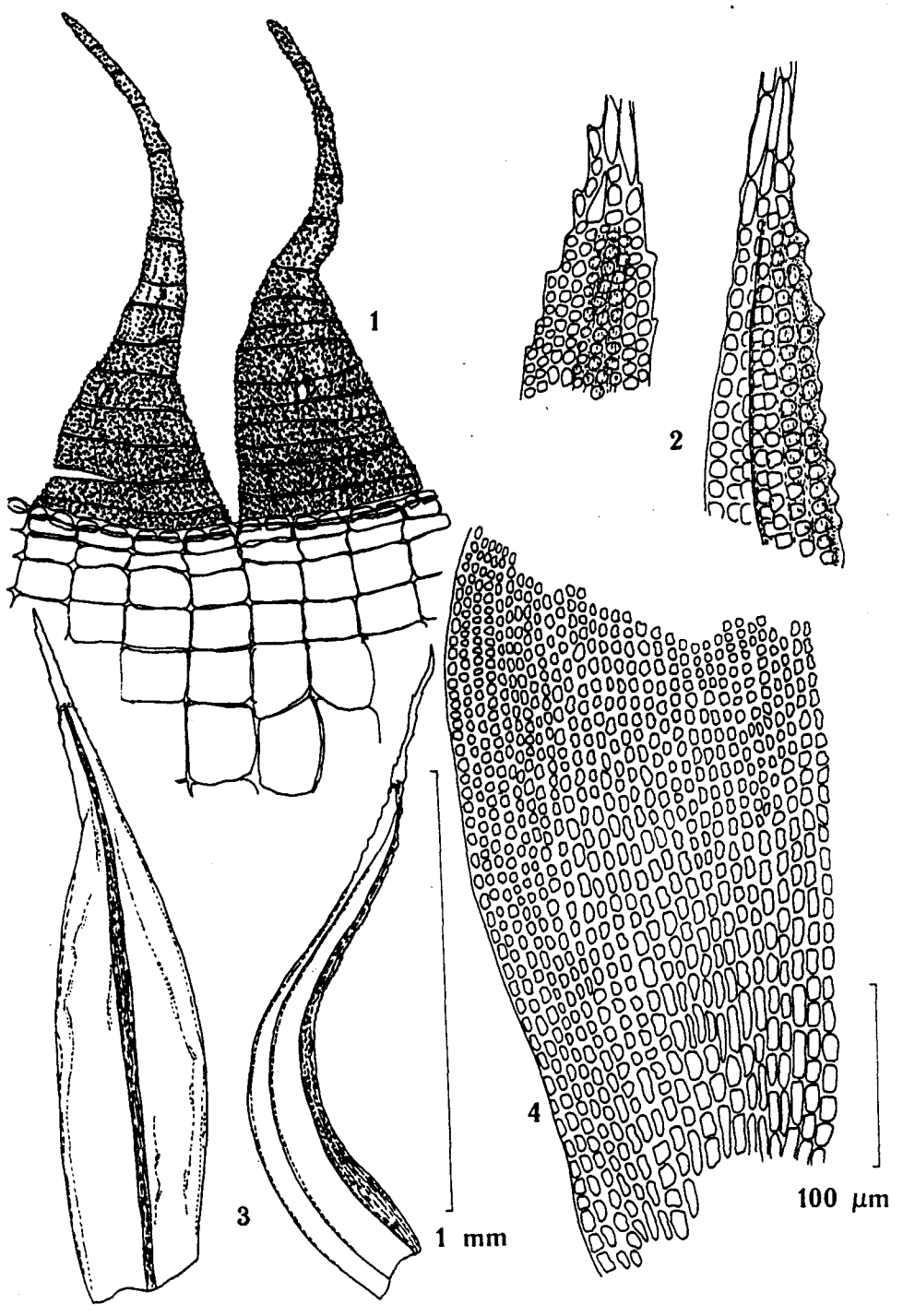


Fig. 29. *Schistidium strictum* (Turn.) Loeske ex Maort. (from *Kukol* 1800 m Ignatov 0/432): 1 - peristome teeth; 2 - cells of leaf tips; 3 - leaves; 4 - cells of leaf base. Scale bars: 1 mm - for 3; 100 μm - for 1, 2, 4.

much less massive peristome, and smaller spore size. From *S. apocarpum* it differs in having totally muticous leaves, smaller leaf size, shape of cells at leaf base, and by the rounded, somewhat mamillose, cells of the upper lamina. This species is intermediate in many ways between *S. rivulare* and *S. apocarpum*.

Schistidium strictum (Turn.) Loeske ex Maort., Kgl. Sv. Vetensk. Avhandl. & Naturskydd. 14: 110. 1956. Fig. 29.

Grimmia stricta Turn., Musc. Hibern. Spic. 20, pl. 2: f. 1. 1804

Plants rather slender, in loose tufts, green above and red-brown or ferruginaceous below. Stems up to 5 cm high, with distinct or often indistinct central strand. Leaves ovate-lanceolate to lanceolate, up to 3 mm long, keeled above, with recurved margins which are often obtusely serrate above, and sometimes reaching mid-leaf level. Costa moderately thick, papillose at back in upper half. Hyaline hairpoint developed in many leaves, 1/7-1/3 of the lamina length. Upper lamina cells 5-7 μm wide; basal leaf cells at margins similar, but in paracostal area, short-rectangular, up to 2:1. Autoicous. Seta shorter than capsula, ca 0.4 mm. Capsula immersed, 1.0-1.2 mm long. Peristome teeth lanceolate, red, attenuate in upper part, densely and uniformly papillose throughout. Operculum obliquely beaked. Calyptra small, cucullate. Spores ca. 10 μm, smooth.

Schistidium strictum is a rather uniform in Altai. Rather slender plants constitute variously variegated tufts. Upper leaves are often green, but becoming ferruginaceous (reddish-brown) soon with age, so that a large part of the tuft (and sometimes the whole tuft) is of this color. Such change in coloration was never observed in *S. apocarpum*. In some alpine situations, especially when being flooded or growing in snow melt near temporary snow bed, *S. strictum* could loose this specific color, becoming darker, up to totally black; but this is a rare phenomenon. The most important character for distinguishing of *S. strictum* is its papillosity on the abaxial surface of costa in the upper portion of leaf (easily observed under the stereo-microscope). However, degree of papillosity varies considerably and in some (few) collections costa was nearly smooth. However, the combination of other characters such as slender appearance, variegated coloration of tufts, with or without a poorly developed central strand, long hairpoints on most of the leaves, and the somewhat attenuate peristome teeth, allow the attribution of such forms to *S. strictum*. Leaf hairpoint is usually present on stem leaves, without a sharp difference in perichaetial leaves. Peristome teeth are uniformly attenuate, unlike the mostly triangular teeth of *S. apocarpum* (although in some of the Altaian specimens attributed to *S. apocarpum*, their peristome teeth are also attenuate).

Distribution: Schistidium strictum have been reported from many European countries. We saw materials from Great Britain (including the type specimen), Belgium, Hungary, Estonia, Ukrainian Carpatians, most regions of Asiatic Russia, Caucasus, mountains of Middle Asia, Mongolia, China, Japan, India and from temperate to arctic North America. The species is also reported from Mexico, Guatemala and Hawaii. In most regions in Europe, *S. strictum* is much less frequent than *S. apocarpum*. The situation is reverse in the Asian parts of the former USSR (including the Altai) and in China and Japan where *S. strictum* is common and abundant in all zones (in Mongolia, however, *S. strictum* was reported to be rarer than *S. apocarpum*). In Altai *S. strictum* is fairly common in all altitudes. It grows on rocks in wide range of habitats. Occasionally (several observations), it grows also on tree trunks (especially on inclined trunks of *Betula alba*) and rotten logs (leafy trees and conifers), among other mosses, in rather sunny places, in lower forest and taiga zones.

Specimens examined: Artybash 450 m (22/2); *Artyshtu Creek* 600 m (Zolotukhin 20.IX.1989); *Ayukol* 1000 m (0/896); *Ayulyuyuzyuk Creek* 2100 m (0/133); *Baigazan* 450 m (19/1); *Bayas Creek* 850 m (16/39); *Berekhtuyaryk* 1600 m (0/433); *Bolshoi Shaltan Creek* 530 m (0/886); *Bolshoye Istyube Creek* 470 m (18/122; 18/51; 18/96); *Buguzun Creek, at mouth of Sailyugem Cr.* 2100 m (Pavlov V.N. 19.VIII.1993); *Chemal* 400 m (29/30), 500 m (Makarov 27.VI.1972); *Chemal Creek, 3 km upstream* 450 m (34/211); *Chemal, 10 km upstream along Katun* 450 m (34/216); *Chiri* 450 m (17/51; 17/93); *Chulcha River, in middle course* 1100 m (9/162); *Derbogach* 450 m (0/34); *Kairu Creek, 8 km upstream* 1000 m (15/108; 15/129); *Kairu-Bazhi Peak* 2100 m (13/27; 13/82) 2150 m (13/154); 2300 m (13/1; 13/117); *Kamga Bay* 450 m (Zolotukhin 20.X.1988); *Kamga Creek, 12 km upstream* 550 m (0/102); *Karagai* 440 m (0/274; 0/285; 0/894), 450 m (Zolotukhin 11.VIII.1988; 0/892), 500 m (Zolotukhin 10.VIII.1988); *Kayakkatuyarykskij Creek* 1850 m (8/53), 1900 m (8/273), 1920 m (3/134), 1940 m (3/281), 1950 m (3/113), 2000 m (3/241), 2050 m (3/109; 3/19), 2280 m (7/8); *Kishte* 440 m (Zolotukhin 11.VII.1988); *Kobiguayuk Creek* 2000 m (0/734), 2150 m (0/887), 2300 m (0/733), 2400 m (0/327), 2800 m (0/890); *Kobukhtushka* 440 m (Zolotukhin 28.III.1988); *Kukol* 1750 m (0/895), 1800 m (0/432); *Kumzir* 450 m (20/26); *Kyga River, 2 km upstream* 500 m (0/434); *Malyi Yaloman* 950 m (25/140); *Malyi Yaloman Creek, 2 km upstream* 950 m (25/179); *Malyi Yaloman Creek, 7 km upstream* 1000 m (25/65); *Ok-Porok Creek, at mouth* 440 m (Zolotukhina 30.III.1988) 470 m (2/15; 2/24; 2/45); *Tabozhok Creek, 12 km upstream* 2200 m (30/19); *Tabozhok Peak* 2100 m (31/278); *Tura Creek, in middle course* 1300 m (28/24); *Ust-Sema* 580 m (24/20; 24/90); *Yailyu* 450 m (0/888; 1/19), 470 m (0/889), 550 m (0/891); *Yakhansoru Lake* 1870 m (Zolotukhin 28.VI.1990); *Yazula* 1520 m (0/893).

Schistidium liliputanum (C. Muell.) Deguchi, J. Sci. Hiroshima Univ., ser. B, Div. 2, Bot. 16: 229. 1978 [1979]. Fig. 30.

Grimmia liliputana C. Muell., Nuovo Giorn. Bot. Ital. n.ser., 5: 188. 1898.

Plants small, forming dense, reddish-brown to green cushions. Stem 0.5-1.0 cm high, without cen-

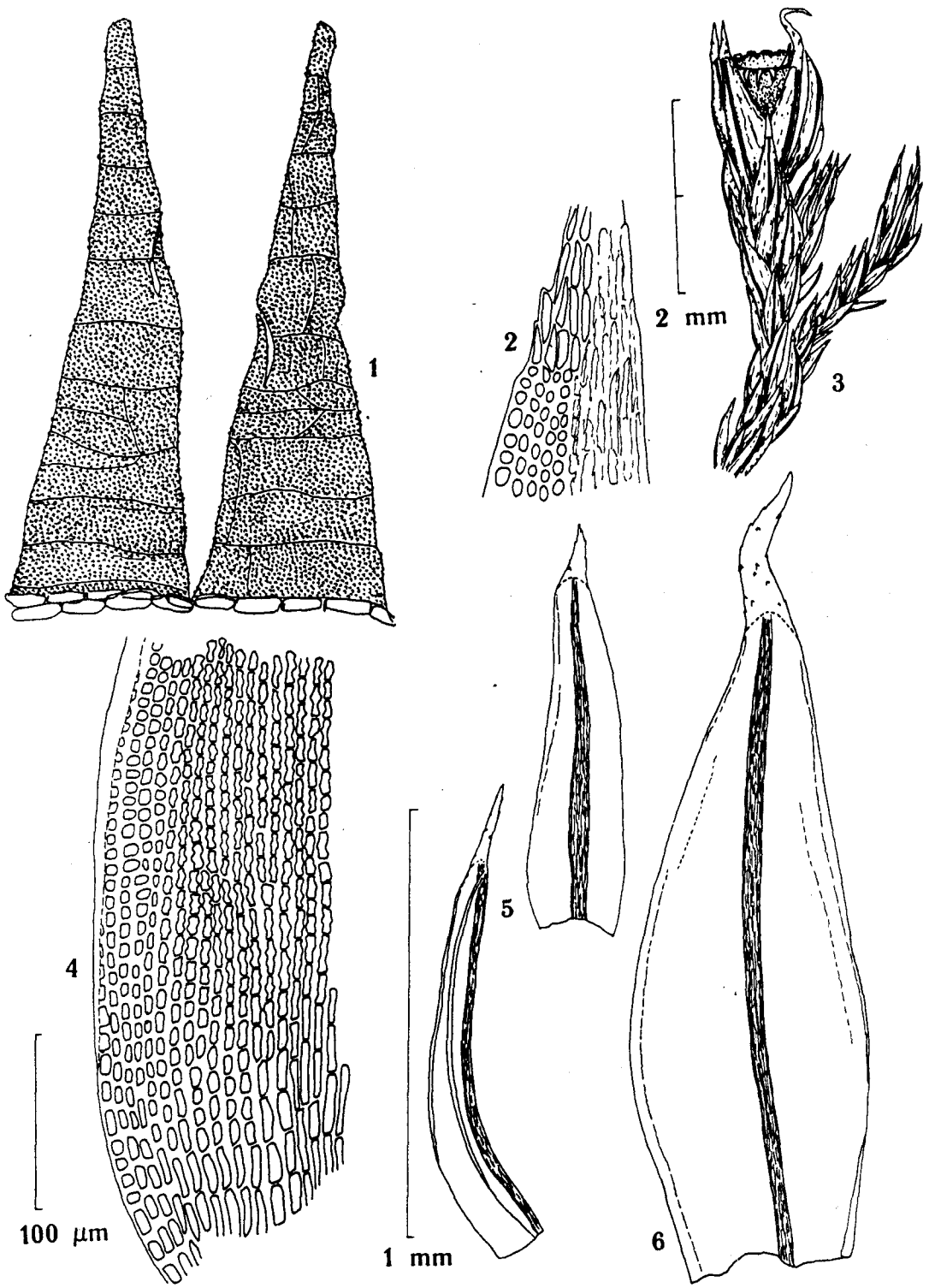


Fig. 30. *Schistidium liliputanum* (C. Muell.) Deguchi (from *Kobiguayuk Creek* 2000 m Ignatov 0/953): 1 - peristome teeth; 2 - cells of leaf tip; 3 - habitus; 4 - cells of leaf base; 5, 6 - leaves. Scale bars: 2 mm - for 3; 1 mm - for 5, 6; 100 µm - for 1, 2, 4.

tral strand. Leaves lanceolate, lower one less than 1 mm long; upper leaves up to 1.5 mm long, keeled, margins bistratose, recurved. Hyaline hairpoint present in nearly all leaves, 1/7-1/5 of lamina length, slightly toothed. Upper lamina cells small, ca. 6 mm, becoming rectangular at mid-leaf level with distinctly sinuose walls. Basal cells at margin small, quadrate to rectangular, 7-12 x 6-7 μm, with transverse walls thicker than longitudinal walls, to nearly equally thick walls. Leaf cells in paracostal area rectangular, up to 5:1. Autoicous. Seta 0.2 mm long, shorter than urn. Capsula deeply immersed in perichaetial leaves, ca. 1 mm long. Peristome teeth narrowly triangular, orange-red, ca 0.3 mm high, slightly perforated, densely papillose throughout. Operculum with short straight beak. Calyptra small, cucullate. Spores ca. 10 μm, nearly smooth.

Schistidium liliputanum differs from *S. apocarpum* in having very small stem leaves that are markedly contrasting with the much larger perichaetial leaves. In *S. apocarpum*, stem leaves gradually change into the size of perichaetial leaves. Also, leaf basal cells are much smaller in *S. liliputanum* than in *S. apocarpum*, and have a much more thickened and somewhat sinuose cell walls, while in *S. apocarpum*, the latter has thin and straight cell walls. The differences between *S. liliputanum* and *S. strictum* include the smooth abaxial surface of costa and a much smaller plant size. We have not seen small form of *S. strictum* from Altai as well as from other regions.

The differences between *S. liliputanum* and European forms described as *S. confertum* need further observations. The usually mentioned diagnostic features of *S. confertum* are almost the same as those of *S. liliputanum*. Some European collections of *S. confertum* that we examined have plants with small leaf cells just like those seen in *S. liliputanum*, although the cells have less sinuose walls. In *S. confertum*, the plants are of different sizes, varying from very small to the average size of *S. apocarpum*. In addition, there is no obvious size difference between its perichaetial and stem leaves. This last mentioned feature was shown in the drawing of Bremer (1981) for the lectotype of *S. confertum*. However, the color of peristome in *S. confertum* and its cribrosity seem too variable to be of use for a delimitation of this species. The same conclusion was reached by Bremer (1981) who was unable to correlate one character with the other.

In conclusion, we prefer to keep *S. liliputanum* as a species apart from *S. confertum*, even though the only constant difference between these two taxa is the proportion between the stem leaves and perichaetial leaves. The difference in their leaf cell wall thickness at basal margin, mentioned by Deguchi (1979a), appears to be unstable, even with the lectotype of *S. liliputanum*. The other difference suggested by Deguchi, that of obtusely/sharply keeled leaf, again, seems too arbitrary to call it for a certainty. Judging from his illustrations, we can suppose that Japanese materials of *S. confertum* probably belong to *S. liliputanum*.

Distribution: *Schistidium liliputanum* was described originally from Central China and then found subsequently in North-East China and Mongolia (Mongolia, Darchan, lac. Kossogol. 14.VII.1902. A. A. Elenkin, LE!, sub. *S. confertum*). In Japan, it is rather widespread in mountains exceeding 3000 m from Hokkaido to Kyushu. In Altai, it was found on rocks in several localities on rather xeric, S-facing slopes and at about tree line elevation, or rarer in forest zone.

Specimens examined: *Chulcha River in middle course* 1100 m (9/77); *Kayakkatuyarykskij Creek* 1900 m (8/269; 8/274); 2000 m (8/323); 2100 m (7/107); *Kobiguayuk Creek* 2000 m (0/953).

Racomitrium Brid.

Plants usually robust, in dull extensive mats. Stems creeping to ascending, irregularly to nearly pinnate branching, with central strand. Leaves erect to spreading, lanceolate, acute or acuminate, piliferous in Altaian species, hairpoint papillose or smooth, often more or less serrate or serrulate. Costa single, strong, percurrent to excurrent. Lamina mostly unistratose, often bistratose in upper margins. Upper leaf cells short-rectangular to rectangular, with strongly sinuose walls; lower cells linear, with nodulose walls; basal cells at margin larger, typically short-rectangular, transparent, with straight walls. Dioicous. Archegonia lateral. Seta longer than urn, straight when moist. Capsulae symmetric, oblong-ovoid, more or less smooth. Annulus well-differentiated. Peristome teeth erect, fused at the insertion forming basal membrane and split above into 2-3 narrow or filiform divisions. Preperistome present, consisting of hyaline membrane adhering to the base of teeth. Operculum long-rostrate. Calyptra mitrate. Spores spherical.

KEY TO THE ALTAIAN SPECIES OF *RACOMITRIUM*

1. Leaves ending in papillose hairpoint 2
1. Leaves ending in smooth hairpoint 4

2. Plants regularly and pinnately branched; leaf cells smooth, hairpoint strongly erosodentate at margin, costa apparent from base to apex .... *R. lanuginosum* (p. 119)
2. Plants sparsely and irregularly branched; leaf cells papillose, costa apparent below, in upper half of leaf becoming indistinct from the lamina 3
3. Hyaline hairpoint rather densely papillose; basal leaf cells papillose. *R. canescens* (p. 117)
3. Hyaline hairpoint weakly papillose at most of its length; basal leaf cells smooth ..... *R. panschii* (p. 119)
4. Plants with numerous short branches, leaf with long and flexuose hairpoint, at base bordered with 10-20 thin-walled cells; upper lamina cells linear or long-rectangular ..... *R. microcarpon* (p. 116)
4. Plants rare branching, with few short branches, leaf with short hyaline hairpoint, at base unbordered or bordered with 4-8 thin-walled cells; upper lamina cells short-rectangular to quadrate .. *R. sudeticum* (p. 116)

Racomitrium microcarpon (Hedw.) Brid., Muscol. Recent. Suppl. 4: 79. 1819[1818]. Fig. 31.

Trichostomum microcarpum Hedw., Sp. Musc. Frond. 112. pl. 23: f. 8-12. 1801.

Plants in moderately dense mats or cushions, yellowish-green above, blackish below, often grayish due to long hairpoints. Stem up to 4 cm high, with numerous, subpinnately short branches (some long branches also are subpinnately branched with short secondary branches). Leaves lanceolate, often secund, 2-3 mm long, with recurved margins. Costa percurrent, strongly convex, at middle leaf position usually bistratose. Hyaline hairpoint about 1/7-1/4 of lamina length, typically flexuose. Upper lamina cells rectangular (ca 3-4:1) with sinuose walls, basal and middle cells longer (4-6:1); at basal margin cells larger with straight thin walls forming a distinct border of 15-20 cells. Dioicous. Seta ca. 5 mm long. Capsula ovoid, up to 1.5 mm long. Peristome teeth ca. 0.25 mm long, nearly smooth. Annulus persistent. Operculum with long straight beak. Calyptra mitrate. Spores 12-14 μm.

The *Racomitrium heterostichum*-group is represented in Altai by two species, *R. microcarpon* and *R. sudeticum*. From the latter *R. microcarpon* differs well in: 1) a border of 10-20 thin-walled cells along the leaf base (in *R. sudeticum* - 4-8, if present); 2) long-rectangular laminal cells near the apex (in *R. sudeticum*, they are mostly short-rectangular (1.5-2:1) or quadrate near the apex); 3) 3-4 ventral cells of the costa in the mid-leaf (4-6 in *R. sudeticum*); 4) costa bistratose (in *R. sudeticum* tristratose); 5) long and flexuose hairpoint (short and straight in *R. sudeticum*); 6) numerous short branches throughout the stem (rarely branching in *R. sudeticum*).

Distribution: The distribution of *Racomitrium microcarpon* was discussed and mapped by Frisvoll (1988) and also by Bednarek-Ochyra et al. (1990). This species is common in Northern and Central Europe, especially in the mountains, but avoiding territories with more warm, temperate climate. In lowland there are only scattered relictual localities (Poland, Baltic Region, Vologda Province in Central Russia). *R. microcarpon* is known further from Polar to Southern Ural Mts., Putorana Plateau in Northern Siberia, mountains of South Siberia, and mountain in Amur River Basin (in these regions in all well-explored areas it appears to be common). In addition, *R. microcarpon* is known from the northern part of Russian Far East, Chukotka Peninsula, Arctic and boreal mountains of North America and Greenland. In Altai it is common in alpine and subalpine zone in rather humid areas, while absent in more xeric highlands. Some collections were made on fell fields in taiga and forest zone.

Specimens examined: *Ayulyuyuzyuk Creek* 2500 m (0/395); *Bardaky Lake* 2100 m (11/1); *Bolshoye Kurkure Creek, upper course* 2300 m (Galanin 8.VIII.1976); *Chiik (Altaian State Reserve)* (M.Schmidt 9.VIII.1935 LE!); *Kairu Creek, 16 km upstream* 1400 m (14/56); *Karakol Lakes* 1900 m (28/128); *Kayakkatuyarykskij Creek* 1850 m (8/111), 1950 m (3/20), 2000 m (3/45); *Kobiguayuk Creek* 2250 m (0/426); *Sostuoyuk Creek, upper course* 2600 m (Zolotukhin 19.VI.1990); *Tamanel Peak* 2150 m (34/41); *Uedinennoye Lake* 880 m (0/938).

Racomitrium sudeticum (Funck) Bruch et Schimp. in B.S.G., Bryol. Eur. 3: 141. pl. 264. 1845. Fig. 31.

Trichostomum sudeticum Funck, Deutschl. Moose 26. f. 18. 1820.

Plants in moderately dense tufts, dark-green above, blackish below. Stem 2-4 cm high, irregularly and dichotomously branched. Leaves erect to secund, 1.8-3.0 mm long, margins recurved, bistratose in upper part. Hyaline hairpoint rather short, typically about 1/10 of laminal length, spinulose. Costa convex, in middle leaf position mostly tristratose. Upper lamina cells short rectangular or subquadrate; basal cells rectangular, up to 4:1, with nodulose walls, at margin forming 5-15 slightly differentiated subquadrate to short rectangular cells. Dioicous. Seta ca. 3 mm long. Capsula ovoid, ca 1.5 mm long. Peristome teeth up to 0.2 mm high, finely papillose. An-

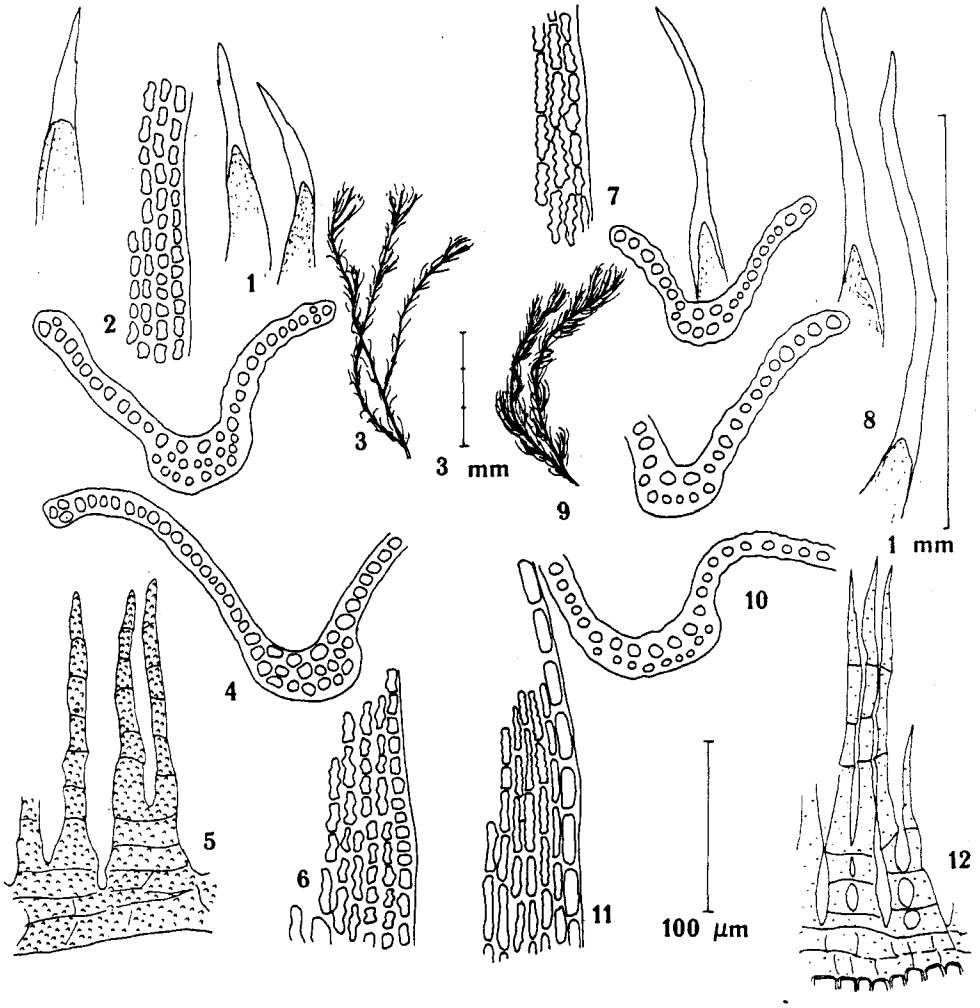


Fig. 31. *Racomitrium sudeticum* (Funck) Bruch et Schimp. in B.S.G. (1-6) and *R. microcarpon* (Hedw.) Brid. (7-12). *R. sudeticum* (from *Karakol Lakes* 1950 m Ignatov 26/121): 1- leaf tips; 2 - upper lamina cells; 3 - habitus; 4 - leaf sections; 5 - peristome teeth; 6 - marginal basal cells. *R. microcarpon*(from *Kayakkatuyarykskij Creek* 1850 m Ignatov 8/111): 7 - upper lamina cells; 8 - leaf tip hairs; 9 - habitus; 10 - leaf sections; 11 - marginal basal cells; 12 - peristome teeth. Scale bars: 3 mm - for 3, 9; 1 mm - for 1, 8; 100 μm - for 2, 4, 5, 6, 7, 10, 11, 12.

nulus well developed, persistent. Spores 13-15 μm.

The differences of this species from *Racomitrium microcarpon*, the most closely related species, are summarized under that species.

Distribution: The distribution of *Racomitrium sudeticum* was discussed and mapped by Frisvoll (1988) and also by Bednarek-Ochyra & al. (1990). In Europe it is mostly restricted to mountain areas and is very rare in lowlands. It penetrates southward along high mountains to Caucasus, Krym, Pyrenees and Corsica; in Asia - to Japan. The species is also known from the Southern Hemisphere in Patagonia, Terra del Fuego, Australian Alps and Antarctic Islands. In Altai *R. sudeticum* occurs in subalpine and in lower part of alpine zones in relatively wet areas.

Specimens examined: Ayulyuyuzyuk Creek 2450 m (0/937) 2500 m (0/428); *Bayas Lake* 2000 m (0/429); *Chiik (Altaian State Reserve)* (M.Schmidt 2.VIII.1935 LE!); *Inskiye Belki* (2106 Kuznetsov 16.VII.1913 LE!); *Kairu-bazhi Peak* 2050 m (13/64); *Karakol Lakes* (Zerov 22.VIII.1940 LVOV!), 1900 m (28/55; 28/66; 28/79) 1950 m (26/121; 28/85); *Kayakkatuyarykskij Creek* 2350 m (7/169); *Lesnoi Creek* 1860 m (Zolotukhin 2.VII.1990).

Racomitrium canescens (Hedw.) Brid., Muscol. Recent. Suppl. 4: 78. 1819[1818].

Fig. 32.

Trichostomum canescens Hedw., Sp. Musc. Frond. 111. 1801

Plants in loose to moderately dense, yellow-green to greenish-gray mats. Stem ascending, up to 6 cm

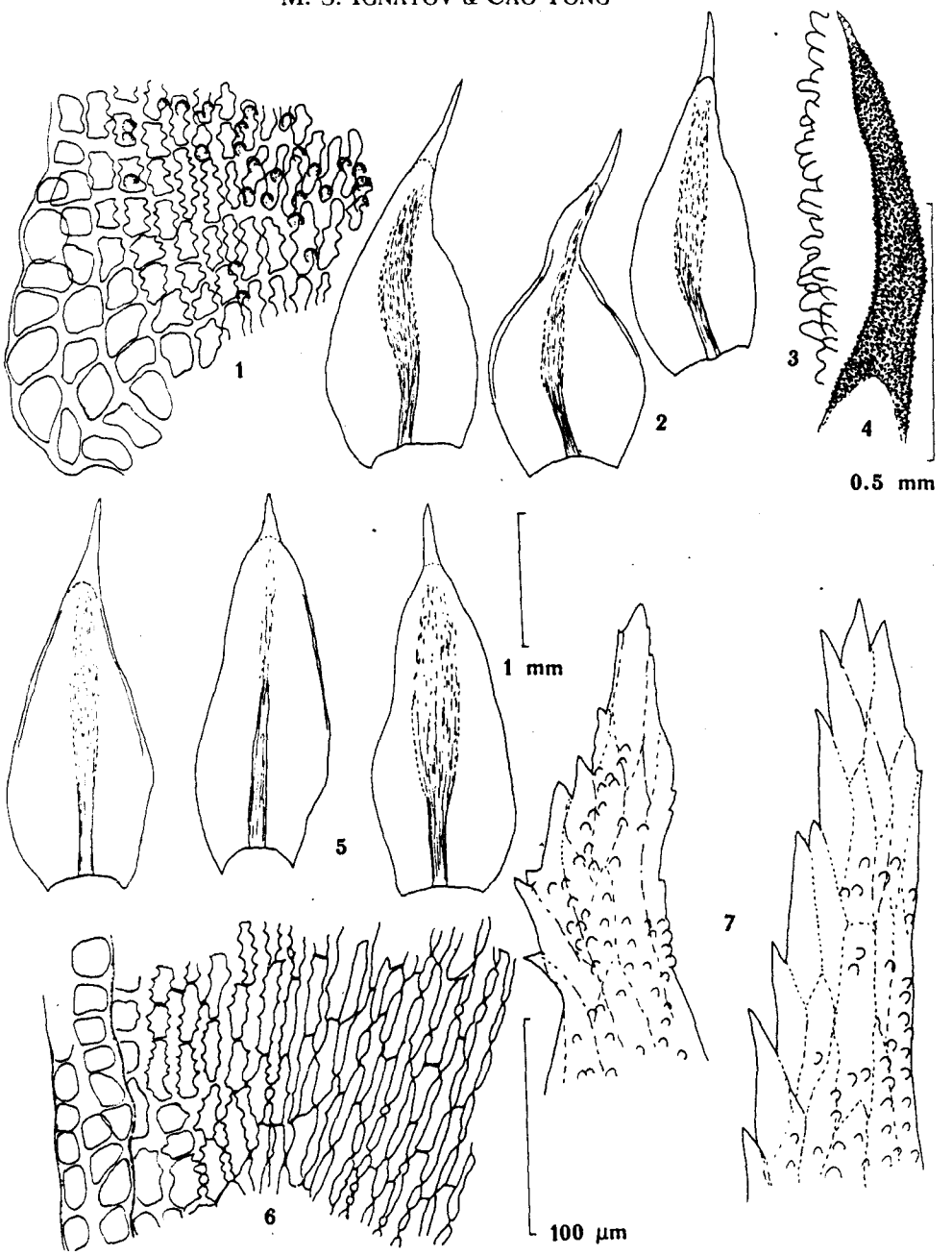


Fig. 32. *Racomitrium canescens* (Hedw.) Brid. (1-4) and *R. panschii* (C. Muell.) Kindb. (5-7). *R. canescens* (from *Bolshoi Shaltan Creek* 520 m Ignatov 0/753): 1 - basal leaf cells; 2 - leaves; 3 - papillae of hair-point; 4 - hair-point. *R. panschii* (from *Trekhglavaya Peak* 3150 m Zolotukhin 19.VII.1990): 5 - leaves; 6 - basal cells; 7 - cells of leaf tips. Scale bars: 1 mm - for 2, 5; 0,5 mm - for 4; 100 µm - for 1, 3, 6, 7.

tall, sparsely fasciculately branched. Leaves broadly lanceolate to ovate, 2-3 mm long, acute to acuminate, sometimes obtuse, margins unistratose, revolute below. Costa percurrent, convex, broad, in upper part indistinct from the lamina. Hyaline hairpoint well-developed, more or less serrulate, densely papillose throughout most of its length, or sometimes absent. Lamina cells, including the basal cells, papillose with large papillae, 1-3(5) per cell. Upper cells short rectangular, 1.5-2.5:1; middle and lower cells rectangular up to 4-6:1, with nodulose walls. Alar group triangular with large, subquadrate cells with straight walls. Dioicous. Seta about 20 mm, straight. Capsula ca 2 mm long, oblong-ovoid, pale-brown. Peristome teeth divided on long filiform divisions, papillose. Annulus deciduous. Operculum with long straight beak. Calyptra mitrate. Spores 7-10 µm.

The strongly papillose leaf cells with strongly

sinuose to nodulose walls distinguish *Racomitrium canescens* s.l. from all other mosses. However, further division of this strongly polymorphic complex is a problem. Frisvoll (1983) has recognized within this group two species - *R. cansecens* and *R. panschii*. Here we follow his treatment, although the variability of characters in separating these two taxa, probably, admits only an infraspecific rank for the latter. The differences of these taxa are discussed under *R. panschii*.

Distribution: Racomitrium canescens s.l. is a very common moss in Arctic and boreal-montanes of Holarctic region, somewhat less frequent in boreal lowlands. Frisvoll (1983) demonstrated that in Arctic occurs only *R. canescens* ssp. *latifolius*, while *R. canescens* ssp. *canescens* occurs across the wide range of boreal and montane regions of Holarctic. In Altai *R. canescens* is very common above the tree line where it grows in a wide range of epilitic and epigeic habitats. In the taiga and forest zones it is rarer and grows usually on sandy to gravelly bars of creeks, usually in rather humid climates.

Specimens examined: Bayas Creek 500 m (Zolotukhin 28.VII.1982); *Bolshoi Shaltan Creek* 520 m (0/753); *Chemal Creek, 3 km upstream* 450 m (34/57); *Kairu-bazhi Peak* 2200 m (13/9); *Kayakkatuyarykskij Creek* 2650 m (7/46); *Kobiguayuk Creek* 2220 m (0/750), 2600 m (0/188), 2650 m (0/197), 2800 m (0/751), 2890 m (0/752); *Talizkiye Belki* (Pobedimova 6.VIII.1929); *Tamanel Peak* 2150 m (34/40); *Yazula* 1800 m (Zolotukhin 21.VII.1979).

Racomitrium panschii (C.Muell.) Kindb., Eur. N. Amer. Bryin. 2: 236. 1897. Fig. 32.

Grimmia panschii C. Muell., Koldevey's Nord Pole Exped. 72. 1873.

Plants in rather dense, green to greenish-gray mats. Stem ascending, up to 5 cm tall, sparsely fasciculately branched. Leaves broadly lanceolate to ovate, 2-3 mm long, acute to acuminate, margins revolute below. Costa percurrent, convex, broad, in upper part indistinct from the lamina. Hyaline hairpoint well-developed, serrulate to serrate, weakly papillose below, nearly smooth above. Lamina cells papillose, basal cells smooth. Upper cells short rectangular, 1.5-2.5:1; middle and lower cells rectangular up to 4-6:1, with nodulose walls. Alar group consists of large, subquadrate cells with straight walls. Altaian plants sterile.

In many treatments *Racomitrium panschii* was not separated from *R. canescens* at all or it merited only a varietal rank as var. *robustum* (Lindb. et H. Arnell in H. Arnell) Par. Frisvoll (1983) brought evidence to maintain it as a species. The differences of this species from *R. canescens* include: (1) smooth basal cells, and (2) slightly or non-papillose upper part of hairpoint. Frisvoll also mentioned that leaves of *R. panschii* are principally acute, while in *R. canescens* s. str. they are acuminate; but this latter character seems not correlate with the two former features. In Altai the papillosity of hairpoint changes more or less gradually among populations from lower elevations to high mountains. The papillosity of leaf base, however, is more uniform and is absent only in a few collections, all of which have also very weakly papillose hairpoint. Such forms are referred here as *R. panschii*. The status of this taxon, however, needs additional supportive study.

Distribution: According to Frisvoll (1983) and some of his identifications at LE, *Racomitrium panschii* has a circumpolar, mainly arctic distribution, occurring in Europe only in Svalbard, and in Asia, in Siberian and Beringian Arctic, Yakutia, Transbaikalia, Amurskaya Province, Khabarovsk Territory, Khamar-Daban Range in Baikal Area and Altai Mts. In America it is known from Alaska and the nearby parts of Yukon and Northwest Territories, Arctic Archipelago, Greenland (all around) and Labrador. From Altai, Frisvoll cited two specimens: 1) *Dschankantae* in den Tschuja Alpen, 20.VIII.1915, Grano (H); 2) *Terektai-Jugum*, 2.VIII.1909. Kursky (H). According to our observations, *R. panschii* occurs mostly in upper alpine zone, with occasional penetration into the taiga zone.

Specimens examined: Itykul Lake 1665 m (Zolotukhin 22.VI.1990); *Kairu-Bazhi Peak* 2300 m (13/98); *Kobiguayuk Creek* 2850 m (0/400); *Sai-Khonash* 2720 m (Zolotukhin 9.VII.1990); *Trekhglavaya Peak* 3150 m (Zolotukhin 19.VII.1990).

Racomitrium lanuginosum (Hedw.) Brid., Musc. Recent. Suppl. 4: 79. 1819. Fig. 33.

Trichostomum lanuginosum Hedw., Sp. Musc. 109. 1801.

Coarse, robust plants forming moderately dense, grayish, hoary mats. Stem erect, up to 10 cm high, pinnately branched with short lateral branches. Leaves up to 5 mm long, narrow lanceolate, keeled, gradually narrowing to a long hyaline hairpoint. Hyaline cells of hairpoint and its decurrent bases densely papillose; otherwise, leaf cells smooth. Upper lamina cells rectangular, ca. 3-4:1, with sinuose to nodulose walls; cells at marginal and basal decurrent parts longer and with straight, thin walls. Middle and basal cells about 5:1, with thick nodulose walls, at margin forming one row of elongate to quadrate cells with straight walls. Dioicous. Altaian plants sterile.

Racomitrium lanuginosum is a distinctive moss having a coarse and robust plant size with regu-

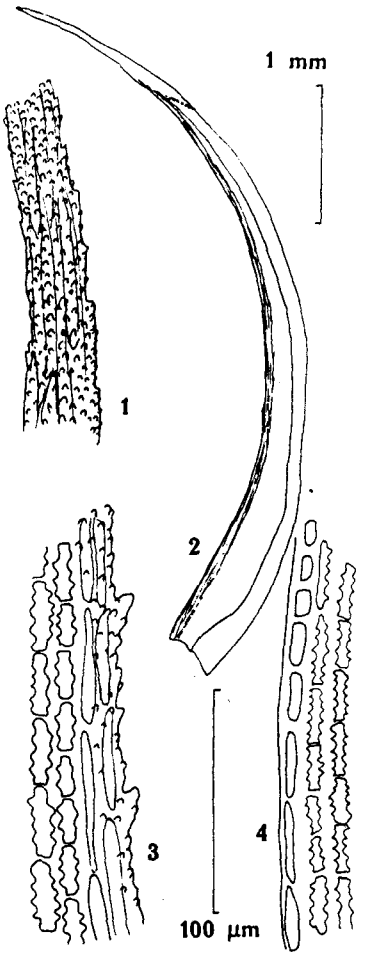


Fig. 33. *Racomitrium lanuginosum* (Hedw.) Brid. (*Booshkon Pass* 2700 m Zolotukhin 5.VII.1990): 1 - cells of hair-point; 2 - leaf; 3 - upper leaf cells; 4 - marginal cells at leaf base. Scale bars: 1 mm - for 2; 100 µm - for 1, 3, 4.

larly pinnate branches. Leaves are long, narrowly tapering, with long and broad hairpoint which extends decurrently to the lamina. Microscopically, it is impossible to confuse this species with other taxa because of its papillose and eroso-dentate hairpoint coupled with smooth leaf cells.

Distribution: The most widespread species of the genus, it is known in nearly all European countries, from Arctic islands (Svalbard, etc.), through the mountains of Central Europe, to Mediterranean countries, Azores, Canaries and Madeira, Middle East and Caucasus. In territories of the former USSR, it is known from all arctic and mountain regions, while in the lowland it is rather rare in the oceanic region (Baltia). *Racomitrium lanuginosum* is known further from Japan, China (southward to Taiwan), Mongolia, Himalayas, Indonesia, Philippines, New Guinea, Australia, New Zealand, Hawaii, Antarctic Islands and even from mainland Antarctic. In Pacific side of America, the species is reported from Alaska to Terra del Fuego (including the Andes in tropical latitudes); and in other arctic and eastern boreal regions of North America, it ranges southward to Maine (for details see Vitt & Marsh, 1988; Ochyra & al., 1990). In Altai *R. lanuginosum* is not very common. It has been observed in several places of subalpine and, especially, the alpine zone, reaching the upper limits of vegetation. It grows on rock and lithosoil in alpine zone, often in open, windy places, preferring the most "lifeless" situations.

Specimens examined: *Ayulyuyuzyuk Creek* 2450 m (0/131); *Booshkon Pass* 2700 m (Zolotukhin 5.VII.1990); *Karakol Mt. Range* 2000 m (Zerov 22.VIII.1940 LB!); *Kayakkatuyarykskij Creek* 1920 m (3/263), 2150 m (4/5), 2200 m (6/1); *Kobiguayuk Creek* 2450 m (0/417), 2700 m (0/118); *Kurkure Creek, upper course* 2500 m (Galanin 9.VIII.1976); *Kurkurebazhi Peak* 3100 m (Zolotukhin 13.VIII.1976); *Merok Peak* 2650 m (Zolotukhin & al. 24.VII.1980); *Ozernaya Creek* 2190 m (Zolotukhin & al. 9.VIII.1978); *Tamanel Peak* 2150 m (34/39).

UNCONFIRMED AND ERRONEOUS RECORDS

Dryptodon patens (Hedw.) Brid.

This was reported for Altai by Krylov (1925) from a locality in the Katunskiye Belki Mt. Range near Multinskoye Lake. There is, however, no specimens of this species in the herbarium of Tomsk University.

Grimmia pulvinata (Hedw.) Sm.

Having been reported from Chike-Taman Pass by Bardunov (1974), no specimen of this species was available for confirmation. Although *G. pulvinata* is principally a western species in Eurasia, it does penetrate eastward to Tibet in China, reaching some of the mountains of Middle Asia (Pamir, Kopet-Dag) and also was reported from Mongolian Altai. It certainly can be expected in the Altai. *G. pulvinata* can be recognized by the broad leaves which is distinctly keeled, the long and slightly serrate hairpoint, the nearly unistratose lamina except at the margins, the almost straight cell walls, paroicous sexual condition (sporogones usually present), the distinctly curved seta, and a strongly ribbed capsula.

Schistidium confertum (Funck) Bruch et Schimp. in B.S.G.

The species was mentioned for Altai and Sayan mountains by Bardunov (1974) who, however, referred the same species later as a synonym of *S. apocarpum* in his list of Siberian mosses (Bardunov, 1992). We have studied Bardunov's specimens from Altai (Tyudraly and Ak-Tura) at IRK and found them to be *S. liliputanum*, while so-named specimens from Sayan Mts. and Baikal area appeared to be just a small expressions of *S. apocarpum*.

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