# A REVISION OF THE GENERA GRIMMIA, SCHISTIDIUM, AND COSCINODON OF JAPAN

BY

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# I. Introduction

According to the Index Muscorum (Wijk, Margadant & Florschütz, 1959, 1962, 1967), about 250 species of *Grimmia*, 20 species of *Schistidium*, 16 species of *Coscinodon* have been hitherto described on the whole globe. Most species of these genera are distributed in temperate to boreal regions, and are best developed especially on higher mountains. Some species occur in tropical regions, where, however, they are restricted to the elevated area under the climate corresponding that of temperate to boreal regions. Nearly all the species are known as epilithic mosses growing on bare or thinly soil-capped rocks.

Since the first record by Mitten (1891), the Japanese Grimmian flora has been little by little enriched. Twenty-four species and 12 varieties of *Grimmia* (including *Schistidium*) and two species of *Coscinodon* have been known to occur in Japan (Iwatsuki & Noguchi, 1973). Loeske (1913, 1930) and Jones (1933) published monumental papers respectively on the European and on the North American species of these genera. The Japanese species reported have, however, not been critically revised except for *Coscinodon japonicus* (Takaki, 1964) and *Grimmia akaishi-alpina* (Takaki et al., 1970). It seemed to me that the species so far reported from Japan comprised not a few doubtful species to be revised taxonomically. The number of species and varieties of these genera in Japan is not so many, but most of them are morphologically little differentiated among the species, and each species shows a rather wide variation. These facts make the taxonomy of the Grimmian species, not only in Japan but also in the world, difficult. Dixon (1924) said, "The species of *Grimmia* are for the most part recognizable as belonging to that genus at first sight, but are difficult of determination specifically."

With these facts in mind, I intend to present a revision of Japanese Grimmia, Schistidium, and Coscinodon, revising taxa on the basis of detailed morphological and anatomical studies. Particular attentions were paid to the typification of the previously described taxa as well as to the variation seen in each species.

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## III. History

### 1. Generic concept

In the epoque of Hedwig (1801) and Weber et Mohr (1803, 1804), the concept of the genus *Grimmia* was in a chaotic condition. Hedwig (1801) enumerated, under the genus *Grimmia*, *G. apocarpa* (=*Schistidium apocarpum*), *G. alpicola* (=*S. alpicola*), *G. plagiopodia*, *G. recurvata* (=*Seligeria recurvata*) and *G. cribrosa* (=*Coscinodon cribrosus*) in his "Species Muscorum", of which *G. plagiopodia* was recently lectotypified for the genus *Grimmia* by Mårtensson (1956). But, some species now recognized as belonging to the genus *Grimmia* (sens. str.) in modern sense are found in the "Species Muscorum" under the genera of the families Dicranaceae, Fissidentaceae and

Pottiaceae: *Dicranum alpestris* (=*Grimmia alpestris*), *Fissidens pulvinatus* (=*G. pulvinata*), *F. pulvinatus* var. *africana* (=*G. pulvinata* var. *africana*), *Gymnostomum pulvinatum* (=*Schistidium pulvinatum*) and *Bryum patens* (=*Grimmia patens*). Weber et Mohr (1803, 1804) soon later added to the genus many species which are, however, of various genera in modern sense, even of the genus of Diplolepideae, such as *Blindia*, *Bryoerythrophyllum*, *Catoscopium*, *Dicranowesia*, *Discelium*, *Ditrichum*, *Kiaeria*, *Leskeela*, *Leucodon*, *Octoblepharum*, *Papillaria*, *Phyllogonium*, *Pottia*, *Pseudoleskeela*, *Pterigynandrum*, *Pterogonium*, *Seligeria*, *Stegonia*, and *Weisia*. This fact tells that the original circumscription of the genus *Grimmia* was entirely artificial and characterized by the superficial features only on the peristome: peristome simple, composed of lanceolate 16 teeth perforated on upper portion. On the other hand, Bridel (1819) established the genus *Schistidium*, emphasizing the character "stoma nudum", and cited *S. caespiticium*, *S. ciliatum*, *S. pulvinatum*, and *S. striatum*. Except *S. pulvinatum*, these species are at present recognized as species of the genera *Stylostegium*, *Hedwigia*, and *Amphidium* respectively, being quite different from the present concept of the genus *Schistidium*. Bridel ( 1826) furthermore added to his *Schistidium* some species without any change of the original circumscription, which was also followed as it was by Nees, Hornschuch et Sturm (1823). It might be not too much to say that the modern generic concept for the genera *Grimmia* and *Schistidium* has wonderfully been established by Bruch, Schimper & Gümbel (1845) in Bryologia Europaea. They grouped Bridel's *Schistidium pulvinatum* and some species treated as of the genus *Grimmia* before under the more natural genus *Schistidium*, neglecting the quite artificial characters given by Bridel (1819) for the genus. In order to distinguish the emended *Schistidium* from Grimmia (sens. str.), the following characters were used by them: the particularity of leaf-areolation, of terete costa of leaf, of structure of sporophyte and its neighbouring organs. Especially, they emphasized the small calyptra, short vaginula and columella adhering to operculum and falling with it.

In spite of that, thereafter, the genus Schistidium has been treated in different ways by the European and North American bryologists and remained without stable taxonomic status up to now. A view of regarding Schistidium as an independent genus was held by Bruch, Schimper & Gümbel (1845), De Notaris (1869), Limpricht (1889), Roth (1904), Loeske (1913, 1930), Podpera (1954), and Nyholm (1956); for the view as a subgenus of the genus Grimmia, Schimper (1856, 1869, 1876), Milde (1869), Boulay (1884), Hagen (1909), Brotherus (1923, 1924), Jones (1933), Lawton (1971) are representative treatment; as a section was supported by C.Müller (1849, as sect. Platystoma), Husnot (1887, as sect. Brevisetae), Mönkemeyer (1927), and Dixon (1924); and Kindberg's (1897) treatment as one of the subdivisions of Grimmia without citation of any distinct taxonomic rank.

Concerning the genus Coscinodon, which was established by Sprengel (1804) and characterized by the sieb-like perforated peristome teeth, it has lead bryologists onto the argument of the taxonomic position whether it should be placed in the family Grimmiaceae or in other family, i.e. Orthotrichaceae. Not a few authors (e.g., Schimper 1856, Milde 1869, Macoun & Kindberg 1892, C.Müller 1849) placed Coscinodon near the genus Orthotrichum or Ulota in the family of Diplolepideae, while some others (Schimper 1860, 1876, Boulay 1884, Lesquereux & James 1884, and Husnot 1887) treated it as an ally of the genus Ptychomitrium (sometimes with the indication of the family Ptychomitriaceae) on the strength of plicated calyptra commonly found in these two genera. But, in general, the genus *Coscinodon* is treated as one of the genera of the family Grimmiaceae by many including all of recent bryologists as far as I know: Limpricht 1889 , Roth 1904, Hagen 1909, Loeske 1913, 1930, Brotherus 1924, Takaki 1951, Podopera 1954, Sakurai 1954, Nyholm 1956, and others. The taxonomic value maintaining the generic rank for *Coscinodon* in the family Grimmiaceae has been doubted and treated under the genus *Grimmia*, sometimes as subgenus *Coscinodon*, by some North American bryologists (Jones 1933, Sayre 1952, Lawton 1971), while *Coscinodon cribrosus* has frequently been treated as a species of the genus *Grimmia* in the first half of nineteenth century.

## 2. Outline of the Japanese species so far reported

At the end of the nineteenth century, Mitten (1891) first reported from Japan six species under the genus *Grimmia* on the basis of the collection made by James Bisset: *Grimmia apocarpa* (=*Schistidium apocarpum*), *G. fasciculare* (=*Racomitrium fasciculare*), *G. canescens* (=*R. canescens*), *G. lanuginosa* (=*R. lanuginosum*), *G. heterosticha* (=*R. heterostichum*), and *G. japonica* (=*R. japonicum*, =*R. canescens*). He circumscribed very widely the genus *Grimmia* including the species belonging to the genus *Racomitrium* of modern sense as did by C.Müller (1849) and Braithwaite (1889-1895), and all of these species are of the genus *Racomitrium* in modern sense except the first one, which is of the gunus *Schistidium*. Soon later, C.Müller (1896) described a new species, *Grimmia limbatula*, maybe from Japan. Its type locality was indicated merely as "ex sylvis Yokohamae, Fr.Schaal, 1879", in his work "Bryologiae provinciae Schen-si sinensis", which was based on the collection made in China mainly by Giraldi.

At the beginning of the present century, Brotherus (1906 in Kono) and Cardot (1908, 1909) described some species and varieties based on the specimens collected in Japan by Kono and U.Faurie respectively: *G. konoi* by Brotherus, *G. apocarpa* var. *aomoriensis*, var. *denticulata*, var. *mamillata*, var. *microphylla*, var. *microtheca*, and *G. decalvata* by Cardot. Thus, the taxonomic study of the genus *Grimmia* of Japan was initiated by European bryologists, who certainly stimulated the Japanese botanists. Okamura (1916) as the first Japanese bryologist submitted a report on two species new to science from Japan: *G. hisauchii* and *G. kiyoshii*. Sasaoka (1921) put on a list of regional moss-flora *G. hartmanii* var. *japonica* Broth. with neither description nor illustrations. This name must be therefore regarded as a nomen nudum. Brotherus (1924) gave the information on the occurrence of other species in Japan with the indication of "Japan" in Engl.-Plantl. Pflanzen Familien: *G. atrata*, *G. donniana* (as *G. doniana*), *G. elatior*, *G. elongata*, *G. funalis*, and *G. pilifera*. New addition of some species to the Japanese moss-flora was made by Ihshiba (1929): *G. apocarpa* var. *gracilis* (=*Schistidium gracile*), var. *rivularis* (=as var. *rivelaris*, =*S. rivulare*), *G. ovata*, *G. patens*, and *G. hartmanii* (as *G. hartmanni*), and at the same time, he proposed the new combination *G. patens* var. *brachydictyon* based on *Racomitrium patens* var. *brachydictyon*, originally described by Cardot (1908) from Japan. Other two new species were reported from Japan: *Grimmia* (*Lithoneuron*) *eurybasis* by Sakurai & Dixon (1934) and *Grimmia* (*Gastrogrimmia*) *otii* by Sakurai (1949). Iwasaki (1941) reported the occurrence of *Grimmia anomala* in Japan. In 1951, a number of species and varieties were augmented at a single heat by the studies succeeded one after another. In the floristic study on *Grimmia* and *Coscinodon* in the mountaneous regions of central Japan, Takaki (1951) reported 10 species and 4 varieties of *Grimmia* (sens. lat.), of which 4 species and 2 varieties were new to Japan: *G. apocarpa* var. *pulvinata* (=*Schistidium pulvinatum*), var. *conferta* (=*S. confertum*), *G. alpestris*, *G. incurva*, and *G. andreaeoides* (=*Gymnostomum andreaeoides*), and one species was new to science, *G. akaishi-alpina*. Takaki & Sakurai (1951) described a new species, *G. cratericola*, from the summit of Mt. Fuji. In addition, Sakurai (1951) enumerated 26 species and 7 varieties of *Grimmia* in his "Muscologia japonica", of which 6 species were new members to our flora: *G. campestris* (=*G. laevigata*), *G. commutata* (=*G. ovalis*), *G. mollis*, *G. pulvinata*, *G. alpicola* (=*Schistidium alpicola*) and *G. platyphylla* (=*S. alpicola* var. *latifolia*). By a careful floristic studies, the occurrence of *Grimmia maritima* (=*S. maritimum*) and *G. olympica* was brought out from the northernmost part of Japan by Iwatsuki (1962) and from central Japan by Noguchi & Saito (1970) respectively. On the other hand, *G. akaishi-alpina* was reduced to the synonymy of *G. ovalis* by Takaki, Amakawa, Osada & Sakura (1970). The first report concerning the genus *Coscinodon* from Japan: occurrence of *C. cribrosus* was made by Ihshiba (1929). In addition, two new species were described: *C. humilis* by Horikawa & Noguchi (in Noguchi 1939); and *C. japonicus* Sakurai (in Takaki 1943). The former should be treated as an illegitimate later homonym because of the presence of *C. humilis* Milde described in 1864 for an European moss. The latter was already reduced to the synonym of *G. decalvata* by Takaki (1951).

In conclusion, the Japanese flora has been proved to comprise 25 species and 10 varieties of the genus *Grimmia* (including *Schistidium*) and two species of the genus *Coscinodon* by the historical research.

## IV. Morphology and anatomy

### 1. Growth form and appearance

Many species of the genera treated form tufts which are either thick or thin and dense or loose, and sometimes dense semi-spheric cushions. *Grimmia elongata*, *G. subsulcata*, and *Coscinodon cribrosus* are representative species forming dense semi-spheric cushions, among which *G. elongata* has been well known in Japan as one of the species forming "moss-ball" in certain ecological condition, growing on rolling stones at the shore of pond (Takaki, 1956, 1958). The appearence of dense semi-spheric cushions of these species resembles each other, but their colorations are different, that is, *Coscinodon cribrosus* is dark-greenish to rather blackish, *G. elongata* is brownish and *G. subsulcata* is bluish-green in the field. Some cushions are frequently confluent and forming patches. *Grimmia affinis* forms dense, fragile tufts and *G. pilifera* makes dark-greenish to blackish, rather loose tufts which are growing low in sunny dry habitat, and high in shaded habitat. In such robust species as *G. brachydictyon* and *G. curvata*, the plants are in loose tufts, often ascending. Many species of *Schistidium* form loose mats when they vigorously grow (*S. apocarpum*, *S. gracile*, *S. rivulare*). *Schistidium confertum*, *S. liliputanum* and *S. subconfertum*, all of which are small-sized plants, make rather dense tufts.

### 2. Ramification

All the branching systems observed here are of intercalary, and they are furthermore classified into two types: monopodial and sympodial branchings. There occurs monopodial branching at non-subfloral parts remoted from the sexual organs, especially on sterile branches("sterile" means here without sexual organs, whereas "fertile" with sexaul organs). In the species of the genera treated here, the branching observed is, in most cases, of subfloral and sympodial branching (Fig. 1 & 2). Monopodial branching is frequently observed in such species as *G. curvata* and *G. brachydictyon*, which are rather temperate in forming the sexual organs. In careful examinations of fertile plants, one or two, rarely three young branches or their primordia are found at the base of perichaetia or perigonia in their apical parts of branches where sexual organs are produced as well as in the parts of diverging points, and each of the successive branches is also arised from the base of perichatia and perigonia. When successive branches are produced in the same direction, they grow into a single stem or branch: the diverging points are hidden by some vegetative leaves (Fig. 1 & 2 ). In some species, e.g., *G. affinis* and *G. subsulcata*, some differentiation was recognized in the branching, that is, on the branches arised from the base of perichaetia (perigonia) are formed perichaetia (perigonia), from whose base further subfloral branching occurs (Fig. 1:1-4). *Schistidium gracile* (typical form) show a relatively constant regularity in occurrence of sexual organs. Perichaetia and perigonia are formed alternatively on the tips of branches (Fig. 1: 6 & 7). In other species of *Schistidium*, such a regularity can not be recognized (Fig. 1: 8 & 9).

Basal parts of branches are so thinner than those of upper parts of branches that they are very fragile and easily detatchable from the stem (older branch) from which they derived. In such a diverging point, some brownish rhizoids are occasionally arised. It is, however, not experimentally confirmed whether the rhizoids-bearing branches detached play the role of a sort of diaspores in the nature or not.

## 3. Stem

Kawai (1965) supplied us the detailed anatomical knowledge of the stem in the genus *Grimmia* (sens. lat.). He distinguished three parts in the cross-section of a stem, each of which is explained as follows with slight modification by me.

1. Epidermal layer, composed of one to several concentric cell-layers, having the most thickened walls among the three parts.
2. Cortical layer, placed between the epidermal layer and the central strand, consisting of cells with the widest cell-cavity among the three parts, occupying the most wide area in the stem-section.
3. Central strand, of which the cells have narrow cavity and very thin walls. It constitutes the central axis of the stem.

The transition between the epidermal and the cortical layers is rather gradual, but the distinction between the cortical layer and the central strand is more or less clear. Based on the three parts mentioned above, Kawai (1965) distinguished four different types of stem-structures in *Grimmia* (sens. lat.). But, I recognized here three principal different structures in the stem.

Type I. The differenciation between the epidermal and the cortical layers is indistinct due to nearly uniform cells of them, and that between the cortical layer and the central strand is clear because of the distinct development of the central strand (Fig. 4: 2).

This type is nearly equivalent to Kawai's type a, though he characterized it both by the obscure distinction between the cortical layer and the central strand, and by the homogeneous cells. Kawai (1965) included in his type a, *Grimmia donniana*, *G. mollis*, *Schistidium confertum* (as *G. conferta*), and *S. alpicola* (as *G. alpicola*). As far as I examined exotic specimens of these species, the distinction between the cortical layer and the central strand was clear, that is, the distinctly developed central strand, composed of much smaller and thin-walled cells than those of the cortical layer was observed. Among the species treated in this monograph, Grimmia subsulcata belongs to Type I.

Type II. Both the distinction between the epidermal and the cortical layers and that between the cortical layer and the central strand are principally clear (Fig. 4: 1). The stems of this type occur either as a rather stable condition or as a variable condition easily subject to a modification passing into the Type III to be explained below. Among the species treated in this paper, G. anomala, G. affinis*, G. apiculata*, G. elongata*, G. atrata, G. donniana*, G. funalis, Coscinodon cribrosus*, Schistidium maritimum*, and S. rivulare belong to this type. In the asterisked species, the epidermal layer is less differentiated, so the distinction from the cortical layer sometimes indistinct. Thus, they may be also classified in the type I. Kawai's types c and d partly correspond to this type. I regard his types c and d are essentially identical.

Type III. The distinction between the epidermal and the cortical layers is celar, but is undifferentiated the central strand (Fig. 4: 3). This type is equivalent to Kawai's type b. Species of this type include G. curvata, G. incurva, G. pilifera, G. brachydictyon, Schistidium gracile. Kawai (1965) included such species with rather distinct central strand of small, thin-walled cells in his type b as G. elongata (as G. decalvata) and S. rivulare (as G. apocarpa var. rivularis). However, the result of my observations differs from that of Kawai's.

## 4. Leaves

### A. Shape

The leaf-shape and -size are considerably variable in most species treated here. In the species forming dense cushions the drastic change of leaf-shape and -size is observed even on a single stem as shown in Fig. 3. Filiform young stems arised from the base of older stems bear loosely arranged, very small leaves which are considerably different from normal vegetative leaves(e.g., *G. funalis*, Fig. 22: 2 & 9). After attaining a certain length, the young stems become thick and form usual larger leaves. For the description and the illustration of leaves in this monograph, such fully developed leaves are sampled, since they seem to show the most characteristic conformation to a species among all the leaves including both perichaetial and perigonial leaves. It is extremely difficult to exactly explain the leaf-form of each species without the aid of illustrations except some species such as *Grimmia atrata*, *G. incurva*, *G. pilifera*, and *Schistidium rivulare*. The lingulato-lanceolate leaves are distinct in *Schistidium rivulare*, whereas *Grimmia incurva* is characterized by the linearly elongated lanceolate leaves. In most species, the leaves are ovate at the base and so gradually narrowed into the upper subulate part, that the shoulder parts are usually less distinct except in *G. pilifera*, in which the basal part of leaf is more or less suddenly contracted into the upper subulate part and the shoulder parts become somewhat distinct.

In most species, the leaves are usually asymmetric and more or less falcate. The difference of width between the left and the right half-laminas occurs in some species, e.g., *G. subsulcata* and *C. cribrosus*.

### B. Hyaline hair-point

The development of a hyaline hair-point is fairly common in the genera treated here and its degree varies from species to species or in some cases from population to population in a species. The hayline hair-point, which is formed by the elongation of the upper laminal cells, is more or less denticulate due to the projection of antical ends of linearly elongated cells. The presence or absence of hair-point has been considered to be unstable, and its taxonomic significance has been depreciated. However, it seems to be unwise to put such character totally aside from the taxonomic considerations. The hyaline hair-point is lacking constantly in such species, at least in the Japanese materials, as *Grimmia atrata*, *G. olympica*, *G. curvata*, *Schistidium rivulare*, and *S. maritimum*. In a great majority of specimens of *G. elongata*, *G. brachydictyon* a very short point is observed, or thoroughly lacking. On the contrary, the hyaline hair-point is well developed in *Grimmia affinis*, *G. apiculata*, *G. funalis*, *G. subsulcata*, and *Coscinodon cribrosus* in which aggregated hair-points on the surface of cushions give them hoary appearence in the field.

### C. Margins

The leaf-margins vary from plane to revoluted or incurved. The revolution of leaf-margins usually occurs first in the widest part of leaf and extends upwards and downwards, sometimes narrowly and sometimes widely. In the species having revolute margins, two types of revolution are recognized: in one type the margins are revolute on both sides, in which one side is usually stronger than the other; in the other type, the margins revolute on one side and plane on the other side. The margins of the latter type occasionally occurs in some leaves of the species which bear principally the former type margins. However, there exsist the species in which the revolution of leaf-margins seems to be genetically regulated. For example, in *Grimmia elongata*, leaf-margins are always revolute on one side and plane on the other, and by this feature, it can be easily distinguished from its relatives, *G. donniana*. The margins of *G. incurva* may be to some extent the case of *G. elongata*, but occasionally plane on both sides. In the species with non-revoluted leaf-margins, the margins are plane on both sides or somewhat incurved. *Grimmia donniana*, *G. olympica* and *Coscinodon cribrosus* show the former form, and *G. subsulcata* the latter. A peculiar feature is observed in *G. atrata*, in which the leaf-margins are clearly revolute on one side downwards to the insertion and incurved on the other side by the bistratosed margin. In species having well developed hair-point, such as *Coscinodon cribrosus*, a form of *Schistidium gracile*, and *S. liliputanum*, the denticulation of hair-point stretches downwards along the upper margins of leaf. The margins are entire throughout the length except some species. *Schistidium rivulare* and a form of *S. gracile* (Mod. *denticulatum*) have low serrulateions on the upper margins. Therefore the serrulation of the upper leaf-margins is of no taxonomic significance.

### D. Lamina

The lamina is principally unistratose in the genera *Grimmia*, *Schistidium*, and *Coscinodon*, but quite frequently has a plasticity to be multistratose partially, especially when plants grow in an environment provided with the proper amount of moisture. No Japanese species have leaves unistratose throughout including the marginal portion. The multistratosity frequently occurs in the upper two thirds of the leaf, extending often downwards. In many species, the margins are bi-, occasionally tri-stratose in one or sometimes 3-4 rows of cells along the upper margins of leaf. Kawai (1965) classified the species of *Grimmia* (sens. lat.) according to the condition of margins. He referred *G. anomala* and *G. cratericola* to his type "Mo" (margins one cell in thickness). Putting aside the latter species which has been reduced to a synonym of *Arctoa fulvella* var. *andersonii* by me in this monograph, *G. anomala* has actually bistratose margins in the upper 2/3 of leaf length. The sections observed by Kawai are clearly from a part near the base of leaf. Most of the Japanese species have unistratose margins in the basal part of leaf, but *G. atrata* has bistratose margins even near the leaf-insertion. Excepting the marginal parts, bi (or tri-) stratosed portions are distributed in spots throughout the lamina. The most pronounced case of partial thickning of lamina is seen in *Schistidium rivulare* where bistratosed portions of lamina appear in dark striae under the microscope. When such bistratosity is longitudinally developed in the laminas on both sides of costa, it makes appearance of plicated leaf (*Coscinodon cribrosus* and *Grimmia subsulcata*).

### a. Laminal cells

In the lamina are observed various shapes of cells, with or without thickened walls. In the description of the species, representative cells, which appear most frequently in the parts to be explained are used.

In the genus *Grimmia*, the upper laminal cells are generally quadrate to short-rectangular, in places transversely rectangular. The middle laminal cells are more elongated than the upper ones, rectangular; the sinuosity of walls is usually pronounced in the middle part of the leaf. An example of a distinct variation of cell-shape is shown by *G. apiculata* (Fig. 15). The basal laminal cells are in most cases much elongated, rectangular to linearly elongated rectangular, frequently lose the contents and forms a translucent area. They are rarely less differentiated and remain in short rectangular shape. The basal lamina cells show the most characteristic features of the species. This has long been known by many specialists and used as a criterion in diagnosing a species or the species-group (sections or subgenera) in the family. Among the basal cells, the marginal rows of cells are of characterristic of the highest value in the taxonomy of the Grimmiaceae. Three types of marginal basal cells are recognized as followings:

Type A: Cells are much differentiated from the cells of the middle part of leaf, elongated rectangular, with thin to somewhat thickened walls (longitudinal and transverse walls are of equal thickness), transparent. *Grimmia affinis*, *G. apiculata*, *G. donniana*, *G. elongata*, *G. incurva*, *G. pilifera* belong to this type.

Type B: Cells are less differentiated from the middle ones, short rectangular (up to 3:1), with moderately thickened walls, transparent or occasionally chlorophyllose. *G. anomala*, *G. brachydictyon*, and *G. atrata* are of this type.

Type C: Cells are less differentiated, rectangular (usually up to 3:1), with thin longitudinal and thick transverse walls, transparent. *G. subsulcata* is of this type.

In the genus *Schistidium*, the laminal cells are rather homogeneous in contrast with those of many species of the genus *Grimmia*. The upper laminal cells are quadrate to short-rectangular, on margins transversely rectangular, gradually, but less distinctly elongated towards the base. There occur elongated cells in the basal paracostal regions, but they do not form transparent or translucent, distinct area as seen in Grimmia. The laminal cells are frequently sinuosed as commonly seen in Grimmia. The cells on leaf-margins are transversely rectangular to quadrate and chlorophyllose even on the basal margins (S. apocarpum, S. gracile, S. rivulare), occasionally are elongated-rectangular and become transparent (S. liliputanum, S. maritimum, and S. subconfertum). S. liliputanum has characteristically thick transverse and thin longitudinal walls belonging to the type C of Grimmia.

In Coscinodon cribrosus, the laminal cells are transversely rectangular to quadrate, somewhat collenchymatous in the upper part, becoming longer towards the base, in the marginal parts transparent, with thick transverse and thin longitudinal walls. As pointed out by Nyholm (1956) for the European material, the basal paracostal cells are elongate and form a translucent region, which becomes one of the clues to separate the allied species in gametophytic features. In spite of the great diversity of laminal cells even in the same species, Kawai (1965) challenged to grasp the variation of cells of Grimmia (sens. lat.) and recognized fifteen types of laminal cells. He symbolized the cells from the basal, middle, and upper parts of leaf by only one symbol respectively. For example, G. decalvata was represented by "Ala", "Bla", and "B3a" for cells of the basal, the middle, and the upper parts of leaf, respectively. This method by symbol, however, can hardly cover the actual variation of cells in a species, even in a single leaf. His symbols seem to be too much overweighted to apply to each species.

b. Extra thickenings of laminal cell-walls

Special thickenings are recognized on cell-walls of laminal cells. According to the conformation, the thickenings are sorted out into three kinds: papillae, ridge-like thickening, and joint thickening.

*Papillae.* The occurrence of papilliferous cells is limited to the following two species: *Schistidium gracile* and *S. maritimum*. The papillosity becomes readily indistinct in a species, sometimes in a single gathering. But, the papillae are usually admitable on young leaves even when they are indistinct on fully matured leaves.

*Ridge-like cuticular thickenings.* Only in *Grimmia anomala* is known this kind of thickenings, which has been examined in detail by certain authors (Loeske, 1913, 1930; lawton, 1959). As cleared up by Loeske (1913, 1930), the thickenings are not papillae in the usual sense but cuticular thickenings longitudinally developed and being not uniform in height which appear papillae in the cross-sections of leaf. Therefore the laminal cells of *G. anomala* have been described as being papillose by many bryologists (Limpricht, 1889; Salmon, 1900; Nyholm, 1956; et al.). Limpricht (1889) wrote on such thickenings as "Lamina beiderseits, wie die Rippe, mit rundlichen Papillae über dem Lumen der Zellen". The ridge-like cuticular thickenings are principally developed on the cell-lumens and not restricted on both ends of vertical walls in the cross-section of leaf.

*Joint thickenings.* The joint thickenings newly called here by me have so far frequently misunderstood as "papillae" and caused the misunderstanding of the species. This kind of thickenings has been, however, recognized by Loeske (1913) who explained it for *G. hartmanii* var. *montenegrina* as "Die Lamina ist..., und über den Pfeilern papillös aufgetrieben." As obvious in his expression, the thickenings are developed strictly on both ends of vertical walls (Pfeiler) in the cross-section of leaf, namely at the spots (joints) where vertical walls come across free walls of laminal cells. As far as I experienced, the joint thickenings are developed on the plants growing in a exceedingly dry habitat and commonly observed in many species not only of the Grimmiaceae but also of the Dicranaceae and Seligeriaceae. This also appears low-papillose in the cross-section of leaf and wins over the bryologists into the misunderstanding of the species. Iwasaki (1941) and Takaki (1956) recorded G. anomala as new to the Japanese moss-flora, based on the same gathering. But, the material they used possesses the leaves whose cell-walls have the distinct joint-thickenings, and it was identified by me as being no more than G. hartmanii. Another example is the case of G. pilifera (Fig. 25: 14-16). The plants of this species from dry habitat have the joint-thickenings and there are many specimens named G. elatior, since G. elatior is characterized by true-papillated leaves, but detected as G. pilifera among the specimens borrowed from various herbaria. Furthermore, they are distinctly developed in G. olympica.

## E. Costa

All species treated in the present monograph have the stout, percurrent costa. The costa is mainly projecting dorsally, so appear keeled semi-circular, rarely projecting on both surfaces with rounded outline in the cross-section. The ontogeny and the inner structure of the costa were amaizingly studied in detail by Kawai (1965) who discriminated three kinds of tissues: a-part ( adaxial epidermal cells of costa, connected with laminal cells and first appearing as a midrib-constituting tissue), c-part ( abaxial epidermal cells formed by basiscopic cell-divisions of the cells of c-part), and b-part (cells sandwitched by a- and c-parts, being derived from the cells of c-part). Then, he counted the number of cells for each part and formulated the inner structure of the costa from various levels as shown in the following example from the upper part of the costa in *G. anomala*: 9=2a=1b=6c, which means the costa in the level dissected is comprised of nine cells, of which two cells belong to a-part tissue, one to b-part, and six to c-part. The results given by him disclose the reasonable universality of the number of a-part (2a) from the upper part in many species of *Grimmia* (including *Schistidium*). *Coscinodon cribrosus* has also 2a upper costal cells. When the cells of b-part are increased in number and their lumens become very small, they might be called, in mass, a stereid band. In *Schistidium maritimum*, there occur the distinct stereid bands among which a chain of large cells (guide cells) are developed in the middle, therefore the ventral and the dorsal stereid bands are distinguished. The costa with such structure is universally observed in the species of *Ptychomitrium*. *Schistidium rivulare* has the terete costa as seen in *S. maritimum*, but the cells of costa are rather homogeneous. The papillae, ridge-like cuticular thickenings, and joint thickenings are also developed on both adaxial and abaxial epidermal cells of costa in the species bearing these thickenings on laminal cells. Some of the abaxial epidermal cells in certain species (*G. brachydictyon* and *G. curvata*) make extra cell-divisions and form longitudinal lamellae (wings). This kind of wings, though low in height, is known also in *G. elatior* (Loeske, 1913) and *G. hartmanii* var. *montenegrina* as well as *G. trichophylla* var. *muehlenbeckii* (Loeske, 1930). Wing-formation on the dorsal surface of costa seems to be restricted to the genus *Grimmia* in the family Grimmiaceae.

### 5. Perichaetial and perigonial leaves

No structural difference exists between perichaetial and vegetative leaves, and also between perigonial and vegetative ones. Vegetative leaves change very gradually both into large perichaetial leaves near the apex of stem (or branch) where archegonia are formed, and into small perigonial leaves near the apex where antheridia are produced. Therefore, inner largest perichaetial and smallest perigonial leaves are concerned here. The perichaetial leaves are generally much longer and wider than the vegetative leaves, from which they are indistinctly discriminated by their enlarged, somewhat convoluted base which is loosely areolated, with very thin walls. The hyaline hair-point is very pronounced also on the perichaetial leaves of the species having it on their vegetative leaves (Grimmia affinis, G. apiculata, G. donniana, G. funalis, G. pilifera, G. subsulcata; Schistidium apocarpum, S. liliputanum). Schistidium maritimum has the exeedingly elongated perichaetial leaves attaining nearly twice as long as the vegetative leaves, by which S. maritimum is recognized even in the field. In Grimmia brachydictyon, G. elongata, G. curvata, and G. olympica, the perichaetial leaves are less differentiated from the vegetative ones. The difficulty in distinguishing Schistidium liliputanum from S. gracile is sometimes created when they show the papillosity on the upper dorsal surface of costa. In the perichaetial leaves, however, the widest part is situated higher in S. liliputanum than in S. gracile (Compare Figs. 30-33 and Fig. 34). Thus the perichaetial leaves show to some extent a taxonomic importance. The perigonial leaves are rather uniform throughout the species treated here. The lower half of the perigonial leaf is generally tinged with brown, loosely areolated, and much convoluted. Even the species with a hyaline hair-point on vegetative leaves lack it on perigonial leaves. No taxonomic significance could not be recognized in the genera treated here.

### 6. Gemmae

The vegetative reproduction by means of gemmae is strictly limited to *Grimmia brachydictyon* and *G. anomala* among the Japanese species of the genera treated here. The gemmae are globular, multicellular, dark-green in fresh material, becoming yellowish-brown in aged or dried material, clustered on the tip of branches or stems, strictly speaking, on the tip of leaf with stalk composed of a few very thin-walled, hyaline and fragile cells. Cells composing the surface part of gemmae are smooth, but slightly thick-walled. It is very useful to distinguish the above two species from other species of *Grimmia*, but hardly possible to distinguish the two species from each other by the aid of only gemmae characters. It is of interest that the gemmae-formation is restricted to the genus *Grimmia*, and has never been known in other genera of the Grimmiaceae except an undetermined species of *Racomitrium* reported by Deguchi (1977).

### 7. Capsule

#### A. Urn

The urns of the species treated here are straight and never gibbose. The shape of urns is semi-spherical, spherical, obovate or ovate-oblong. Each species usually has its own shape except the case of *Grimmia apiculata* where considerably different shape and size of urns are observed as illustrated by Fig. 16, but has the urns of various dimentions possibly induced by different amounts of the nutritional supply. In the Japanese species of *Grimmia*, obovate to ovate-oblong urns are common. *Grimmia olympica*, in Japanese specimens, has exceedingly small-sized urns of nearly spherical form, attaining up to 0.3-0.4 mm long as contrasted with over 0.9 mm long in other species of the genus. *G. brachydictyon* possesses the characteristic shape of urn being clavate, sharing it with closely related species, *G. hartmanii* and *G. anomala* ( Japanese material of the latter species are always known only in sterile condition). The apophysial part is gradually narrowed into a seta. Short, semi-spherical to obovate, occasionally ovate-oblong urns occur in *Schistidium apocarpum* and a form of *S. gracile* (Mod. *trichodon*). The ribs on the surface of urn are formed when dry either distinctly or indistinctly in species of *Grimmia*. The distinct ribs are observed in *G. curvata* and a form of *G. apiculata*. As seen in Fig. 16, the ribbed urns of *G. apiculata* easily pass into the smooth urns where some "nods" are formed at the apophysial part. On the urn of *Schistidium apocarpum*, the indistinct fine ribs are observed which are rather exceptional in the genus *Schistidium*.

## B. Exothecial cells

The character of exothecial cells has not been payed attention in the taxonomy of Grimmiaceae, whereas, recently Ando (1972) recognized its taxonomic importance in the Hypnaceae. It is the fact that the exothecial cells are very variable in shape even in a single urn, namely, those from the middle part of urn are large and gradually become smaller towards the base of urn and rather suddenly do so towards the orifice. It is considerably difficult and rather wastful to describe all shapes of cells or cell-wall condition. However, the most frequent shape of cells from the middle part of urn may be used as a characteristic to the species.

*Coscinodon cribrosus*, *Schistidium maritimum*, and *S. rivulare* are grouped by means of very thick-walled exothecial cells, among which *S. rivulare* can be distinguished from the other two species in having quadrate to short rectangular cells. In *Schistidium maritimum*, and *Coscinodon cribrosus*, the exothecial cells are elongated rectangular. In the genus *Schistidium*, *S. apocarpum* and *S. maritimum* have elongated rectangular cells and the other species have transversely rectangular cells. In *Grimmia*, the exothecial cells from the middle part of urn are of no use to distinguish the species: they are equally elongated hexagonal, with more or less thin walls. In species having ribs on the surface of dried capsule, such as *G. apiculata*, *G. curvata*, and *G. funalis*, cells of ribs are more strongly elongated than those of neighbouring non-rib portions. In the apophysial part, phaneroporous stomata are developed, whose number ranges from 6 to 12 in all species studied except *G. apiculata* which has many stomata, 15-20 in number, arranged in two concentric rows.

### C. Peristome teeth

Detailed and accurate studies on the peristome structure of mosses were made by Philibert (1884-1890). In his second article, Philibert (1884) treated the genera *Grimmia*, *Coscinodon*, and *Racomitrium*, in comparison with other genera of various families of the Haplolepidous mosses. According to his interpretation, the peristome teeth of *Dicranum* as well as other genera of the Dicranaceae (*Campylopus*, *Dicranella*, *Cynodontium*, *Dichodontium*, *Dicranodontium*, *Aongstroemia*, and *Trematodon*) are composed of two plates derived from juxtaposed outer and inner periclinal walls of two concentric cell-layers. In this developmental view point, the peristome teeth of Grimmia are similar to those of the Dicranaceae. But, some important, different structures between the Grimmiaceae and Dicranaceae have been described by Phibibert (1884) and reconfirmed by me. These are summerized as follows: 1. Outer thin and inner thick plates in the Dicranaceae in contrast to outer thick and inner thin plates in the Grimmiaceae. 2. Transverse lamellae of peristome teeth develop on the inner surface in the Dicranaceae, and they develop on the outer surface in the Grimmiaceae. 3. On the outer surface, vertical striae develop in the Dicranaceae, while papillae develop in the Grimmiaceae.

On the other hand, Caver (1964) classified the mosses based on the peristome conformation and divided the Haplolepideae into five subdivisions. According to him, the Grimmiaceae, together with only the Seligeriaceae, are assigned to his fifth group (V) Platycranoideae, which is characterized as follows: teeth broad and thin, undivided or perforated by slits — more rarely split into two or three lobes — , outer teeth (layer?) thicker than inner, no basal membrane, properistome sometimes present. The Dicranaceae belong to the second group (ii) Dicranoideae, being characterized as follows: teeth usually cleft into two or rarely three lobes, outer layer with longitudinal striations and thinner than the inner layer, which has more or less distinct transverse bars, no basal membrane, no properistome. In the Dicranoideae are included the families Fissidentaceae and Leucobryaceae besides the Dicranaceae. It seems to me that the system established by Caver (1964) would be more reasonable than Philibert's view point that the Grimmiaceae are rather closely related with the Dicranaceae.

In the Grimmiaceae, is observed the trend that the inner plates become as thick as the outer plates in the middle part of teeth as observed in *Racomitrium*, but in this case thick outer plates are seen at their basal parts. The increase of thickness in the inner plates seems to be correlated with the slenderness of peristome tooth. Among the genera treated here, any essential differences could not be realized between *Grimmia* and *Schistidium*. But, in *Coscinodon*, the inner plates are as thick as the outer ones and approach to those of *Racomitrium*. The inner and outer plates are covered with papillae arranged without any regularity. The basal outer plates occasionally lack such papillae and remain smooth. Various degrees of perforation on the peristome teeth are found equally in the genera, or also in a species of *Grimmia* and *Schistidium*. The genus *Coscinodon* has in most cases strongly cribrosed teeth, rarely less so as seen in the type specimen of *C. humilis* Horik. et Nog. The perforation frequently occurs in the upper part, occasionally in the middle part of teeth, and never in the basal part. When the perforation is advanced, the teeth appear to be divided into 2-3 branches, but it is restricted to the upper part of teeth and never extend to the base as seen in *Racomitrium*. Therefore, the degree of perforation and number of branches from a single tooth are not reliable to the taxonomy of our genera. The absence of basal membrane in *Grimmia*, *Schistidium*, and *Coscinodon* may be used as one of the characters distinguishing them from *Racomitrium*. Thus, the peristome characters might hold good for the basis to distinguish the higher rank of taxa than species in the Grimmiaceae. As rare cases, much reduced and rudimentary peristome teeth are eventually used for the recognition of *S. subconfertum* and total absence of peristome teeth for *G. olympica*.

D. Operculum

The operculum consists of the dome-shaped basal part and the beak being arised from the top of the former. Various beak-shapes are observed in the species treated here, being short or long, upright or oblique. In the Japanese Grimmian species, the upright beak is common, but occasionally occurs the obliquely elongated long beak with a sharp point (Grimmia curvata, G. pilifera). In Grimmia donniana, G. elongata, G. olympica, and G. subsulcata, the beak is indistinctly developed, therefore the whole operculum is in a conic form. In Grimmia apiculata, G. atrata, and G. funalis, the beak is upright and thick, with a blunt apex. An example of the variation of its length is demonstrated by G. apiculata ( Fig. 16). In Grimmia brachydictyon, the upright elongated beak is observed, which reminds us of the form observed in the species of Racomitrium. In species of Schistidium, the beak is always characteristically oblique and hooked beak as far as I examined. This shape seems to be characteristic of the genus, since the similar shape is hardly known in the family Grimmiaceae. In Coscinodon cribrosus, the beak is upright and elongated, with a sharp point. The proportion of the operculum to the urn in this species is diagnostically large as compared with those of species of Grimmia and Schistidium. The operculum always falls detached from the columella in all species of Grimmia and Coscinodon. However, it always falls with the columella in the Schistidium except an occasional case in S. maritimum. This character has been considered one of the best features in recognizing the genus Schistidium since Bruch, Schimper & Gümbel (1845). I support this, although several authors depreciated it as a variable and unreliable feature for the recognition of the genus (e.g., Hagen 1909).

## E. Annulus

The taxonomic importance has been recognized in the configuration of the annulus of the capsule. Mizushima (1960) appreciated its value in distinguishing the two subgenera of *Entodon* according to wheather the annulus were developed or not. In the history of the taxonomy of the family Grimmiaceae, Bruch, Schimper & Gümbel (1845) raised the absence of annulus in the genus *Schistidium* as one of the diagnostic features in distinguishing it from the genus *Grimmia*. But, this character has long been depreciated or has slipped from the mind of bryologists. The question wheather *Schistidium* should be recognized as an independent genus or a section or subgenus of the genus *Grimmia* were hitherto repeatedly discussed. But, the configuration of the annulus was not pur forward argument by any bryologists. Thériot (1929), however, separated his genus *Jaffueriobryum* from the genus *Coscinodon* on the basis of the presence of annulus. In the present work, its taxonomic value in the genera treated was admitted, especially in distinguishing the closely related genera, namely the genus *Schistidium* is clearly distinguished from the other genera of the Grimmiaceae by the absence of the annulus. Following three types of the annulus were recognized in the genera treated here:

1. *Affinis* type. (Fig. 9: 3) Annulus is well differentiated, composed of (2-) 3-4 rows of cells, which are thick-walled, but transparent, and becoming larger from the lower to the upper rows. After the operculum is detached from the urn, the superposed constituent cells of annulus are raising up and revoluting, being attached the front, free walls each other, and separated the other walls. Cells of annulus are sharply distinguished from those of both the operculum and the urn by their shape, size, and thickness of walls as well as the transparency even in the deoperculated

condition. The annulus detaches the operculum from the urn by means of its hygroscopic movement. Upper rows of cells of annulus are also taken off when the lid falls, but lower rows of them remain attached to the orifice of urn, disjointing little by little in course of time.

Among the species treated here, the following species belong to this type: G. affinis, G. anomala, G. apiculata, G. brachydictyon, G. curvata, G. olympica, and G. pilifera.

2. Schistidium type. (Fig. 9: 1) Annulus is not distinctly developed, or almost absent. Exothecial cells gradually elongate transversely toward the orifice, in which several rows of transversely linear cells are directly juxtaposed with the marginal cells of the operculum, which are rounded hexagonal and thick-walled. All species of Schistidium belong to this type. grouped in this type.

3. Elongata type. (Fig. 9: 2) This type might be considered as an intermediate type between the two types mentioned above. The cells of annulus are transparent, but thick-walled, and distinctly differentiated. The constituent cells resemble in shape marginal cells of both the operculum and the orifice of urn, and are mostly quadrate to short-rectangular. Grimmia donniana, G. elongata, G. incurva, and G. subsulcata as well as Coscinodon cribrosus.

8. Seta

The setae in the genera treated here are pale yellow, yellowish-brown to dark-brown; smooth or somewhat mamillose on surface; and rounded to elliptic in cross-section. The seta is usually longer than the urn in the genus Grimmia, or as long as or shorter in the genera Schistidium and Coscinodon as well as two exceptional species of Grimmia: G. olympica (Japanese material) and G. pilifera.

The length variation of seta is remarkable in *Grimmia*, whose extreme case is seen in *G. olympica*, namely, 0.8-1.1 mm were measured in North-American plants (Noguchi & Saito, 1970) against 0.01 mm (nearly sessile) in Northern Japanese plants. In *Schistidium*, *Coscinodon*, and *Grimmia pilifera*, the variation is less distinct. Straight or arcuate seta occurs in the genus *Grimmia*, and straight one in the genera *Schistidium* and *Coscinodon*. Among the Japanese Grimmian species, straight setae are observed in *G. affinis*, *G. atrata*, *G. donniana*, *G. elongata*, *G. pilifera*, and *G. subsulcata*, and distinct arcuate setae in *G. apiculata*, *G. curvata*, and G. *funalis*. In both *G. anomala* (all the Japanese plants are known in sterile condition) and *G. brachydictyon*, the setae are indistinctly arcuate to nearly straight. The arcuate or non-arcuate seta assumes to some extent a taxonomic importance when it shows a close correlation with other features found in both (or either) sporophyte and (or) gametophyte.

All the species of the genus *Grimmia* which I have studied have the setae twisted to the left throughout when dry (i.e., the spirals ascend towards the left to an observer supposed to be standing within the spiral, Dixon, 1924). Even in the genera, *Coscinodon* and *Schistidium* and some species of *Grimmia* with short setae, the seta-twisting to the left can be observed though it is indistinct. Dixon (1924) admitted the efficacy of the direction of seta-twisting in distinguishing certain two allied species each other, and it was recently followed by Saito (1975) who separated *Barbula convoluta* from other species of Barbula in using this character. In addition, Ando (1972) realized the taxonomic significance in the direction of seta-twisting in relation to the phylogeny of the genus *Hypnum*, based on the fact that closely related species usually show a similar feature in seta-twisting. Ando's (1972) observation is also applicable to the family Grimmiaceae, in which the seta twisted to the right occurs in the genera *Racomitrium* and *Ptychomitrium* whose close relationships is pointed out in terms of peristome structure by Noguchi (1974). In the cross-section of seta, three kinds of layer are observed as in the stem-section: the epidermal layer, the cortical layer, and the central strand. These three kinds of layer are distinguished in every species concerned in this monograph though the distinction between the epidermal and the cortical layers sometimes becomes indistinct. The central strand is composed of very fragile cells and frequently remains hollow by the breaking up of the cell-walls when or after the seta comes to maturity (Fig. 5: 2). The outer sufaces of epidermais are more or less crenulate in the cross-section due to the bulging of the cells. The shape of the epidermal cells on the surface view varies in a genera, generally corresponding to the length of seta. All the species of the genus *Schistidium*, *Coscinodon cribrosus*, *Grimmia olympica* (Japanese material), and *G. pilifera*, whose setae are commonly shorter than the urn, have the quadrate to rectangular epidermal cells (Fig. 5: d-g). On the other hand, the species bearing long seta have generally elongated cells as represented by *G. affinis*, *G. apiculata*, and *G. brachydictyon* (Fig. 5: a-c).

## 9. Calyptra

The form of the calyptra has been used in distinguishing species, section or genus in the taxonomy of the Grimmiaceae. One of the extremes is seen in Hampe's (in C.Müller, 1846) treatment, who established the genus *Guembelia*, separated from the genus *Grimmia*, counting upon only cucullate calyptra. Unfortunately, however, the genus *Guembelia* seems to be quite artificial. The calyptral from is very variable in certain species of *Grimmia* such as *G. donniana* and *G. elongata*, but is should not be always neglected, because it is rather constant, and of taxonomic importance in some species. As a variable case, cucullate-like calyptra occurs in the species bearing usually mitrate calyptra, when one of the slits at base of calyptra extends deeply upward as observed in some populations of *G. donniana* and *G. elongata*. Elongated conical calyptra is observed in *G. subsulcata* since it is detached before the maturity of capsule. The calyptra of *Schistidium rivulare* usually falls accompanied by attached operculum. In matured sporophytes, the calyptra covers only the operculum in *Schistidium*, both operculum and a part of urn in *Grimmia*, deeply the urn in *Coscinodon*. The small calyptra covering partially the operculum has been drawn attention as one of the diagnostic characters concerning the genus *Schistidium* (sometimes as the subgenus *Schistidium* of the genus *Grimmia*) (Bruch, Schimper & Gümbel, 1845; Schimper, 1860, 1876; Limpricht, 1889; Jones, 1933 and others). In addition to the form, the anatomical feature of calyptra was investigated by Noguchi (1974) about the related genus *Racomitrium*, which has 3-4 layers of thick-walled cells in the middle part (Fig. 10: 11-17). The result of his work suggested me to extend further investigation to *Grimmia*, *Schistidium*, and *Coscinodon*. As the result of my examination on the above three genera, it has become evident that all species have thinner calyptra than that of *Racomitrium* : calyptra is composed of (2-) 3 layers of thick-walled cells in the middle part except *G. curvata* composed of 3-4 layers (Fig. 10: 1-10). The surface condition of the calyptra of the genera *Grimmia* and *Schistidium* is smooth (neither scabrous nor plicate) throughout, occasionally somewhat scabrous calyptra, but restricted in the upper part, is observed in Grimmia curvata and G. brachydictyon. In the related genus Racomitrium, scabrous upper parts of calyptrae are universally found. That of Coscinodon is not scabrous, but has many radial plicae as seen in the related genus Ptychomitrium.

The thickness and the surface condition of the calyptra offer clues to separate Racomitrium from Grimmia, Schistidium, and Coscinodon.

### 10. Vaginula

The vaginula is a haploid element sheathing and supporting the foot of seta and its form is varying in the genera, that is, long cylindric in Grimmia, Racomitrium, and Ptychomitrium, short cylindric in Schistidium and Coscinodon as well as an exceptional species of Grimmia, G. pilifera. The vaginular part originates from both a part of the venter of archegonium and a part of epidermal cells of the apical portion of archegonia-producing stem (or branch). This is demonstrated by the position of aborted archegonia which are found at the basal part of vaginula (Fig. 25: 17; 32: 17). The vaginula of the species of the genera treated is composed of 3-4 concentric cell-layers with thin walls, of which the innermost walls are adhered to epidermal walls of seta.

The epidermal cells have thin and smooth walls (Fig. 7). In the upper free end of a vaginula is developed a transparent "collar" called "ochrea" by Limpricht (1889). In the taxonomy of the family Grimmiaceae, little attention has been payed to the vaginula except Hagen (1909) who used the contorted vaginula as an important criterion to separate Grimmia atrata from other species of the genus Grimmia and established a monotypic subgenus Streptocolea. According to my observation such tortion of vaginula is caused not by its proper histological background, but by secondary mechanical force resulted from the tortion of setae by desiccation. In addition, such tortion is observed not only in *G. atrata*, where it is not always observed, but also in other species of *Grimmia*, for example, *G. elongata* which is not so closely related to *G. atrata*.

I have newly evaluated the conformation of vaginula to separate the genera *Grimmia*, *Schistidium*, and *Coscinodon* from their relative genus *Racomitrium*. The epidermal cells of vaginula in the genera *Grimmia*, *Schistidium*, and *Coscinodon* have thin walls against thick and pitted or nodulous walls in *Racomitrium* (Fig. 8: 5-11). However, those of *G. curvata* (Fig. 8: 12) approach those of *Racomitrium*.

### 11. Spores

In most species of the genera *Grimmia*, *Schistidium*, and *Coscinodon*, the spores are spherical and vary from 8-15 µm in diameter. Character of spores is usually less important to recognize the species except *Schistidium rivulare* and *S. maritimum*, which have large spores of 19-28 µm in diameter and are remarkable in all species of the genera treated here. Loeske (1913) made mention of the spore-size in the family Grimmiaceae that the species with small-sized spores are distributed widely on the whole globe and grow mainly in dry habitats and the species with large-sized spores have rather small geographic repartitions and grow in wet habitats. The surface of spores is more or less minutely papillose or nearly smooth.

### 12. Sexual condition

The sexuality is exclusively autoicous in the species of the genus *Schistidium* treated here. Perichaetia and archegonia are formed on the tips of stems (or branches), so acrocarpous, and perigonia and antheridia also on the tips of male branches.

In the genus Grimmia, two kinds of sexaulity are observed, namely, monoecism and dioecism. Synoecism has been reported as an abnormal case by Loeske (1913). However, Agnew (1973) recently described a synoicous species, G. gibbosa, from Iraq. Autoecism is observed in Grimmia affinis, G. apiculata, G. donniana, G. olympica, and G. subsulcata. In G. apiculata, perichaetia are formed just above the perigonia on different branches. In this case, it looks as if it were paroicous in sexuality. However, distinction is clear between paroicous and autoicous by the criterion whether perichaetial and perigonial leaves are located on the same or separate branches. Brotherus (1924) overlooked the perigonia of Grimmia micropyxis (=G. apiculata) produced just below the perichaetia and described the species as a dioicous one. G. subsulcata and G. olympica offer the same special condition of sexuality, the latter of which has long been considered as dioicous species until the careful examination by Noguchi & Saito (1970). In these species perichaetia and perigonia are produced at the tops of elongated branches arised from the same stem. When successive branchings including subfloral innovations continue, and lower aged branches are decomposed in years, upper new branches having different sexual organs appear as if they are of different individuals. This circumstance often leads bryologists to misunderstanding of the sexuality. In addition to this, the unbalanced occurrence of male and female sexual organs complicates the taxonomic study, especially on the species exhibiting a wide variation in gametophytic features. In G. donniana and G. affinis, perigonia are formed on tips of branches located more or less remote from perichaetia and therefore the case as seen in G. subsulcata and

and *G. olympica* is sometimes encountered on examining the herbarium specimens. The dioecism occurs in *G. anomala*, *G. atrata*, *G. elongata*, *G. curvata*, *G. brachydictyon*, *G. funalis* and *G. pilifera*.

## V. Morphological relationships among the five genera of the family Grimmiaceae

The characters of gametophyte and sporophyte are not to be equivalently evaluated in considering the relationships among the genera, because a genus closely related with other genus in the gametophytic characters is sometimes remetely related with it in the sporophytic ones, or vice versa. The genera *Racomitrium*, *Ptycomitrium*, *Coscinodon*, and *Schistidium* have peculiar features positively characterising them respectively, but the genus *Grimmia* has no specific features common within the genus. From this fact, I presume that the genus *Grimmia* may be the most primitive genus among the genera concerned here. As already indicated by Noguchi (1974), *Racomitrium* and *Ptychomitrium* are in a close relationship, especially related by the character of peristome teeth. These two genera are also related by characters of calyptra and seta as seen in Tab. 1, among which the twisting of seta to the right is remarkable, though some exceptional species are known in *Racomitrium* (*R. lanuginosum*, *R. canescens*, *R. ericoides*). The genus *Racomitrium* has been vaguely circumscribed by a peculiar character that the basal laminal cells are finely sinuose. This character may seem to be unreliable independently to recognize the genus, but it is worthy of being evaluated in consideration of its corelation between the nature of epidermal cell-walls of vaginula. The coexistence of these two kinds of conformation is known only in the genus *Racomitrium* within the family Grimmiaceae except *G. curvata* which has been often treated as a member of Racomitrium. It is no doubt that G. curvata is related to both genera Racomitrium and Grimmia. The relationship between Grimmia and Schistidium is not supported by the occurrence of intermediate species, though the two genera are evidently closely allied each other. There is seen a discontinuity in the morphology of annulus. In addition, the characteristic phenomenon that the operculum falls with columella distinguishes the genus Schistidium from Grimmia, and the other genera of the family. The genera Racomitrium and Ptychomitrium also are related with Coscinodon in having thick inner plates of peristome teeth. Each tooth of Coscinodon is not slender, but much cribrosed tooth is inclined to give rise to many slender branches. Coscinodon has a close relationship with Ptychomitrium in having the plicate calyptra. The plication of calyptra is caused by the localizing of multistratosed portion. The degree of the localisation is far weaker in Coscinodon than in Ptychomitrium.

Table 1. Morphological relationships among the five genera of the family Grimmiaceae

| | <u>Racomitrium</u> | <u>Ptychomitrium</u> | <u>Coscinodon</u> | <u>Schistidium</u> | <u>Grimmia</u> |
|---|---|---|---|---|---|
| Epidermal cells of vaginula with thick and pitted walls(+) or with thin and smooth walls(-) | + | - | - | - | - |
| Basal laminal cells finely sinuosed(+) or smooth to coarsely nodulose(-) | + | - | - | - | - |
| Calyptra scabrous(+) or smooth(-) in upper part | + | - | - | - | - |
| Calyptra of 3-4 or more cell-layers(+) or of 2-3 cell-layers(-) | + | + | - | - | - |
| Seta twisted to right(+) or to left(-) | + | + | - | - | - |
| Peristome teeth linear-lanceolate and deeply divided into two filiforme branches(+) or lanceolate and perforated or irregularly divided in upper part(-) | + | + | - | - | - |
| Basal membrane of peristome present(+) or absent(-) | + | + | - | - | - |
| Male small branch present(+) or absent(-) in perichaetial leaves | - | + | - | - | - |
| Costa with two steried bands(+) or without stereid bands(-) | - | + | - | - | - |
| Calyptra plicate(+) or smooth(-) | - | + | + | - | - |
| Seta shorter(+) or longer(-) than urn | - | - | + | + | - |
| Calyptra covering only a part of operculum(+) or both operculum and a apart of urn(-) | - | - | - | + | - |
| Columella falling with operculum(+) or separated from operculum(-) | - | - | - | + | - |
| Annulus absent(+) or present(-) | - | - | - | + | - |
| Exothecial cells transversely rectangular to quadrate(+) or elongated-rectnagular(-) | - | - | - | ± | - |
| Dioicous(+) or monoicous(-) | + | - | ± | - | ± |

# VI. Taxonomic Treatment

Representation of data in the description and the illustrations. Unusual characters of strongly deviating specimens are not included in the description. Sampling and measurement of organs are made as follows: Leaves are sampled from the upper portion of stem (or branch), neither too young nor too old, mainly from the green part; the length are measured, disregarded the hyaline hairpoint even if it develops, the width are gained without taking into consideration the revoluted parts, under the condition that soaked leaves in water are pressed slightly between cover and slide glasses. The "middle " part of lamina means the transitional part where the basal part becomes narrower into the upper subulate part. The illustrations are prepared from moistened material, with the exception of some parts of plant, capsule, and calyptra. The leaves are illustrated from the dorsal side in order to show the revolution of margins.

For the habitat information of each species, the system of vegetation zones made by Hämet-Ahti, Ahti and Koponen (1974) was employed.

## Key to the genera Grimmia, Schistidium, Coscinodon and their allied genera

1. Male small branches present just beside vaginula; calyptra plicate. ....................Ptychomitrium (see Noguchi 1955)
1. Male small branches absent; calyptra plicate or smooth. ...2
2. Annulus absent; operculum falling with columella ; calyptra covering only a part of operculum. ..........Schistidium (p. 91 )
2. Annulus of hyaline cells developed; operculum falling detached from columella ; calyptra covering both operculum and upper part of run. ...............................................3
3. Calyptra plicate, campanulate, deeply covering urn; peristome teeth strongly cribrosed. ...............Coscinodon (p.122 )
3. Calyptra smooth, cucullate to mitrate, shallowly covering urn; peristome teeth entire to irregularly perforated. .........4
4. Epidermal cells of vaginula with thin and smooth walls; calyptra thin, 2-3 cells in thickness in the middle; peristome teeth non-divided or divided in upper 1/3 of whole length, without basal membrane; stem with or occasionally without central strand. ..........................Grimmia (p.42 )
4. Epidermal cells of vaginula with thick and nodulose walls; calyptra thick, 3-5 cells in thickness in the middle; peristome teeth deeply divided into two slender branches, with basal membrane; stem without central strand. ..............5
5. Seta straight, in most species twisted to the right when dry, capsule smooth on surface when dry; walls of basal laminal cells strongly sinuose; wings absent on the dorsal surface of costa. ................................Racomitrium (see Noguchi 1974)
5. Seta arcuate in wet, flexuose and twisted to the left when dry; capsule ribbed when dry, walls of basal laminal cells nodulose; wings of 2-4 lamellae developed on the dorsal surface of costa.

...............................*Grimmia* *curvata* (p.64 )

## *Grimmia* Hedw.

Spec. Musc. 75. 1801.

Plants small to robust, generally yellowish-green, dark-green or blackish, in dense cushions or dense to loose tufts. Stems upright to ascending, occasionally procumbent, moderately branched and often fastigiated, with or without central strand. Leaves ovate-lanceolate, gradually narrowing toward the apex, terminated by a hyaline hair-point or muticous point, strongly or obtusely keeled; lamina generally unistratose, often bistratose at places in upper part; margins variously revoluted, either on one side or on both sides and either narrowly or widely so in the widest part, thickened in two, at places three layers in upper part; costa single, rigid, percurrent, projecting in weakly keeled ones, composed of almost homogeneous cells, smooth on dorsal surface (excl. *G. anomala*); laminal cells transversely rectangular, quadrate or elongated rectangular (up to 2:1), with variously thickened walls which are more or less sinuose in upper part, much elongated; occassionally less elongated, and transparent or translucent, with thin or thick and more or less nodulose walls. Autoicous or dioicous. Inner perichaetial leaves large with wider base than vegetative ones, from which outer perichaetial leaves less differentiated, basal part convoluted, with much loose areolation, of thin-walled cells. Capsule symmetric, obovate, ovate or oblong, occasionally short clavate; urn smooth or ribbed; exothecial cells rounded- to elongated-hexagonal or rectangular, becoming shorter and smaller toward both base and orifice; stomata in one or two concentric rows, restricted to apophysial part. Annulus well developed, consisting of transparent, thick-walled cells in 3-4 rows, superposed, separable from both operculum and urn. Peristome teeth 16, lanceolate, yellowish-brown to reddish-brown, imperfectly divided into 2-3 branches in the upper part; outer surface papillose throughout, but occasionally weakly so or smooth near the base, inner surface papillose throughout. Seta straight, generally longer than urn, twisted to the left when dry. Operculum low-conic, with short or long and upright or oblique beak. Columella persistent, not falling with opercula. Calyptra mitrate to cucullate, 2-3 cell-thick in the middle, extending to the urn.

Lectotype species: Grimmia plagiopodia Hedw.

## Key to the Japanese species

1. Plants small, up to 5 mm high; leaves not keeled; costa from middle part plane-convex to biconvex in cross-section; capsule immersed in perichaetial leaves; peristome teeth absent. .... ........................................ 11. G. olympica (p.80 )

1. Plants larger (more than 5 mm high); leaves obtusely to sharply keeled; costa from middle part concave; capsule exerted on longer seta than urn (except G. pilifera); peristome teeth well developed. ................................................ 2

2. Leaves with wings on dorsal surface of costa. ............. 3

2. Leaves without wings on dorsal surface of costa. .......... 4

3. Leaves with globular gemmae on tip; basal paracostal cells similar to those of middle part, not nodulosely thickened, but with moderately thickened and smooth longitudinal walls; seta straight; capsule smooth on surface when dry; operculum with long upright beak. ............ 5. G. brachydictyon (p. 59 )

3. Leaves without globular gemmae on tip; basal paracostal cells much elongated than those of middle part, much nodulosely thickened in longitudinal walls; seta arcuate or flexuose; capsule

ribbed on surface when dry; operculum with long oblique beak. .................................... 6. _G._ _curvata_ (p.64 )

4. Many ridge-like cuticular thicknings developed on leaf; globular gemmae present on leaf-tip. ............. 2. _G._ _anomala_ (p.49 )

4. Ridge-like cuticular thicknings absent; globular gemmae absent. ........................................................ 5

5. Leaves with rounded apex, never hyaline hair-pointed; basal margins recurved on one side and somewhat incurved on the other side; marginal cell-rows bistratose. ....... 4. _G._ _atrata_ (p.57)

5. Leaves with acute apex, mucronate or hyaline hair-pointed; basal margins plane on both sides or recurved on one side and plane on the other side; marginal cell-rows unistratose. ....6

6. Plants pale bluish-green in fresh material; leaves soft; margins never recurved, rather slightly incurved; basal laminal cells with thick transverse and thin longitudinal walls. .......... .................................... 13. _G._ _subsulcata_ (p.87 )

6. Plants yellowish-green to dark-green, or blackish; leaves rigid; margins recurved at least on one side; basal laminal cells with thin transverse and longitudinal walls or thick (nodulosely thickened) longitudinal and thin transverse walls. ..........7

7. Hyaline hair-point absent or very shorton leaves including perichaetial leaves. ......................... 8. _G._ _elongata_ (p.71 )

7. Hyaline hair-point well developed, especially on perichaetial leaves. ................................................. 8

8. Plants robust, growing mainly in lowland; leaves usually longer than 2 mm,quickly recurved by absorbing water; capsule immersed in perichaetial leaves. ............... 12. _G._ _pilifera_ (p.83 )

8. Plants small to medium, growing in high mountains; leaves usually shorter than 2 mm; capsule exerted. ........................ 9

9. Capsule distinctly arcuate. .................................. 10

9. Capsule straight to slightly inclined. .................... 11

10. Basal marginal cells of 3-4 rows thin-walled; plants autoicous, perigonia just below perichaetia. ... 3. G. apiculata (p.52)

10. Basal marginal cells of 3-4 rows thick-walled; plants dioicous .................................... 9. G. funalis (p.74 )

11. Basal paracostal cells with thin longitudinal walls; leaf-margins plane. ........................... 7. G. donniana (p.68 )

11. Basal paracostal cells with nodulosely thickened longitudinal walls; leaf-margins recurved. ............................ 12

12. Photophyte. Leaves ovate-lanceolate. ....... 1. G. affinis (p.45 )

12. Chasmophyte. Leaves linearly elongated lanceolate. ......... ........................................ 10. G. incurva (p.77 )

### 1. Grimmia affinis Hornsch. (Fig. 11 & 12)

Flora 2: 443. 1819.

Type: Windischmattreyer Tauern ( B-Brid, lectotype selected here).

Grimmia ovata auct. non Web. et Mohr: B.S.G. in Bryol. Eur. 3: 123. 1845; Limpr., Laubm. Deutschl. 1: 745. 1889.

Grimmia ovata var. affinis (Hornsch.) B.S.G., Bryol. Eur. 3: 123. 255B. 1845.

Grimmia ovalis auct. non (Hedw.) Lindb.: Jones in Grout, Moss. Fl. N. Am. 2(1): 33. 1933; Takaki, Bot. Mag. Tokyo 64: 178. 1951; Takaki, J. Hattori Bot. Lab. 33: 186. 1970.

Grimmia akaishi-alpina Tak., Bot. Mag. Tokyo 64: 180. 1951.

Type: South Japanese Alps, Sensui pass (2700 m, Aug. 15, 1950, no. 10137) (holotype in private herbarium of Takaki).

Plants rigid, dark-greenish to often hoary above due to hyaline hair-points of leaves, blackish-brown below, in dense fragile cushions or tufts. Stems moderately branched and fastigiate, up to 2 cm long, with central strand. Leaves imbricate, closely appressed when dry, lanceolate from ovate base, ending in faintly denticulated hyaline point, concave below, obtusely keeled above, 1.3-2 mm long and 0.37-0.55 mm wide. Margins entire, narrowly revoluted on one side below. Lamina in upper part bistratose or unistratose at places, with 3-4 stratosed margins, in lower part unistratose, with 1-2 stratose margins. Upper laminal cells rounded quadrate to short rectangular, often transverse-rectangular, ±8 µm wide, with rather equally thickened walls; middle ones rectangular with sinuosed walls; lower ones elongated rectangular, near the costa (paracostal cells) much elongated (up to 10:1), with thick longitudinal and thin transverse walls; alar part consisting of up to 5-6 rows of transparent, rectangular cells with thin longitudinal and thick transverse walls, becoming narrower upward. Autoicous. Perigonia often on branch arising from the older basal part of stem. Perichaetial leaves larger, with longer hyaline hair-point reaching 1.5 mm long, plane or faintly revoluted in parts on margins, somewhat convolute. Capsule exerted, ovoid to cylindric, more or less narrowed at mouth, smooth, 1.1-1.5 mm long, 0.5-0.7 mm thick. Operculum suddenly contracted to short, straight or slightly oblique and obtuse beak. Seta pale, straight, 1.3-2.7 mm long. Calyptra subcucullate to mitrate, 3-4 lobed at base. Peristome teeth lanceolate, yellowish-brown, imperfectly creft in 2-3 branches up to the middle; outer surface smooth in lower half and papillose above; inner surface densely papillose throughout. Annulus in 3-4 rows of large separable cells (Affinis type). Stomata 10-15 in number. Exothecial cells variable in shape, rounded hexagonal to elongated hexagonal with equally thickened walls. Spores 9-11 µm in diameter, nearly smooth.

Distinguishing features:

1. Seta straight.
2. Leaves more or less rigid, with recurved margins, sometimes on one side only, sometimes on both sides.
3. Basal laminal cells differentiated, much elongated to rectangular, transparent to translucent; marginal ones moderately thick-walled.
4. Annulus of Affinis type.
5. Autoicous.

Before Sayre (1951), the distinction between *G. affinis* Hornsch. and *G. ovalis* (Hedw.) Lindb. was in a chaotic condition because of nomenclaturally and taxonomically entangled problems. Besides these two species, *G. ovata* Web. et Morh and *G. commutata* Hüb. were concerned to this matter and that has made it even more complicated. Sayre (1951) found two taxa among these names and admirably distinguished them by such characters as the leaf-form, the degree of keel of leaf, the condition of leaf-margins, the shape of costa in its cross-section, and the shape of calyptra and the sexuality. Mårtensson (1956) hesitated to employ the name *G. affinis* accepted by Sayre (1951) for the autoicous plants in question, because two *Grimmia affinis* were described by the same author in Flora vol. 2, p. 85 and p. 443, in 1819, based on different types. The later name on page 443, however, is not a homonym of the earlier name, because Hornschuch (1819) renamed the earlier *G. affinis* as *G. apiculata* on page 443 of that journal. According to article 64 of the International Code of Botanical Nomenclature (1972), *G. affinis* is accepted as the legitimate name for the species described on page 443 of Flora vol. 2. Therefore, *G. apiculata* was nomenclaturally published on page 85 in Flora vol. 2.

In consulting the references published threafter, dealing with the names, Bridel (1826, p. 178) mentioned in the remark of *G. affinis* as follows: "*G. affinis* Hornsch. in litt. non autem *G. affinis*. Bot. Zeit.(=Flora) II, p. 85. quae *G. apiculata* eorundem est". The indication of the locality of it was made as: in Alpibus carintiacis et salisburgensibus, ubi Hoppe et Hornschuch detererunt. In addition, in the column of the synonymous names of *G. apiculata*, which was substituted by Hornschuch for the earlier *G. affinis*, Bridel made the following citation: *G. affinis* (an mendo typographico pro apiculata?)..., Hornschuch New. Bot. Zeit. II. 85. The locality cited there corresponds to that on page 85 of Flora coworked with Nees (Nees, Hornschuch et Stürm, 1827), the page 443 for *G. affinis* and the page 85 for *G. apiculata* were cited as the pages concerning to their original descriptions. With the cortesy of the curators of B and H, I could examine the original specimens (probably so) of both *G. affinis* and *G. apiculata*. The specimens named as *G. affinis* conserved in B-Brid, was accompanied by the note of the handwriting in ink: Windischmattereyer, tauern, Hornschuch mist. 1819. The other specimen named as *G. apiculata* also conserved in the same herbarium posessed that name on a small herbarium label, on which the same locality was found. Another specimen of *G. apiculata* was found in H-SOL, being enveloped by a small sized paper packet, on which were found the simple indication of the locality and the collector's name as: *G. apiculata* Hornsch. Carinthia (=Kärnten, prefectural name of S. Austria, to which Windischmattereyer belongs), leg. Hornschuch.

According to my re-examination of the voucher specimens, "*G. ovalis*" reported by Horikawa (in Asahina, 1939), Takaki (1951) and Takaki et al. (1970) from Japan was actually *G. affinis*. Takaki (1951) described *G. akaishi-alpina* from central Japan, emphasizing the hexagonal cells from the middle part of leaf. It was, however, later reduced to a synonym of *G. ovalis* ( in effect, of *G. affinis* as discussed above) by Takaki et al. (1970). My study of the holotype specimen of *G. akaishi-alpina* has proved that it exhibits the typical features of *G. affinis*.

Habitat. On sunny exposed, non-calcareous rocks in the summit regions of mountains in the orohemiboreal to the oroboreal zone.

Range. Japan (Hokkaido, Honshu, Shikoku); Europe, Morocco, mountains of central Africa, Caucasus, Himalaya, Ceylon, North and East Asia, North and Central America, Andes, Greenland, Bormes.

### 2. *Grimmia anomala* Hampe ex Schimp. (Fig. 13)

Syn. ed. 2, 270. 1876.

Type: Ad rupes prope Zermatt Valesiae rever. Bertram legit. (holotype in BM).

*Grimmia philibertiana* Britt., Bull. Torr. Bot. Cl. 18: 51. 114f, 18-28. 1891.

Type: On quartz croppings of metaliferous veins, 6,000 ft. alt., divide between Traile River and Independence Creek, Sept. 27, 1889 (219). (holotype in NY; isotype in PC).

*Grimmia phyllantha* Lindb. ex Broth., Act. Soc. Sc. Fenn. 19(12): 83. 1892.

Type: Cauc. major occ.: Radscha, in monte Bereleti pr. Uzeri, ad saxa regionis alpinae, leg. S.O.Lindberg, in 1892 (holotype in H-BR; isotype in PC).

*Dryptodon anomalus* (Hampe ex Schimp.) Loeske, Hedwigia 49: 32. 1909.

_Grimmia_ _hartmanii_ Schimp. var. _alpinoborealis_ Loeske, Laubm. Eur. 1: 141. 1913. _nom_. _inval_. in _syn_.

_Grimmia_ _hartmanii_ Schimp. var. _anomala_ (Hampe ex Schimp.) Moenk., Laubm. Eur. 369. 1927.

_Grimmia_ _hartmanii_ Schimp. ssp. _anomala_ (Hampe ex Schimp.) Loeske, Biblioth. Bot. 101: 182. 1930.

Plants dark-green above, blackish or yellowish-green below in loose tufts. Stems creeping below, ascending above, reaching 1-2 cm long, moderately branched, with well developed central strand consisting of many small, thin-walled cells. Leaves loosely and irregularly imbricated when dry, spreading when moist, lanceolate to lingulate with ovate base, gradually narrowed towards the apex, terminated by an acuminate chlorophyllose point, occasionally by short hyaline hair-point, or by obtuse point due to the gemmae-formation, 1.6-1.9 mm long and 0.4-0.7 mm wide. Margins entire, revolute on both sides in the middle part, on one side more faintly so. Lamina unistratose, at places bistratose in the upper and middle parts including the margins. Costa stout, prominent , semicircular in cross-section, composed of nearly homogeneous cells with thin-walls. Upper laminal cells quadrate to shortly rectangular (up to 2:1), 7-8 µm wide, with somewhat incrassate and sinuosed walls, basal angular cells rectangular (2-3:1), 8-10 µm wide, rather thin- and nearly smooth-walled, not forming hyaline parts. Cuticular thickenings developing with unequal height on both surfaces of leaf, appearing papillae in cross-section, less distinct in the basal part of leaf. Multicellular and globular gemmae produced on the tip of leaf, intercarated by hyaline, thin-walled cells. Neither perichaetia nor perigonia are known in Japanese collection.

Distinguishing features:

1. Globular gemmae present at leaf-apex.
2. Central strand present in stem.
3. Ridge-like thickenings which appear like papillae in cross-section of leaf, present on both surfaces of leaf.
4. Wing-formation on dorsal surface of costa absent.
5. Hyaline hair-point usually absent, rarely present.
6. Basal angular part less differentiated.

This species has often been treated as subspecies or variety of G. hartmanii, but I am of the opinion that G. anomala should be retained in the specific level, because it is never allied to any related species by intermediate forms. The specific identity of G. phyllantha described by Brotherus (1892) with G. anomala was indicated by Correns (1899). Salmon (1900) reconfirmed Correns's treatment after an examination of the holotype specimen, showing the copies of Schimper's original drawings, where were illustrated somewhat acuminate leaves with hyaline hair-point and the ridge-like cuticular thickenings running longitudinally on the leaf, which are the most characteristic feature of this species. The distinction between G. anomala and G. brachydictyon is shown in the remark of the latter species (p. 62 ).

The fructification is considerably rare in this species. Hitherto, the detailed descriptions of sporophytes have been made by Britton (1891) for her new species, G. philibertiana, which is at present treated as a synonymy of G. anomala, and by Lawton (1959) for the North American plants of G. anomala as well as by Limpricht (1889) et al. for the European plants. No Japanese plant with sporophyte has been collected.

Habitat. On partially shaded, silicious rocks in woods in the lower and middle oroboreal zone.

Range. Japan (Honshu); Fennoskandias, Alps, North America, Ireland.

### 3. Grimmia apiculata Hornsch. (Fig. 14, 15 & 16)

Flora 2: 85. 1819.

Type: An etwas feuchten Felsenwänden der Messerlingswand auf dem Windischmattreyer Tauern (labelled on lectotype specimen as: Windischmattreyer Tauern, Hornschuch misit. 1819. lectotype selected here, in B-Brid; isotype in H-SOL).

Grimmia affinis Hornsch., Flora 2: 85; non Hornsch., Flora 2: 443. 1819.

Grimmia micropyxis Broth., Sitzungsber. Ak. Wiss. Wien Math. Nat. Kl. 133: 567. 1924. syn. nov.

Type: Prov. Setschwan austro-occid.: In montis Tschahung — Nyotscha, trans flumen Yalung ad septentr. oppide Yenüen, 28°15', regione alpina, ad rupes schistosa; ca. 4150-4300 m, Nr. 2671, leg. Handel-Mazzetti, 6. VIII. 1915 (holotype, not found in H; isotype in PC).

Grimmia subdonniana Nog., Candollea 19: 175. 1964. syn. nov.

Type: Nepal. Moraine, near Lobuje (27°57', 86°49'), alt. 4870 m, April 2, 1952, Zimmermann 301 ( holotype in G, not seen; isotype in Noguchi's private herbarium).

Plants in dense cushions or tufts, yellowish-green to green above, greenish-brown to dark brown below. Stems up to 1 cm long, with well-developed central strand, moderately branched. Leaves lanceolate with ovate base, gradually becoming narrower upwards, terminated by smooth hyaline hair-point attaining 0.5 mm long, sharply keeled in the upper part, appressed and more or less controted against the stem when dry, 1.6-2 mm long and 0.4-0.5 mm wide. Margins revoluted on both sides (on one side usually faint) in the widest part of leaf, thickened in two cell-layers in the upper half. Costa percurrent, smooth to mamillose on dorsal surface, with or without several thin-walled small cells in the middle in cross-sections. Lamina usually unistratose throughout, sometimes bistratose at places in upper part. Upper laminal cells transversely or longitudinally rectangular (0.8-1.5:1), 9-10 µm wide, more or less sinuose, sometimes mamillose; cells of transitional part very variable, less sinuose to distinctly so, rectangular ( 1.5-2:1), or in plants growing on exceedingly dry habitat, elongated rectangular (3-7:1), distinctly sinuose as observed in <u>Racomitrium</u>; basal laminal cells much elongated; basal paracostal cells with smooth to more or less nodulose and thin or somewhat thickened walls; cells from margins faintly swallen with very thin-walls, forming alar parts which become narrower to the level of the widest part of leaf. Autoicous. Perichaetial leaves longer, with wider and larger base than the vegetative ones, terminated by elongated hyaline hair-point. Capsule emergent, on arcuate seta, variable in size and shape as well as in surface condition when dry, 0.7-1.2 mm long, 0.5-0.6 mm thick, ovate-globose to ovate-oblong, smooth or ribbed; in case of the smooth surface, nods appearing at apophysial part. Peristome teeth lanceolate, non-perforated or divided into 2 branches in the upper parts for short capsules, widely lanceolate and divided into 2-3 branches in the same parts for long capsules; both external and internal surfaces papillose throughout. Exothecial cells elongated-hexagonal to linear. Stomata many, 15-20 in number. Annulus of Affinis type. Operculum with beak in various lengths; obtuse. Calyptra mitrate. Spores very finely papillose, ±10 μm in diameter.

Distinguishing features.

1. Seta distinctly arcuate.
2. Capsule with many stomata at apophysial part, 15-20 in number.
3. Plants autoicous: androecia located just below perichaetia.
4. Angular cells of leaf elongated, with thin walls.

This species reveals rather wide variation in both gametophytes and sporophytes. All the variations observed seem to be ascribed to ecological conditions where plants grow.

1) Laminal cells are variously thickened, less sinuose to distinctly sinuose in the upper and middle parts of leaf, evenly to nodulosely so in the basal part. This sinuosity is most pronounced at the transitional part if it is present. Plants growing in more or less mesophytic environment have less sinuose cells and the lamina frequently bistratosed at places in upper part of leaf. Those growing in dry, sunny exposed habitat have unistratosed and bright lamina, and distinctly sinuose and nodulose cells. From these facts, <u>Grimmia micropyxis</u> could be deduced to be a modification induced by drier habitat.

2) Features of dried leaves. In plants from dry, sunny exposed habitat, leaves are somewhat spirally twisted against the stem.

3) Capsule-size varies either in every population, or even in a single population. In general, long capsules have ribs on surface; short capsules have no ribs and smooth on surface, but have nods at the apophysial part. The shape of beak varies even in a single population.

4) Peristome teeth are also subject to variation. In a large, elongated and ribbed capsules, wide lanceolate peristome teeth are observed, whose upper parts are divided into 3, sometimes 2,

branches, whereas in short, smooth capsules, narrowly lanceolate and non-divided teeth are found. However, these two extrem types of teeth are well connected by a complete series of intermediate forms.

Parts of the original specimen of G. apiculata studied by Hornschuch are conserved both in B-Brid and in H-SOL. The material in B-Brid consists of two parts adhered on a paper sheet, which is accompanied by a label with the handwritten note as "Grimmia apiculata nobis. Windischmattreyer tauern. Hornschuch misit. 1819." The locality corresponds to that given for G. affinis described in Flora 2: 85, 1819. The features observed in this specimen are as followings: capsule spherical to ovate-oblong, without ribs on surface; seta distinctly curved; peristome teeth lanceolate, irregularly perforated and imperfectly crefted in the upper part, densely papillose throughout on both outer and inner surfaces; operculum short, obtusely pointed; annulus well developed, of Affinis type; leaves ovate-lanceolate, terminated by a hyaline hair-point, recurved on one side in the lower half; laminal cells much incrassate and sinuose-nodose, rectangular (usually 2-3:1) in the upper part, gradually elongated towards the base; those of basal angular part transparent, of thin and smooth walls. The specimen in H-SOL has the same characters as those in B-Brid.

It has occasionally been overlooked that the perigonia are located just below the perichaetia and they are hidden by the vegetative leaves. Grimmia micropyxis Brotherus (1924) was first described as a dioicous species. It is, however, evidently of illustrative case of overlooking of perigonia. The original specimen (isotype) in PC shows all features corresponding well to the original description with sole exception that the plants are autoicous.

For further investigation on the discrepancy in the sexuality, the holotype specimen was seeked in the Brotherus's herbarium at Helsinki, but it was failed to be found out. However, another authentic specimen determined by Brotherus could be available. It has a herbarium label with the following information: Nr. 7497. Grimmia micropyxis Broth. det. monasterio Muli ad septentr. pagi Yünnanensis Yungning versus Dschungdien siti regione alpina, ad rupes udas. Substr. schistaceo; alt. s.m. ca. 4650 m, Leg. 6. VIII. 1915. Dr. Heinr. Frh. v. Handel-Mazzetti (Diar. Nr. 1359). This specimen was also in autoicous condition.

Grimmia subdonniana was described from Nepal by Noguchi (1964), who compared it with G. pulvinata and G. ovalis. But it is quite identical with G. apiculata, having oblong capsules and leaves with considerably sinuosed upper and middle laminal cells.

Grimmia pulvinata, which resembles G. apiculata in having distinct arcuate seta, has been added to the Japanese moss-flora by Sakurai (1954), who gave a rough information on the locality as "Honshu". Unfortunately, no Japanese specimens labelled as G. pulvinata were detected in his herbarium in MAK. In addition, I have never come across any Japanese plants referable to G. pulvinata in the course of my present study. G. pulvinata is easily distinguished from G. apiculata by the thick and rigid leaves and the nearly homogeneous laminal cells throughout the leaf: even basal marginal cells being short rectangular (usually up to 4:1).

Habitat. On exposed siliceous or occasionally calcareous rocks in the summit regions of mountains, in the middle to upper oro-boreal subzone.

Range. Japan (Honshu); Fennoskandias, Central Alps, Tatra, Himalaya.

4. Grimmia atrata Mielich. ex Hornsch. (Fig. 17)

Flora 1: 85. 1819.

Type: In Salzburg, an Felsen bei der Brube Schwarzwald in der Grosall. Iul. (lectotype in B-Brid, selected here).

Dryptodon atratus (Mielich. ex Hornsch.) Limpr., Laubm. Deutschl. 1889.

Plants in dense tufts, dark green above, blackish below, 1-1.5 cm high. Stems erect, without central strand. Leaves solid, with somewhat metalic lustre, lingulate-lanceolate, from ovate base gradually or suddenly narrowed to obtuse, rounded apex, without hyaline hair-point, very obtusely keeled, appressed and twisted in upper part when dry, 1.8-2.3 mm long and 0.45-0.55 mm wide. Margins entire throughout, plane except the inferior part of leaf, where one side faintly and narrowly recurved and the other side very faintly incurved. Costa strong, broad, vanishing below the apex. Upper part of lamina uni- or bistratose, of which several marginal rows of cell regularly 2-3-stratose, attaining near the base; lower part of lamina unistratose. Upper and middle laminal cells subquadrate to rectangular, ±8 µm wide, moderately incrassate, slightly or distinctly sinuose, becoming longer to elongated rectangular toward the transitional part where the sinuosity of cell-walls is much pronounced. Basal laminal cells except marginal ones less differentiated, resembling those of the transitional part, but not so strongly sinuose. One or two rows of basal marginal cells more or less inflated, quadrate to rectangular, transparent, with smooth walls, ascending up to the shoulder. Dioicous. Perichaetial leaves less differentiated, resembling the vegetative leaves, but convoluted in the basal part. Capsule ellipsoidal to subcylindric, ±1.2 mm long, ±0.6 mm thick, smooth on surface. Peristome teeth lanceolate, dark yellowish-brown, entire, densely papillose on both surfaces. Exothecial cells rather thin-walled, transversely or longitudinally rectangular (3:1). Stomata few. Seta straight or weakely inclined, 3-4 mm long. Lid with obtuse, straight, sometimes slightly oblique beak. Annulus of Affinis type. Calyptra mitrate or cucullate. Spores papillose, variable in size, 10-20 µm in diameter.

Distinguishing features.

1. Plants resembling a Racomitrium in both habit and leaf morphology.
2. Leaves lingulate-lanceolate, obtusely keeled, with margins revoluted on one side and slightly involuted on the other side.
3. Leaf-apex obtuse, muticous, never hyaline-pointed.
4. Costa stout (wide and thick), 4-5 cells in thickness in the middle of leaf.
5. Upper part of lamina bistratose (at places unistratose).

This species resembles a species of Racomitrium in both habit and sinuosity of cells in the widest part of leaf, but differs from the latter by the basal cells with smooth walls, stout costa, and thickened upper lamina. Grimmia elongata might be the most closely related species in the general appearence among the Japanese species of Grimmia, but it differs from G. atrata by the smaller and sharply keeled leaves, 1.2-2 x 0.25-0.45 mm against 1.8-2.3 x 0.45-0.55 mm in G. atrata, by the well differentiated basal cells of very thin-walls, and by the presence of central strand in stems. The distorted vaginula was emphasized by Hagen (1909) for establishing his monotypic subgenus Streptocolea with G. atrata. As far as I examined, such tortion is very faint or absent in this species, so that it should not be considered as a character of taxonomic importance.

A part of the plants studied by Hornschuch is located at Bridel's herbarium at Berlin. It consists of only a single stem with a sporophyte, whose capsule is in the condition of maturity just before the deoperculation. This material was selected as a lectotype by me since Hornschuch's herbarium was destroyed. The examination by dissecting the capsule in this material was withheld for the present study, because of the poverty of the material. It seems sufficient to recognize this species only by examining the leaf-characters which fully supplies us most of the diagnostic features in convincing the identity between this material and Japanese one.

The occurrence of this species in Japan has been uncertain except the record by Brotherus (1924), who simply indicated its locality as "Japan". I could study, with a verification of the determination, the Japanese speçimen which was the basis of Brotherus's record: Tokachiyama, 1500 m, 19)5, leg. U. Faurie, no. 3380 (in H-BR).

Habitat. On soil-capped rocks in woods, in the orohemiboreal to the upper oroboreal zone.

Range. Japan (Hokkaido, Honshu); Fennoskandias, West and Central Europe, Pyrenees.

### 5. Grimmia brachydictyon (Card.) Deguchi comb. nov.

(Fig. 18)

Racomitrium patens (Hedw.) Hüb. var. brachydictyon Card., Bull. Herb. Boiss. ser. 2, 8: 333. 1908.

Type: Namikawa, rocher, à 800 m, leg. U.Faurie, No.2807 in 1904 (holotype in PC; isotype in H-BR, KYO).

Grimmia hartmanii Schimp. var. japonica Broth., in Sasaoka, Bot.

Mag. Tokyo 35: 272. 1921. nom. nud.

Grimmia patens (Hedw.) B.S.G. var. brachydictyon (Card.) Ihs., Cat. Moss. Japan 77. 1929. syn. nov.

Grimmia anomala auct. non Hampe ex Schimp.; Iwasaki, Trans. Sappro Nat. Hist. Soc. 16: 239. 1941.

Grimmia hartmanii Schimp. var. anomala auct. non (Hampe ex Schimp.) Moenk.; Takaki, Bot. Mag. Tokyo 64: 179. 1951.

Grimmia patens auct. non (Hedw.) B.S.G.; Iwatsuki, J. Hattori Bot. Lab. 25: 112. 1962.

Plants in loose tufts, green to yellowish-green above, yellowish-brown below, frequently blackish when growing on sunny exposed rocks. Stems 4-5 cm long, moderately branched, without central strand. Leaves appressed and twisted to the stem when dry, lanceolate with an ovate base, gradually narrowed into an arcuate apex ending with chlorophyllose cells, or with ±2 short (rarely 4, slightly elongated) hyaline cells, often into an obtuse apex due to the gemmae-production, 1.9-2.5 mm long and 0.9-1.4 mm wide. Margins entire and revoluted on both sides, thickened in upper part. Lamina unistratose, at places bistratose in the upper 2/3 of leaf. Costa stout, percurrent, usually with two lamellae on dorsal surface, which are rarely obscure. Upper laminal cells transversely rectangular to quadrate, ±8 µm wide, somewhat incrassate; middle ones quadrate to short rectangular (up to 2:1); cells from transitional part distinctly sinuose; basal ones elongated-rectangular, with somewhat thick walls; cells in 1-2 marginal rows transparent, quadrate to rectangular cells, not thin-walled; basal paracostal cells rectangular (usually up to 6:1), with moderately thickened, smooth walls; free cell-walls in cross-section of leaf rough by joint-thickenings. Gemmae globular, dark green, 90-140 µm in diameter, becoming yellowish-brown when old. Dioicous. Perichaetial leaves larger than vegetative leaves, enlarged and loosely areolated at base. Capsules short-clavate, gradually contracted into the seta, ca. 1 mm long, 0.4 mm thick, smooth on surface when dry. Peristome teeth entire, yellowish- to reddish-brown, deeply inserted below the orifice, about 440 µm long, 80 µm wide at base, on outer surface with high papillae in the upper 2/3 and smooth in the other parts, on inner surface papillose throughout. Seta 3-4 mm long, slightly curved or straight. Exothecial cells rounded long-hexagonal, with equally thickened walls. Stomata 6-8 in number. Columella excurrent beyond the orifice of capsule. Operculum with long upright beak. Calyptra mitrate, divided at base. Spores minutely papillose, 12-15 µm in diameter.

Distinguishing features.

1. Globular gemmae produced on leaf-apex.
2. Central strand absent in stem.
3. Wings developed on the dorsal surface of costa.
4. Ridge-like thickenings absent, but joint-thicknings present.
5. Costa composed of rather thick-walled cells; outer adaxial epidermal walls strongly thickened.
6. Hyaline hair-point usually absent, rarely present, but it is very short, of 2-4 slightly elongated cells.

The formation of wings on the dorsal surface of costa is distinct in the upper part of leaf, which gradually becomes indistinct toward the leaf-base. Total absence of this character was not detected in any single population studied. In addition to this character, the hyaline hair-point on leaf-apex is totally absent or much weaker, even if it is present, as compared with that of

G. hartmanii, which is most closely related to G. brachydictyon. The European and North American specimens examined of G. hartmanii always possessed elongated hyaline hair-point. The plants of G. hartmanii without the hyaline hair-point have been described as var. epilosa Milde, but they differ from G. brachydictyon by the longer leaves and costa without wings.

The gemmae are usually found on the tip of upper leaves destined to form them, intercalated by a ew thin-walled, hyaline, fragile cells. The leaf-form varies according to whether leaves have been destined for formation of gemmae or not. In the former case, leaves remain short, with obtuse apex, while in the latter case, leaves longer, with acute-pointed and elongated upper subulate part. As already mentioned by Loeske (1913) for G. hartmanii, it is also observed in G. brachydictyon that the ability of the formation of gemmae becomes weak in fertile plants.

This species lacks the ridge-like thickenings on leaf-surfaces as observed in the related species, G. anomala, but the localized thickenings differing from those of G. anomala occur on both ends of vertical walls in the cross-section of leaf, where they appear as if they were true papillae (Fig. 18: 18). Loeske (1913) explained this thickening as "papillen über den Pfeilern", Such thickening sometimes lead the bryologists to the confusion of G. brachydictyon with G. anomala. For example, Iwasaki (1941) and Takaki (1951) reported G. anomala from Japan, but the close examination of the material reported by them (Pref. Niigata, Kotaki-mura, no. 11659 in Herb. Sakurai, Coll. Masaki, July 31, 1938, det. H.N.Dixon; MAK) showed the joint-thickenings, but neither true papillae nor ridge-like thickenings as seen in G. anomala.

This species would be readily mistaken for G. curvata (Brid.) De Sloov. because both species have distinct wings on the dorsal

Table 2. Distinction between *Grimmia curvata* and *G. brachydictyon*

| | *G. curvata* | *G. brachydictyon* |
|---|---|---|
| gemmae-formation | absent | present |
| stratum of lamina (excl. margins) | unistratose, rarely bistratose at places | unistratose, frequently bistratose at places |
| free cell-walls in cross-section of leaf | smooth | rough by joint-thickenings |
| paracostal cells | linearly elongated, with nodulose, thick walls | rectangular (usually up to 6:1), with smooth, moderately thickened walls |
| seta | arcuate in wet, flexuose in dry conditions | straight or somewhat weakly curved |
| capsule | oblong, with ribs on surface when dry; apophysial part rather suddenly contracted into seta | clavate, with or indistinct ribs when dry; apophysial part gradually contracted into seta |
| operculum | longly rostrated, and curved or somewhat hooked | longly rostrated, and upright |

surface of costa. Iwatsuki (1962) reported G. curvata under the name, G. patens (Dick.) Hedw. from Rishiri Isl., northernmost part of Japan. I could examine the specimens used by him and found that the materials are without doubt identical with G. brachydictyon. The features for the distinction between the two species are raised in Tab. 2.

The plants of G. brachydictyon have been distributed as the exsiccata of "Musci Japonici, Ser. 15 (1959), ed. by A.Noguchi, 730. Racomitrium heterostichum var. sudeticum. On boulders by a stream, Furiko-dani valley, ca. 1200 m. s.m., Mt. Daisen, Tottori Prefecture. Coll. M.Mizutani, July 23, 1958. Det. A.Noguchi".

Habitat. On siliceous boulders or rocks along creek or mountain trail in woods, in the orotemperate to the upper oroboreal zone.

Range. Endemic to Japan (Hokkaido, Honshu).

### 6. Grimmia curvata (Brid.) De Sloover (Fig. 19)

Bull. Jard. Bot. Nat. Nat. Belg. 37: 445. 1967.

Orthotrichum curvatum Brid., Bryol. Univ. 1: 791. 1826.

Type: In insula Terre Neuve. An arboreum ? Ex herbario Pylaesiano (holotype in B-Brid).

Bryum patens Dicks. ex Hedw., Spec. Musc. 86. 1801.

Type: Ad rupes in rivulis alpinis Scotiae, Ben Nevis (holotype in BM ? not seen; not detected in G).

Trichostomum patens (Dicks. ex Hedw.) Schwaegr., Spec. Musc. Suppl. 1: 151. t.37. 1811.

Campylopus patens (Dicks. ex Hedw.) Brid., Mant. Musc. 73. 1819.

Dryptodon patens (Dixks. ex Hedw.) Brid., Bryol. Univ. 1: 192. 1826.

Racomitrium patens (Dicks. ex Hedw.) Hüb., Musc. Germ. 198. 1833.

Grimmia patens (Dicks. ex Hedw.) Bruch & Schimp., Bryol. Eur. 3: 120. f. 246. 1845. hom. illeg.

Plants robust, yellowish-green above, dark brown below, in loose tufts. Stems ascending, up to 5-6 cm long, moderately branched, without central strand. Leaves loosely appressed on stem, somewhat secund when dry, erect-spreading when moist, lanceolate, from ovate base gradually narrowed upwards and terminated by a chlorophyllose denticulate point, 2.5-3 mm long and 0.5-0.6 mm wide. Lamina unistratose, but at places bistratose. Costa stout, with 2(-4) lamellae (=wings) on dorsal surface. Margins entire, recolute on both sides in the middle, thickened in 2 cell-layers in the upper part, unistratose in inferior part. Upper laminal cells quadrate to transversely rectangular, at places longitudinally rectangular (up to 2:1), with less sinuosed walls, 6-9 µm wide; cells from middle part rectangular (up to 5:1), with distinctly sinuosed walls: longitudinal walls much more thicker than transverse walls; paracostal cells much elongated and linear, becoming shorter toward margins; basal marginal cells transparent, elongated-rectangular, with equally thickened and smooth walls. Perichaetial leaves less differentiated, resembling vegetative leaves in both form and size, but differentiated in loosely areolated, thin-walled cells at base. Dioicous. Capsule ribbed when dry, 0.9-1.6 mm long, 0.6-0.8 mm thick. Exothecial cells rounded-hexagonal, more elongated in the part of ribs. Seta elongated, 2-3 mm long, distinctly arcuate when wet and flexuose when dry. Peristome teeth lanceolate, divided into two slender branches in upper two thirds, with basal membrane, not passing the annulus; outer surface densely papillose in upper half, roughly so in lower half; inner surface papillose throughout. Calyptra mitrate. Epidermal cells of vaginula with thick, somewhat nodulose walls. Operculum with obliquely elongated beak. Annulus well differentiated, of Affinis type. Spores large, 13-18 µm in diameter.

Distinguishing features.

1. Globular gemmae absent.
2. Central strand absent in stem.
3. Wings present on dorsal surface of costa.
4. Hyaline hair-point absent.
5. Basal paracostal cells linearly elongated, with nodulose, thick walls.
6. Capsule on arcuate seta, ribbed on surface when dry.

This species possesses the following features, which share characters of both the genera *Grimmia* and *Racomitrium*. *Grimmia*-like features: 1) capsule ribbed when dry; 2) seta curved when moist, twisted to the left when dry; 3) wings developed on dorsal surface of costa; 4) laminal cells not so finely sinuosed as in *Racomitrium*. *Racomitrium*-like features: 1) the peristome teeth with basal membrane; 2) peristome teeth more or less deeply divided into two slender branches; 3) epidermal cells of vaginual with thick, nodulose walls; 4) plants of *Racomitrium*-like appearence.

Bridel (1826) established a new genus, *Dryptodon*, including 17 species and placed it between the genera *Grimmia* and *Racomitrium*. The genus *Dryptodon*, however, is rather heterogeneous as recently pointed out by Crundwell (1971). I agree with the opinion of Mårtensson (1956) that the genus should be typified by *Dryptodon patens* (Dick. ex Hedw.) Brid. which was first enumerated in Bridel's treatment. The plants of *G. curvata* had long been treated as *G. patens* (Dick. ex Hedw.) Bruch & Schimp. until De Sloover (1967) found that the epithet "*patens*" cannot be used under the generic name *Grimmia*, because an earlier homonymous name, *G. patens* Hornsch. exists. If we recognize this species as a member of *Grimmia*, we should use the name *G. curvata* (Brid.) De Sloover which was originally described as a species of *Orthotrichum*. Many bryologists have treated the present species as a member of *Racomitrium* (Hübener, 1833; Milde, 1869; Schimper, 1860, 1876; Lesquereux et James, 1884; Husnot, 1886; Jones in Grout, 1933; Mönkemeyer, 1927; Lawton, 1971). The usage of the generic name *Dryptodon* for this species was favoured by Bridel (1826), Limpricht (1889), and Roth (1904), et al. The position under the genus *Grimmia* has been supported by Bruch, Schimper & Gümbel (1845), Schimper (1956), De Notaris (1869), Boulay (1884), Kindberg (1897), Hagen (1909), Loeske (1913, 1930), Brotherus (1923, 1924), Ihshiba (1929), Podpera (1954), Sakurai ( 1954), et al. There have appeared several outstanding discussions concerning the taxonomic position of this moss, which were summerized by Jones (1933). Crundwell (1971) recently discussed again on this species and suggested that the best course is to place it in a monotypic genus intermediate between *Grimmia* and *Racomitrium*. It is uncertain whether the divergent characters seen in this species are worth while to separate *G. curvata* from both *Grimmia* and *Racomitrium* and to support the monotypic genus *Dryptodon*. Here I prefer to place the species in the genus *Grimmia* from the practical consideration, namely, the leaves show the very Grimmian characters and they are easy to be examined.

*Grimmia patens* (Dicks. ex Hedw.) Bruch & Schimp. was first reported from Japan by Ihshiba (1929) with a rough reference to the locality as "Honshu", but no material which he used was available for the present studies. Iwatsuki (1962) recorded it from Rishiri isl., as new to Hokkaido. The examination of the voucher specimens, however, showed that the features clearly belong to *G. brachydictyon*.

The distinction between *G. curvata* and *G. brachydictyon* is made in Tab. 2.

Habitat. On partially shaded siliceous (granite) rocks, in the oroboreal zone.

Range. Japan (Honshu); Fennoskandias, Icelanad, Faeroes, in mountains through Europe, Altai, North America, Greenland.

### 7. *Grimmia donniana* Sm. (Fig. 20)

Engl. Bot. 18: 1259. 1804.

Syntypes: On large stones near a water-fall on a mountain in Angusshire, 18 miles to the north of Forfar, coll. G.Donn (LINN, not seen; isosyntype in PC); On old pales at Beddgelart, North Wales, coll. D.Turner (LINN, not seen).

*Grimmia obtusa* Schwaegr., Spec. Musc. Suppl. 1(1): 88. 1811. *hom. illeg.*

Type: In alpe Carinthiae Brennkogel, summo monti Glockner vicina, August fructificantem (holotype in G).

*Grimmia alpestris* Sommerf., Suppl. Fl. Lapp. 49. 1826. fid. Zett. in Par., Ind. Bryol. ed. 2, 2: 262. 1904.

Type: In saxis rupibusque siccis circa sinum saltensem Nordlandiae, e.gr. ad Saltnaes, Bertnaes (O, not seen).

*Grimmia bohemica* Schkur in Brid., Bryol. Univ. 1: 176. 1826. *nom. inval.* in *syn.*

*Grimmia donniana* Sm. β *bohemica* Steud., Nomencl. Bot. 189. 1824. *fid.* Limpr., Laubm. Deutschl. 1: 736. 1889.

Type: In Sudetis. Ludwig (type not seen).

*Grimmia sudetica* Spreng. ex Schkur, Deutschl. Krypt. Gew. 2(2): 48.

f. 22. 1811. nom. illeg. incl. spec. prior (G. donniana Sm.)

Plants dark-green to blackish, occasionally hoary above, in dense cushions. Stems short, up to 1 cm long, composed of thin-walled cells, with central strand. Leaves appressed to the stem when dry, less shrinked, ovate-lanceolate to narrowly lanceolate from ovate base, gradually narrowed upperwards, terminated by a piliform hyaline hair-point, 1.5-2 mm long and 0.35-0.5 mm wide. Margins plane throughout, on both sides, thickened into two cell-layers above. Lamina unistratose, at places bistratose in upper part, unistratose in lower part. Costa percurrent, thick, smooth on back. Laminal cells transversely or longitudinally rectangular (up to 2:1), with slightly sinuose walls, 7-10 µm wide in upper part, rectangular (2-4:1) in middle part, much elongated-rectangular (4-8:1), transparent to translucent, with thin to slightly thickened, but smooth walls in basal paracostal part, elongated-rectangular, transparent, with very thin walls in basal marginal cells. Autoicous. Perichaetial leaves larger than vegetative ones, with wide and loosely areolated base, terminated by elongated hyaline hair-point. Urn ovate to oblong, pale yellowish-brown, smooth on surface, 0.9-1 mm long, ca. 0.5 mm thick. Exothecial cells mainly elongated-hexagonal to rectangular, with rather thin walls; stomata present at apophysial part. Peristome teeth yellowish-brown, with blunt tip; outer surface papillose in upper half, smooth in lower half; inner surface papillose throughout. Seta straight. Annulus in 2-3 rows, of transparent quadrate cells, of Elongata type. Operculum conic, with very indistinct or occasionally very short beak. Calyptra mitrate. Spores finely papillose, ca. 10 µm in diameter.

Distinguishing features.

1. Plants autoicous.
2. Leaves with distinct hyaline hair-point, plane on whole margins.
3. Seta straight.
4. Annulus of Elongata type.

This species is morphologically related with G. elongata, especially in the areolation of leaf and the sporphytic characters. The distinction between them is given easily by examining the following features: the sexuality (autoicous in G. donniana; dioicous in G. elongata), the leaf-margins (plane on both sides in G. donniana; plane on one side and narrowly recurved on the other side in G. elongata). The frequent absence of hyaline hair-point of leaf and the reddish-brown color of plants are also reliable to to some extent to recognize G. elongata.

Habeeb (1950) reduced both G. montana Bruch et Schimp. and G. alpestris (Schleich.) Nees et Hornsch. to synonyms of G. donniana, and his treatment was followed by Wijk, Margadant & Florschütz (1956). For his argument, he raised the similarities in the operculum, the basal leaf-cells, and the calyptral shape, based on the specimens he examined and on the descriptions and plates in Bryologia Europea (plates 249, 250, 251) so far. I don't know which specimens was examined as G. donniana, G. alpestris, or G. montana by Habeeb (1950). I am agree with him concerning to the shape of operculum, but disagree as to the other two characters. As Habeeb (1950) indicated, it is true that the mitrate calyptra occasionally appears cucullate when one of slits is longer than the others. As far as I examined, only the true cucullate calyptra were observed in the European specimens of G. montana, in which the calyptra has only a single slit, and no other small slits at the base. Such a calyptra can not be observed in *G. alpestris* and *G. donniana*. The calyptra of *G. alpestris* is usually detached from the capsule in a shape of needle before taking a distinct from of either cucullate or mitrate. Consequently, calyptra is of taxonomic importance in distinguishing *G. montana* from *G. alpestris* and *G. donniana*. As to the basal leaf-cells, the distinct difference exists between *G. donniana* and other two species: *G. alpestris* and *G. montana*. The basal cells, especially of marginal part of leaf, have thin transverse and longitudinal walls in *G. donniana*, while thick transverse and thin longitudinal walls in *G. alpestris* and *G. montana*. This difference is illustrated in Bryologia Europaea. In addition, *G. donniana* is distinguished from *G. alpestris* and *G. montana* in the autoicous sexuality, and in more obtuse keeling in the upper part of leaf.

Habitat. On sunny exposed rocks in the summit region of mountains in the oroboreal to the orohemiarctic zone.

Range. Japan (Hokkaido, Honshu); Europe, Kamtschatka, western North America, Greenland.

8. *Grimmia elongata* Kaulf. (Fig. 21)
in Sturm, Deutschl. Fl. 2(15): 14. 1816.
Type: Im August 1812 auf der Seethaler Alpe in Steyermark in Steinritzen mit reifen Früchten, leg. Kaulfuss (S not seen).
*Dryptodon elongatus* (Kaulf.) Hartm., Hand. Skand. Fl. ed. 4: 374. 1843.
*Grimmia decalvata* Card., Bull. Herb. Boiss. n. ser. 2, 8: 332. 1908. *syn. nov.*
Type: Komagatake, 2500 m, no. 3316, leg. Faurie (lectotype

in PC-Card., selected here; labelled as "Japon: sommet du Komagatake, 2300 m, Leg. Faurie, n°3316"; isolectotypes in H-BR, KYO); Faurie no. 3342 (isoparatype in KYO); Ontake, 2500-2300 m, Faurie, Nos. 3319, 3321, 3326 (isoparatypes in KYO).

Plants brown to blackish-brown, often blackish-green, in dense, fragile, semi-circular cushions, often confluent and forming wide patches. Stems 1-2 cm long, with weakly developed central strand, sometimes without central strand, moderately branched and fastigiated, frequently half-buried in soil. Leaves crowded, appressed, often twisted when dry, lanceolate, straight or slightly falcate, muticous or often shortly hyaline hair-pointed, keeled above, characteristically tinged with reddish-brown, 1.2-2 mm long and 0.25-0.45 mm wide. Margins always narrowly recurved on one side, thickened in two cell-layers in the upper part. Lamina unistratose, at places bistratose. Upper laminal cells incrassate, transversely or longitudinally rectangular (0.8-2:1), more or less mamillose in cross-section of leaf; middle laminal cells more elongated-rectangular (2-3:1), conspicuously sinuose; basal cells transparent, much elongated to longly rectangular (5-10:1), with smooth and thin walls, some of margins narrowly extending up to the chlorophyllose parts. Costa stout, percurrent, a little narrowed toward the base, consisting of nearly homogeneous cells, at times with small, thin-walled cells in the middle of the cross-section. Dioicous. Perichaetial leaves resembling the vegetative ones, but with wider, convoluted, and much loosely areolated base. Capsules obovate or elliptic, 0.6-1 mm long, 0.3-0.4 mm thick. Seta pale-yellow, 1.3-2.3 mm long. Operculum conic, obtusely beaked. Peristome teeth pale-yellow or yellowish-brown, with somewhat obtuse tip; outer surface densely papillose in the upper 2/3 and sparesely so in the lower 1/3 of whole length; inner surface densely papillose throughout. Exothecial cells variable in shape, rounded-quadrate to rectangular, or long-hexagonal. Stomata ±8 in number. Annulus differentiated, rounded-hexagonal or hexagonal, in 1-2 rows of cell, of Elongata type. Calyptra mitrate or cucullate. Spores 11-13 µm in diameter, very finely papillose.

Distinguishing features.

1. Plants often reddish-brown, half-buried in soil.
2. Leaves narrowly recurved on one side only and usually muticous at tip.
3. Basal leaf-cells well differentiated, elongated-rectangular, smooth- and thin-walled.
4. Dioicous.

The entity of this species has long been recognized under the name G. decalvata in Japan, though Takaki (1954) enumerated both G. elongata and G. decalvata at the same time without any mention of the characters distinguishing them. In spite of my careful examination of the type specimen of G. decalvata, comparing with some authentic exsiccatae of G. elongata (Husnot, Musci Galliae, 712; Rabenhorst, Bryotheca europaea, 616), I could not detect any morphological differences between the two species.

As Cardot (1908) stated under the name G. decalvata, G. elongata has a close relationship with G. donniana, but differs from it by the leaves narrowly recurved on one side and usually muticous on tip, and dioicous sexuality.

Iwatsuki & Noguchi (1973) listed G. unicolor in their Index Muscorum Japonicarum. According to my reexamination, however, most of the Japanese specimens determined as G. unicolor were proved to be no more than *G. elongata* and a few remainders were *Coscinodon cribrosus* in sterile condition. *G. unicolor* can be readily distinguished from *G. elongata* by the leaves, which are more thick and rigid, very obtusely keeled (the costal part being quite indistinct, since the costa hardly projecting dorsally), terminated by more obtuse apex, having non-revoluted, but plane margins, and varnish lustre.

Habitat. On sunny exposed rocks or boulders in the summit region of mountains, in the oroboreal to the orohemiarctic zone.

Range. Japan (Hokkaido, Honshu); Fennoskandias, Europe, Caucasus, Ural, East Siberia, Himalayas, Taiwan, Greenland.

9. *Grimmia funalis* (Schwaegr.) B.S.G. (Fig. 22)

Bryol. Eur. 3: 119. 247. 1845.

*Trichostomum funale* Schwaegr., Spec. Musc. Suppl. 1(1): 150. 37. 1811.

Type: Legit in subalpinis Sudeticis C. Ludwig., aestate fructiferum (holotype in G, not seen).

*Campylopus funalis* (Schwaegr.) Brid., Mant. Musc. 75. 1819.

*Dryptodon funalis* (Schwaegr.) Brid., Bryol. Univ. 1: 193. 1826.

*Grimmia spiralis* Hook. in Grev., Scott. Crypt. Fl. 4: 203. 1826. fid. Braithwait, Brit. Moss Fl. 2: 13. 1888.

Type: East side of Slemish mountain, County of Antrim, Ireland. leg. Hooker ( holotype in BM, not seen).

*Dryptodon spiralis* (Hook.) Brid., Bryol. Univ. 1: 771. 1827.

*Trichostomum patens* var. *funalis* Hook. et Tayl. ex Brid., Bryol. Univ., 1: 193. 1826. *nom. inval.* in *syn. err. pr. Trichostomum patens* var. *pilifera* Hook. et Tayl.

Grimmia cernua Nees et Hornsch., Bryol. Germ. 2(1): 174. 24f. 23. 1827. nom. illeg. incl. spec. prior (G. spiralis Hook., 1826).
Grimmia cernua var. spiralis (Hook.) Nees et Hornsch., Bryol. Germ. 2(1): 177. 24f. 23a. 1827.

Plants slender, yellowish-brown only in upper part, blackish-brown in middle and lower parts. Stems sparlingly branched, with well-developed central strand composed of thin-walled small cells. Thread-like slender stems arising from basal part of aged stems, having small cymbiform and distinctly carinate leaves without hyaline hair-point. Leaves rigid, spirally imbricate (stems with so arranged leaves have rope-like appearence) when dry, sharply keeled, ovate-lanceolate, from ovate base gradually narrowed into rather smooth hyaline hair-point which becomes longer in upper leaves and have wide base being frequently decurrent along margins, 1.45-1.8 mm long and 0.48-0.6 mm wide. Lamina unistratose, in upper part bistratose at places. Margins revolute on one side at the widest part of leaf, thickened in two cell-layers in upper part. Costa smooth on back, becoming narrower toward the base. Laminal cells considerably incrassate; upper ones predominantly rounded-quadrate, transversely rectangular at places, 6-8 µm wide; middle ones rectangular (1.5:1) with thick walls; basal ones near costa elongated-rectangular to narrowly much elongated (more than 5:1), which gradually narrowed in short rectangular toward margins, with thick walls but less sinuose; basal marginal ones transparent and short to long rectangular, forming hyaline borders in one cell-row. Dioicous. Perichaetial leaves larger, with hyaline hair-point longer than the half-length of leaf, with wide and loosely areolated base. Capsuels ovate to short oblong, ribbed when dry, ±0.75 mm long, ±0.45 mm thick, on arcuate exerted setae. Peristome teeth yellowish-brown, lanceolate, imperfectly crefted above; outer surface coasely papillose above, nearly smooth below; inner surface coarsely papillose throughout. Annulus well-developed, of Affinis type. Exothecial cells somewhat thin-walled, elongated-hexagonal to long-rectnagular. Stomata present, ca. 8 in number. Operculum with upright, obtuse point. Calyptra unknown in Japanese material. Spores ±15 µm in diameter, papillose.

Distinguishing features.

1. Seta distinctly arcuate.
2. Leaves rigid, appressed and spireally imbricated when dry; stem with so arranged leaves have rope-like appearance.
3. Basal part of leaf differentiated, consisting of translucent, elongated-rectangular cells with somewhat nudulose walls; basal marginal cells thick in both longitudinal and transverse walls.
4. Dioicous.

This species is closely related to *G. apiculata*, but is separated from it by the spirally arranged and rigid leaves having longer hyaline hair-point attaining about 1/2 length of leaf, laminal cells more incrassate even in basal part, fewer stomata, more coasely papillosed spores, and the dioicous sexuality. *G. funalis* was first recorded from Japan by Brotherus (1924) without detailed locality (indicated as "Japan" only). Thereafter, Ishiba (1929) reported it from Mt. Akagi (=Mt. Kurobi), central Japan. The material for Brotherus's (1924) report has become evident to be no more than *C. cribrosus* (see the discussion for *C. cribrosus*, p. 122 ). Ishiba's material could not be located anywhere.

Habitat. Unknown.

Range. Japan (Hondhu); Europe, Algeria, Canaries, Caucasus, Altai, East Nepal, Greenland.

10. Grimmia incurva Schwaegr. (Fig. 23)

Spec. Musc. Suppl. 1: 90. 1911.

Type: In summis alpibus Carintiae, Glockner. C.Ludwig. (holotype in G, not seen).

Dicranum contortum Wahlenb., Fl. Carp. 364, f.4. 1814.

Type: In cruptis saxorum ad lacum alpinum Langesee im Volksground (holotype in S-PA, not detected; isotype in H-SOL).

Campylopus contortus (Wahlenb.) Brid., Mant. Musc. 74. 1819.

Dryptodon contortus (Wahlenb.) Brid., Bryol. Univ. 1: 199. 1826.

Grimmia contorta (Wahlenb.) Arnott, Mem. Soc. Linn. Paris 5: 243. 1827.

Grimmia hagenii Kaur., Nyt. Mag. Naturvid. 31: 217. 1888. fid. Limpr., Laubm. Deutschl. 1: 751. 1889.

Grimmia incurva Schwaegr. var. hagenii (Kaur.) C.Jensen, Medd. Groenland 15: 426. 1898.

Plants dark-green to blackish, in loose, soft cushions. Stems attaining 3 cm long, moderately branched, with or without poorly developed central strand. Leaves irregularly crisped when dry, linear-lanceolate, from elongated-rectangular base gradually or rather suddenly narrowed to much elongated subulate upper part, terminated with either chlorophyllose point or smooth hyaline hair-point, usually 2-3 mm long and 0.35-0.45 mm wide. Lamina mostly unistratose, but bistratose in upper half-margins. Margins usually narrowly recurved on one side and plane on the other side in basal part. Costa percurrent, smooth on back, indistinct in uppermost part of leaf, where the cross-section of leaf appears elliptic in outline and no distinction exsists between costal and laminal parts; abaxial epidermal cells of costa much more elongated than paracostal cells of lamina in the middle part of leaf. Laminal cells quadrate to rectangular (up to 2:1) in the upper part, gradually becoming longer towards the base, elongated-rectangular, with thin transverse walls and nodulosely thickened longitudinal walls in the middle part; basal cells elongated-rectangular: angular ones transparent, with thin and smooth walls; basal paracostal cells with thin transverse and nodulosely thickened longitudinal walls, occasionally with nearly smooth, but somewhat thickened longitudinal walls. Dioicous or autoicous. Perichaetial leaves less differentiated from vegetative leaves, but with wider base loosely areolated. Capsule pale yellowish-brown, ovate to oblong, ±0.9 mm long, ±0.48 mm thick. Peristome teeth yellowish-brown, lanceolate; outer surface papillose throughout, but densely so in upper part, sparingly in lower part; inner surface densely papillose throughout. Exothecial cells hexagonal to elongated-hexagonal, with thin walls. Stomata ca. 10 in number. Annulus of quadrate cells in 2-3 rows superposed, of Elongata type. Seta straight, weakly inclined. Operculum obtusely rostrated. Calyptra mitrate. Spores papillose, ca. 10 µm in diameter.

Distinguishing features.

1. Leaves linearly elongated-lanceolate, with margins narrowly revoluted on one side, and plane on the other side in basal part.
2. Basal paracostal cells with nodulosely thickened longitudinal walls.

This species has been known as a chasmophyte, growing directly on siliceous rocks in the pile of rocks or on fully shaded rocks, and well characterized by the features mentioned above as well as charactristic ecological niche. The Japanese plants grown on fully shaded rocks reveal the very features so far repeatedly appeared in many textbooks. However, those grown on mouth of crevices or on sunny exposed spots always have both sexual organs and many sporophytes. Those plants bothered me too much, since the plants with sporophytes was autoicous in sexual condition. The European *G. incurva* has been described as dioicous. To resolve this discrepancy on the sexuality, I examined many European specimens, especially those bearing sporophytes. The result reconfirmed the description in the textbooks. Careful field and microscopical observations were carried out on the Japanese materials grown in a small area exposed to a gradual series of light-intensity. After these observations, I reached the conclusion that the fructified and sterile plants are inseparable as different two taxa. The fructified plants make rather dense, low cushions and have the leaves somewhat shorter and frequently with plane margins on both sides. These autoicous plants with sporophytes and plane leaf-margins are passing into *G. donniana*. The capsule of the European *G. incurva* are sometimes ribbed, sometimes nearly smooth on surface, and on somewhat arcuated setae. But, the capsules of Japanese materials are nearly smooth on surface and on almost straight setae, as seen in *G. donniana*. As far as the type specimens of both *G. donniana* and *G. incurva* are concerned, these two taxa are quite distinct from each other in the gametophytic features and far beyond the suspicion of the relation between the two. The most distinct differential features are the shape of leaf, and the areolation of basal laminal cells, especially of paracostal regions as well as the condition of leaf-margins.

I tentatively treated the plants bearing linear leaves with recurved margins on one side as G. incurva, even if they were autoicous, and the plants bearing rather wide leaves with plane margins as G. donniana, neglecting not a few intermediate specimens bearing linear leaves with plane margins.

Coscinodon japonicus belongs to this unresolved plants, though it has ever been reduced to the synonymy of G. decalvata (now G. elongata) by Takaki (1951).

Habitat. On rocks (hanging from ceiling or ascending from floor in crevices of rock-piles) or on otherwise fully shaded rocks, in the middle to upper oroboreal subzone.

Range. Japan (Honshu). Europe in arctic and alpine regions, Caucasus, Nova-Zembla, western part of North America, Greenland.

### 11. Grimmia olympica E.G.Britt. (Fig. 24)

Bryologist 13: 59. 1910.

Type: Olympic mountains, Washington. Queets river valley, near Humes' glacier. Altitude 5,500 feet. T.C.Frye, No. 614, Aug. 14, 1907. (holotype in NY).

Plants very small, blackish-green to brownish-green, in low dense cushions. Stems short, 3-5 mm long, composed of nearly homogeneous cells, without central strand. Leaves very small, more or less secund, narrowly lanceolate to ovate-lanceolate, with somewhat trapezoid base, more or less abruptly narrowed at shoulder part, terminated by a muticous point, rarely by a very short hyaline hairpoint, 1.2-1.8 mm long and 0.2-0.4 mm wide. Margins entire throughout, plane or weakly incurved, never recurved, not thickened. Costa percurrent, not keeled, rather plane-convex to biconvex in in cross-section, adaxial epidermal cells not differentiated resembling adjacent laminal cells in middle and upper parts of leaf. Lamina bistratose above, unistratose below half. Laminal cells transversely or longitudinally rectangular (2-4:1) in upper part, 7-8 µm wide, with smooth, uniformely thickened walls in middle part, elongated-rectangular, longer and wider, transparent, with very thin walls in basal part; joint thicknings developed (distinct in cross-section of leaf, appearing as papillae on both ends of vertical walls). Autoicous. Perichaetial leaves resembling vegetative ones, but with wider base. Capsule spherical, pale yellowish-brown, 0.4-0.42 mm long, 0.36-0.38 mm thick. Seta very short, 0.1-0.2 mm long. Peristome teeth absent. Exothecial cells elongated-hexagonal or -rectangular, with moderately thickened walls. Annulus of Affinis type. Operculum with short or somewhat elongated and straight to oblique beak. Calyptra mitrate or subcucullate. Spores smooth, ± 10 µm in diameter.

Distinguishing features.

1. Plants very small, 3-5 mm long.
2. Costa biconvex or plane-convex in the middle and upper parts; adaxial epidermal cells not differentiated, resembling adjacent laminal cells.
3. Peristome teeth absent.
4. Annulus well developed, of Affinis type.
5. Seta very short and curved.
6. Capsule slightly plicate when dry.

The distributional ranges of this species had been considered to be restricted to the states of Washington and Oregon in USA, as well as Vancouver Island in Canada, before the discovery of the species from central Japan by Noguchi & Saito (1970). Noguchi &

Saito observed the disagreement between Japanese and N. American plants as to the sexuality and the length of setae. Their careful examination of the type specimen of G. olympica has proved that it is an autoicous moss. But, the question on the gap of the length of setae remains unsolved even at present, though it was considered by them to be in a variational range of setae of the species. The length of 1-2 mm and 0.8-1.1 mm was measured by Jones (1933) and Noguchi et Saito (1970) respectively in the type specimen, and the latter authors showed 0.4 mm long for Japanese material. The other specimen newly recorded here from Hokkaido, Northern Japan, possesses the setae exceedingly short, only up to o. 2 mm long excluding the part of foot, therefore the capsules appearing immersed in the perichaetial leaves. A careful morphological and anatomical studies of the gametophytic characters showed no features which warrant taxonomic recognition of Japanese plants as a different taxon.

The taxonomical position of this species in the genus Grimmia seems to be doubtful because of its minuteness of plants and complete lack of peristome teeth as well as the texture of leaves, which suggest me of a member of the family Seligeriaceae, especially of the genus Brachydonteum, which is distinct in having the ribbed capsule when dry and the papillosed peristome teeth as well as the annulus. In addition to this, the leaves of G. olympica show a close anatomical resemblance to those of Brachydonteum trichodes (Web.) Fuern. rather than to those of Grimmia. Final conclusion on this problem, however, is retained until the more detailed knowledge on the family Seligeriaceae is supplied.

Habitat. On sunny exposed soil-capped rocks (lava?), in the oroboreal zone.

Range. Japan (Hokkaido, Honshu); North America.

12. Grimmia pilifera P. Beauv. (Fig. 25 & 26)

Prodr. 58. 1805.

Type: Les Etats-Unis d'Amerique (holotype in G?, not seen)

Grimmia pensylvanica Schwaegr., Spec. Musc. Suppl. 1(1): 91. 25. 1811.

Type: In Pensilvaniae rupibus a rev. Mühlenbergio (holotype in G, not seen).

Grimmia tenax C.Müll., Nuov. Giorn. Bot. Ital. n. ser. 3: 109. 1896.

Type: China interior, provincia Schen-si sept. in medio monte Si-ku-tzui-san. Jul. 1894, leg. J.Giraldi. sub. no. 878 (lectotype in Fl, selected here ; isolectotype in PC, H).

syn. nov.

Grimmia hisauchii Okam., Journ. Coll. Sci. Tokyo Impr. Univ. 38: 10. 1916. syn. nov.

Type: Prov. Sagami, Ikego, Dushi, leg. K.Hisauchi, 12. XII. 1914. (holotype in NICH, not seen; isotype in TNS).

Grimmia elatior var. squarrifolia Dix. et Thér., Hong Kong Nat. Suppl. 2: 10. 1933. syn. nov.

Type: Exposed granite rock, 400-500 ft. alt., Amoy I., 1931. Coll. G.A.C.Herklots, B. 8A (holotype in BM, not seen; isotype in PC).

Grimmia eurybasis Dix. et Sak., Bot. Mag. Tokyo 53: 287, f.1. 1939.

Type: Kyushyu. Prov. Higo, Isyoti, leg. K.Mayebara, 23. Feb. 1936, K.Sakurai 9506 (holotype in MAK, not seen).

Plants robust, dark-green or blackish, in fragile, somewhat loose cushions. Stems sparingly branched, without central strand. Leaves appressed when dry, quickly recurved on absorbing water, erect-patent when moist, lanceolate with wide, sheathing base, suddenly narrowed and forming distinct (occasionally indistinct) shoulder parts, terminated by denticulated hyaline hair-point, 2.5 -4.5 mm long and 0.6-0.8 mm wide. Lamina unistratose, at places bistratose in upper part. Margins recurved on both sides, occasionally on one side in basal part, thickened in 2-3(-4) cell-layers in upper part. Costa strong, percurrent, smooth on dorsal surface, becoming indistinct in contour toward the base, transversely narrowed-obtriangular in cross-section at base; abaxial epidermal cells 12-15 in number in the middle part. Laminal cells short-rectangular (up to 2:1), at places transverse-rectangular, 5-8 µm wide, more or less sinuosed, sometimes smooth in upper part, gradually elongated towards base, rectangular (up to 3:1) in the middle, more elongated and thick-walled in the base; basal marginal cells rectangular, with longitudinal walls as thick as transverse ones. Dioicous. Perichaetial leaves more enlarged with wider sheathing base which are much loosely areolated than the vegetative leaves. Capsule immersed in perichaetial leaves, oblong-ovoid, 1.4-1.5 mm long, 0.9-0.95 mm thick, on short seta (shorter than urn). Peristome teeth dark reddish-brown, imperfectly divided into 2-3 branches in upper part, sometimes perforated at places in the middle; outer surface papillose in upper 1/3, smooth in lower 2/3; inner ones papillosed throughout. Exothecial cells rounded-hexagonal, with more or less thin walls. Annulus of Affinis type. Operculum with elongated, straight beak. Calyptra mitrate. Spores finely papillose, 12-15 µm in diameter.

Distinguishing features.

1. Capsule on short seta, immersed in perichaetial leaves.
2. Leaves rigid, narrowly lanceolate with ovate, somewhat sheathing base, suddenly narrowed into upper subulate part, forming shoulder parts.

Leaves are variable in the form and the thickness of lamina. Plants growing on shaded rocks in the forest have narrowly elongated leaves with distinct shoulder and subulate part distinctly bending backwards when wet (distinct when leaves are detached from the stem), while those on sunny exposed, dry rocks, have more or less wider leaves with less distinct shoulder and less distinct bending of subulate part.

In usual form, leaves are bistratose and more thickened in margins, 3-4-stratose on the middle margins. Thicker, 4-6-stratose margins were found in the specimens (HK-2423, HD-12394) from Hokkaido, northern Japan where _G. pilifera_ grows less commonly. In these specimens, however, both the heavily thickened and usual leaves were found even on a single stem.

The extent of leaf keeling is also subject to vary with environmental conditions. In plants growing on shaded habitat, keeling is distinct, and costae distinctly projecting dorsally, while, in plants growing on sunny exposed, dry rocks, the keel is indistinct, and costae are weakly projecting dorsally where the distinction between the costal and laminal parts is not clear even in a cross-section of leaf.

Between Japanese and N. American plants, there occur slight morphological differences. They seem not to be evaluated as having taxonomic importance, but to be considered as a mere regional variation. The leaves of N. American plants have a wider costa and it is the only feature distinguishing them from Japanese plants.

According to Sayre (1952), the costa occupies about 1/4 width of the leaf-base. In addition, the wider costa was also illustrated by Sullivant (1864, Tab. 43, as G. pensylvanica). As far as I examined a North American specimen in the exsiccata (Musci Boreali-Americani, n. 138 in HIRO), I could measure higher ratio of costa to leaf-base, but not so high as given by Sayre (1952). The most stricking differential character concerning the costa is whether the costa becomes narrower or wider toward the leaf-base. In N. American plants studied, the costa becomes wider toward the leaf-base, while in Japanese ones narrower. Another difference is less distinctly seen in the leaf-texture, that is, thin in N. American plants, thick in Japanese ones.

The plants growing in fully shaded places such as on rocks in the forests show much elongated upper subulate part, and are possibly mistaken for G. elatior. But, G. elatior clearly differs from G. pilifera in that the leaves are distinctly keeled and the costa is composed of nearly homogeneous cells of thin walls; their margins recurved on one side only; the free walls of adaxial epidermal cells of costa being as thin as those of other cells of costa, as well as the laminal cells having distinct true papillae on cell-lumen. G. elatior has repeatedly been reported from Japan since the first record by Brotherus (1924) (Ihshiba 1929, Horikawa 1939, Sakurai 1954, and Takaki et al. 1970). A single Japanese collection determined as G. elatior by Brotherus is conserved in Brotherus's herbarium (H-BR) (Prov. Ise: Mt. Gozaisho, Oct. 17. 1914, coll. K.Murat, sent. H.Sasaoka, No. 249). Having examined this specimen, I have reached the conclusion that this specimen was no more than G. pilifera. In Takaki's private herbarium, I found the specimens labelled as G. elatior, which contained the plants bearing narrowly much elongated leaves, and being identical with G. pilifera.

Other specimens used for the above mentioned reports were not available for the reconfirmation of occurrence of G. elatior in Japan. In addition to these facts, I could find no specimens referable to G. elatior among the Japanese specimens examined.

Habitat. On dry, sunny exposed rocks or stone-walls in or near human habitation, or on shaded rocks in woods, in mainly the oromeridional to the orotemperate zone, occasionally ascending up to the upper oroboreal zone.

Range. Japan (Hokkaido, Honshu, Shikoku, Kyushu); Amoy Isl., North America.

### 13. Grimmia subsulcata Limpr. (Fig. 27)

Laubm. Deutschl. 1: 757. 1889.

Type: Auf Grimmerschiefer "Speiereben bei Schäder", 2300 m, in Steiermark, leg. J.Breidler, am 9 August 1888 (holotype in BP .

Guembelia lamellosa C.Müll., Bot. Zeit. 12: 318. 1854.

Type: In Pyrenaeis centralibus, in rupibus ad lacum Espingo, altitudine 5600 pedum, mense August, 1851. leg. Joh.Lange (lectotype in PC, selected here; isolectotype in H-SOL).

Grimmia lamellosa (C.Müll.) Limpr., Laubm. Deutschl. 1: 757. 1889. nom. invalid in syn.

Plants small, bluish-green, hoarly cushions or tufts in field, yellowish-brown in age. Stems upright, 5-6 mm long, sparcely branched and fastigiated, with rather thick central strand, occupying about 1/3 diameter of the stem. Leaves loosely appressed to stem when dry, sharply keeled and channelled somewhat cymbiform, lanceolate with nearly rectangular or ovate base, more or less plicate, with nearly smooth, long hyaline hair-point, 1.2-1.4 mm long and 0.3-0.5 mm wide. Lamina opaque above due to bistratosed cell-layers, but at places unistratose, in upper margins 3-4-stratose, unistratose below. Margins plane but slightly incurved in upper part. Costa consisting of thin-walled cells, smooth or mamillose on back. Upper lamina cells quadrate to rectangular, often transversely rectangular, with thin, more or less sinuose walls, usually 8-11 µm wide, mamillose in cross-section of leaf; lower ones 9-13 µm wide, quadrate to rectangular (1-5:1), with thin longitudinal and thick transverse walls, often both walls thin; basal marginal parts hyaline, consisting of (1)-2-3 rows of transparent quadrate to rectangular cells, with smooth, thin longitudinal and thick transverse walls. Autoicous. Perichaetial leaves attaining 2.5 mm long, lanceolate with wide ovate, convoluted base, occasionally secund, extending to the base of the capsule. Capsule exerted, straight, ovate to oblong, yellowish-brown to brown, 1-1.2 mm long , 0.5-0.6 mm thick. Seta pale yellow, 1.5-2.3 mm long, slightly curved to straight. Operculum conical, obtusely pointed. Exothecial cells varing in shape, usually rounded- or elongated-hexagonal, with euqlly thickened walls. Stomata present. Annulus of Elongata type. Peristome teeth yellowish-brown, lanceolate with piliferous apices; upper part perforated or imparfectly crefted into 2-3 branches; outer surface densely papillose above, nearly smooth below; inner surface densely papillose throughout. Calyptra conico-cylindric. Spores nearly smooth, ±8 µm in diameter.

Distinguishing features.

1. Plants bluish-green in fresh material.
2. Leaves, small, soft; margins plane but somewhat incurved in the upper part.
3. Laminal cells thin-walled, mamillose; angular cells transparent

with thick transverse and thin longitudinal walls; basal paracostal cells not so elongated, chlorophyllose.

4. Plants autoicous (frequently and superficially dioicous due to the decomposition or the separation of aged stems (or branches.)
5. Capsule pale yellowish-brown, with stomata.

The Japanese plants so far called as *G. alpestris* do not fit well to European *G. alpestris*. The European specimens examined show a dioicous sexuality, and the capsules more darker than *G. subsulcata*, with thicker walls, tinged with deep brown. *G. subsulcata* and *Guembelia lamellosa* are the most closely allied species or conspecific to Japanese so-called "*G. alpestris*". The former species was described by Limpricht (1889) in emphasizing the following features: capsule with stomata, leaves with longitudinal plicae and the exothecial cells with thinner walls than in *G. alpestris*, among these the first character was stressed by him. But, Hagen (1909) indicated the presence of stomata on the capsules of thin exothecial cells of the Norvegian specimens of *G. alpestris* examined by him, and furthermore mentioned the occurrence of plicated leaves in Norvegian *G. alpestris*. As to the sexuality, he considered that the species is normally autoicous and becomes true dioicous under the some unknown conditions as seen in *G. ovalis*, *G. subsulcata*, and *G. sessitata*. Consequently Hagen (1909) concluded that *G. subsulcata* should be reduced to a synonym of *G. alpestris*. Limpricht (1889) treated *Guembelia lamellosa* originally described by C.Müller (1846) from the Pyrenées to be conspecific with *G. alpestris* and this was followed by Hagen (1909). *Guembelia lamellosa* was first described as a dioicous species, but it is actually an autoicous species. This was confirmed by me on the material conserved in PC (lectotype, selected here). I failed to trace the connection between perichaetia and perigonia on the material in H-SOL (isolectotype) due to the poverty of specimen. The plicae on leaf and the thin-walled exothecial cells as well as the pale yellowish-brown capsules were also confirmed on the materials in both herbaria. As to the stomata, the results were negative on either mateiral. Except the absence of stomata (or possibly unrecognizable due to the secondary thicknings of the walls), G. lamellosa can be considered as conspecific with Grimmia subsulcata. In Grimmia subsulcata and Guembelia lamellosa, there really occur the specimens with only perichaetia, but we should not consider such plants as dioicous, since the unusual distribution sexual organs is known as indicated by Hagen (1909, p.8) himself, and here again shown by me in Japanese specimens of G. affinis and G. subsulcata (Fig. 1: 1-3, 5). They are no more than superficially dioicous. As far as I examined many European G. alpestris, plants with both perichaetia and perigonia on the successive stems (or branches) were never observed. Therefore, it must be truly dioicous. I could not examine the the specimen of G. alpestris. The picture of that taxon grasped by me is based on the description made by Limpricht (1889) and Nyholm (1956). I tentatively distinguish G. subsulcata from G. alpestris by the autoicous sexuality and the pale yellowish capsule. These characters seem to me insufficient to distinguish them. The decisive conclusion on the relation between G. alpestris and G. subsulcata should be made after the examination of the type specimen of G. alpestris and further detailed comparison between them.

Habitat. On exposed, but somewhat moistened rocks in the summit region of mountains, in the oroboreal zone.

Range. Japan (Hokkaido, Honshu); Europe, Altau, Caucasus.

Schistidium Brid. emend. B.S.G.

Brid., Mant. Musc. 20. 1819; Brid.; Bryol. Univ. 113. 1826; Hüb., Bryol. Germ. 88. 1823; B.S.G., Bryol. Eur. 3: 97. 1845; De Not., Briol. Ital. 709. 1869; Limpr., Laubm. Deutschl. 1: 702. 1889; Loeske, Laubm. Eur. 18. 1913; Loeske, Biblioth. Bot. 101: 49. 1930; Podp., Consp. 266. 1954; Nyholm, Ill. Moss Fl. Fenn. 142. 1956.

Grimmia sect. Platystoma C.Müll., Syn. 776. 1849.

Grimmia sect. Brevisetae Husn., p.p., Musc. Gall. 122. 1886.

Grimmia subgen. Schistidium (Brid.) Schimp., Coroll. 45. 1856; Syn. 1: 198. 1860; Syn. 2: 238. 1976; Hagen, K. Norsk. Vid. Selsk. Skrift. 1909(5): 6. 10. 1909; Brotherus, Nat. Pfl. ed. 2, 10: 307. 1924; Jones in Grout, Moss Fl. N. Am. 2: 11. 1933; Takaki, Bot. Mag. Tokyo 64: 175. 1951; Lawton, Moss Fl. Pac. Northwest 123. 1971.

Grimmia sect. Schistidium (Brid.) Mitt., J. Linn. Soc. Suppl. 1: 43. 1859; Braithw., Birt. Moss-Fl. 2: 4. 1888-1895; Dix., Stud. Hand. Brit. Moss. 138. 1924; Mönkmeyer, Laubm. Deutschl. 346. 1927.

Lectotype species: Schistidium pulvinatum (Hedw.) Brid.

Plants green to dark-green, reddish-brown or dark-brown, in loose tufts or cushions. Stems prostrate to procumbent or upright, frequently branched. Leaves ovate to ovate-lanceolate, terminated by a hyaline hair-point, sometimes mucronate point. Lamina unistratose, striately bistratose at places in upper part. Margins revolute on one side or both sides in the widest part of leaf, thickened in two cell-layers in the above, entire or denticulate due to either the projection of a corner of cells or the papillosity. Costa single, rigid, percurrent or vanishing a short distance below apex, smooth or papillose on dorsal surface, composed of nearly homogeneous cells in cross-section except S. maritimum. Laminal cells rounded-rectangular, transversely rectangular at places, or elongated-rectangular (usually up to 1.5:1), with smooth to somewhat sinuosed walls in the above 2/3 of leaf, slightly elongated toward base, especially near costa (paracostal region), but never forming translucent basal part; basal marginal cells usually chlorophyllose, transversely rectangular to quadrate, occasionally transparent and rectangular. Autoicous. Both gynoecia and androecia terminal, but appearing lateral by a subfloral innovation streaching to nearly the same direction as that of the preceding stem. Capsule submerged in perichaetial leaves or somewhat emergent, straight, semi-spherical to oblong; exothecial cells transversely rectangular, hexagonal or elongated rectangular in the middle part of urn, gradually becoming transversely rectangular toward the orifice. Stomata restricted at apophysial part. Annulus absent. Peristome teeth 16 in number, well developed, occasionally rudimentary, lanceolate, yellowish-brown to reddish-brown, entire or irregularly perforated, sometimes divided in upper part; outer surface papillose throughout or occasionally smooth in basal part; inner surface papillose throughout; outer plates thicker than inner ones. Operculum low-conic, with short or more or less elongated, oblique beak, somewhat hooked. Columella falling with operculum. Calyptra mitrate or cucullate, small, whose base not extending to the urn. Spores 10-28 um in diameter, more or less papillose.

Distinguishing features.

1. Annulus absent.
2. Calyptra very small, whose base hardly reaching the urn.
3. Capsule on a short seta, being shorter than urn, uniformely immersed in perichaetial leaves.
4. Vaginula less differentiated, very short.
5. Laminal cells more or less homogeneous.
6. Operculum with an arcuate, sometimes hooked beak.

As mentioned before in the historical survey (p.4 ), the genus Schistidium was first established by Bridel (1819), who included in his genus heterogeneous species without peristome teeth. The concept of the genus was well emended in a form comparable to the modern sense by Bruch & Schimper (1845), who excluded all the species except S. pulvinatum from Bridel's Schistidium and grouped S. pulvinatum and some species of the genera Gymnostomum and Grimmia of Hedwig (1801) and Bridel (1819, 1826) into his revised genus Schistidium Brid. emend. Bruch et Schimp. The reformed Schistidium was characterized by: 1) the particularity of the areolation of leaf and of the median costa, 2) the configuration of capsule, and 3) the minuteness of both calyptra and vaginula.

After careful consultation of their work, the diagnostic charatters 1) and 2) are remained ambiguous for the recognition of the genus.

The emended genus was thereafter variously treated as one of the subgenera or sections of the genus Grimmia, or as an independent genus. In general, subgeneric or sectional status is supported by many North American bryologists and generic status , on the other hand, is accepted by many modern European authors. Consequently, no dicisive status is given for it even now. Recently, among the N. American bryologists, Steere & Brassard (1976) followed the usage of *Schistidium* as a generic rank as done by many Europeans, pointing out that *Schistidium* is not integrated in *Grimmia*. As its substantial differences from *Grimmia*, Steere & Brassard (1976) indicated, 1) the uniformly immersed capsules with a short seta, 2) the columella attached to the operculum and falling with it, and 3) the more or less perforated or cleft peristome teeth, and 4) the stems generally longer and forming looser tufts than most species of *Grimmia*. I consider that the features 3) and 4) are less reliable to separate *Schistidium* from *Grimmia*. To recognize *Schistidium* as a genus, more essential features never intermingled with those of *Grimmia* should be considered. The morphological study provided us very distinct characters of taxonomic importance so far less emphasized.

The first is the absence of annulus in *Schistidium*. Although this fact has been cited in the descriptions by Limpricht (1889) and Brotherus (1923), in such expressions as "meist fehlend" and "meist nich differenziert" respectively, it attracted no attention of Schimper (1860, 1867), Dixon (1924), C.Müller (1849), Roth ( 1904), Hagen (1909), Jones (in Grout, 1933), Nyholm (1956), and others. The annulus of *Schistidium* is actually not differentiated between the brims of operculum and urn, both of which directly juxtaposed without any intervention of transparent cell-rows called annulus. The second essential character was originally evaluated by Bruch & Schimper (1845) for *Schistidium*, namely, a small-sized calyptra not covering any part of urn: this was admitted by Schimper (1869, 1876), Roth (1904), Hagen (1909), and Brotherus (1923), but they all regarded *Schistidium* as only a subgenus or a section of the genus *Grimmia*. The third one is the minuteness of the vaginula: this was noted by e.g., Limpricht (1889), Hagen (1909), and Brotherus (1923). Thus, Schistidium is now a very distinct genus in the family Grimmiaceae, best characterized by the features summerized in the above features 1-5.

## Key to the Japanese species

1. Costa with two stereid bands developed on both sides of guide cells; halophyte, growing on rocks on seashore of northern Japan. ........................ 18. S. maritimum (p.112)

1. Costa without stereid bands, non halophyte. .................2

2. Leaves widely ovate-lanceolate, without hyaline hair-point; costa biconvex in cross-section in the middle; exothecial cells thick-walled; spores large, 19-23 µm in diam., growing on periodically irrigated rocks in or by creek or brook. ............ ................................ 19. S. rivulare (p.116 )

2. Leaves ovate-lanceolate, with short to long hyaline hair-point, occasionally absent; costa not biconvex, keeled; exothecial cells thin-walled; spores small 8-15 µm in diam., growing on dry habitat. ...........................................3

3. Peristome teeth rudimentary; perichaetial leaves slightly overtopping the capsule. ............... 20. S. subconfertum (p.119)

3. Peristome teeth well developed; perichaetial leaves overtopping far beyond the capsule. ...................................4

4. Costa papillose or low serrulated on back due to projection of cells at least in young leaves. ...........................5

4. Costa smooth on back. ......................................6

5. Basal marginal cells transversely rectangular in most part, with equally thickened transverse and longitudinal walls; basal leaf-margins recurved at least on one side, extending to leaf-insertion; perichaetial leaves without hyaline hair-point or with short to somewhat elongated hair-point. ................ ................................ 16. S. gracile (p. 102)

5. Basal marginal cells longitudinally rectangular in most part, with thick transverse and thin longitudinal walls; basal leaf-margins usually plane on both sides; perichaetial leaves long hyaline hair-pointed. .......... 17. S. liliputanum (p.108 )

6. Basal marginal cells with thick transverse and thin longitudinal walls. ........................17. S. liliputanum (p.108 )

6. Basal marginal cells with equally thickened transverse and longitudinal walls. ..........................................7

7. Exothecial cells elongated-rectangular; plant growing restrictly on calcareous rocks in lowland to montane regions. ....... .................................. 14. S. apocarpum (p.96 )

7. Exothecial cells transversely rectangular to short rectangular; plant growing on siliceous rocks. ..........................8

8. Plants forming low, dense cushions; leaves smaller, ca. 0.4 mm wide; growing in summit regions of high mountains. .......... .................................15. S. confertum (p. 99 )

8. Plants forming loose cushions or mats; leaves larger, ca. 0.6 mm wide; growing in lowland to montane regions. ............ ...................................... 16. S. gracile (p.102)

## 14. Schistidium apocarpum (Hedw.) Bruch. et Schimp. (Fig. 28)

Bryol. Eur. 3: 99. 233. 1845 (fasc. 25-28, Mon. 7. 3)

Grimmia apocarpa Hedw., Spec. Musc. 76. 1801.

Syntypes: Lipsiae ad piscinam Lindenthalensem; Gothanam versus Ileburgum; Dresdae ad rivulum Weiseriz ( lectotype in G, selected here ; lectotype lacking the type locality).

Grimmia fasciculata Brid., Musc. Rec. Suppl. 4: 37. 1819.

Type: In Monte Olympo Mysiae (N.W.Turkey, Asia Minor), D.Seezen legit (holotype in B).

Grimmia platyphylla Stirt., Scott. Naturl. 27: 219. 1890.

hom. illeg. pro G. platyphylla Mitt.

Grimmia gracillima Bartr., Bryologist 27: 72. 1924.

Type: On shaded boulders along the Baldy Trail, Santa Rita Mts., Arizoan (U.S.A.), E.B.Bartram, No. 858, February 4, 1924. Altitude 8000 ft (holotype in FH).

Plants olive-green above, dark-green to blackish-green below, in loose or dense tufts. Stems fairly freely branched, reaching 4 cm long, with distinct central strand. Leaves lanceolate, from ovate base gradually narrowed to denticulated hyaline hair-point or sometimes chlorophyllose point, appressed when dry, more or less distantly foliate, 2-2.5 mm long and 0.6-0.8 mm wide. Margins recurved on both sides in the middle extending to the base, plane above, thickened in 2-3 cell-layers above. Costa distinct, semi-curcular in cross-section, smooth on dorsal surface. Lamina unistratose, striately bistratose at places. Upper and middle laminal cells transversely rectangular to rounded-quadrate, 8-10 µm wide; basal paracostal cells rectangular (1.5-5:1), with equally thickened walls; those of basal median and angular parts transversly rectangular to quadrate. Autoicous. Perichaetial leaves larger, frequently terminated by denticulated hyaline hair-point. Capsule immersed, short cylindric, 0.9-1 mm long, 0.6-0.7 mm thick, faintly and longitudinally ribbed on surface when dry. Peristome teeth yellowish-brown in upper half, reddish-brown below, lanceolate, piliferous, often perforated in the upper part; outer surface papillose in upper 2/3, smooth below; inner surface papillose throughout. Exothecial cells elongated-hexagonal, with equally thickened walls. Stomata present. Operculum obliquely long-rostrated. Calyptra mitrate or cucullate, but in the latter case lacelated at base. Spores 13-15 µm in diameter, papillose on surface.

Distinguishing features.

1. Leaves with entire margins and smooth costa.
2. Capsule oblong with longitudinally developed faint ribs.
3. Exothecial cells elongated-hexagonal.
4. Growing always on calcareous rocks.

This species is well characterized by its ecological requirement, namely, it always growing on calcareous rocks. The elongated hexagonal exothecial cells are effective to distinguish S. apocarpum from the other Japanese species of Schistidium (except S. maritimum). In Japan, S. apocarpum has been understood in confusion with S. gracile, especially in respect to plants growing in lowland which have leaves with nearly smooth costa. But, S. apocarpum is clearly distinguished from S. gracile by the exothecial cells, namely, elongated-hexagonal in the former species against transversely rectangular in the latter species. The plants distributed by Noguchi & Hattori in 1956 (Musci Japonici, Ser. 10, 469. Grimmia apocarpa var. microtheca Card., Coll. Y. Kuwahara, Apr. 27, 1952) are the very thing, S. apocarpum. For the typification of Grimmia apocarpa, the present author met with much difficulty to select a lectotype among the specimens sent from the herbarium of Hedwig at Genève. Three different localities are raised in Hedwig's (1801) Species Muscorum: Lipsiae ad piscinam Lindentalensem; Gothanam versus Ileburgem; and Dresdae ad rivulum Weiseriz. In examining them, one specimen could be integrated in the range of the variation of Schistidium gracile. As the lectotype of this species, the present author here propose to select the specimen having the following indication on the sheet: Grimmia apocarpa Hedw. St. Cr. I. p.113. t.39.

*Grimmia strigosa* described by Bridel (1826) was reduced to a synonym of *S. apocarpum* by C.Müller (1849). By the examination of type specimen of *G. strigosa*, however, it should rather be treated as a synonym of *S. gracile* because of the presence of distinct papillae developed on the dorsal surface of the costa of leaf and shorter exothecial cells.

Habitat. On exposed or partially shaded calcareous rocks, in the oromeridional to the orotemperate zone.

Range. Japan (Hokkaido, Honshu, Kyushu); Europe, North and South America, Greenland, Australia, New Zealand, Tasmania.

### 15. *Schistidium confertum* (Funck) Bruch et Schimp.

(Fig. 29)

Bryol. Eur. 3: 99. 232. 1845. (fasc. 25-28. Mon. 7. 2)

*Grimmia conferta* Funck, Deutschl. Moose 18, 12, f.19. 1820.

Type: Funck, Crypt. Gew. d. F. Fasc. II. no. 208 (G. cribrosa), in fissuris rupeium. Mart. (not seen)

*Grimmia latifolia* Brid., Bryol. Univ. 1: 162. 1826.

Type: In America septentrionali prope Noveboracum, unde D.Torrey misit, habitat. An saxatilis? (holotype in B-Brid).

*Grimmia apocarpa* Hedw. var. *conferta* (Funck) Spreng., in Linn., Syst. Veg. ed. 16, 4(1): 153. 1827.

*Grimmia glacialis* Nees, Hornsch. et Sturm, Bryol. Germ. 2: 118. 1827. fid. C.Müll., Syn. 1: 777. 1849.

Type: bei dem sogenannten Malerbrunnen auf der grünen Thürneben dem oberen Paterzengletscher bei Heiligenblüt auf Felsblöcken, Hoppe! Laurer! (not seen)

Grimmia pruinosa Wils. in Schimp., Syn. ed. 2, 241. 1876.

fid. Limpr., Laubm. Deutschl. 1: 710. 1889.

Type: In rupibus basalticis pf. Bowling in vicinitate urbis Glasgow (Mac Kinlay, Stirton). (not seen)

Grimmia apocarpa Hedw. ssp. conferta Dix., Stud. Handb. Brit. Moss ed. 1, 132. 1896.

Schistidium apocarpum (Hedw.) Bruch. et Schimp. ssp. confertum (Funck) Loeske, Laubm. Eur. 1, 35. 1913.

Plants yellowish- to olive-green, in more or less dense, small fragile tufts. Stems short, 0.5-1 cm high, freely branched, with central strand. Leaves small, ovate to ovate-lanceolate, obtusely keeled, usually with rather flattened, wide spinulose hyaline hair-point having wide base, 1.3-1.6 mm long and 0.45-0.7 mm wide. Margins thickened in two cell-layers in the upper 1/2 of leaf, recurved on both sides either widerly or narrowly from the base to far below the apex (generally wider leaves having more widely recurved margins). Costa thick above, becoming narrower towards the base, percurrent, smooth throughout on dorsal surface. Lamina unistratose (excl. margins), rarely sporadically bistratose. Upper laminal cells transversely or longitudinally rectangular ( usually up to 2:1), with somewhat thick and sinuose walls; middle ones rectangular (2-3:1), distinctly or indistinctly sinuose; basal paracostal cells much elongated, long rectangular (up to 10:1), with smooth walls; basal marginal cells quadrate to short rectangular with as thick transverse walls as longitudinal walls. Perichaetial leaves much larger than vegetative ones, convoluted at base, ±2 mm long. Capsule small, usually 0.5 mm long, 0.4-0.5 mm thick. Peristome teeth well-developed, lanceolate, irregularly perforated in upper part; outer surface papillose in upper 2/3, smooth in lower 1/3; inner surface papillose throughout. Exothecial cells transversely rectangular to short rectangular, with rather thin walls. Operculum with oblique and more or less hooked beak. Calyptra cucullate, but shallowly divided at base. Spores very finely papillose or nearly smooth, 7-8 µm in diameter.

Distinguishing features.

1. Peristome teeth well-developed.
2. Perichaetial leaves overtopping far beyond the capsule (capsule deeply immersed in perichaetial leaves).

Grimmia apocarpa var. conferta (Funck) Spreng. was first recorded from Japan by Takaki (1951). The examination of the specimen on which the report was based (Mt. Nekodake, Sugadaira Heigts, 2195 m, July 10, 1942, Takaki-911) shows that the plants are evidently Coscinodon cribrosus.

Nyholm (1956) suggested that S. confertum might be a merely modified form of S. apocarpum growing in extrem habitat. In Japan, S. confertum is clearly different from S. apocarpum in the morphological features of plants as well as in the distributional pattern. S. confertum has much smaller leaves (1.3-1.5 mm long) and capsules (up to 0.8 mm long) than S. apocarpum, and is growing in the upper oroboreal subzone in Japan, while S. apocarpum is growing restricted on calcareous rocks in lowlands or montane areas ( oromeridional to orotemperate zone) with more mild climate. In addition, any kind of intermediate forms have never been found.

Schistidium confertum has a close relationship with S. liliputanum in both gametophytic and sporophytic characters. Therefore, there occasionally occur the specimens being difficult to be determined. However, the following distinguishing features are observed between the two species, that is, in S. confertum the upper part of leaf obtusely keeled when dry; the hyaline hair-point shorter and wider; the angular marginal cells with thin transverse and longitudinal walls; in S. liliputanum the upper part of leaf sharply keeled when dry, more or less conduplicated; the hyaline hair-point longer and slender; the angular marginal cells with thick transverse and thin longitudinal walls.

The confirmation of the Japanese specimens as S. confertum was based on the specimen adhered on the plate 12 (f. 19) of Funck's Deutschland Moose (1820) preserved at Paris (PC).

Habitat. On rocks in the summit regions of mountains, in the upper oroboreal subzone.

Range. Japan (Hokkaido, Honshu); Europe, Africa, Caucasus, Persia, North America.

### 16. Schistidium gracile (Roehl.) Limpr. (Fig. 30-33)

Laubm. Deutschl. 1: 705. 1889.

Grimmia apocarpa Hedw. var. gracilis Roehl., Ann. Wetterau. Ges. 3(1): 97. 1812.

Type: Schleicher's exsiccata. Cent. III. no. 14 (Frequens ad rupes subalpinas) (lectotype in G, selected here)

Schistidium apocarpum (Hedw.) Brid. var. gracilis (Roehl.) Bruch et Schimp., Bryol. Eur. 3: 99. 234B. 1845.

Grimmia apocarpa Hedw. ssp. gracilis (Roehl.) Bertsch., Moossfl. 57. 1949.

Schistidium apocarpum (Hedw.) Brid. ssp. gracilis (Roehl.) Meylan, Bull. Soc. Vaudoise Sc. Nat. ser. 5, 41: 100. 1905.

Grimmia gracilis Schleich. ex Schwaegr., Spec. Musc. Suppl. 1(1): 98. 23. 1811. hom. illeg.

Grimmia stricta Turn., Musc. Hib. 20. 2f, 1. 1804.

Type: A.D.Scott primum in saxis prope Swanlinbar est detecta, mox in Snowdoni jugis ipse legi (holotype in BM).

Grimmia alpicola Hedw. var. stricta (Turn.) Wahlenb., Fl. Lapp. 320. 1812.

Grimmia apocarpa Hedw. var. stricta (Turn.) Hook. et Tayl., Musc. Brit. 37. 1818.

Schistidium strictum (Turn.) Loeske, Hedwigia 47: 177. 1908. nom. inval. in syn.

Grimmia trichodon Brid., Bryol. Univ. 1: 171. 1826.

Type: In Alpibus italicis et in Apennis aestate 1820. cum thecis deoperculatis legimus (holotype in B-Brid).

Grimmia strigosa Brid., Bryol. Univ. 1: 171. 1826. syn. nov.

Type: In Alpibus valesiacis in rupibus habitat. Thomas anno 1820 aestate detexit. (holotype in B-Brid, mixed with Racomitrium heterostichum).

Grimmia apocarpa Hedw. var. mamillata Card., Bull. Herb. Boiss. 2 ser. 8: 332. 1908. syn. nov.

Type: Japon. Kattasan, 8 Oct. 1903, à 1900 m. (holotype in PC, not detected; isotype in KYO).

Grimmia apocarpa Hedw. var. microtheca Card., Bull. Herb. Boiss. 2 ser. 8: 332. 1908. syn. nov.

Syntypes: Japon. Aomori, leg. Kinashi, Faurie-30; Jizogatake, à 2000 m, Faurie-2423; Arima, sur vieux arbres, à 200 m, Faurie-2300 (lectotype in PC, selected here; isolectotype in H-BR). Corée. Ile Quelpaert, Faurie-504 (paratype in PC).

Grimmia apocarpa Hedw. var. denticulata Card., Bull. Soc. Bot. Genève ser. 2, 1: 122. 1909. syn. nov.

Type: Japon. Tobetsu, Oct. 1907. Faurie-3790 (holotype in PC, not detected; isotypes in H-BR, KYO).

Grimmia konoi Broth. in Kono, Bot. Mag. Tokyo 20: 79. 1906. syn. nov.

Syntypes: Nigitsu park, Hiroshima, Japan (lectotype in H-BR, selected here); Arashiyama, Japan (paratype not seen).

Grimmia kiyoshii Okam., J. Coll. Sc. Imp. Univ. Tokyo 38(4): 12. f.5. 1916. syn. nov.

Type: Prov. Idu, in monte Amagi, leg. Kiyoshi Fuji, 18. VIII. 1914 (holotype in NICH, not seen; isotype in TNS).

Plants olive-green to dark-green in fresh, yellowish-brown to reddish-brown in aged material, in loose tufts or mats. Successive stems (branches) reaching 10 cm long, with or without poorly developed central strand, rather distantly foliated. Leaves variable in shape and size, ovate-lanceolate, somewhat secun, terminated by a chlorophyllosed point or a short, denticulated hyaline hair-point, 2-2.5 mm long and 0.6-0.7 mm wide. Lamina unistratose, at places bistratose. Margins bistratose in upper part, unistratose below, recurved on both sides in the middle, usually extending to leaf-insertion. Costa percurrent, with papillae or mamillae (due to the projection of cells) on dorsal surface of costa, where frequently low, irregular serrulation appear (distinct in lateral view of costa). Laminal cells transversely rectangular to short rectangular, usually with somewhat collenchymatous walls, with papillae on cell-lumen, frequently absent, 7-8 µm wide in upper part, rectangular, usually with roughly sinuose walls; basal paracostal cells elongated-rectangular, with moderately thickened, smooth walls; angular cells transversely rectangular in most part, with as thick transverse walls as longitudinal walls. Autoicous. Perichaetial leaves larger than vegetative leaves, with wide, loosely areolated base; hyaline hair-point absent or short. Urn urceolate to obovate, 0.65-1.5 mm long, 0.45-0.95 mm thick. Operculum with oblique and hooked beak. Peristome teeth yellowish- to reddish-brown, with filiform point; both outer and inner surfaces papillose throughout. Exothecial cells transversely rectangular to short rectangular, with rather thin walls. Stomata present at apophysial part. Calyptra mitrate, occasionally cucullate, but lobed at base. Spores papillose, 8-10 µm in diameter.

Distinguishing features.

1. Costa with papillae or mamillae on dorsal surface.
2. Exothecial cells transversely rectangular.
3. Basal marginal cells transversely rectangular to short rectangular, with thick transverse and longitudinal walls.

This species was first described by Schwaegrichen (1811) under the name of Grimmia gracilis Schleich., which was a later homonym of Grimmia gracilis (Hedw.) Web. et Mohr (=Pterogonium gracile ( Hedw.) Sm.). Thereafter, it appeared in the varietal rank of G. apocarpa: var. gracilis Roehl. (actually appeared as var. gracilis Schleich.) in the work of Roehling (1812). It is evident that the Schleicher's exsiccata (Cent. III. No. 14) was based on both Grimmia gracilis Schleich. ex Schwaegr. and Grimmia apocarpa var. gracilis Roehl., judging from the way of the citation of the author's name. More detailed data for the type was supplied by various textbooks (Bridel, 1819, 1826; Nees, Hornsch. & Strum, 1827; Paris, 1894; etc.) as Schleicher's exsiccata Crypt. Helv. exsicc. cent. III., no. 14. A lectotype specimen should be chosen among the materials distributed. I prefer to select the material studied by Schwaegrichen and conserved in G (Genève).

The identity of *S. gracile* with *G. stricta* is quite evident from comparing of both type specimens.

*Grimmia trichodon* can not be directly integrated in the taxon of *S. gracile*, as far as only type specimens of the two species are concerned. *G. trichodon* is best characterized by the piliform peristome teeth as originally mentioned by Bridel (1826), and by the less papillose leaves as well as the blackish coloration of plants. In Japan, such form occurs restricted to the calcareous regions, where also occurs the form slightly different from *G. trichodon* type-plants, in having distinct papillae on leaves. The exsistence of such plants with distinctly papillosed leaves leads me the same conclusion as that of C.Müller (1849) who regarded *G. trichodon* to be conspecific with *S. gracile*.

*Grimmia strigosa* has long been considered as a synonymous taxon of *Schistidium apocarpum* after C.Müller (1849). I critically reexamined the type specimen of *G. strigosa* which is conserved in B-Brid (Berlin). On the herbarium sheet are adhered the plants belonging to the two different taxa, namely, *Schistidium gracile* (p.p. minor) and *Racomitrium heterostichum* (p.p. major). The original description evidently refers the plants with immersed capsule: *S. gracile*. The distinct papillae developed on both costa and lamina were observed on the type specimen. There no doubt to consider *G. strigosa* to be conspecific with *S. gracile*.

This species shows, in Japan, the widest variation among the species of *Schistidium*, some of which stand outside the descriptions made by many European and North American bryologists. By the combination of characters, several forms are recognizable among the specimens investigated, though each form is connected by a series of intermediate forms. All the varieties except var. microphylla described from Japan and Korea by Cardot (1908, 1909) under the name of Grimmia apocarpa, belong to this polymorphous S. gracile. Other two species described from Japan: Grimmia kiyoshii and G. konoi respectively by Okamura (1916) and by Brotherus (in Kono, 1906) also are forms of S. gracile. It might be rather reasonable to refrain the employment of certain name of infraspecific taxa for such forms and to call under provisional names not restricted by the nomenclature, pending the discovery of some new characters resolving the intermediate forms. The recognized forms are described below together with their ecological informations.

Mod. typicum. (Fig. 31) Plants slender, yellowish-brown to reddish-brown, resembling the habit of mod. trichodon, but not blackish. Leaves usually narrowly lanceolate; lamina mostly unistratose, rarely bistratose at places; costa with distinct papillae on back; papillae usually vertically projecting to the axis of costa. The papillosity is most pronounced in the plants growing on calcareous rocks.

Mod. commune. (Fig. 30) The characters of this modification are given in the description of the species. Plants of this modification are most commonly found in Japan, on rocks in the orotemperate to oroboreal zone. G. apocarpa var. aomoriensis Card. and var. microtheca as well as G. kiyoshii belong to this modification.

Mod. trichodon. (Fig. 32) Plants slender, blackish, reddish-brown at tip of branch, growing on sunny exposed calcareous rocks. Leaves unistratose except margins where bistratose in upper part; costa less papillose or smooth on back, occasionally distinctly papillose. Capsule oblong, having long peristome teeth with piliform tip. Operculum long rostrated.

Mod. denticulatum (Fig. 33) Plants robust, green to dark-green, with thick stem which is densely foliated, growing usually on rocks covered with more or less thick soil deposition. Leaves large, usually 0.8-0.9 mm long, 1.7-2 mm wide, widely ovate-lanceolate; costa with sparce and low papillae or mamillae due to the projection of cell-angle of abaxial epidermal cells, occasionally nearly smooth. The papillose or mamillose costa appears to be serrulate in lateral profile. This is the commonest modification in the lowland of Japan, especially near or in the human habitation, occurring on the stone-walls or rocks. Mainly growing on acidic rocks. G. apocarpa var. denticulata Card. and var. mamillata Card. are the very form of this modification.

Var. mamillata was diagnosed by the mamillose operculum by Cardot (1908), but such conformation is not observed even in both vertical and radial sections of operculum.

Habitat. On mesic to dry boulders or rocks, sometimes stone-walls at sunny exposed or shaded palces in woods or sometimes in or near human habitation, in the oromeridional to oroboreal zone.

Range. Japan (Hokkaido, Honshu, Shikoku, Kyushu); Europe, Himalayas, China, Siberia, North America.

### 17. Schistidium liliputanum (C.Müll.) Deguchi comb. nov. (Fig. 34)

Grimmia liliputana C.Müll., Nuov. Giorn. Bot. Ital. n. ser. 5: 188. 1898. syn. nov.

Type: China interior, prov. Schen-si sept., in loco sic dicto "Zu-lu" Oct. 1896 (lectotype in Fl, selected here; isolectotype in PC, H).

Grimmia apocarpa Hedw. var. microphylla Card., Bull. Herb. Boiss. 2 ser. 8: 332. 1908. syn. nov.

Type: Arima, pières, à 300 m, no. 2287, leg. U.Faurie (holotype in PC-Thér; isotypes in KYO, H-BR).

Grimmia (Gasterogrimmia) Otii Sak., Bot. Mag., Tokyo 62: 144. 1949. syn. nov.

Type: Sikoku. Prov. Iyo, leg. K.Oti, no. 1228, Nov. 1954 (holotype in MAK).

Plants usually reddish-brown in sunny exposed habitat, olive-green in partially shaded habitat, in low dense cushions, often half-buried in soil. Stems usually short, reaching 1 cm long, sometimes more elongated up to 2 cm, frequently branched, with or without central strand. Leaves small, narrowly lanceolate, from rather obtrapezoid base gradually narrowed towards apex, usually terminated by spinulose hyaline hair-point, 1.3-1.6 mm long and 0.27-0.45 mm wide. Margins entire, sometimes denticulate near apex, revoluted on both sides (one of which sometimes extending to leaf-base) in the middle part of leaf, thickened in two cell-layers in upper 2/3 whole length of leaf, with rather straight marginal lines at base. Lamina unistratose, at places bistratose in upper part. Laminal cells variously sinuosed or non-sinuosed, transversely or longitudinally rectangular to quadrate (1.5-2:1), 5-7 µm in the above; basal paracostal cells elongated-rectangular (up to 8:1), with smooth walls; some marginal cells in a few rows, usually rectangular, transparent, with thick transverse and thin longitudinal walls. Costa percurrent, distinct, tinged with thick reddish-brown in aged material, usually smooth on back, occasionally low papillose near the apex. Autoicous. Perichaetial leaves distinctly larger than the vegetative leaves, with relatively long denticulate to spinulose hyaline hair-point. Capsule yellowish-brown to brown, obconic when deoperculated, usually 0.5-0.7 mm long and thick; capsule walls very thin. Exothecial cells transversely rectangular, with thin walls. Seta ±0.25 mm long. Operculum conic. Peristome teeth brownish to pale-yellowish, irregularly perforated above; outer surface densely papillose in upper 2/3, smooth below; inner surface papillose throughout. Calyptra mitrate. Spores minutely papillose, 10-12 μm in diameter.

Distinguishing features.

1. Capsule deeply immersed in the perichaetial leaves with long, hyaline hair-point.
2. Leaves small, with costa usually smooth on back.
3. Basal margins plane, occasionally revolute on one side.
4. Basal marginal cells transparent, rectangular with thick transverse and thin longitudinal walls.
5. Capsule walls very thin.
6. Perichaetial leaves with elongated, spinuose, hyaline hair-point; the widest part is situated in or somewhat below the middle.

The plants having leaves with slightly papillose costa in the upper part resemble a form of _S_. _gracile_,of which leaves have nearly smooth costa. The following features of this species, however, play a role in distinguishing this species from _S_. _gracile_: 1) the deeply immersed capsule in the perichaetial leaves with denticulated long hyaline hair-point, 2) the angular cells of vegetative leaves, and 3) the form of perichaetial leaves.

Cardot (1908) described a new variety, *Grimmia apocarpa* var. *microphylla* based on Faurie's collection from Japan, comparing it with *G. liliputana* described from Prov. Schen-si, PRC, by C.Müller (1898). The former author distinguished his variety from *G. liliputana* by the longer stems and the entire to slightly divided peristome teeth. Such characters, however, are so variable, that they can not be evaluated as having taxonomic significance in the genus *Schistidium*. In examining both type specimens, they are closely linked up with the characters summerized above, though a slight difference as to the robustness of plants is observed between them as indicated by Cardot (1908). The peristome teeth of the isotypes of *G. liliputana* are imperfectly perforated in upper parts; some pores often vertically confluent each other and forming vertical slits which enable the teeth to divide.

Skurai (1949) described, *Grimmia otii*, which he considered as a species to be place in the subgen. or sect. *Gasterogrimmia* (as *Gastrogrimmia*) of the genus *Grimmia*. The examination of the type specimen conserved in MAK shows that the species has no diagnostic characters circumscribing *Gasterogrimmia* such as the ventricosed capsule and the arcuate seta. Sakurai (1949) mentioned about the uni-papillosity on laminal cells, but it was not confirmed in the type specimen.

Habitat. On either sunny exposed or partially shaded rocks or boulders along creeks or rivers, or in woods, in the oromeridional to the upper oroboreal zone.

Range. Japan (Hokkaido, Honshu, Shikoku, Kyushu); China.

### 18. Schistidium maritimum (Turn.) Bruch et Schimp. (Fig. 35)

Bryol. Eur. 3: 102, f.235. 1845

Grimmia maritima Turn., Musc. Hib. 23. 1804.

Type: In saxis maris aestui objectis prope Balbriggen, leg. D.Scott (holotype in BM).

Grimmia rigida Brid., Bryol. Univ. 1: 768. 1826.

Type: In Insula Terre Neuve in saxis et glareosis caespitose habit. La Pylaei detexit et communicavit (holotype in B-Brid).

Guembelia crassinervia C.Müll., in Röll, Bot. Centralbl. 44: 389. 1890.

Type: Vancouver Island, Victoria, 22 Majo 1888 (lectotype in H-BR, selected here).

Grimmia kindbergii Holz., Bryologist 14: 32. 1911.

Type: Catala, Alaska, coll. G.C.Britton 1904 (holotype in MIN, not seen; isotype in H-BR).

Plants olive-green above, blackish-green in the middle, blackish-below, in small, dense, rigid cushions. Stems erect, about 1 cm long, moderately branched, with central strand. Leaves solid, stiff, incurved or somewhat crispate when dry, muticous, ovate-lanceolate, 1.8-2.3 mm long and 0.5-0.7 mm wide. Margins entire, recurved in lower half or extending to above the middle on both sides. Lamina opaque above due to bistratose cell-layers , uni-stratose or at places bistratose below and middle, thickened in two cell-layers on margins. Upper laminal cells 5-7 µm wide, incrassate, conspicuously papillose or often smooth, lower ones 5-8 µm wide with rather thick-walls, more elongated to long rectangular or quadrate towards margins. Costa percurrent or vanishing below the apex, papillose on dorsal surface, more or less biconvex with stereid bands between a chan of median guide cells and abaxial and adaxial epidermal cells in cross-section. Autoicous. Perichaetial leaves very much elongated, reaching 4 mm long, ovate-lanceolate, somewhat convolute at sheathing parts. Capsule immersed, semi-globular, ±0.8 mm long and thick. Exothecial cells quadrate to rectangular, with much thickened walls. Stomata 6-8 in number. Peristome teeth lanceolate, reddish-brown below 2/3 and yellowish-brown above 1/3, irregularly perforated or crefted above; outer surface papillose in upper half, smooth in lower half; inner surface papillose throughout. Seta about 0.5 mm long. Calyptra mitrate or subcucullate. Spores large, distinctly papillose, 23-28 µm in diameter.

Distinguishing features.

1. Halophyte.
2. Leaves muticous, usually bistratose in upper and middle parts; laminal cells papillose or mamillose on both surfaces.
3. Costa stout, with a chain of guide cells between stereid bands, biconvex in cross-section.
4. Perichaetial leaves much elongated, usually twice as long as vegetative leaves.
5. Spores large, 23-28 µm in diameter.
6. Exothecial cells elongated-rectangular (usually 3-4:1) with thick walls.

This species is clearly distinguished from other species of the genus by the features mentioned above. For this moss, however, <u>Grimmia rigida</u>, <u>Guembelia crassinervia</u>, and <u>Grimmia kindbergii</u> were described by Bridel (1826), C.Müller (1890), and Holzinger (1911) respectively. The first species was reduced to a synonym of

*G. maritima* by C.Müller (1849) and the other two species by Jones (in Grout, 1933). *G. rigida* was published without comparison with any species of the genus. By an examination of the holotype specimen in B-Brid(Berlin), no divergent features to be noted specially here were found except only the plants' colour being tinged with dark reddish-brown. *Guembelia crassinervia* was compared with *Grimmia conferta* (=*Schistidium confertum*) when published and separated from it by the long perichaetial leaves, stout and papillosed costa, etc. Any species other than *S. maritimum* does not possess all the characters mentioned above. By an investigation of the lectotype specimen of *Guembelia crassinervia*, it was shown that it contained the plants with thick and rigid leaves, which had some metalic luster. The thick and rigid texture of leaves can be ascribed to pluristratosity of lamina being 2-3, at places 4 cell-layers in thickness, in the upper half of leaf. The metalic luster on leaves is due to indistinct papillosity or mamillosity on laminal cells and on epidermal cells of the costa (but somewhat distinct on young leaves at branch-tip). However, the biconvex costa, the two stereid bands of costa, large-sized spores, enlarged perichaetial leaves, and somewhat elongated seta and foot were also observed, by which *S. maritimum* is best characterized in the gnus *Schistidium*. Thus, I agree with Jones' ( in Grout, 1933) treatment of regarding *G. crassinervia* as a synonym of *S. maritimum*.

The original specimen of *G. kindbergii* was first reported under the name of *G. agassizii* by Holzinger (1910), but he admitted many different features from those in the description of *G. agassizii* and gave a detailed description concerning it, with special emphasis to bistratose lamina. In the next year, Holzinger (1911) finally published it as a new species, *G. kindbergii*. He compared it with *G. maritima* (=*S. maritimum*) besides *G. agassizii* (=*S. aga-*

sizii (=S. agassizii) and concluded that G. kindbergii was decidedly differentiated from these two species in several important respects, especially in the bistratose lamina. The examination of an isotype specimen conserved in H-BR lead me to the agreement with the opinion of Jones (1933).

The identity of the three species discussed above with Grimmia maritima was confirmed by the examination of their type specimens.

In Turner's herbarium (BM), two specimens on different herbarium sheets were put forward as candidats for the type of G. maritima. The specimen (1 or a) on the sheet no. 2 was accompanied with the following information in the right lower corner: 1. Ireland, D.Scott. 1802; while the other on the sheet no. 3 was neither numbered nor alphabetised, but had a small piece of paper (a part of letter envelope) on which the undecipherable handwriting in pencil was given: Grimmia maritima found pretty abundant on some..........stone .....in the coast near Balbry along with lichen....covered by the sea....tide. On the reverse side of the small piece of paper was detected another handwriting "Scott Esq." with two postmarks. I could not get any clue to know whether the specimens no. 2-1(or -a) and no. 3-s.n. were the plants collected at the same time and at the same locality, though Balbry is situated in Ireland. But, I prefer to designate the specimen of No. 2-1( or -a) as the lectotype and consider that of no. 3-s.n. as the isotype.

The present species is, in Japan, restricted to rocky coast in Rishiri isl., northernmost of Hokkaido, where Iwatsuki (1962) first recorded it from Japan. Owing to much elongated perichaetial leaves it is rather easily recognized even in the field.

Habitat. On sunny exposed rocks within a streach of sea-water spray, in the orohemiboreal subzone.

Range. Japan (Hokkaido); North and West Europe, Eastern and Western part of North America.

19. *Schistidium rivulare* (Brid.) Podp. (Fig. 36 & 37) Beih. Bot. Centralbl. 28(2): 207. 1911.

*Grimmia rivularis* Brid., Journ. f. Bot. 1800 (1): 276. 1801.

Type: Ad Thuringici saltus rivulos frigidos, ex. gr. prope Klein Schmalkalden, E-Germany (holotype in B-Brid).

*Grimmia apocarpa* Hedw. var. *rivularis* (Brid.) Nees et Hornsch., Bryol. Germ. 2(1): 101. 1827.

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

*Schistidium apocarpum* (Hedw.) Bruch et Schimp.var. *rivulare* (Brid.) Bruch et Schimp., Bryol. Eur. 3: 100, 234 r. 1845.

*Schistidium apocarpum* (Hedw.) Bruch et Schimp. form. *rivulare* (Brid.) Loeske, Biblioth. Bot. 101: 53. 1930.

Plants brownish- to blackish-green, in loose, soft, large tufts. Stems reaching 7 cm long, leafy above, defoliated or with decayed leaves below, often branched, with central strand. Leaves imbricated when dry, usually ovate to ovate-lanceolate, obtuse or muticous at apex, somewhat concave, obtusely keeled, usually 1.8-2.5 mm long and 0.7-1.3 mm wide. Margins entire, but at apical part of leaf irregularly denticulate or serrulate, recurved on both sides (one side stronger than another, extending from leaf-base to upper part of leaf), thickened in two cell-layers in 2-4 marginal rows of cells in upper part of leaf. Costa very rigid, tightly attached to stem, percurrent or vanishing below the apex, towards the base becoming wider and thicker, plane-convex to biconvex in cross-section from middle portion of leaf, consisting of nearly homogeneous cells, with 2-4 adaxial epidermal cells. Laminal cells smooth, sometimes collenchymatous, 7.5-9.5 µm wide, nearly homogeneous except at base; basal cells longly rectangular (2-4:1). Autoicous. Perichaetial leaves more concave; upper quadrate or shortly rectangular cells passing downward in a V-shaped line into basal part of laxly rectangular, hyaline cells. Capsule immersed, semi-globular, dark-brown, ca. 0.8 mm long and thick. Seta ca. 0.4 mm long. Exothecial cells rounded-quadrate or rectangular, with thick walls. Stomata ±10 in number. Peristome teeth lanceolate, with filiform tip, dark purple-red at base and reddish-brown above; perforated in upper half; outer and inner surfaces densely papillose throughout. Operculum obliquely beaked. Calyptra cucullate, generally falling attached to operculum. Spores large, papillose on surface, 19-23 µm in diameter.

Distinguishing features.

1. Aquatic plants.
2. Leaves large, 1.8-2.5 mm long, 0.7-1.3 mm wide, with rather obtuse apex; upper margins irregularly serrulate or denticulate; lamina frequently bistratose in many striae.
3. Costa stout and tightly attached to the stem, therefore leaves are not easily detachable from the stem and only the costal part remains on the stem after the lamina were eroded by the current water.
4. Stems with well-developed central strand.
5. Exothecial cells with thick-walls.
6. Spores large, ranging 19-23 µm in diameter.

Among the salient diagnostic characters mentioned above, the growing habitat is the most useful clue to recognize this species in the field. This species is closely related to _S. appcarpum_, but easily differs from it by the leaf-characters: leaves ovate to ovate-lanceolate, muticous, irregularly serrulate on upper margins; costa stout, plane- to bi-convex in cross-section, the collenchymatous quadrate exothecial cells with thick walls and the large-sized spores.

An exotic species, S. alpicola (syn. S. agassizii), is closely similar to this species in both ecological and morphological characters, but the two species can be differentiated from each other in following point:

| | S. rivulare | S. alpicola |
|---|---|---|
| leaf-form | ovate-lanceolate, keeled and concave in upper part | lingulate, plane in upper part |
| lamina (excl. margins) | unistratose, striately bistratose at places | unistratose throughout |
| margins | narrowly to widely recurved on both sides, extending from the base to near the apex; almost bistratose | plane or narrowly recurved on both sides at the shoulder parts, never extending to the upper part; almost unistratose |
| capsule | immersed in perichaetial leaves | emergent or partially immersed in perichaetial leaves |

Schistidium rivulare was described by Bridel (1801) under the genus Grimmia. Later, it has been treated as a variety of G. apocarpa (Nees et Hornsch., 1827), S. apocarpum (Bruch et Schimper, 1845), G. alpicola (Wahlenberg, 1812), or as a forma of Schistidium apocarpum (Loeske, 1930). Many bryologists except Podpera (1911), have treated the present species as an infraspecific taxon. Recently, Deguchi (1978) clarified the identity of S. agassizii with G. alpicola which had long been misunderstood by the interference of the different taxon. *S. rivulare* (=*G. rivularis*) has thus lost the authority to be treated as a variety of *G. alpicola*. So-called "*G. alpicola*" and its variety var. *latifolia* have been first recorded from Japan by Sakurai (1954) and by Takaki et al. (1970) respectively. No specimens determined as "*G. alpicola*" could be detected in Sakuri's herbarium in MAK. The speciemens labelled as var. *latifolia* conserved in both Sakurai's and Takai's herbaria (Mt. Senjo, South Japanese Alps, 2900 m, Aug. 10, 1953. leg. Takaki) contain the plants with leaves of various shapes from ovate-lanceolate to ovate, whose upper margins varing from nearly entire to low-serrulate or denticulate. These specimens are not *G. alpicola*, but are clearly identified as *S. rivulare*.

Habitat. On periodically irrigated boulders or rocks in or beside creeks or rivers, mainly in the orohemiboreal to the upper boreal zone, occasionally in the orotemperate zone.

Range. Japan (Hokkaido, Honshu); Europe, North America.

### 20. *Schistidium subconfertum* (Broth.) Deguchi *comb. nov.*

(Fig. 38)

*Grimmia subconferta* Broth., Sym. Sin. 4: 45. 1929. *syn. nov.*

Type: An nassen Schieferfelsen der Hg. st. auf dem Gonschiga SW von Muli gegen Dschungdien, 4650 m, c. sp., 6. VIII. 1915, No. 7493 (holotype in H-BR; isotype in PC).

Plants dark-green above, blackish below, in low dense small tufts. Stems short, 1-1.5 cm long, frequently branched, with or without central strand. Leaves from widely ovate base gradually narrowed to lanceolate upper subulate part, without or rarely with short hyaline hair-point, 1.1-1.6 mm long and 0.42-0.65 mm wide.

Margins throughout entire, thickened in two cell-layers from the middle to the top, recurved on one side, extending from near the leaf insertion to the middle. Costa stout, percurrent, gradually narrowed toward the base, smooth throughout on dorsal surface. Lamina unistratose in most part, bistratose in 1-2 rows on upper margins. Upper and middle laminal cells transversely rectangular to quadrate, with nearly smooth walls; lower ones elongated to rectangular (to 4:1), with somewhat sinuose walls; basal paracostal cells transparent, more or less inflated, forming the transparent area; basal marginal cells of a few rows also becoming transparent extending upwards in a short distance. Autoicous. Perichaetial leaves larger, ovate-lanceolate, with cuspidate apex whose cells are more or less eroded and distorted in shape. Capsule sharrowly immersed in perichaetial leaves. Peristome teeth rudimentarily developed, papillose on both outer and inner surfaces. Exothecial cells variable in shape, varying from transversely rectangular to quadrate, with equally thickened walls. Stomata ca. 8 in number. Operculum obliquely rostrated, somewhat hooked. Spores small, finely papillose, 9-10 μm in diameter. Calyptra cucullate.

Distinguishing features.

1. Peristome teeth rudimentary.
2. Perichaetial leaves scarcely overtopping the capsule (capsule sharrowly immersed in perichaetial leaves).

This species is best characterized by the rudimentary peristome teeth. According to the textbooks, S. pulvinatum resembles S. subconfertum in the structure of peristome. After my examination of the specimen of S. pulvinatum conserved in H-SOL ( as Gymnostomum pulvinatum; isotype ?) which possesses the following handwriting date (may be of Lindberg): "*Gymnostomum pulvinatum* Hoffm. Hab. in rupestribus Göttingia leg. Hoffman (Sp. orig. ex hb. dr. sc. Pitrop.)", it became evident that the material in question was no more than what we call at present *Grimmia* (sect. *Grimmia*) *anodon* being characterised by the total lack of peristome teeth and the ventricosed capsule, immersed in the perichaetial leaves (by the immersion of capsule in perichaetial leaves, this species appears like a member of the genus *Schistidium* and leads bryologist (e.g., Loeske 1913 ) to misunderstanding of placing it in this genus.

I failed to examine the holotype specimen of *Gymnostomum pulvinatum* conserved at Hedwig-Schwaegrichen's herbarium at Genève. Therefore the entity of *Gymnostomum pulvinatum* remains vague to me even though the detailed description was given in various textbooks, e.g., by Limpricht (1889). If the result of my examination of the material at H-SOL is applicable to the original specimen eventually studied by Hedwig for the description of *Gymnostomum pulvinatum*, it will evoke a number of nomenclatural changes, resulting in that all taxa known at present under the generic name *Schistidium* should be newly combined under a new generic name, for the reason that the genus *Schistidium* has already been automatically lectotypified by Bruch et Schimper (1945) who cited only *S. pulvinatum* among the species of the genus *Schistidium* of Bridel in the emended *Schistidium*, transferring Bridl's other species of *Schistidium* in various other genera. *Anoectangium flaccida*, *Grimmia sphaerica*, and *G. hoffmanii*, all of which have been regarded as the synonymy of *S. pulvinatum*, have not been examined by me, so I would like to use, to prevent the confusion, the Brotherus's epithet given for a Chinese moss, whose type is certainly located in H-BR and PC, until the study of the type specimens of the synonymous taxa as well as the holotype of *Gymnostomum pulvinatum*. Japanese plants of *S. subconfertum* differ from the type in size, namely, larger in many organs: leaf, laminal cells, capsule and exothecial cells, and width of peristome teeth, etc. But, these differences seem to be of little importance and do not warrant separate taxonomic recognition for Japanese ones.

*S. subconfertum* is most closely related with *S. confertum* among the Japanese species of *Schistidium*, but the former differs from the latter by the rudimental peristome teeth and the shallowly immersed capsule. In sterile condition they are hardly distinguished from each other.

Habitat. On rocks in the summit region of high mountains in the upper oroboreal subzone.

Range. Japan (Honshu); China.

### *Coscinodon* Spreng., Einl. Stud. Krypt. Gew. 281. 1804.

Type species: *C. pulvinatus* Spreng.

### 21. *Coscinodon cribrosus* (Hedw.) Spruce (Fig. 39)

Ann. Mag. Nat. Hist. ser. 2, 3: 491. 1849.

*Grimmia cribrosa* Hedw., Spec. Musc. 76. 1801.

Type: In patris Goslaria, Persson et Schrader (holotype in G).

*Coscinodon pulvinatus* Spreng., Einl. Stud. Crypt. Gew. 372. 8f. 75. 1804. *nom. illeg. incl. spec. prior.*

*Coscinodon humilis* Horik. et Nog., J. Jap. Bot. 14: 25. 1. 1939. *hom. illeg. pr. Coscinodon humilis* Milde, 1864. *syn. nov.*

Type: Kyusyu. Mt. Kudyu (ca. 1500 m), Prov. Bungo, A.Noguchi, no. 3298, Nov. 1932 (holotype in HIRO).

Plants blackish-green to blackish, hoary above, in dense, fragile cushions, often confluent and forming wide patches. Stems short, o.5-1 cm long, with central strand, moderately branched and fastigated. Leaves densely crowded, imbricated, occasionally spirally imbricated, small, ovate-lanceolate or lanceolate, clearly keeled above, usually cymbiform in upper part of leaf, with a hyaline hair-point which are slightly or clearly tooth, often smooth, reaching nearly as long as the length of the leaf, 1-1.5 mm long and 0.3-0.5 mm wide. Margins entire, more or less thickened above. Lamina unistratose, often striately bistratose in upper part of leaf, with margins bistratose above, unistratose at middle and below. Costa percurrent, usually with small median cells of very thin-walls. Laminal cells more or less homogeneous, 6-9 µm wide, usually transversely rectangular or quadrate with rather thick walls in upper and middle parts; basal paracostal cells elongated, smooth-walled, becoming translucent and forming distinct translucent area; cells from marginal 3-5 rows quadrate to rectangular or transversely rectangular with thin longitudinal and thick transverse walls, forming transparent angular area. Dioicous. Perichaetial leaves larger and wider, ovate-lanceolate, with long hyaline hair-point extending as long as the length of the leaf. Capsule immersed or more or less emergent, obconic, 0.85-0.95 mm long, 0.8-0.9 mm thick. Seta short, 0.5-0.8 mm long, straight. Operculum large for urn, with long, straight beak. Peristome teeth reddish-brown, lanceolate, strongly perforated like sieb and often divided into filiform branches above, rarely less cribrose; outer surface densely papillose in upper 2/3, smooth below; inner surface densely so on whole surface. Exothecial cells elongated-rectangular, at places rounded-rectangular or hexagonal with thick walls, mamillose in cross-section. Annulus of Elongata type. Calyptra mitriform, clearly plicated, lacelated at base. Spores papillose on surface, 12-15 µm in diameter.

Distinguishing features.

1. Calyptra with plicae, covering almost the whole capsule.
2. Peristome teeth cribrose.
3. Leaves keeled, cymbiform; margins plane on whole margins.
4. Laminal cells with thick walls; angular cells transparent, thick transverse and thin longitudinal walls; basal paracostal cells elongated, translucent.

There occasionally occur the plants with leaves somewhat spirally imbricated when dry as observed in <u>Grimmia</u> <u>funalis</u>. Such plants, when without sporophytes, are confused with smalle-sized plants of <u>G.</u> <u>funalis</u>, especially the form of var. <u>calvescens</u>. The specimens (Mt. Kurobi, Kotsuke, No. 187, Sept. 19, 1914, A.Yasuda; Prov. Kotsuke, no. 384, June 1916, A.Yasuda) in H-BR which was reported from Japan by Brotherus (1924) as <u>G.</u> <u>funalis</u> fall under this case, though from the same locality, true <u>G.</u> <u>funalis</u> has been collected (No. 40535, 19 Sept. 1914, coll. K.Tsunoda, det by Yasuda;TNS). Even if it were in effect collected by Tsunoda, the specimen No. 187 can not be regarded as a part of No. 40535 sent him for the determination. <u>C.</u> <u>cribrosus</u>, even when sterile and the leaves spirally imbricated, can be distinguished from <u>G.</u> <u>funalis</u> by the basal marginal cells with thin longitudinal and thick transverse walls.

Sterile plants of <u>C.</u> <u>cribrosus</u> may also lead to the misidentification as <u>G.</u> <u>subsulcata</u>, from which it differs in gaving more rigid leaves, laminal cells with more thickened walls, and basal paracostal cells being elongated-rectangular (usually more than 3:1) and frequently translucent, differentiated from neighboring quadrate to short rectangular cells (up to 3:1). The last character has been used by Nyholm (1956) for distinguishing it from *G. caespitica*.

The plicae on lamina is variously developed in this species, wether distinctly or indistinctly. The species with non-plicated leaves of the genus *Coscinodon* has been treated as *C. humilis* Milde in Europe and *C. humilis* Horik. et Nog. (*nom. illeg. homonym*) in Japan. The type specimen of *C. humilis* Milde was not available for this study, therefore, the taxonomic comments on European *C. humilis* should be withheld. As far as Japanese *C. humilis* is concerned, it should be regarded as being integrated in the range of variation of *C. cribrosus*.

Habitat. On exposed rocks in the summit region of mountains, in the orotemperate to the upper oroboreal zone.

Range. Japan (Hokkaido, Honshu, Shikoku, Syushu); Europe, North Africa, Kashmir, Arctic Siberia, Arctic North America, Greenland.

## VII. Species to be excluded from the family Grimmiaceae

### 1. *Grimmia cratericola* Sak. et Tak.

This small-sized plants were described by Sakurai and Takaki (1951) based on the plants from the summit of Mt. Fuji. It has the capsules immersed in perichaetial leaves and the leaves with as same metalic luster and thin texture as many species of Di

*Dicranum* or its relative genera. In the cross-section of leaf, the lamina consists of somewhat transverse-rectangular cells, not of vertically elongated-rectangular cells which are observed in common in the species of *Grimmia* and other genera of the Grimmiaceae. The most important, essential feature enough to exclude this species from the genus *Grimmia* and to place it in the Dicranaceae, is the structure of peristome teeth. The peristome teeth of *G. cratericola* are divided into two branches to the middle and on the outer surface longitudinal narrow grooves (appearing like vertical striae) are developed as seen in common in the Dicranaceae, on the inner surface the coarse papillae are scatteringly distributed. In the genus *Grimmia*, on the outer surface of the peristome dense papillae are arranged in random, rarely horizontally or obliquely on the inner surface the minute papillae are densely distributed throughout the surface. The bifid teeth also occur in some species of *Grimmia*, but not extending to the middle. Dusén (1900) described *Grimmia jan-mayensis* from the island Jan Mayen (c. N 71$^{\circ}$long, W 8$^{\circ}$30' Lat.) and his species was characterized by the features which also remind me of the characteristics of *Grimmia cratericola* mentioned above. By the courtesy of the curator of S-PA, I could examine the holotype of *G. jan-mayensis* and found it was conspecific with our *G. cratericola*. In the monograph, Loeske (1930) wrote about the species, *G. jan-mayensis*, as "sieht nach der Abbildung einem *Schistidium*, etwa einem lockerer *S. maritimum* merkwürdig ähnlich, wurde aber von Hagen als *Dicranum anderssonii* erkannt. Ein in morphologischer und systematischer Hinsicht sehr bemerkenswerter Fall !" According to Index Muscorum (van der Wijk, Margadant & Florschütz, 1962), *G. jan-mayensis* is dealt as having been reduced to a synonymy of *Arctoa fulvella* var. *andersonii* by Loeske in "1913".

However, no referrence is found in Loeske's work of the year 1913. It seems to be an error of citation. In addition, even though Loeske (1930) mentioned *Dicranum anderssonii*, it is not followed by the author's citation. Therefore, the management in reducing *G. jan-mayensis* to a synonym of *Arctoa fulvella* var. *anderssonii* is not admitable, since an earlier homonym, *Dicranum anderssonii* C.Müll., exists. Further and final examination should be extended to the type of *Arctoa anderssonii* Wich. which is known at present as a variety of *Arctoa fulvella*. Though I cannot find the oppotunity to examine the type specimen of *A. anderssonii*, Wichra's (1859) original description and his illustrations are enough to confirm the identity of *G. jan-mayensis* and *G. cratericola* with *Arctoa anderssonii*.

*Arctoa fulvella* (Dicks.) B.S.G. var. *anderssonii* (Wich.) Grout, Bryologist 43: 87. 1846. —— *Arctoa anderssonii* Wich., Flora 42: 432. 7f. 3-8. 1859. Type: Auf dem felsigen Gipfel des Njunnats ohngefähr 4000 fuss hoch über der Meeresfläche. leg. M.Wichura (type not seen). —— *Dicranum anderssonii* (Wich.) Schimp., Syn. 1: 689. 1860. *hom. illeg.* —— *Grimmia jan-mayensis* Dus., Bih. K. Svensk. Vet. Ak. Handl. 26 Afd. 3(13): 13. ab. 1. 1900. *syn. nov.* —— *Grimmia cratericola* Sak. et Tak., J. Hattori Bot. Lab. 6: 2, f2. 1951. *syn. nov.* Type: On soil in crevices of lava, altitude about 3700 m, Mt. Fuji. Coll. N.Takaki, July 22, 1950. No. 9068 ( holotype in private herbarium of N.Takaki; isotype in MAK).

## VIII. Species not available

1. *Grimmia limbatula* C.Müll., Nuov. Giorn. Bot. Ital. n. ser. 3: 108. 1896.

Type: ex sylvis Yokohamae (Fr. Schaal 1897).

This species was described by C.Müller (1896) in "Bryologia Provinciae Schen-si Sinensis", with the following description and the reference to the specimen: "ex sylvis Yokohamae (Fr. Schaal 1897) partibus omnibus proxima differt doliis distinctius denticulatis mucrone destitutis atque alieno areolatis". "Yokohama" may be Yokohama city, Kanagawa Pref. Central Japan. Paris (1904) indicated the distributional range as "Japan" for *G. limbatula* in his Index Bryologicus (p. 278). Unfortunately I could not locate the Schaal's specimen. Judging from the original description and the fact that this species was described incidentally under 56. *Grimmia* (*Platystoma*) *filicaulis* which is closely related or conspecific with *Schistidium gracile*, this may be a form of *Schistidium gracile* especially the form described by Cardot as *Grimmia apocarpa* var. *denticulata*.

## XI. Specimens examined

### 1. *Grimmia affinis* Hornsch. (Map 1)

HOKKAIDO. *Rebuntohokubu*. Mt. Rebun (480 m, HD-12012, 12016). *Asahidake*. Mt. Hakuun (1750 m, HD-12272). *Yamabe*. Mt. Ashibetsu (1720 m, HD-12367, 12358; 1725 m, HD-12370, 12372, 12373, 12374, 12375, 12378; 1500 m, HD-12365). *Daisetsuzan*. Mt. Hakuun (2050 m, HD-12237). *Rusutsu*. Mt. Yotei (1800 m, HD-12674).

HONSHU. Pref. Iwate. *Hayachinesan*. Mt. Hayachine (K.Ogura, det by Brotherus as *G. unicolor* in H-BR). Pref. Miyagi. *Sendai*. Sendai (Ihshiba-377, det by Brotherus as *G. commutata* Hüb. in H-BR). Pref. Toyama. *Tateyama*. Mt. Tateyama (2720 m, HD-13178). *Shiroumadake*. Mt. Shirouma (2790 m, HD-12787; TN-4290), Mt. Hakubayari - Kaerazunoken (2740 m, HD-12789; 2750 m, HD-12791, 12793, 12794, 12795). Pref. Nagano. *Shiroumadake*. Mt. Norikura (2436 m, HD-12758), Mt. Shakushi - Mt. Hakubayari (NT-7055), Mt. Shirouma (NT-9554), Mt. Norikura - Hakubaoike (2436 m, HD-12757). *Omachi*. Mt. Karamatsu (2400 m, HD-12817), Mt. Kashimayari (2450 m, HD-12823), Mt. Jigadake (2500 m, HD-12840). *Yarigadake*. Mt. Otensho (2800 m, HD-12890), Mt. Yari (3000 m, RW-11667), Mt. Otensho - Mt. Nishidake (2600 m, HD-12912, TN-801). *Kinpusan*. Jumonji pass (HD-8264), Mt. Mikuni (1900 m, H.Kashiwadani-s.n.). *Ontakesan*. Mt. Ontake (2780 m, HD-13126b). *Miyota*. Uchiyama valley (750 m, H.Kashiwadani-s.n.). *Ichinose*. Sensui pass (2720 m, NT-10087), Mt. Senjo (2600 - 3000 m, KS-9166). *Akaishidake*. Mt. Akaishi (3000 m, NT-6808, 6818). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2700 m, TS-8385; 2800-3190 m, KS-9437; 2900 m, HD-13239, 13240; 2950 m, HD-13246, 13250; 3000 m, HD-13257; 3100 m, NT-14366, 14384, 14387, Sakurai-s.n., HD-13303; 3100 m, HD-13288, 13289; 3175 m, HD-13283), Mt. Notori - Narata (1670 m, HD-13322), upper course of Norogawa river

(1750 m, NT-14278), Mt. Senjo (2700 m, NT-14534, det by Takaki as *G. elongata*, NT-14539, 13540, det by Takaki as *G. ovata*). *Okawara*. Mt. Shiomi (3000 m, NT-14992). *Akaishidake*. Mt. Higashidake (3000 m, NT-6808, NT-6818 in MAK).

SHIKOKU. Pref. Ehime. *Nihama*. Mt. Maeakaishi (1620 m, HD-11466).

### 2. *Grimmia anomala* Hampe ex Schimp. (Map 2)

HONSHU. Pref. Nagano. *Kamikochi*. Mitsumata - Mt. Chogadake ( 2600 m, HD-12874). *Akaho*. Mt. Komagadake (2300 m, HK-9056). Pref. Ishikawa. Kyogadake. Mt. Hakusan (1000-2000 m, KANA-36644).

### 3. *Grimmia apiculata* Hornsch. (Map 3)

HONSHU. Pref. Pref. Toyama. *Tateyama*. Mt. Tateyama (2850 m, HD-13146; 2960 m, HD-13162). Pref. Nagano. *Omachi*. Mt. Kashimayari (2450 m, HD-12821, 12827, 12828, NT-10398, 10403). *Yarigadake*. Mt. Tsubakuro (2700 m, NT-19747, + *Arctoa fulvella*), Mt. Yari (2700 m, NT-12561; 3050 m, HD-12934; 3100 m, NT-19748). *Norikuradake*. Mt. Norikura (2670 m, NT-39810). *Akaho*. Mt. Komagadake (2850 m, HD-12996, 12997b; 2880 m, HD-12998, 13006). *Yatsugadake*. Mt. Tasu (2700-2830 m, KS-13520; 2800 m, HA-9433; 2899 m, NT-4752, 4755 + *Arctoa fulvella* var. *anderssonii*, NT-4826 +*Schistidium gracile*). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2900 m, HD-13241; 2950 m, HD-13244; 3000 m, HD-13273; 3020 m, HD-13304, 13308; 3100 m, HD-13258b, 13259, 13263, 13286, 13293, NT-14406; 3170 m, HD-13272, 13269; 3180 m, HD-13281). *Fujisan*. Mt. Fuji (3000 m, RW-4293, NT-39940, 39950, K.Ota-5872; 3775 m, RW-4182, 4263; 3776 m, RW-4241). Pref. Shizuoka. *Fujisan*. Mt. Fiji (3720 m, NT-9057; 3776 m, NT-39918, 39936). *Okawara*. Mt. Shiomi (2900 m, RW-6015).

4. *Grimmia atrata* Mielich. ex Hornsch. (Map 4)

HOKKAIDO. Sharidake. Mt. Shari (1000 m, HD-12514). Tokachidake. Mt. Furano (1850 m, HD-12357), Tokachiyama (Faurie-3380 in KYO, H-BR, PC).

HONSHU. Pref. Fukushima. Nihomnatsu. Mt. Tetsuzan (ca. 1700 m, RW-1691 in MAK). Pref. Nagano. Shiroumadake. Mt. Karamatsu - Mt. Goryu (2700 m, HD-12803). Yarigadake. Upper course of Yumata river (1700 m, NT-19010). Pref. Nara. Sanjogadake. Mt. Wasamata (1460 m, HD-10555), Shakagadake (1790 m, HD-6776).

5. *Grimmia brachydictyon* (CArd.) Deguchi (Map 5)

HOKKAIDO. Rishirito. Oniwaki (100 m, NT-15425, NICH-27399), Himenuma (130 m, HD-12165, 12166; 140 m, HK-8517), Mt. Rishiri ( 1-1000 m, NICH-30103; 320 m, HD-12064; 340 m, 12067; 350 m, HK-8467, HD-12068, 12070, 12071, 12072; 370 m, HK-8460; 450 m, HD-12092; 500-600 m, NICH-27390; 510 m, HD-12080; 540 m, HD-12081; 560 m, HD-12082; 610 m, HD-12084; 650 m, HK-8481; 820 m, HD-12094; 910 m, HD-12098b; 1010 m, HD-12102; 1320 m, HD-12146; 1450 m, HD-12129). Rebuntohokubu. Mt. Rebun (400 m, HD-11993). Asahidake. Kogenonsen (1300 m, HK-9761; 1500 m, HK-9736), Mt. Hakuun - Mt. Chubetsu (1800 m, HD-12290), Mt. Kaun (1260 m, HD-12317). Tokachigawajoryu. Tomuraushi spa (450 m, HD-11828, 11861; 530 m, HD-11829; 650 m, HD-11936). Yamabe. Mt. Ashibetsu (600-900 m, NICH-121633; 620-700 m, NICH-113589; 1200 m, HD-12389, HK-2167). Mikage. Mt. Tsurugi (680 m, HD-12397; 720 m, HK-2441; 800 m, HD-12390, 12391, 12392, 12398). Horoizumi. Mt. Apoi (750 m, HA-24109; 810 m, NT-16233, HA-24114, NICH-22270). Sharidake. Mt . Shari (650 m, HD-12490; 710 m, HD-12497; 1220 m, HD-12520, 12521). Shiretokomisaki. Mt. Shiretokodake (50 m, HK-3076). Rausu. Mt. Rausu (200 m, HK-

4257, 4285; 720 m, HD-12549; 750 m, HD-12552; 800 m, HD-12588, 12589). *Kokuryo*. Mt. Shokanbetsu (700 m, HD-12656, 12658; 850 m, HD-12667; 1000 m, HK-3365; 1100 m, HK-3428). *Rusutsu*. Mt. Yotei (850 m, HD-12599; 950 m, HD-12594; 1300 m, HD-12602, 12603; 1750 m, HD-12607, 12608; 1800 m, HD-12611, 12612).

HONSHU. Pref. Aomori. *Hakkodasan*. Mt. Hakkoda (1400 m, HK-9360). Pref. Iwate. *Hayachinesan*. Mt. Hauachine (1400 m, NT-3670; 1700 m, RW-5107). Pref. Fukushima. *Azumayama*. Hibarako lake (850 m, RW-1198). *Fujiwara*. Oze (1400 m, HK-9165). Pref. Yamagata. *Yamagata*. Yamadera (NT--24349). Pref. Nigata. *Myokosan*. Mt. Myoko (1190 m, HD-12987; 1290 m, HD-12988; 1580 m, HD-12975; 1900 m, HD-12973; 1930 m, HD-12974; 2150 m, HD-12983). Pref. Toyama. *Shiroumadake*. Mt. Shirouma (1600 m, RW-7933; 2790 m, HD-12781; NT-6853, 6897, 6899, 6917, NT-s.n.), Kurobishi hutte (1250 m, NT-10240). Pref. Nagano. *Togakushi*. Mt. Togakushi (1500 m, HD-13194; 1600 m, HD-13195; 1700 m, HD-13201; NT-12246), Togakushi (1100 m, HD-13195; 1200 m, HD-13194), Mt. Kurohima (N.Iwasaki-1375 in MAK). Naebasan. Koakazawa (850 m, HD-14713). *Suwa*. Kirigamine (1600 m, HK-9093; NT-6540). *Nakano*. Shiga Heights (2000-2250 m, KS-12753). *Suzaka*. Sugadaira Heights (Sakurai-14532, NT-860). *Omachi*. Mt. Harinoki (1700 m, NT-10467), Mt. Kashimayari (2800 m, NT-10422), Mt. Yari (NT-s.n. + *Paraleucobryum longifolium*, *Lesquereuxia robusta*, *Diplophyllum albican*, *Lophozia sp.*). *Kamikochi*. Mitsumata - Mt. Chogadake (1430 m, HD-12843; 1440 m, HD-12845, 12850; 2180 m, HD-12859; 2200 m, HD-12860; 2550 m, HD-12864), Mt. Yari - Kamikochi (1500 m, HD-12943; 1800 m, HD-12941, 12946, 12947; 2000 m, HD-12939). *Akaho*. Mt. Komagadake (2350 m, NT-17717; 2450 m, HD-13068). *Kajikazawa*. Kitazawa (1750 m, NT-14247 + *Racomitrium canescens* var. *ericoides*, *R. fasciculare*, *Thuidium philibertii*, *Schistidium gracile*, *Pogonatum alpinum*, *Bartramia pomiformis*). *Akaishidake*. Mt. Higashi

(200-2250 m, KS-12753). Ichinose. Mt. Senjo (2600-3000 m, KS-9149; 2600 m, RW-18762), Mt. Kitadake (2800 m, HD-13311). Pref. Ishikawa. Hakusan. Mt. Hakusan (1400 m, HK-8793; 1450 m, HK-8861; 1700 m, HA-26279, HK-8828, 8854). Pref. Shizuoka. Akaishidake. Mt. Osawa (2500 m, TS-6404). Okawara. Mt. Shiomi (2750 m, RW-6120), Mt. Gonemon (2650 m, RW-6017). Pref. Nara. Odaigaharazan. Mt. Odaigahara (1040 m, HD-7929 + Schistidium liliputanum; 1450 m, HD-10137). Pref. Hyogo. Wakasa. Mt. Hyonosen (1000 m, HD-12714, 12719). Pref. Tottori. Muraoka. Mt. Hyonosen (1500 m, Ochi-8611). Daisen. Mt. Daisen (760 m, HA-6687, 11913, 17430; 800 m, HA-17486, HD-6081; 850 m, HD-5865, 5866; 880 m, HD-6144; 900 m, HK-3879; 1360 m, HD-5942). Pref. Hiroshima. Sandankyo. Sandankyo (600 m, HD-13397, 13400, 13402), Okusandankyo (750 m, HD-15152), Nakatsuya river (750 m, HD-14892; 900 m, HD-14958), Mt. Kanmuri (700-800 m, HD-14916; 800-900 m, HD-14929; 900-1000 m, HD-14940, 14957).

6. Grimmia curvata (Brid.) De Sloov. (Map 6)

HONSHU. Pref. Nagano. Shiroumadake. Mt. Shirouma (NT-6964 + Polytrichum piliferum, Pogonatum alpinum). Yarigadake. Mt. Yari (2600 m, HD-12921; 2850 m, ST-3477), Mt. Otensho - Mt. Nishidake (2600 m, HD-12914), Mt. Eboshi (2400 m, NT-12404). Akaho. Mt. Komagadake (2300 m, HK-9007; 2520 m, HD-13064; 2530 m, HD-13062). Akaishidake. Mt. Akaishi (NT-674). Ichinose. Mt. Kitadake (2800 m, NT-14357; 3000-3100 m, KS-9382, RW-16908).

7. Grimmia donniana Sm. (Map 7)

HOKKAIDO. Shari. Mt. Shari (1540 m, HD-12527, 12531). Daisetsu-zan. Mt. Hokkai (2050 m, HD-12227). Asahidake. Mt. Hakuun - Mt.

Chubetsu (1900 m, HD-12292). Nukabira. Mt. Nipesotsu (2000 m, HD-12474 + Andreaea rupestris var. fauriei).

HONSHU. Pref. Yamanashi. Ichinose. Mt. Kitadake (2950 m, HD-13245; 3185 m, HD-13278). Pref. Nagano. Shiroumadake. Mt. Shirouma (2400 m, HD-12810 + Andreaea rupestris var. fauriei). Omachi. Mt. Jigadake (2500 m, HD-12839 + Andreaea rupestris var. fauriei). Yarigadake. Mt. Otensho (2500 m, HD-12907). Kamikochi. Mt. Chogadake (2650 m, HD-12869). Akaho. Mt. Komagadake (2800 m, HD-13023; 2830 m, HD-12995 + Grimmia apiculata).

8. Grimmia elongata Kaulf. (Map 8)

HOKKAIDO. Rishirito. Mt. Rishiri (1310 m, HD-12115; 1340 m, HK-8450; 1680 m, HD-12140, 12142). Daisetsuzan. Mt. Kurodake - Mt. Hokkai (1850 m, HD-12210; 1900 m, HD-12217, 12218; 1920 m, HD-12216; 1950 m, HD-12214), Mt. Kurodake (2000 m, NT-15523, 16015), Mt. Hokkai (2050 m, HD-12222, 12226, 12233, 12234, 12236, 12240, 12242; 2150 m, HD-12251, 12255; 2200 m, HD-12256). Asahidake. Mt. Hakuun - Mt. Chubetsu (1750 m, HD-12273, 12274, 12281, 12284, 12285; 1800 m, HD-12267, 12288), Mt. Tomuraushi (1800 m, HK-544; 1900 m, HK-136), Mt. Kaun (1954 m, HD-12295, 12296). Nukabira. Mt. Nipesotsu (1800 m, HD-12458, 12460; 2000 m, HD-12472, 12475), Mt. Upepesanke (1650 m, HD-12419). Tokachidake. Mt. Furano (1750 m, HD-12356, 12347, 12351). Rusutsu. Mt. Yotei (1800 m, HD-12616, 12618, 12620, 12621, 12622, 12624, 12628, 12630, 12632, 12635).

HONSHU. Pref. Aomori. Hirosaki. Mt. Iwaki (1540 m, HK-9306). Pref. Iwate. Hachimantai. Mt. Iwate (1500 m, RW-4987; 1960 m, NT-21378; 2000 m, RW-4686). Pref. Yamagata. Gassan. Mt. Gassan (1900 m, RW-2115). Kaminoyama. Mt. Kumano (1800 m, NT-24367; 1840 m, RW-1716). Pref. Fukushima. Idesan. Mt. Ide (2100 m, RW-3893). *Azumayama*. Mt. Azuma (1700 m, Sakurai-s.n.; 1900-2000 m, NT-36074). *Nihonmatsu*. Mt. Hiuchigadake (2346 m, NT-16528). Pref. Nigata. *Myokosan*. Mt. Myoko (2350 m, HD-12984; 2360 m, HD-12985, 12986; 2440 m, HD-12990). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2700-3190 m, KS-12990; 2799 m, NT-14487 + *Andreaea rupestris* var. *fauriei*; 2900 m, HD-13238; 2950 m, HD-13252; 3020 m, HD-13310; 3100 m, NT-s.n., KS-9532; 3180 m, HD-13280; 3185 m, HD-13279; 3192 m, TS-8447, 8452). *Yatsugadake*. Mt. Gongen (1500 m, RW-6690; 2300 m, RW-6601; 2700 m, RW-6543). *Fujisan*. Mt. Fuji (2500 m, RW-15636; 3000 m, RW4165; 3300 m, RW-4267). Pref. Toyama. *Tateyama*. Mt. Tateyama (2720 m, HD-13179, 13180, 13181, 13182, 13183, 13186, 13292; 2850 m, HD-13145). *Shiroumadake*. Mt. Norikura (2430 m, HD-12756; 2440 m, HD-12745; 2450 m, HD-12754), Mt. Shirouma (NT-s.n., NT-6940; 2500 m, RW-8246; 2600 m, NT-10369; 2650 m, HK-8574; 2700 m, RW-8044, HD-12763; 2720 m, HD-12764; 2780 m, HD-12773, 12775; 2890 m, HK-8620; 2930 m, RW-8133), Mt. Karamatsu (2600 m, NT-10300), Mt. Karamatsu - Mt. Goryu (2400 m, HD-12811; 2500 m, HD-12837, 12838). *Tateyama*. Mt. Harinoki (2600 m, NT-10042). *Yarigadake*. Mt. Yari (2550 m, HD-12929; 2600 m, RW-11402; 2800 m, RW-11539, HD-12931; 2900 m, RW-11592; 3000 m, RW-11492, 11604, 11647, NT-s.n. +*Coscinodon cribrosus*; 3080 m, NT-12576), Mt. Otensho - Mt. Nishidake (2600 m, HD-12908, 12910), Mt. Higashitenjo - Mt. Otensho (2740 m, HD-12884, 12885; 2780 m, HD-12887; 2800 m, HD-12889), Mt. Tsubakuro - Mt. Otensho (2500 m, HD-12903, 12904; 2600 m, HD-12892, 12893; 2700 m, Sakurai-s.n., HD-12891, 12895, NT-19753), Mt. Minamigaki (2600 m, NT-12700), Mt. Noguchigoro - Mt. Suisho (NT-12469), Mt. Momisawa (2600 m, NT-12544). *Kamikochi*. Mt. Chogadake (2550 m, HD-12871; 2650 m, HD-12868; 2660 m, HD-12866, 12867; 2663 m, HD-12865), Mt. Jonen (2760 m, HD-12877; 2780 m, HD-12878; 2800 m, HD-12879, 12880). *Tateshinayama*.

Natsuzawa pass - Mt. Iwodake (2393-2742 m, TS-14457, 14467, 14468, 14477, 14501), Mt. Tengudake (2645 m, TS-6870), Shibunoyu spa (2000 m, NT-38967). *Norikuradake*. Mt. Norikura (2670 m, NT-39808). *Yatsugadake*. Mt. Yatsu (2645-2742 m, KS-13464; 2700 m, Sakurai-s. n.; 2742-2830 m, TS-14513, 14514, 14516, 14518, 14525, 14527, 14534, 14538; 2800 m, NT-4739, 4744, Sakurai-s.n., S.Nakanishi-9434). *Ontakesan*. Mt. Ontake (HA-19430; 2400 m, HD-13079, 13080, 13081; 2450 m, HD-13083; 2490 m, HD-13086; 2500 m, HK-8948, 8951; 2600 m, NT-14009; 2750 m, HK-8932, 8937, NT-17450, 17451, 17452; 2780 m, HD-13122, 13125, 13136, 13130; 2790 m, HD-13090; 2830 m, HD-13095; 2850 m, HD-13092, 13093, 13094, 13096, 13098, 13101, 13104; 2900 m, NT-13918, 13922, 13923, 17483, 17484, 17485, 36477; 3000 m, HA-15425, NT-17485, Musci Japonici Ser. 9, 1955. no. 423, as *G. decalvata*). *Akaho*. Mt. Komagadake (2520 m, HD-13163; 2700 m, HD-13009, HK-9035; 2800 m, HD-12993; 2840 m, HD-13014, 13017, 13019, 13020; 2850 m, HD-13026, 13027, 13030; 2930 m, HD-13033; 2956 m, HK-9044). *Akaishidake*. Daishojidaira (NT-6767), Mt. Hijiri (3011 m, NT-39774, 39775), Mt. Higashi (NT-681 + *Andreaea rupestris* var. *fauriei*, *Arctoa fulvella*; 2650 m, HA-26322). Pref. Shizuoka. *Fujisan*. Mt. Fuji (2500 m, NT-8989; 3300-3400 m, IK-3567, 3570, 3609, 3610, 3611, 3612, 3613; 3600 m, NT-9070; 3700 m, NT-9028, 9031, 9032, 9033, 9035 + *Pogonatum capillare*, *Diplophyllum albicans*, *Arctoa fulvella*, 9036, 9040; 3750-3776 m, NT-39920, 39921, 39929, 39930, 39932, 39933, 39934). *Fujinomiya*. Mt. Fuji (2400-2600 m, IK-3506; 2450 m, IK3458, 3469; 2520 m, NT-36893; 2620 m, NT-39900). *Akaishidake*. Mt. Higashi (3000 m, NT-28902, 28906), Mt. Senmai (2800 m, NT-28897, 28898 +Grimmia affinis), Mt. Chausu (2550 m, NT-35304). *Okawara*. Mt. Shiomi (2850 m, RW-6143; 2900 m, RW-5874, 6111, 6245).

9. *Grimmia funalis* (Schwaegr.) Bruch et Schimp. (Map 9)
HONSHU. Pref. Gunma. *Numata*. Mt. Akagi ( Coll. K.Tsunoda, det. A.Yasuda, Sept 19, 1914 in TNS F.569).

10. *Grimmia incurva*. Schwaegr. (Map 10)
HONSHU. Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2950 m, HD-13254; 3050 m, HD-13302; 3100 m, HD-13258c). Pref. Toyama. *Tateyama*. Mt. Tateyama (2720 m, HD-13174*, 13176*, 13177 + *Andrearea rupestris* var. *fauriei*, 13185, 13187*, 13188 + *Andreaea rupestris* var. *fauriei*, 13190, 13191; 2750 m, HD-13140 + *Andreaea rupestris* var. *fauriei*; 2940 m, HD-13149*, 13152* + *Arctoa fulvella*, *Andreaea rupestris* var. *fauriei*, 13155 + *Andreaea rupestris* var. *fauriei*; 2960 m, HD-13163* + *Andreaea rupestris* var. *fauriei*, 13164* + *Andreaea rupestris* var. *fauriei*, *Racomitrium heterostichum* var. *diminutum*). Pref. Nagano. *Yarigadake*. Mt. Tsubakuro - Mt. Otensho (2500 m, HD-12905; 2600 m, HD-12915). *Kamikochi*. Mt. Jonen (2800 m, HD-12881, 12886). *Ontakesan*. Mt. Ontake (2490 m, HD-13087 + *Andreaea rupestris* var. *fauriei*, *Arctoa fulvella*, 13120 + *Andreaea rupestris* var. *fauriei*, 13121*, 13123* + *Andreaea rupestris* var. *fauriei*, 13124 + *Andreaea rupestris* var. *fauriei*, *Drepanocladus uncinatus*, *Racomitrium lanuginosum*, *R. fasciculare*, *G. elongata*, 13128* + *Arctoa fulvella*, 13130b). *Akaho*. Mt. Komagadake (2840 m, HD-13010* + *Andreaea rupestris* var. *fauriei*, *Arctoa fulvella*, 13011*, 13015*, 13016*, 13018* + *Arctoa fulvella*; 2850 m, HD-13028 + *Andreaea rupestris* var. *fauriei*, *Arctoa fulvella*, 13031; 2880 m, HD-13003, 13004, 13005 + *Andreaea rupestris* var. *fauriei*; 2900 m, HD-12999; 2930 m, HD-13032 + *Andreaea rupestris* var. *fauriei*, 13035 + *Andreaea rupestris* var. *fauriei*, *Racomitrium heterostichum* var. *diminutum*, 13036, 13040, 13041; 2995 m, HD-13021, 13022).

13021, 13022). The specimens with asteriscs (*) consist oft sterile plants.

### 11. *Grimmia olympica* E.G.Britt. (Map 11)

HOKKAIDO. *Rausu*. Mt. Rausu (1660 m, HD-12578).
HONSHU. Pref. Nagano. *Suzaka*. Sugadaira Heights (2100 m, KS-2098).

### 12. *Grimmia pilifera* P.Beauv. (Map 12)

HOKKAIDO. *Mikage*. Mt. Tsurugi (700 m, HK-2434; 800 m, HD-12393, 12394, 12396; 900 m, HD-12400). *Tokachigawajoryu*. Kirifuki fall (450 m, HD-11935). *Horoizumi*. Mt. Apoi (760 m, HA-24113; 811 m, NT-16211, 16212).
HONSHU. Pref. Aomori. *Oma*. Oma cape (3-5 m, HS-19458). Pref. Iwate. *Iwaizumi*. Ryusendo (190 m, RW-17196), Iwaizumi (200 m, NT-36866, 36872). *Kawai*. Kawai (430 m, HD-12705). *Miyako*. Koshihama (NT-35652). *Ichinose*. Genbikei (NT-43017). Pref. Fukushima. *Kawamata*. Domeki (300 m, RW-1210). Pref. Tochigi. *Shiobara*. Shiobara spa (545 m, RW-174). *Nikko*. Nikko (590 m, RW-2230). Pref. Gunma. *Shima*. Mt. Tanigawa (RW-4540). Pref. Ibaragi. *Makabe*. Mt. Tsukuba (500 m, RW-3321). Pref. Saitama. *Yorii*. Nagatoro (NT-13185). *Manba*. Mt. Futago (400 m, RW-16397, 16402; 420 m, RW-16344; 450 m, RW-16386, RW-s.n.; 480 m, RW-16377), Shigasaka (600 m, RW-15786). *Kawagoe*. Agano (400 m, RW-4461), Koma (250 m, RW-4495), Okurayama (260 m, RW-16053; 270 m, RW-16178; 280 m, RW-16114, 17690, 17712; 300 m, RW-16060; 370 m, RW-17738). *Mitsumine*. Tochimoto (NT-13262, 13095; 740 m, RW-14455; 1200 m, RW-14396), Otaki (500 m, RW-14840), Ohinata (NT-13261). *Chichibu*.

Mt. Buko (NT-13302; HA-3049; 300 m, RW-7505; 400 m, RW-7515; 450 m, RW7497; 600 m, RW-7334, 7339; 700 m, RW-17536; 800 m, RW-7329). Pref. Tokyo. Itsukaichi. Mt. Mitake (350 m, RW-7679, 7727; 900 m, RW-7648), Okutama (NT-1734). Tokyotohokubu. Ueno (NT-21949). Pref. Kanagawa. Hatano. Minoe (400 m, RW-6935). Odawara. Owakudani (NT-22652). Pref. Yamanashi. Yatsugadake. Mt. Gongen (2500 m, RW-6532; 2700 m, RW-6703), Mt. Amigasa (1600 m, RW-6632, 6718). Nirasaki. Mt. Kitadake (1080 m, HA-9535; 1130 m, HA-9546; 1500 m, NT-14449; 1520 m, HD-13202; 1580 m, HD-13208; 1200-1900 m, TS-8337). Ichinose. Mt. Notori (1300 m, HD-13321). Kajikazawa. Ashikura (800 m, TS-8236), Yashajin pass (1770 m, TS-8251). Pref. Nagano. Karuizawa. Mt. Asama (1600 m, NT-31461). Miyota. Mt. Akaru ( 1000 m, M.Inoue-11281). Komoro. Komoro (660 m, RW-s.n.; 700 m, RW-15186). Wada. Shiga (NT-39671), Mt. Sansai (NT-19026), Utsukushigahara (1900 m, NT-22467). Yatsugadake. Mt. Yatsu (NT-33229; 1600 m, HD-14695). Ontakesan. Mt. Ontake (1200 m, NT-17352, 17362). Ichinose. Todai (900 m, NT-9741; 1000 m, NT-11875, 11878, 11884; 1100 m, NT-11847, RW-11840, 18848, 18850, 18857; 1120 m, TS-17304; 1150 m, NT-11937, RW-18715), Shiozawa (1000-1100 m, NT-11685; 1120 m, NT-11709). Akaho. Mt. Kamagadake (680 m, HK-9016). Okawara. Okawara - Koshibu spa (NT-636), Okawara - Karasawa (NT-6604), Shiokawa river (750 m, RW-5853; 800 m, RW-5884), Fukazawa (900 m, RW-s.n.; 1000 m, RW-9488), Oga (1300 m, RW-9443; 1400 m, RW9511, 20284). Tsumago. Mt. Shizumo (NT-36000). Pref. Shizuoka. Atami. Atami (20 m, RW-4320, 4322, 4324, 4344, 4350). Shizuoka. Mt. Kuno ( 250 m, HK-7489; 300 m, HD-11172). Ieyama. Mt. Hakko (NT-19642). Tenryu. Shirakura (400 m, NT-30444). Hamamatsu. Hamamatsu (200 m, NT-35830). Pref. Gifu. Takayama. Takayama (600 m, HD-13134). Shirotori. Hirugano (820 m, NT-20758). Mino. Katajidani (600 m, NT-19504). Tsushima. Yoronotaki (HA-5221). Pref. Aichi. Mikawa-

*ono*. Mt. Horaiji (NT-13407, 30552, 43168; 450 m, HA-18045; 550 m, RW-9881). *Gifu*. Inuyama (50 m, NT-39883), Mt. Jokoji (160 m, HA-17906). *Taguchi*. Shitara (500-700 m, NT-36221, 36280). *Asuke*. Asuke (NT-21744). *Tabara*. Kasayama (10-70 m, NT-40613, 40616, 40675). Pref. Mie. *Nagashima*. Nagashima (50 m, NT-30515). *Kimoto*. Arima (NT-36181, 36184, 36206), Atashika (40 m, HD-7521). *Odaigaharazan*. Osugidani valley (HA-2055, 2056; 520 m, HD-8037). *Owase*. Mt. Yaki (100 m, NT-37685, 33692), Kotsu (80 m, NT-30524). Pref. Wakayama. *Kokawa*. Mt. Ryumon (100 m, HD-8963; 750 m, HD-8911). *Kawarago*. Mt. Toragamine (300 m, HD-9345, 9403, 9404, 9413). *Nachikatsuura*. Kozagawa (NT-35457). *Shingu*. Kawayu ( 180 m, HD-7180; 300 m, HD-7188). Mt. Eboshi (380 m, HD-7074), Funada (25 m, HD-7134). *Kurusugawa*. Upper course of Yasukawa river (600 m, HD-8678). *Tanabe*. Kumanogawa (400 m, HD-9144, 9176). *Esumi*. Kotonotaki fall (220 m, HD-8792), Kozagawa (40 m, HD-8857). Pref. Nara. *Odaigaharazan*. Nakaoku (500 m, HD-9751, 9754), Sannoko (500 m, HD-9074), Mt. Odaigahara (1040 m, HD-7923, 7930). *Sanjogadake*. Funanokawa river (700 m, HD-5481), Mt. Wasamata (1400 m, HD-10496). Shakagadake. Zenki (800 m, HD-6801). *Totsukawa*. Mt. Tamaki ( 300 m, HD-7341; 340 m, HD-7505; 500 m, HD-7417). Pref. Hyogo. *Kobe*. Mt. Rokko (800 m, HK-5479). *Sayo*. Mt. Funakoshi (NT-24128). Pref. Tottori. *Chizu*. Nagi (310 m, HD-12712). Pref. Shimane. *Kawamoto*. Ichiki (HD-14774). *Tsuwano*. Tsuwano (300 m, HD-11526). Pref. Okayama. *Katsuyama*. Kanba fall (470 m, HD-13343). Pref. Hiroshima. *Shobara*. Taishakukyo (440 m, HD-14740; 400-500 m, HD-11217). *Joge*. Soryo (HA-8770; 300-400 m, HA-8738). *Miyoshi*. Kawanishi (230 m, TS24979). *Kabe*. Haji (250 m, HD-5595), Sasai (300-400 m, HD-8333, 8338, 8339, 8352). *Kake*. Mt. Tenjo (250 m, HK-7881), Akiimuro (100 m, HK-5913, 5914). *Sandankyo*. Sandankyo (350 m, HA-11497; 450 m, HD-13396). *Kaitaichi*. Saka (HA-5328).

Takehara. Nyuno (150 m, HK-7185; 200 m, HK-7181). Hiroshima. Mt. Chausu (400 m, TS-16465). Tsuta. Mt. Kanmuri (700 m, N.Nishimura-677), Mt. Omine (660 m, TS-15632), Yoshiwa (380 m, TS35798). Kure. Hiro (HA -1026). Itsukushima. Miyajima isl. (50 m, HK-3538, HD-10908; 100 m, HD-9526; 330 m, HD-9506, 9514). Otake. Otake (130 m, HD-15255), Asahara (350-400 m, HD-15210), Kayanohara (560 m, HD-8271), Maeiidani (100 m, HD-15311). Hashiraijima. Okimi (TS-10122). Pref. Yamaguchi. Otake. Nishimukuno (50-100 m, HD-14119), Futayogi (270 m, HD-14969), Yasakakyo (HD-14738). Asa. Mt. Shimofuri (230 m, Umezu-39).

SHIKOKU. Pref. Kagawa. Kankakei. Kankakei (60 m, HA-5343; 180 m, HA-5372). Pref. Tokushima. Awatomioka. Mt. Tairyuji (450 m, HA-5670). Kannoura. Shishikui (HA-5528, 5532). Pref. Ehime. Niihama. Mt. Akaishi (1600 m, HD-11396; 1620 m, HD-11472; 1630 m, HD-11467). Ishizuchisan. Mt. Ishizuchi (1600 m, H.Kashiwadani-s.n.). Matsuyamahokubu. Dogo (160 m, TS-s.n. +Hedwigia ciliata). Uwajima. Nametoko (450 m, HA-7398), Uwajima (200 m, HA-7558). Pref. Kochi. Ochi. Mt. Yokogura (TS-8038; 100-200 m, HA-6328). Oyu. Tsunogawa - Fujinokawa (40 m, HA-13063; 80 m, HA-13078; 160 m, HA-13331), Kuchiyanai - Kuroson (40 m, HA-13372).

KYUSHU. Pref. Fukuoka. Fukuoka. Fukuoka city (30 m, HD-15367). Amagi. Mt. Kosho (200 m, HA-26429). Pref. Oita. Oita. Mt. Yufu (670 m, HA-10796; 890 m, HA-10822). Pref. Nagasaki. Nagasaki. Nagasaki (100 m, HA-10173). Sasuna. Mt. Mitake (490 m, HD-13331). Pref. Kagoshima. Kirishimayama. Mt. Karakuni (HA-2428).

### 13. Grimmia subsulcata Limpr. (Map 13)

HOKKAIDO. Asahidake. Kogenonsen (1500 m, HK-9726, 9757), Hisagonuma (1800 m, HK-720; 1900 m, HK-705), Mt. Hakuun - Mt. Chubetsu

(1800 m, HD-12266). *Poroshiridake*. Mt. Poroshiri (2000 m, HK-1278).

HONSHU. Pref. Toyama. *Tateyama*. Mt. Tateyama (2250 m, HD-13167, 13168, 13169; 2600 m, HD-13171; 2720 m, HD-13172, 13173), Mt. Kashimayari (2450 m, HD-12832). Pref. Nagano. *Shiroumadake*. Mt. Shirouma (1650 m, HK-8554, 8556; 2100 m, NT-9536; 2260 m, HK-8595; 2350 m, HK-8586, 8594; 2400 m, RW-8042; 2450 m, RW-7887; 2700 m, HD-12762; 2740 m, HD-12785; 2770 m, HD-12767; 2890 m, HK-8602), Mt. Hakubayari (2000 m, RW-8108). *Yarigadake*. Mt. Yari (2550 m, HD-12925, 12928; 2580 m, HD-12922, 129223, 12924; 2600 m, HD-12930; 3050 m, HD-12933, 12035), Mt. Otensho - Mt. Nishidake (2600 m, HD-12916, 12929), Mt. Mitsumatarenge (2600 m, NT-12520). *Kamikochi*. Mot. Yari - Kamikochi (2100 m, HD-12938; 2200 m, HD-12937; 2300 m, HD-12950; 2400 m, HK-9060; 2900 m, Sakurai-13727 in MAK). *Ontake-san*. Mt. Ontake (2600 m, NT-14010). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2620 m, RW-16861; 2790 m, HD-13314; 2800 m, NT-14361; 2900 m, HD-13237), Mt. Senjo (NT-9990; 2300 m, RW-18672; 2600-3000 m, KS-9148), Mt. Notori - Narata (2800 m, HD-13317). Pref. Shizuoka. *Akaishidake*. Mt. Arakawa (3000 m, TK-48838), Mt. Koakaishi (3080 m, NT-28971). Pref. Ishikawa. *Hakusan*. Mt. Hakusan (2600 m, HK-8844; 2700 m, HK-8892).

14. *Schisitidium apocarpum* (Hedw.) Bruch et Schimp.

HONSHU. Pref. Iwate. *Iwaizumi*. Tyusendo (190 m, RW-17045, 17116), Yokomichi (200 m, NY-36841, 36875). Pref. Fukushima. *Tokiwa*. Mt. Otakine (600 m, RW-1374). Pref. Saitama. *Kinpusan*. Jumonji pass (1850 m, NT-19997). *Chichibu*. Mt. Buko (NT-13304; 800 m, RW-15425; 920 m, RW-15284; 1150 m, RW-15350). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2700-3190 m, KS-13118). Pref. Nagano. *Ichinose*. Shiozawa river (1000-1100 m, NT-11601, 11610, 11620), Makuiwa (

1250 m, NT-10113), Todai (980 m, NT-9742; 1080 m, RW-18990; 1200 m, RW-18542), Shiraiwa (1200 m, KS-9001). Pref. Shiga. *Nagahama*. Mt. Ibuki (700 m, NY-29920; HA-643, 650). Pref. Mie. *Gozaishozan*. Mt. Fujiwara (200 m, NT-35007, HD-15271; 150-300 m, HA-8021; 1165 m, NT-21991; NT-33670), Tashitadani (200-300 m, NT-31191), Fujiwara (HA-5160). Pref. Nara. *Sanjogadake*. Dorogawa (950 m, HD-6355; 1100 m, HD-3487). *Odaigaharazan*. Nakaoku (500 m, HD-9750). Pref. Okayama. *Katsuyama*. Kanbanotaki (470 m, HD-13332, 13334, 13337, 13340, 13347). *Hashibe*. Makido (500 m, HD-15354). Pref. Hiroshima. *Shobara*. Taishakukyo (330 m, HA-17231; 400 m, NT-29574, HK-7675; 440 m, HD-14745; 450 m, HD-14743; 460 m, HD-14742, 14748; 400-500 m, HD-11173, 11174, 11175, 11187, 11207, 11212). Pref. Yamaguchi. *Yamaguchi*. Akiyoshidai (200 m, RW-21728, 21837, 21840, 21842). KYUSHU. Pref. Fukuoka. *Amagi*. Mt. Koshi (Musci japonici Ser. 10, 1956, no. 469, as *Grimmia apocarpa* var. *microtheca*).

15. *Schistidium confertum* (Funck) Bruch et Schimp. (Map 15)
HOKKAIDO. *Rausu*. Mt. Rausu (460 m, TS-24100, 24101; 600 m, HD-12547a, NT-33950, 33951, 33952).
HONSHU. Pref. Nagano. *Shiroumadake*. Mt. Shirouma (2300 m, NT-9550; 2400 m, HK-8577; 2540 m, HK-8590; 2600 m, HK-8600). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (3100 m, HD-13285a, NT-14400). *Fujisan*. Mt. Fuji (2850-3050 m, NT-39952, 39953). Pref. Shizuoka. *Akaishidake*. Mt. Higashi (3146 m, NT-28931).

16. *Schistidium gracile* (Roehl.) Limpr. (Map 16)
HOKKAIDO. *Rebuntohokubu*. Mt. Rebun (480 m, HD-12005). *Rishirito*. Oiso (130 m, HD-12160, 12164; 140 m, HK-8521), Kitami shrine (20 m,

HD-12061), Oiso (8 m, HD-12124, 12026, 12029, 12031), Mt. Rishiri (380 m, HD-12074; 910 m, HD-12098; 1200 m, HD-12107; 1270 m, HD-12109). *Nakatonbetsu*. Nakatonbetsu (100 m, HD-12179, 12181). *Shiretokomisaki*. Shiretoko cape (30-40 m, HS-20916, 20918), Mt. Shiretoko (80 m, HK-3077; 150 m, HK-3193). *Rausu*. Iwaobetsu (30 m, TS-23940; 40 m, TS-23891; 50 m, TS-23898, 23901), Shari (250 m, HA-28466), Mt. Rausu (300 m, HK-4360; 510 m, TS-24075, 24087; 600 m, 12547, 12548; 750 m, HD-12551; 800 m, HD-12587). *Utoro*. Oshinkoshin fall (100 m, HS-21048). *Sharidake*. Mt. Shari (620 m, HD-12486, 12487, 12488; 780 m, HD-12500; 860 m, HD-12540). *Daisetsuzan*. Goshikigahara (1900 m, HK-2822). *Asahidake*. Futamata (530 m, HK-9387; 680 m, HK-9429), Goshikigahara (1400 m, HK-4164; 420 m, TS-23354; 430 m, TS-23300, 23302). *Tokachigawajoryu*. Tomuraushi spa (480 m, HD-11550, 11661, 11667, 11689, 11693, 11752, 11912; 500 m, HK-8155; 520 m, HD-11647). *Yamabe*. Nunobe (HA-3174), Mt. Ashibetsu (1720 m, HD-12385). *Shikaribetsuko*. Mt. Hakuun (800 m, HD-12434, 12435). *Ochiai*. Ochiai (HD-11938). *Mikage*. Mt. Tsurugi (650 m, HK-2417; 720 m, HK-2445; 800 m, HD-12399; 1200 m, HD-12406, 12407). *Jozankei*. Mt. Sapporo (350 m, HA-23736). *Satsunaidake*. Mt. Tottabetsu (1800 m, HK1297). *Tarumaezan*. Shikotsu lake (250 m, HA-23884). *Rusutsu*. Mt. Yotei (500 m, HD-12592; 850 m, HD-12598, 12600; 1200 m, HD-12610). *Horoizumi*. Mt. Apoi (230 m, HA-24072; 700 m, HA-24107). *Urago*. Mt. Apoi (20 m, HA-24031). HONSHU. Pref. Aomori. *Hirosaki*. Mt. Iwaki (1490 m, HK-9297). *Ikarigaseki*. Ikarigaseki (TS-24572). Pref. Iwate. *Hayachinesan*. Mt. Hayachine (900 m, RW-5229). Pref. Yamagata. *Idesan*. Mt. Kitamata (400 m, HK-6346). Pref. Fukushima. *Seki*. Nakamoniwa (120 m, RW-611). *Hobara*. Ryozen (600 m, RW-1953). *Atsushio*. Kawairi (490 m, RW-3980; 600 m, RW-3957; 700 m, RW-4006). *Bandaisan*. Goshikinuma (760 m, RW-6159). *Tokiwa*. Takine (600 m, RW-

1353). *Tajima*. Kanko spa (900-920 m, HS-20618, 20638). Pref. Gunma. *Hiuchigadake*. Sanpei pass (1260 m, HA-739, 741). *Fujiwara*. Hatomachi pass (HA-3193, 3202). *Harunasan*. Ikaho (800 m, HA-9204). Pref. Saitama. *Mitsumine*. Oyama (1720 m, RW-14704), Ohinata (500 m, RW-14815, 14946), Mt. Mitsumine (1200 m, RW-18426). Pref. Tokyo. *Chichibu*. Nippara (680 m, RW-13883, 13884). *Hachioji*. Asakawa (HA03425). Pref. Migata. *Myokosan*. Mt. Myoko (1480 m, HD-12966, 12978). Pref. Yamanashi. *Yatsugadake*. Mt. Amigasa (1650 m, RW-6457). *Nirasaki*. Hirogawara - Shiraneoike (1520 m, HD-13201, 13203; 1540 m, HD-13206; 1580 m, HD-13209; 1600 m, HD-13212). *Ichinose*. Mt. Notori (1300 m, HD-13326, 13327; 1670 m, HD-13319, 13323), Mt. Kitadake (2300 m, HD-13221; 3000 m, HD-13316; 3010 m, HD-13309; 3050 m, HD-13300; 3100 m, HD-13285, 13292; 3170 m, HD-13268). *Kajikazawa*. Arakawa hutte (TS-8308, 8314). Pref. Nagano. *Togakushi*. Togakushi (1080 m, HD-13196), Mt. Togakushi (1500 m, HD-13206; 1550 m, HD-13193; 1600 m, HD-13196, 13203; 1650 m, HD-13197). *Shiroumadake*. Mt. Shirouma (1250 m, HK-8569; 1300 m, RW-7937; 1350 m, RW-18434; 2750 m, HD-12802). *Omachi*. Omachi (860 m, HK-8723), Mt. Karamatsu - Mt. Goryu (2400 m, HD-12814). *Komoro*. Komoro (650 m, RW-13819). *Kamikochi*. Mitsumata - Mt. Chogadake (1440 m, HD-12844), Mt. Yari - Kamikochi (1800 m, HD-12942, 12944). *Kinpusan*. Jumonji pass (1300 m, HD-8266). *Kisofukushima*. Kisofukushima (760 m, HD-13073). *Ichinose*. Todai ( 1040 m, TS-17361; 1120 m, TS-17307), Mt. Senjo (1620 m, RW-18944). *Okawara*. Oshika (1100 m, RW-5915; 1400 m, RW-9210; 1500 m, RW-6234). *Akaishidake*. Nashimoto (TS-7391, 7411). Pref. Ishikawa. *Kanazawa*. Utatsuyama (100 m, HD-14732). *Hakusan*. Shiramine (250 m, HK-8810, 8816). *Kyogadake*. Mt. Hakusan (850 m, HA-26209; 1200 m, HA-26236). Pref. Fukui. *Kyogadake*. Hatogayu (560 m, TS-14729).

Pref. Gifu. Hidafurukawa. Kawai (400 m, HD-12706; 450 m, HD-12708). Tsushima. Yoro (HA-5217). Pref. Mie. Gozaishozan. Fujiwara (HA-5138). Pref. Kyoto. Kyototohokubu. Kuramayama (300 m, HA-8665). Pref. Osaka. Kyotoseinanbu. Mt. Ponponzan (200 m, HD-5427). Pref. Nara. Takamisan. Omata (450 m, HD-8249, 8259), Omata - Myojindaira (800 m, HD-8141). Odaigaharazan. Sannoko (450 m, HD-9021). Sanjogadake. Dorogawa (1000 m, HD-6333; 1100 m, HD-3487b; 1430 m, HD-6521; 1440 m, HD-6531), Mt. Wasamata (1100 m, HD-10641; 1270 m, HD-10483). Totsukawa. Mt. Tamaki (520 m, HD-7418). Pref. Wakayama. Koyasan. Mt. Koya (HA-1580; 600 m, HD-8452; 630 m, HD-8442; 650 m, HD-8416; 800 m, HD-8489, 8493). Kokawa. Mt. Ryumon (700 m, HD-8896; 750 m, HD-8903). Obakodake. Komori (450 m, HD-10353, 10363). Kurisugawa. Osugidani (300 m, HD-9956). Tanabe. Kumanogawa (400 m, HD-9170). Pref. Hyogo. Kasumi. Amarube (50 m, TN-18712). Muraoka. Mt. Hyonosen (1150 m, HD-12717; 1200 m, HD-12716; 1250 m, HD-12715). Wakasa. Mt. Hyonosen (880 m, HD-12721). Osakaseihokubu. Arima (380 m, HA-6969). Kobe. Mt. Rokko (380 m, HK-5509; 800 m, HK-5478). Pref. Okayama. Katsuyama. Kanbanotaki (470 m, HD-13336, 13345, 13348). Pref. Tottori. Daisen. Mt. Daisen (700 m, HD-6190). Kurayoshi. Sanbutsuji (320 m, HA-17560). Neu. Kofu (300 m, HD-15373, 15374, 15375). Pref. Shimane. Saigo. Mt. Washigamine (180 m, HA-26864). Kawamoto. Iwami (250 m, HD-14775, 14777). Tsuwano (200 m, HD-15128, 15129, 15130, 15131). Pref. Hiroshima. Shobara. Taishakukyo (400 m, HA-17184; 440 m, HD-14714, 14744, 14746, 14747). Joge. Hichi (350 m, HS-19734). Miyoshi. Ryoke (300-400 m, HA-8741). Kabe. Haji (230 m, HD-5649; 250 m, HD-5633; 350 m, HS-21539). Kake. Akiimuro (100 m, HK-5910, 5925), Kawato (TS-1606). Sandankyo. Togochi (400 m, HD-15357), Sandankyo (400-500 m, HA-11586; 600 m, TS-16286; 750 m, HD-8284, 8287). Takehara. Kochi (100 m, HK-7182, 7334; 150 m, HK-7189).

*Hiroshima*. Mt. Togo (200 m, HA-7582), Itsukaichi (HA-346). *Tsuta*. Mt. Kanmuri (700-800 m, HD-14885, 14907; 900 m, HD-14955). *Itsukushima*. Miyajima isl. (10 m, HK-7589; 40 m, HD-10900, 10910; 250 m, HD-9475). *Otake*. Mt. Oniishi (350-400 m, HD-15181). Pref. Yamaguchi. *Iwakuni*. Iwakuni (500 m, HK-7532).

SHIKOKU. Pref. Kagawa. *Kankakei*. Kankakei (60 m, HA-5341). Pref. Tokushima. *Tsurugisan*. Mt. Tsurugi (1450 m, RW-19239, TS-13084). Pref. Ehime. *Nihama*. Mt. Akaishi (750 m, HD-11322; 1200 m, HD-11357; 1400 m, HD-11480; 1500 m, HD-11388; 1600 m, HD-11412, 12696; 1620 m, HD-11462; 1680 m, HD-11461). *Uwajima*. Nametoko (550 m, HA-7333). Pref. Kochi. *Tanono*. Dogamori (270 m, HA-13172).

KYUSHU. Pref. Oita. *Yabakei*. Shinyabakei (140 m, HA-10968; 180 m, HA-11061). *Inukai*. Furenshonyudo (200 m, HD-11088). Pref. Nagasaki. *Shimabara*. Unzen (800 m, HD-12685).

17. *Schistidium liliputanum* (C.Müll.) Deguchi (Map 17)

HOKKAIDO. *Rishirito*. Mt. Rishiri (500 m, NT-15900, 15930; 1310 m, HD-12120; 1350 m, HD-12128). *Rebuntohokubu*. Mt. Rebun (400 m, HD-11995; 480 m, HD-11998, 12000, 12001, 12002, 12006, 12008, 12009, 12010, 12012, 12013, 12017). *Shiretokomisaki*. Shiretoko cape (30-40 m, HS-20924). *Asahidake*. Goshikigahara (1400 m, HK-9438). *Akanko*. Mt. Oakan (650 m, HA-2565). *Shikaribetsuko*. Mt. Hakuun (1040 m, HD-12441). *Tokachigawajoryu*. Tomuraushi spa ( 400 m, HD-11863; 450 m, HD-11860; 470 m, HK-8182). *Mikage*. Mt. Tsurugi (1200 m, HD-12402). *Kokuryo*. Mt. Minamishokanbetsu (1296 m, HD-12671). *Rusutsu*. Mt. Yotei (750 m, HD-12596; 1800 m, HD-12644, 12645, 12646).

HONSHU. Pref. Iwate. *Hayachinesan*. Mt. Hayachine (800 m, NT-36643; 880 m, HK-6741). *Rikuchuseki*. Yamagata (300 m, NT-29936).

Pref. Yamagata. Aterazawa. Yanagawa (350 m, RW-8378). Pref. Miyagi. Shiroishi. Gaga (900 m, RW-2033). Pref. Nigata. Washisaki. Nyugawa (Sasaoka-17597 in TNS). Pref. Fukushima. Fukushima. Niwasaka (100 m, RW-1348), Shinobuyama (150 m, RW-582), Tsuchiyu (850 m, RW-1378). Itozawa. Anabaraonsen (80 m, RW-1727). Bandaisan. Okinajima (520 m, RW-634). Azumayama. Hibara (820 m, NT-29937). Pref. Tochigi. Nantaizan. Chuzenji lake (1273 m, RW-2244). Pref. Ibaragi. Makabe. Mt. Tsukuba (Sakurai-33969 in MAK; Dixon-4684 in PC). Pref. Saitama. Chichibu. Mt. Buko (NT-13275). Mitsumine. Nakatsugawa (700 m, NT-33016). Pref. Yamanashi. Ichinose. Mt. Kitadake (2950 m, HD-13247; 3100 m, HD-13261). Yatsugadake. Mt. Amigasa (1500 m, RW-6655; 2000 m, RW-6730), Mt. Gongen (1800 m, RW-6466). Pref. Nagano. Togakushi. Mt. Togakushi (1900 m, HD-13200). Omachi. Mt. Karamatsu - Mt. Goryu (2400 m, HD-12812, 12813, 12816). Yarigadake. Mt. Yari (1800 m, RW-11287). Suzaka. Sugadaira Heights (NT-830), Mt. Azuma (2000 m, NT-32650). Karuizawa. Mt. Asama (1500 m, NT-31430; 1800 m, NT-31491; 1900 m, NT-31499). Kamikochi. Kamikochi (1200 m, HD-12948). Suwa. Yashimagahara (NT-8753; 1630 m, HS-18180; 1680 m, HK-9071), Kurumayama (1800 m, HK-9107; 1850 m, HK-9088). Kinpusan. Jumonji pass (1300 m, HD-8263, 8265). Yatsugadake. Mt. Yatsu (1600 m, N.Jinno-s.n.; TN-750). Akaho. Mt. Komagadake (680 m, HK-9029). Ichinose. Mt. Senjo (NT-14538), Mt. Todai (1170 m, TS-17318). Pref. Shizuoka. Akaishidake. Sawarajima (1000 m, NT-28836). Pref. Gifu. Tsushima. Mt. Shogadake (300 m, NT-42923). Pref. Mie. Gozaishozan. Fujiwara (400 m, HA-18299). Pref. Kyoto. Nara. Mt. Kasagi (280 m, HA-5079). Pref. Nara. Takamisan. Mt. Takami (1000 m, TN-13007). Odaigaharazan. Nakaoku (500 m, HD-9704), Sannoko (500 m, HD-9097), Mt. Odaigahara (1040 m, HD-7921, 7929; 1500 m, HD-7853, 7856). Sanjogadake. Mt. Misen (1350 m, HD-6696), Mt. Sanjogadake (1580 m, HD-6530). Shakagadake. Gyojagaeri hutte - Zenki (1750 m, HD-6755, 6762). Pref. Hyogo. Wakasa. Mt. Hyonosen (870 m, HD-12720; 900 m, HD-12725; 1450 m, TN-18470). Pref. Tottori. Yumoto. Mt. Mihira (1010 m, HD-6028, 6029). Pref. Hiroshima. Tsuta. Mt. Kanmuri (700-800 m, HD-14899; 900 m, HD-14961), Mt. Omine (480 m, TS-15613; 620 m, TS-15628; 1030 m, TS-15692). Sandankyo. Sandankyo valley (340 m, TS-16085; 550 m, HD-13422, 13423; 650 m, HD-10668). Otake. Yasakakyo valley (100 m, HD-14763). Pref. Yamaguchi. Otake. Nishimukuno (50-100 m, HD-14117, 14118).

SHIKOKU. Pref. Ehime. Nihama. Mt. Nishiakaishi (1600 m, HD-11411; 1620 m, HD-11469). Ishizuchisan. Mt. Ishizuchi (1650 m, H.Kashiwadani-s.n.).

KYUSHU. Pref. Oita. Oita. Mt. Yufu (760 m, HD-11177; 1250 m, HD-11144). Pref. Fukuoka. Yoshii. Mt. Hikosan (600 m, HA-11292). Pref. Kumamoto. Jigokuonsen (NT-2122).

18. *Schistidium maritimum* (Turn.) Bruch et Schimp. (Map 18)

HOKKAIDO. Rishirito. Oiso (8 m, HD-12027, 12030), Oniwaki (NT-15429), Rishiri isl. (NT-15845, 15846).

19. *Schistidium rivulare* (Brid.) Podp. (Map 19)

HOKKAIDO. Shibetsu. Shibetsu city (H.Kato-2099). Kokuryo. Uryu bog (750 m, HD-12660, 12662). Tokachigawajoryu. Shintoku (470 m, HK-8185), Tomuraushi spa (480 m, HD-11537, 11700, 11739, 11743; 500 m, HD-11866, HK-7918, 7929, 8060). Asahidake. Tenninkyo ( 600 m, HK-9544), Futamata (490 m, HK-9398, 9416). Nishitappu. Furebetsu (775 m, NT-22297), upper course of Nunobe river (1000 m, NT-31813). Ishiyama. Ishiyama (TNS-14494).

HONSHU. Pref. Iwate. Hayachinesan. Mt. Hayachine (620 m, HK-6709).

Pref. Fukushima. Azumayama. Maku spa (1260 m, RW-1818). Bandaisan. Inawashiro lakeside (515 m, RW-271). Fujiwara. Oze (1400 m, HK9208). Pref. Nigata. Naebasan. Mt. Naeba (1070 m, HK-9285). Pref. Nagano. Yarigadake. Mt. Yari (2500 m, HD-12856), Kamikochi (1300 m, HD-12945). Suwa. Suwa lakeside (7 60 m, NT-35702). Yatsugadake. Mt. Yatsu (1600 m, HD-14694). Ichinose. Upper course of Noro river (1800 m, NT-14285), Mt. Senjo (2900 m, NT-14509, 14515; 3000 m, RW-18639). Agematsu. Agematsu (Sasaoka-40539 in TNS). Okawara. Mt. Shiomi (2300 m, NT-14996, 14998), Sanpuku pass (2600 m, RW-6436). Pref. Shizuoka. Akaishidake. Hyakkenbora (2500 m, TS-6405). Pref. Hiroshima. Oasa. Obara (600 m, HD-15356). Kitsuka. Unazuki (720 m, HS-17612). Sandankyo. Tarutoko (710 m, HS-17582), Oku-sandankyo (750 m, HD-8288, 8314). Tsuta. Rakan valley (510 m, HD-14809, 14819, 14829), Mt. Kanmuri (700 m, Nishimura-674).

### 20. *Schistidium subconfertum* (Broth.) Deguchi (Map 20)

HONSHU. Pref. Yamanashi. Ichinose. Mt. Kitadake (3020 m, HD-13306, 13307; 3050 m, HD-13301). Pref. Nagano. Akaishidake. Mt. Higashi (3000 m, NT-6831).

### 21. *Coscinodon cribrosus* (Hedw.) Spruce (Map 21)

HOKKAIDO. Rishirito. Mt. Rishiri (1680 m, HD-12141 + *Grimmia elongata*). Shiretokomisaki. Mt. Shiretoko (800 m, HK-3130). Sharidake. Mt. Shari (1540 m, HD-12522, 12523, 12525, 12526, 12529, 12532, 12533, 12544). Kokuryo. Mt. Shokanbetsu (1400 m, HD-12672, 12673; 1490 m, HD-12674, 12675, 12676, 12677). Daisetsuzan. Goshikigahara (1480 m, HK-9443; 1900 m, HK-2835). Asahidake.

Mt. Ponkaun (1400 m, HK-9602), Mt. Hakuun - Mt. Chubetsu (1750 m, HD-12283; 1800 m, HD-12291; 1930 m, HK-9676), Mt. Kaun (1954 m, HD-12295b, 12301, 12303, 12304). *Nukabira*. Mt. Upepesanke (1650 m, HD-12417, 12418, 12422; 1825 m, HD-12420, 12427, 12428, 12430). *Tokachidake*. Mt. Furano (1500 m, NT-3178; 1700 m, HD-12347; 1730 m, HD-12350, 12353). *Yamabe*. Mt. Ashibetsu (1720 m, HD-12366; 1725 m, HD-12369, 12371, 12377, 12379). *Mikage*. Mt. Tsurugi (1203 m, HD-12408). *Rusutsu*. Mt. Yotei (1800 m, HD-12631, 12633, 12634, 12638, 12639, 12641, 12642).

HONSHU. Pref. Aomori. *Ominato*. Mt. Kamafuse (NT-17977). Pref. Iwate. *Rikuchu-noda*. Noda (Sakurai-s.n., leg. S. Murai, Sept. 19, 1952, det. as *Grimmia plagiopodia* by Sakurai). *Hachimantai*. Mt. Mitsuishi (1400 m, RW-4760). Pref. Miyagi. *Kaminoyama*. Mt. Katta (800 m, Sakurai-s.n.). *Shiroishi*. Gagaonsen (1000 m, RW-1704). Pref. Fukushima. *Seki*. Mt. Handa (600 m, NT-29938). *Bandaisan*. Urabandai (700-800 m, HS-10686; 1000 m, HK-6211). *Idesan*. Mt. Ide (2000 m, RW-4087). Pref. Yamanashi. *Ichinose*. Mt. Kitadake (2950 m, HD-13251; 3170 m, HD-13267, 13275), Mt. Kitadake - Mt. Ainodake (3100 m, HD-13296, 13297, 13298), Mt. Notori - Narata (2800 m, HD-13318; 2850 m, HD-13321). *Yatsugadake*. Mt. Gongen (1500 m, RW-6689; 2700 m, RW-6504), Mt. Amigasa (1600 m, RW-6495). Pref. Nagano. *Naebasan*. Mt. Naeba (2000 m, HD-14723). *Shiroumadake*. Mt. Norikura - Hakubaoike (2430 m, HD-12746, 12748, 12749, 12750, 12753), Kaerazunoken (2750 m, HD-12802), Akanuke - Mt. Norikura (2440 m, HD-12705, 12759), Mt. Shirouma (2760 m, HD-12766; 2780 m, HD-12769, 12770, 12771, 12774). *Omachi*. Mt. Goryu - Mt. Kashimayari (2500 m, HD-12820, 12822), Mt. Goryu (2600-2800 m, NT-10381). *Yarigadake*. Mt. Otensho - Mt. Nishidake (2600 m, HD-12917), Mt. Tsubakuro - Mt. Otensho (2600 m, HD-12902), Mt. Yari

(3000 m, NT-12623; 3100 m, Sakurai-s.n. in MAK). *Suzaka*. Mt. Neko (NT-911), Mt. Azuma (2000 m, NT-32624). *Ontakesan*. Mt. Ontake ( 2450 m, HD-13084; 2470 m, HD-13085; 2780 m, HD-13129 + *Grimmia elongata*; 2870 m, HD-12682). *Akaho*. Mt. Komagadake (2750 m, HD-13007; 2800 m, HD-12994, 13042, 130033, 13045). *Ichinose*. Mt. Senjo ( 2600-3000 m, KS-9162), Mt. Asayo (2400 m, NT-14478; 2799 m, NT-14486, 14493). *Akaishidake*. Mt. Akaishi (3000 m, NT-6830). Pref. Saitama. *Kunpusan*. Jumonji pass (2000 m, HD-13701). Pref. Toyama. *Tateyama*. Mt. Tateyama (2900 m, HD-13165; 2940 m, HD-13151, 13156, 13159, 13160), Mt. Shirouma - Mt. Hakubayari (2790 m, HD-12780). Pref. Shizuoka. *Akaishidake*. Mt. Higashi (3000 m, NT-28905; TK-48859). *Okawara*. Mt. Shiomi (2900 m, RW-6237). Pref. Nara. *Odaigaharazan*. Mt. Odaigahara (1040 m, HD-7922; 1380 m, HD-7862, 7863; 1500 m, HD-7857). Pref. Hiroshima. *Tsuta*. Mt. Omine (1030 m, TS-15691, 15713), Takiwaguchi (380 m, TS-35793). *Itsukushima*. Miyajima isl. (525 m, TS-16501).

SHIKOKU. Pref. Ehime. *Nihama*. Mt. Akaishi (1500 m, NT-20215, 20216; 1600 m, HD-11401, 11402, 11409; 1620 m, HD-11470; 1630 m, HD-11405, 11468; 1650 m, HD-11408). *Ishizuchisan*. Mt. Ishizuchi (1620 m, RW-20096; 1650 m, HD-11523; 1700 m, HD-11524).

KYUSHU. Pref. Oita. *Kuju*. Mt. Kuju (1500 m, A.Noguchi-3298, holotype of *Coscinodon humilis* Horik. et Nog. in HIRO).

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# Figures and Maps

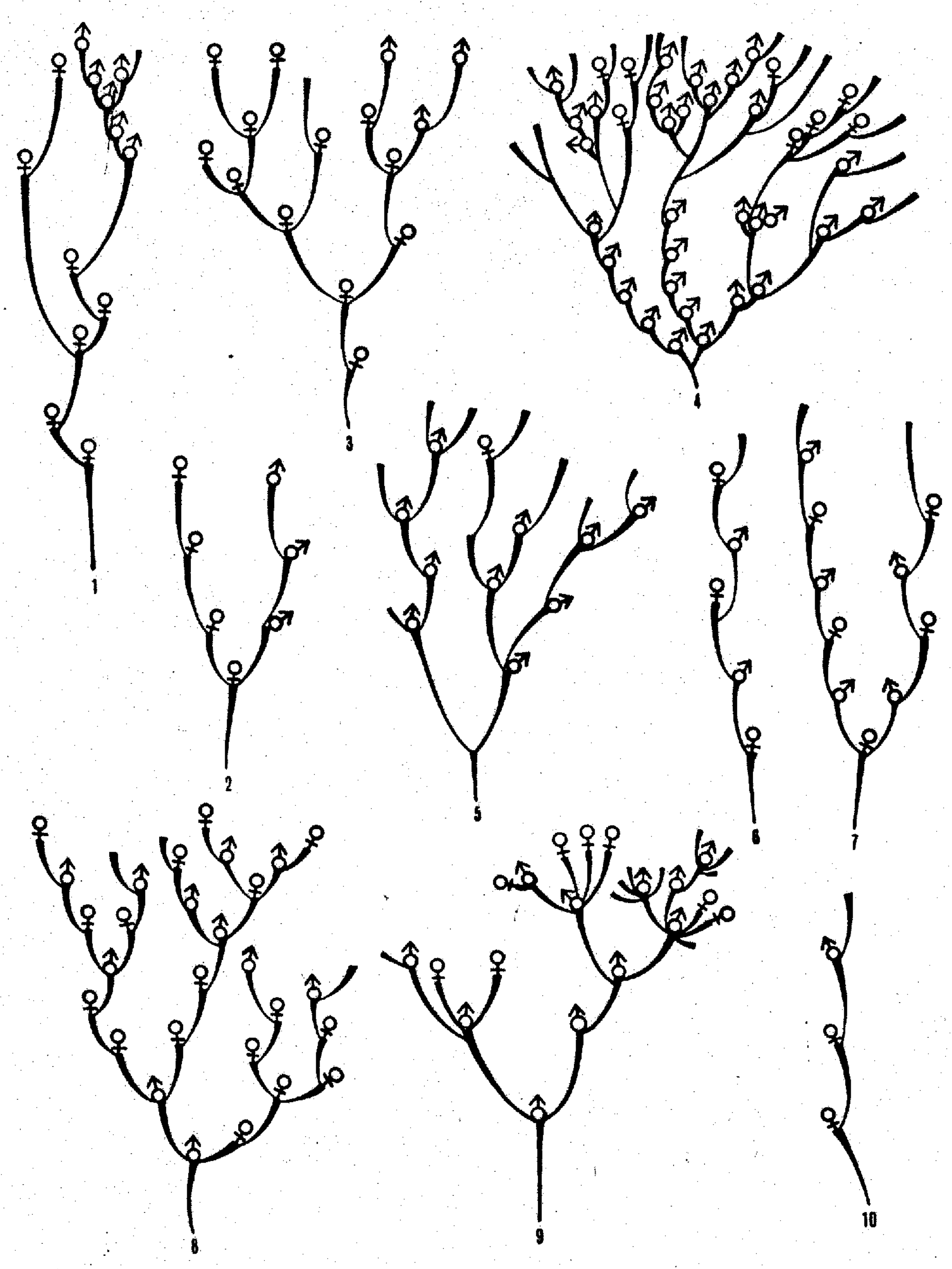


Fig. 1. Schematic representation of branching and distribution of sexual organs. 1 & 5. Grimmia affinis. 2 & 3. G. subsulcata. 4. G. incurva. 6 & 7. Schistidium gracile. 8. S. liliputanum. 9. S. rivulare. 10. S. maritimum.

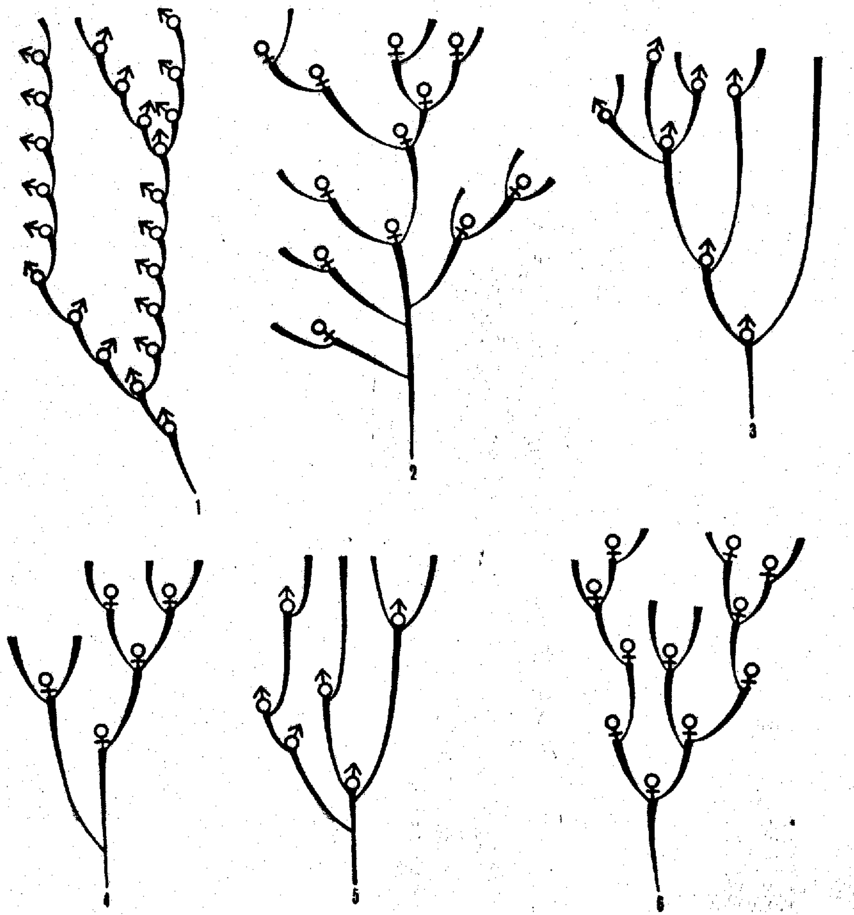


Fig. 2. Schematic representation of branching and distribution of sexual organs. 1 & 2. *Grimmia pilifera*. 3. *G. brachydictyon*. 4 & 5. *G. elongata*. 6. *Coscinodon cribrosus*.

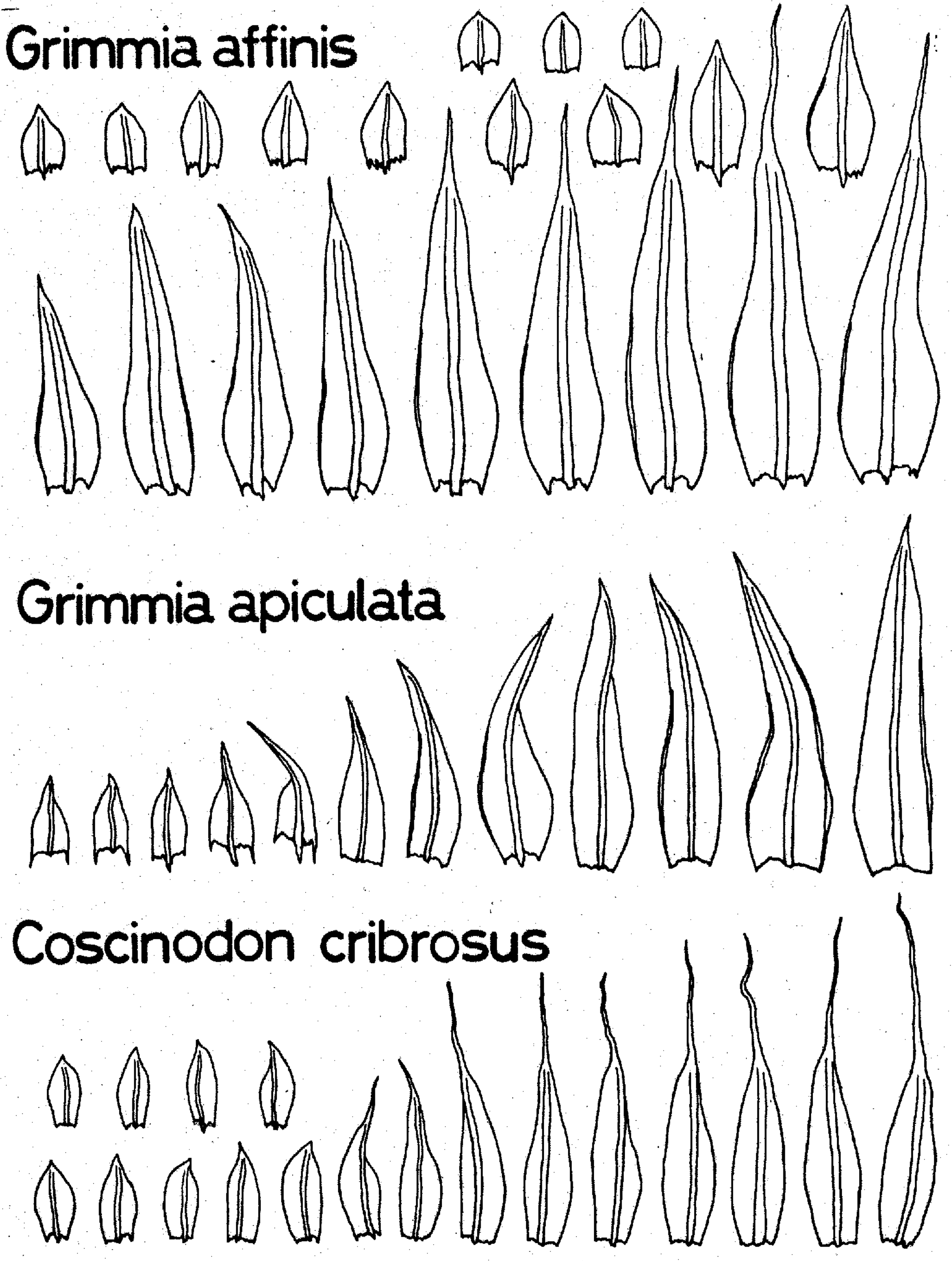


Fig. 3. Variation of leaves from a single stem. Grimmia affinis (Drawn from HIRO-Deguchi 13260); G. apiculata (HIRO-Deguchi 13286); Coscinodon cribrosus (HIRO-Deguchi 12301). x 25.

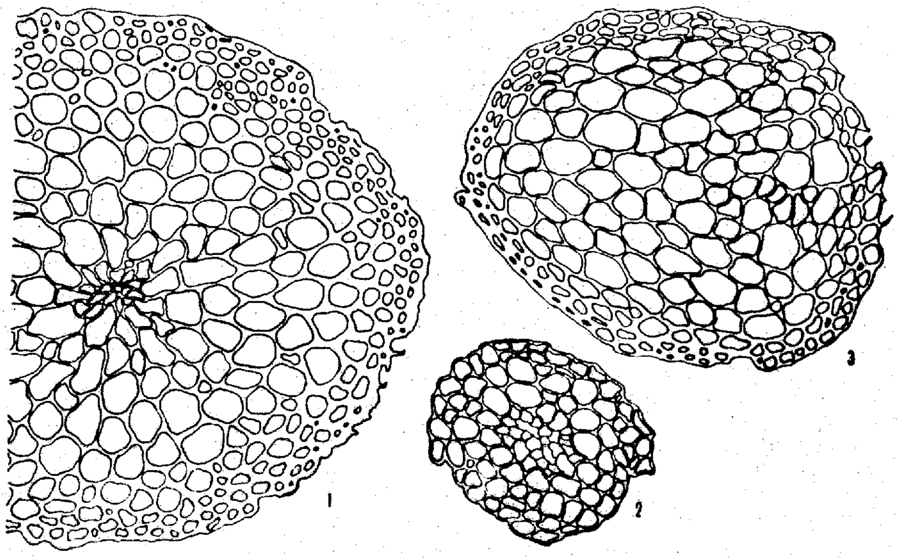


Fig. 4. Cross-sections of stem showing three types of stem structure. 1. Schistidium rivulare (Drawn from HIRO-Deguchi 12948). 2. Grimmia subsulcata (HIRO-Deguchi 12950). 3. Grimmia curvata (HIRO-Deguchi 13064). x 240.

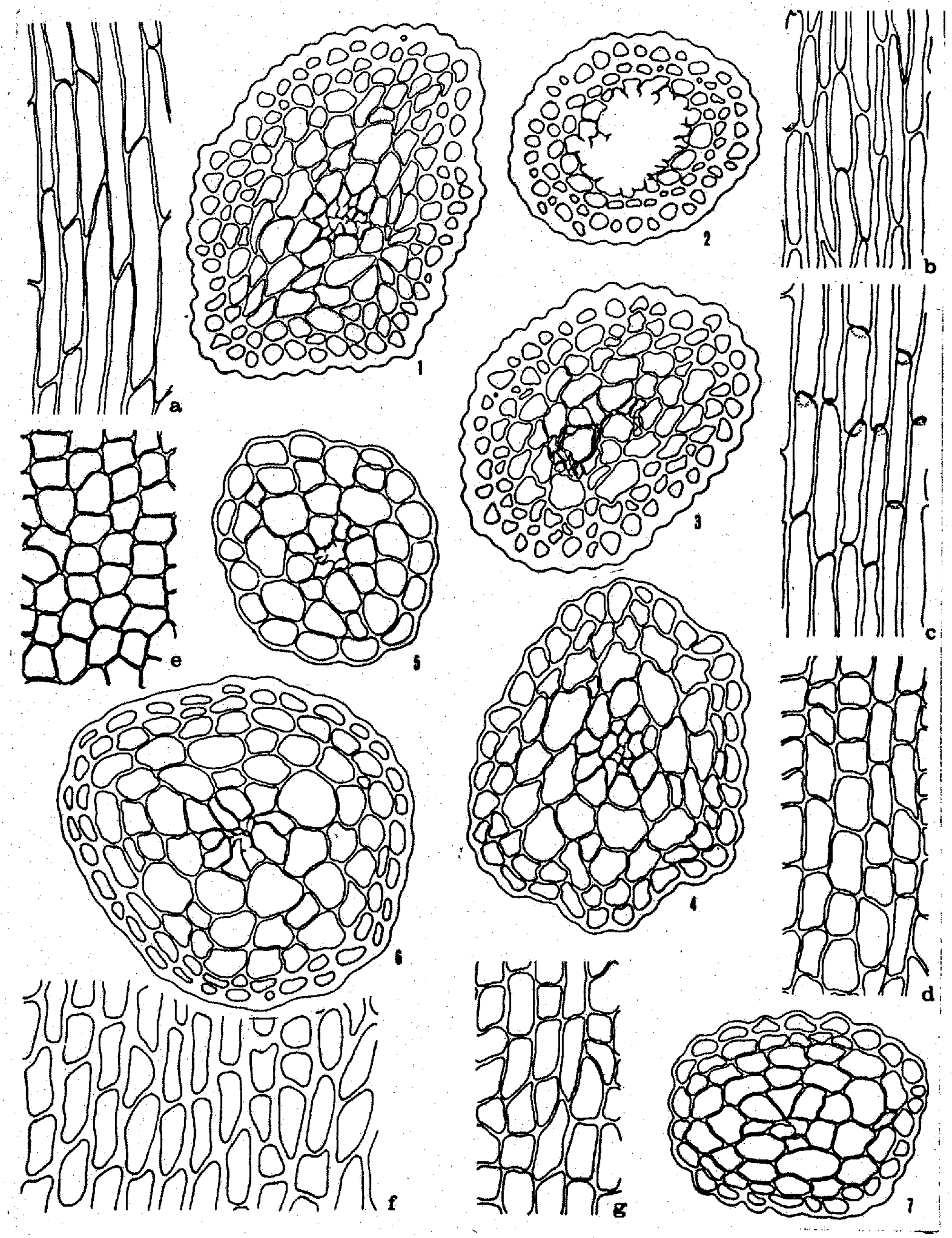


Fig. 5. Cross-sections of seta (1-7) and surface views of epidermal cells of seta (a-g). 1-a. Grimmia apiculata (Drawn from HIRO-Deguchi 13286). 2-b. G. brachydictyon (HIRO-Deguchi 13165). 3-c. G. affinis (HIRO-Deguchi 13260). 4-d. G. pilifera (HIRO-Deguchi 13212). 5-e. Schistidium apocarpum (HIRO-Deguchi 13337). 6-f. S. rivulare (HIRO-Deguchi 12945). 7-g. Coscinodon cribrosus (HIRO-Deguchi 12301). x 240.

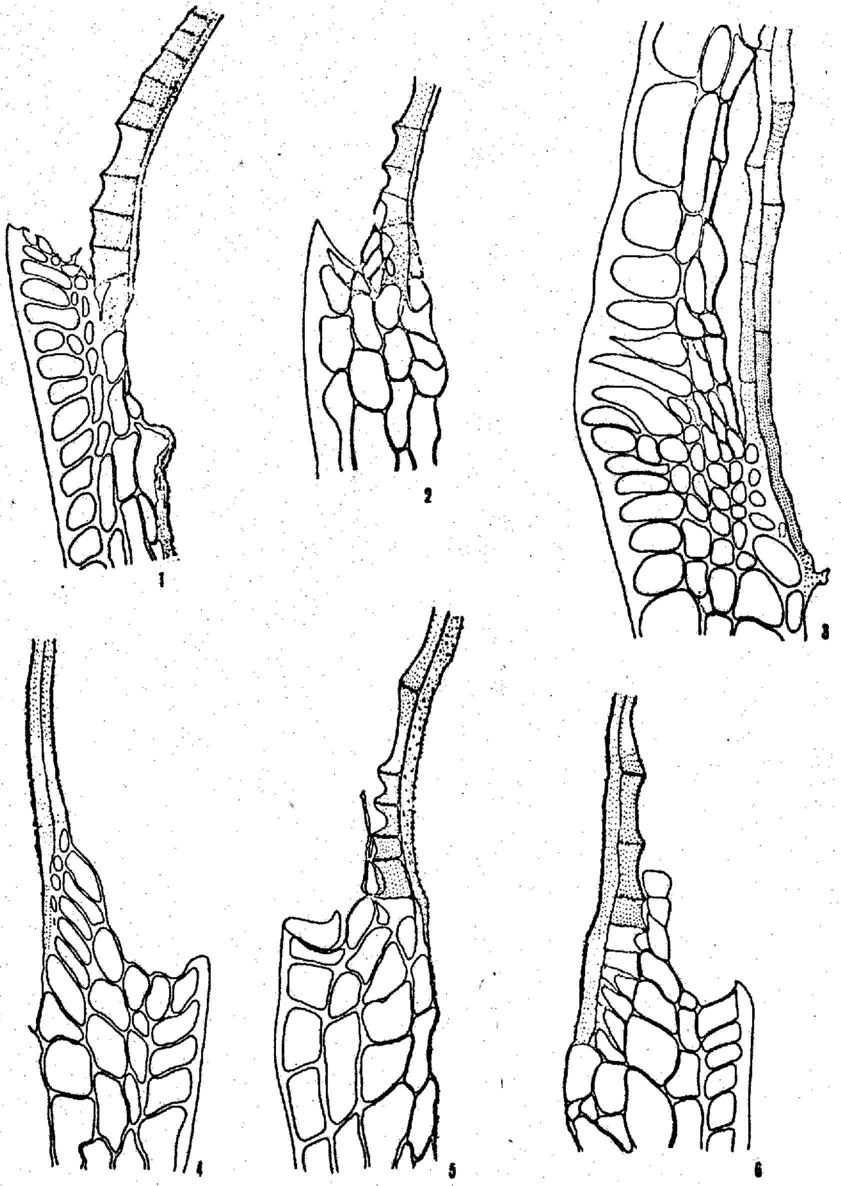


Fig. 6. Longitudinal sections of peristome. 1. *Schistidium rivulare* (Drawn from HIRO-Deguchi 11743). 2. *Grimmia apiculata* (HIRO-Deguchi 13308). 3. *Coscinodon cribrosus* (Loire, Massif du Pilat, 22/3/1954, leg. P.Cuynet, Herb. Bonnot, no. 393). 4. *Racomitrium fasciculare* (Belgique, Herb. Bonnot, no. 387). 5. *R. heterostichum* var. *sudetichum* (France, Haute-Loire, Herb. Bonnot, no. 385). 6. *R. heterostichum* (France, Loire, Herb. Bonnot, no. 389).

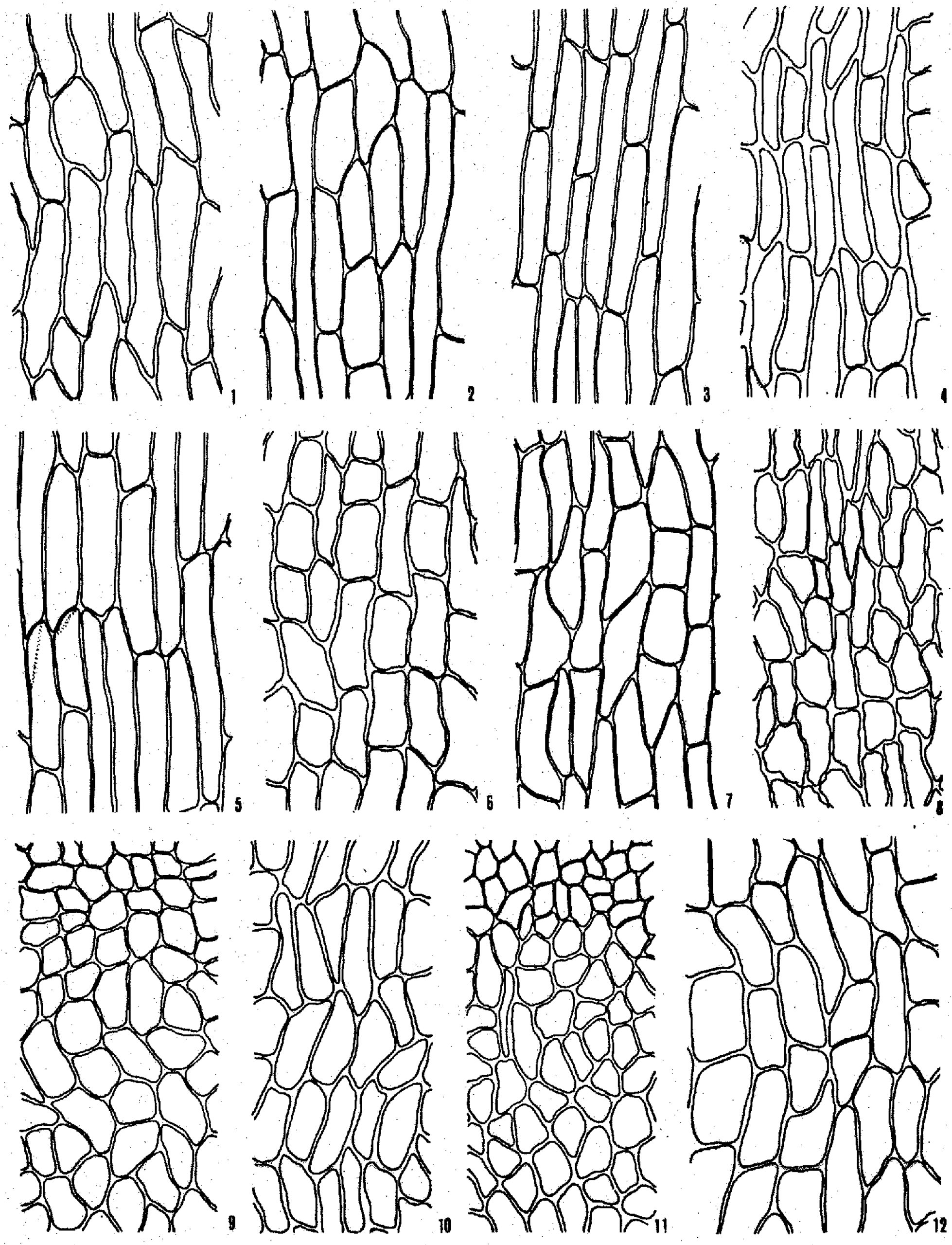


Fig. 7. Epidermal cells of vaginula. 1. *Grimmia affinis* (Drawn from HIRO-Deguchi 13250). 2. *G. apiculata* (HIRO-Deguchi 13304). 3. *G. atrata* (Watanabe-1691 in MAK). 4. *G. brachydictyon* (HIRO-Deguchi 12165). 5. *G. elongata* (HIRO-Deguchi 13130). 6. *G. incurva* (HIRO-Deguchi 13004). 7. *G. subsulcata* (HIRO-Kanda 8602). 8. *Coscinodon cribrosus* (HIRO-Deguchi 12523). 9. *Schistidium apocarpum* (HIRO-Deguchi 11187). 10. *S. rivulare* (HIRO-Deguchi 111743). 11. *S. liliputanum* (HIRO-Deguchi 11177). 12. *S. maritimum* (HIRO-Deguchi 12030). x 325.

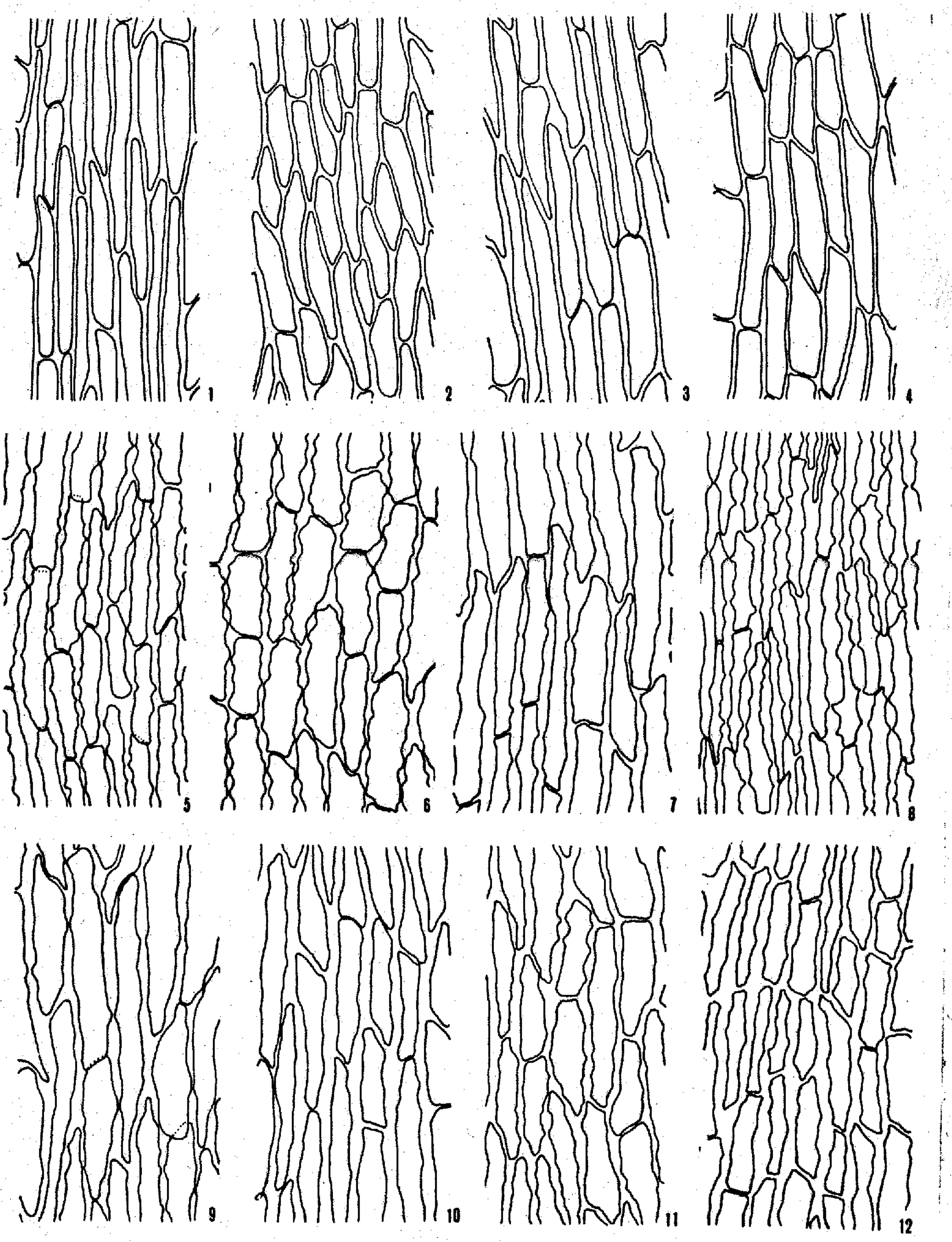


Fig. 8. Epidermal cells of vaginula. 1. Ptychomitrium polyphylloides (Drawn from HIRO-Deguchi 11209). 2. P. linearifolium (HIRO-Deguchi 11158). 3. P. fauriei (HIRO-Deguchi 5157). 4. P. dentatum (HIRO-Deguchi 4461). 5. Racomitrium heterostichum var. diminutum (HIRO-Deguchi 11149). 6. R. heterostichum var. sudeticum (HIRO-Deguchi 12086). 7. R. fasciculare (HIRO-Deguchi 12326). 8. R. fasciculare var. atroviride (HIRO-Deguchi 6121). 9. R. carinatum (HIRO-Deguchi 13132). 10. R. aciculare (HIRO-Deguchi 11723). 11. R. canescens ( HIRO-Deguchi 9157). 12. G. curvata (HIRO-Deguchi 12921). x 325.

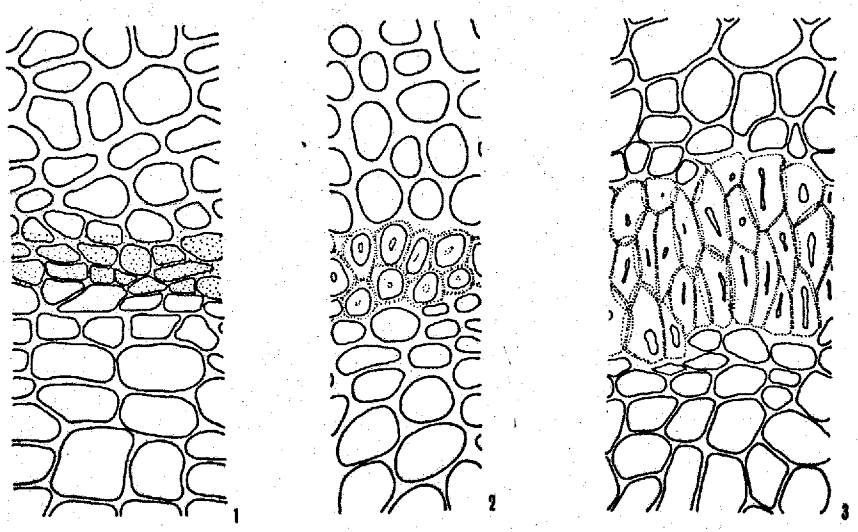


Fig. 9. Three types of annulus. 1. *Schistidium* type: *Schistidium gracile* (Drawn from HIRO-Deguchi 13390). 2. *Elongata* type: *Grimmia elongata* (HIRO-Deguchi 13080). 3. *Affinis* type: *Grimmia affinis* (HIRO-Deguchi 13260). x 400.

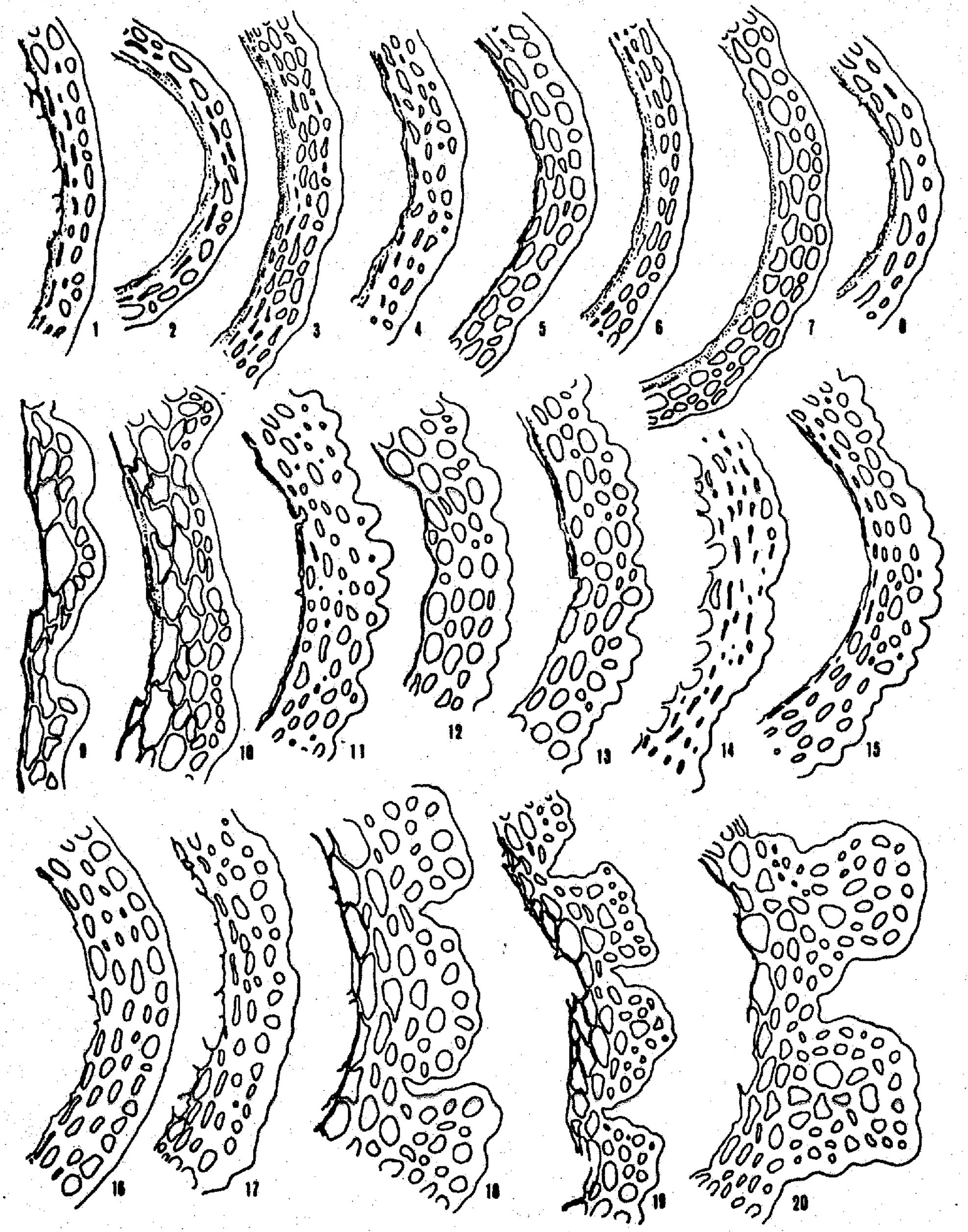


Fig. 10. Cross-sections of calyptra. 1. *Grimmia affinis* (Drawn from HIRO-Deguchi 13274). 2. *G. apiculata* (HIRO-Deguchi 13293). 3. *G. atrata* (HIRO-Deguchi 12803). 4. *G. brachydictyon* (HIRO-Deguchi 12589). 5. *G. curvata* (HIRO-Deguchi 13064). 6. *G. elongata* (HIRO-Deguchi 13130). 7. *G. subsulcata* (HIRO-Deguchi 12950). 8. *Schistidium apocarpum* (HIRO-Deguchi 11187). 9-10. *Coscinodon cribrosus* (HIRO-Deguchi 12301). 11. *Racomitrium canescens* (HIRO-Deguchi 8866). 12. *R. carinatum* (HIRO-Deguchi 13132). 13. *R. fasciculare* (HIRO-Deguchi 12335). 14. *R. fasciculare* var. *atroviride* (HIRO-Deguchi 6121). 15. *R. heterostichum* var. *diminutum* (HIRO-Deguchi 11149). 16. *R. heterostichum* var. *sudeticum* (HIRO-Deguchi 14120). 17. *R. lanuginosum* (HIRO-Deguchi 12576). 18. *Ptychomitrium dentatum* (HIRO-Deguchi 14120). 19. *P. linearifolium* (HIRO-Deguchi 13426). 20. *P. polyphylloides* (HIRO-Deguchi 11218).

x 325

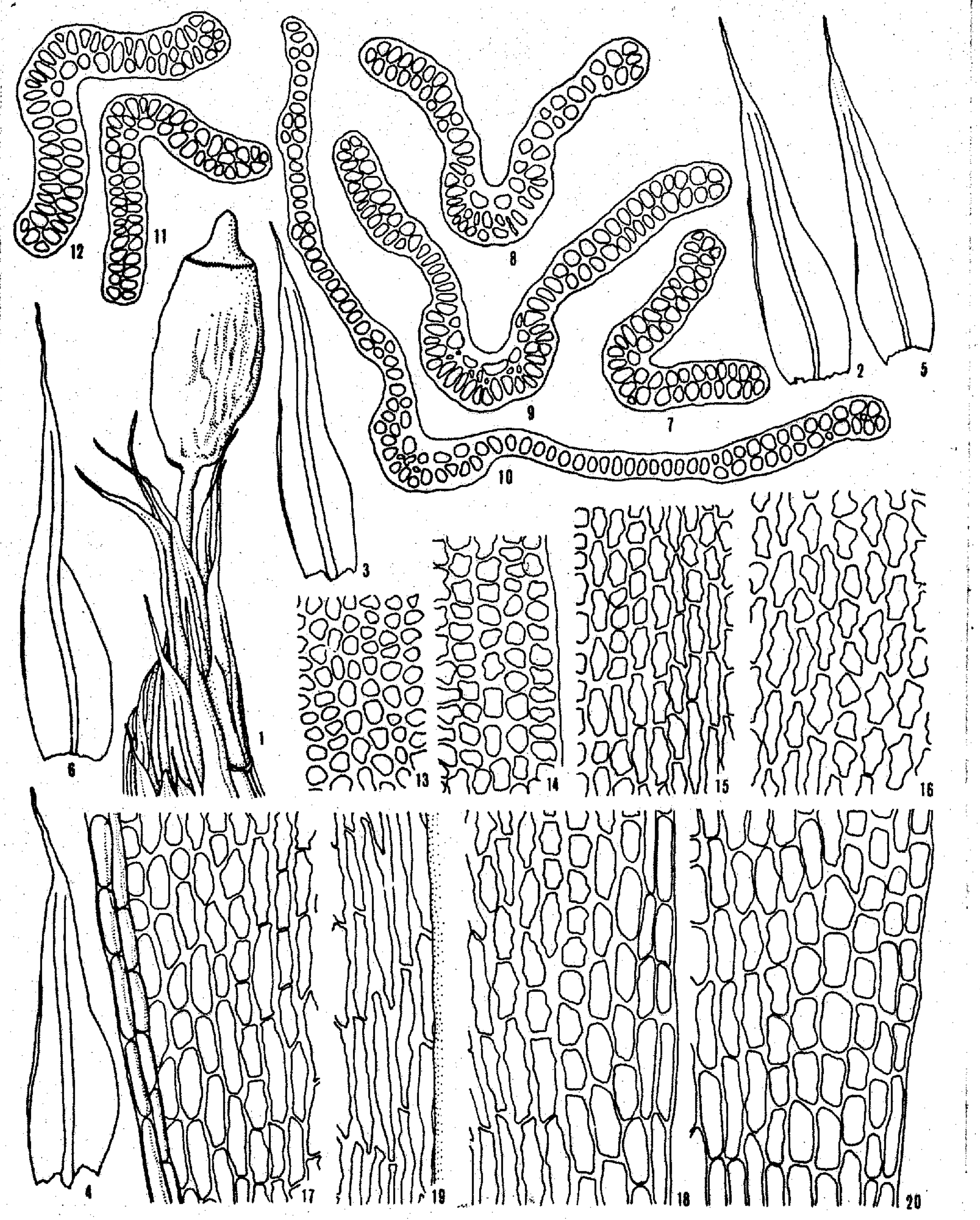


Fig. 11. *Grimmia affinis* Hornsch. 1. Plant, x50. 2-6. Leaves, x50. 7-12. Cross-sections of leaf, x240. 13-20. Laminal cells from upper (13, 14), middle (15, 16), basal angular (17, 18, 20), and basal paracostal (19) parts, x325. (1-4, 7-11, 13, 15, 17-19: drawn from HIRO-Deguchi 13260; 5, 6, 12, 14, 16, 20: holotype of *Grimmia akaishi-alpina* in Takaki's private herbarium).

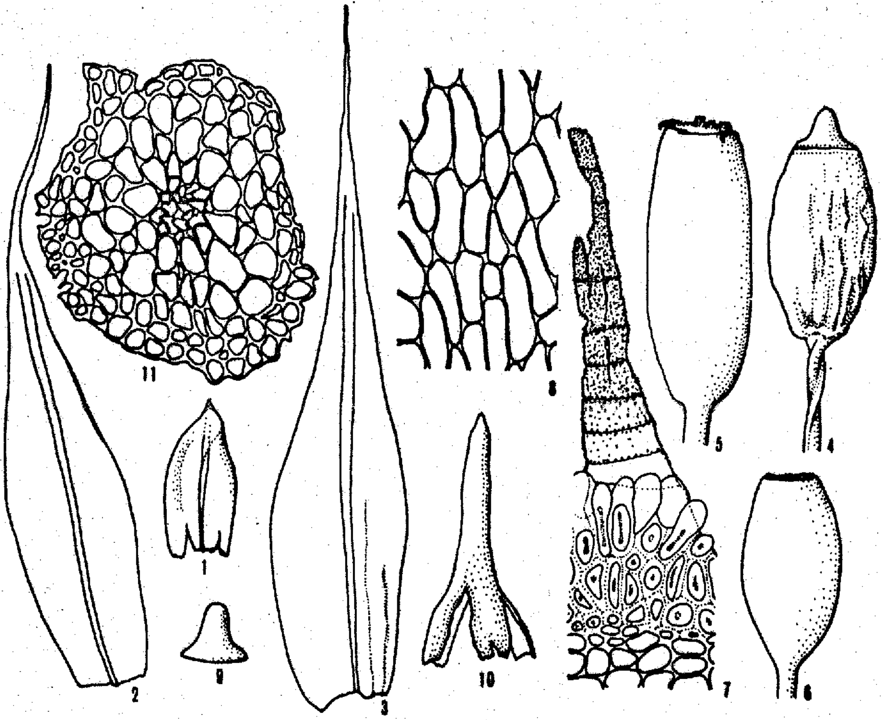


Fig. 12. Grimmia affinis Hornsch. 1. Perigonial leaf, x25. 2,3. Perichaetial leaves, x25. 4-6. Capsules, x25. 7. Peristome, 240. 8. Exothecial cells, x240. 9. Operculum, x25. 10. Calyptra, x25. 11. Cross-section of stem, x240. (1, 2, 4, 7-11:drawn from HIRO-Deguchi 13260; 3, 5, 6: holotype of Grimmia akaishi-alpina in Takaki's private herbarium).

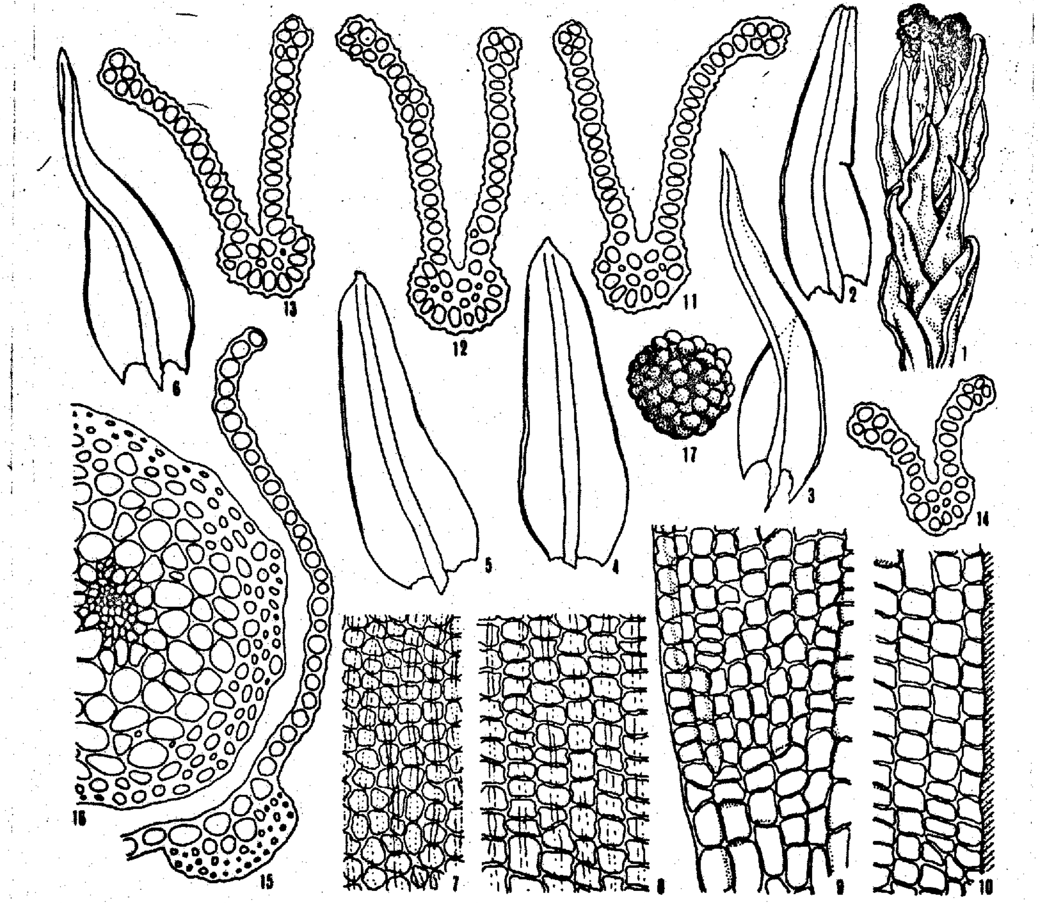


Fig. 13. Grimmia anomala Hampe ex Schimp. 1. Plant, x25. 2-6. Leaves, x25. 7-10. Laminal cells from upper (7), middle (8), basal angular (9), and basal paracostal (10) parts, x325. 11-15. Cross-sections of leaf, x240. 16. Cross-section of stem, x240. 17. Gemma, x240. (Drawn from HIRO-Deguchi 12874).

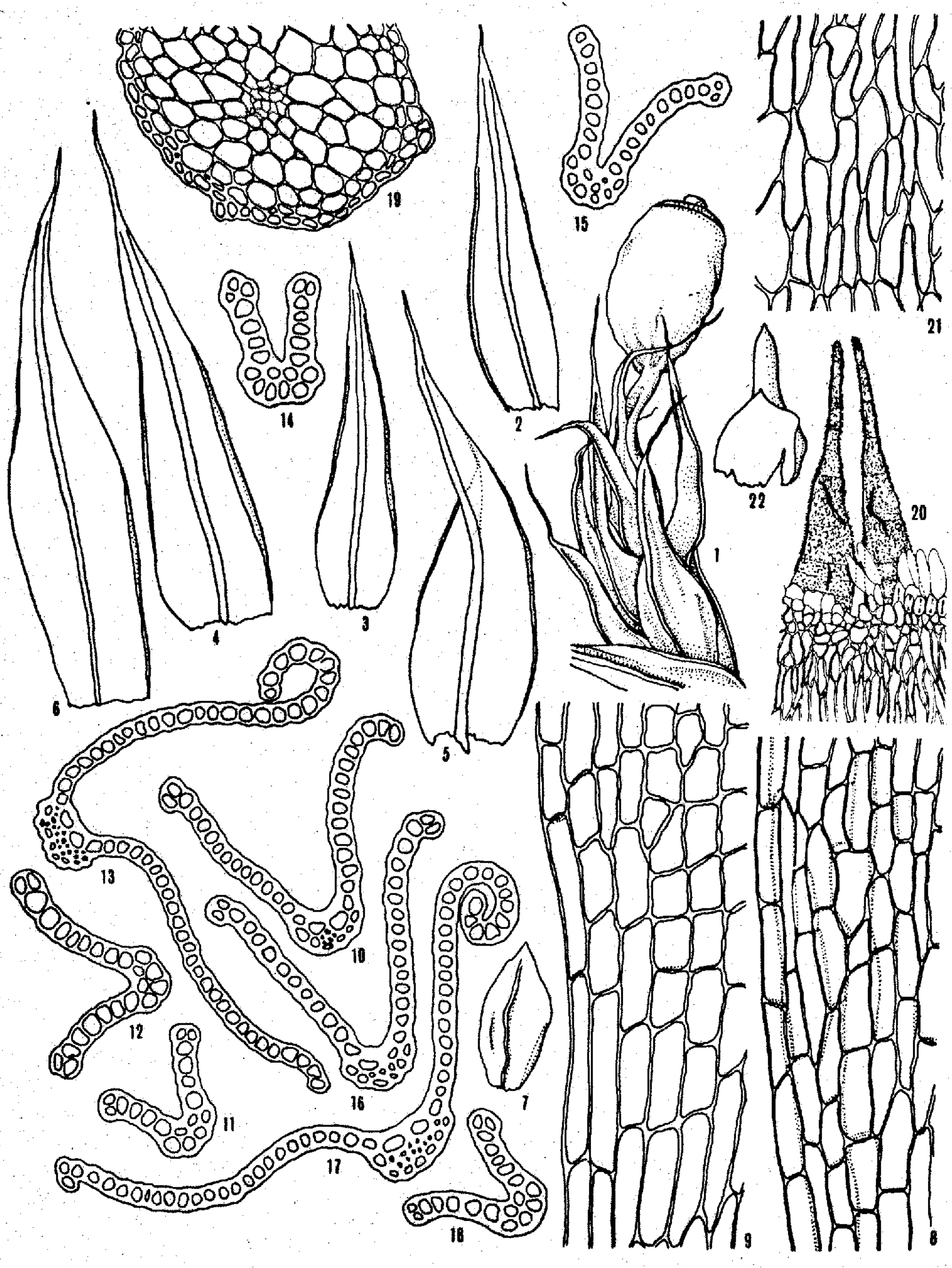


Fig. 14. *Grimmia apiculata* Hornsch. 1. Plant, x25. 2-5. Leaves, x25. 6. Perichaetial leaf, x25. 7. Perigonial leaf, x25. 8 & 9. Laminal cells from angular part, x325. 10-18. Cross-sections of leaf, x240. 19. Cross-section of stem, x240. 20. Peristome, x240. 21. Exothecial cells, x240. 22. Calyptra, x25. (1-9, 19-22: drawn from HIRO-Deguchi 13286; 10-18: HIRO-Deguchi 13269).

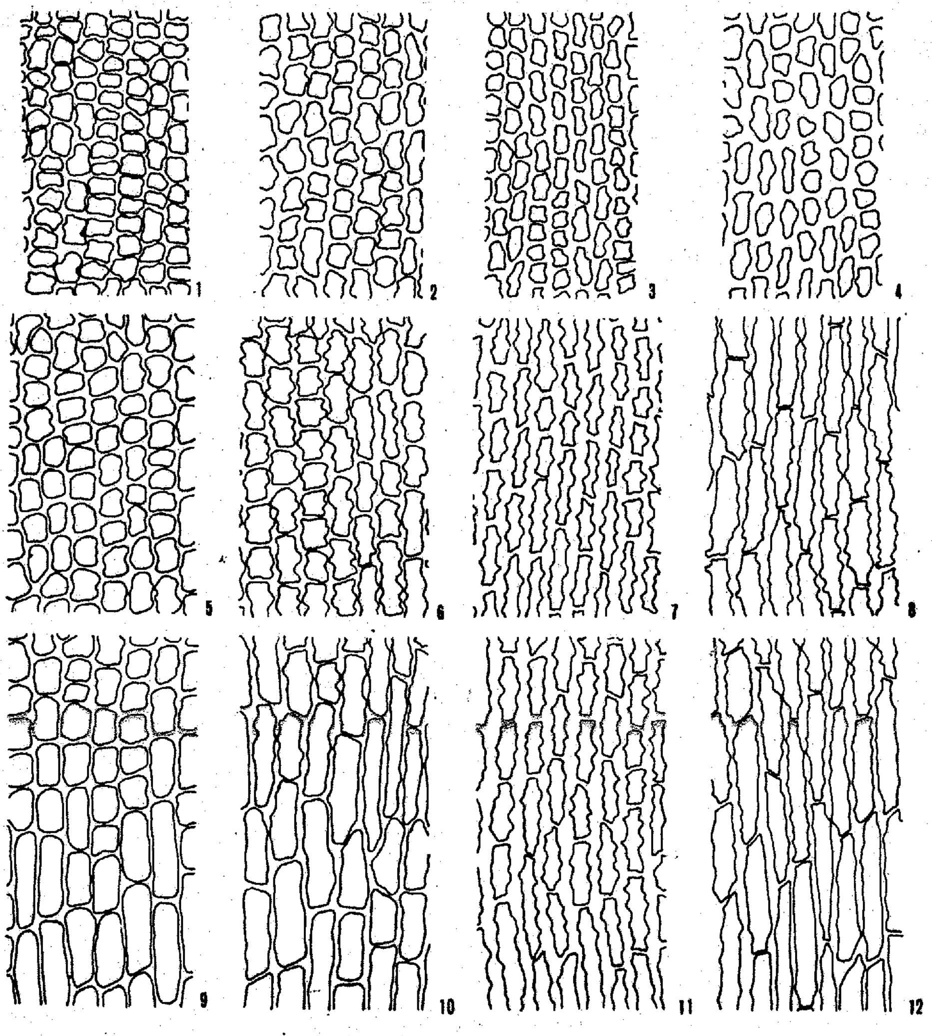


Fig. 15. *Grimmia apiculata* Hornsch. Variation of laminal cells. 1-4. Cells from upper part. 5-8. Ditto from middle part. 9-12. Ditto from the widest part. x 325. (1, 5, 9: drawn from HIRO-Deguchi 13293; 2, 6, 10: HIRO-Deguchi 13263; 3, 7, 11: HIRO-Deguchi 13263b; 4, 8, 12: HIRO-Deguchi 13272).

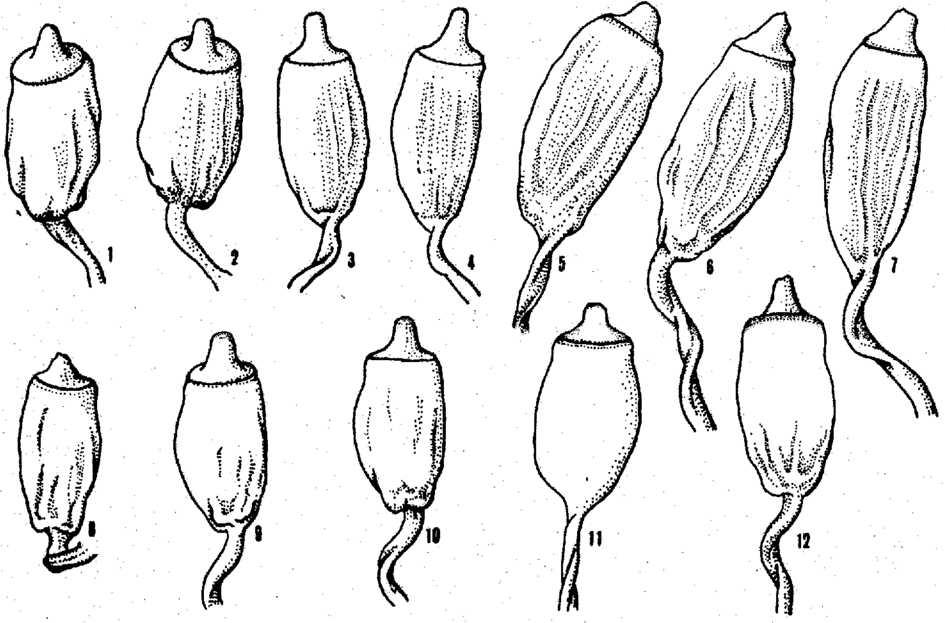


Fig. 16. Grimmia apiculata Hornsch. Variation of capsules. 1-4, 12: drawn from HIRO-Deguchi 13293; 5, 9-11: HIRO-Deguchi 13263; 6 & 7: HIRO-Deguchi 13272. x 25.

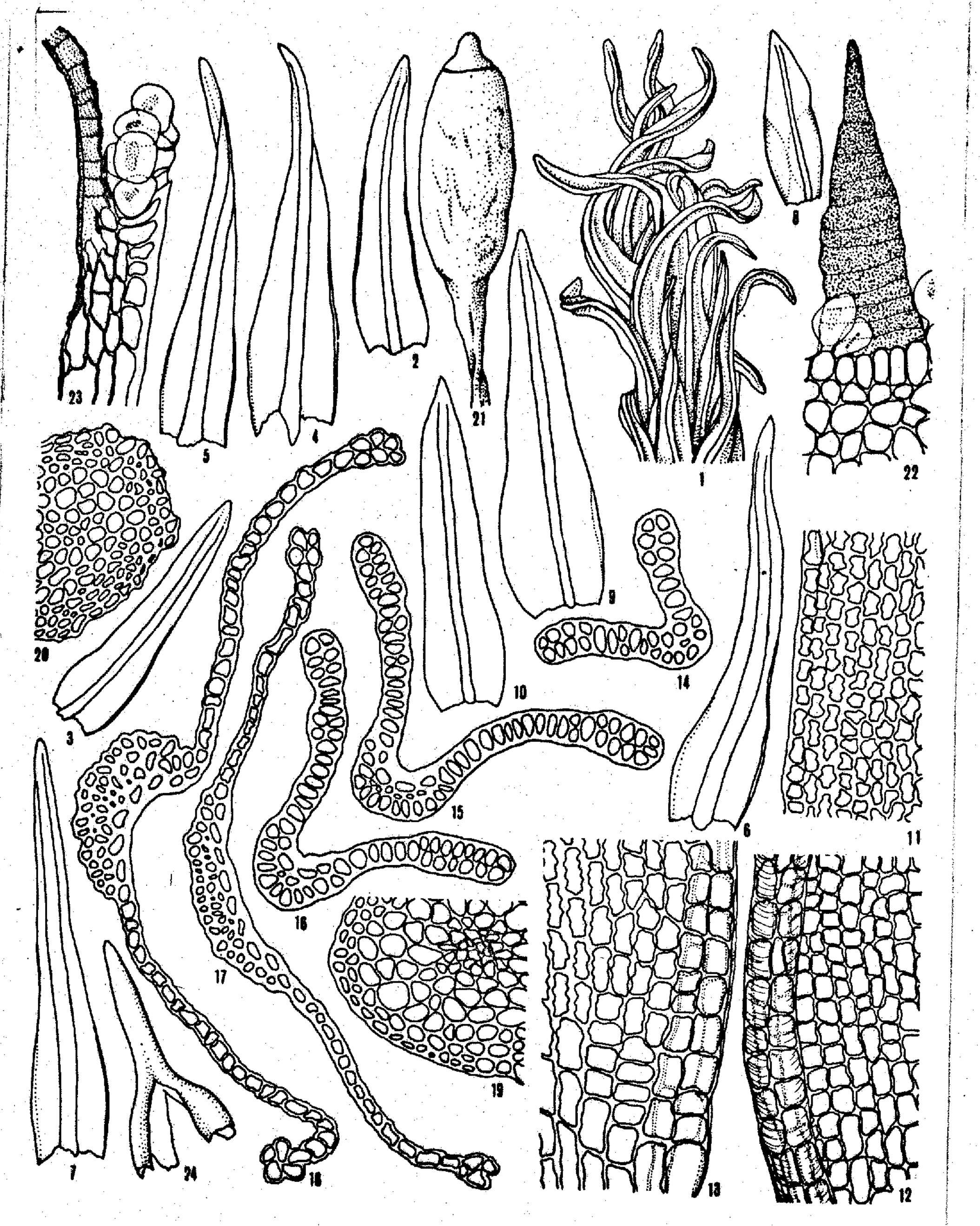


Fig. 17. *Grimmia atrata* Mielich. ex Hornsch. 1. Plant, x25. 2-7. Leaves, x25. 8. Perigonial leaf, x25. 9 & 10. Perichaetial leaves, x25. 11-13. Laminal cells from upper (11) and angular (12, 13) parts, x325. 14-18. Cross-sections of leaf, x240. 19 & 20. Cross-sections of stem, x240. 21. Capsule, x25. 22. Peristome, x240. 23. Longitudinal section of peristome, x240. 24. Calyptra, x25. (1-3, 8-16, 19-24: drawn from HIRO-Deguchi 12308; 4-7, 17, 18: Faurie-3380 in H-BR).

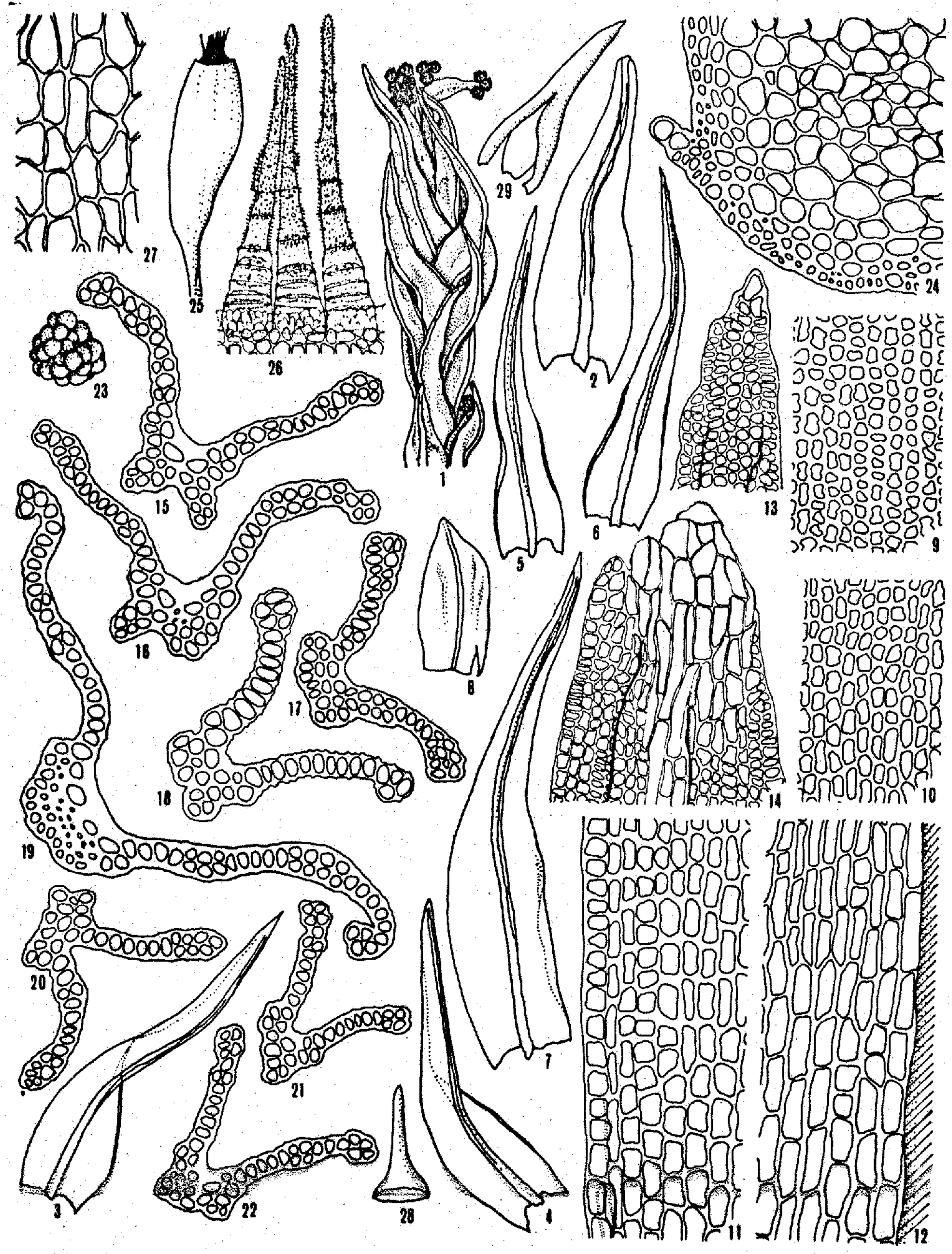


Fig. 18. *Grimmia brachydictyon* (Card.) Deguchi 1. Plant, x25. 2-6. Leaves, x25. 7. Perichaetial leaf, x25. 8. Perigonial leaf, x25. 9-12. Laminal cells from upper (9), middle (10), angular (11), and basal paracostal (12) parts, x325. 13 & 14. Apical parts of leaf, x240. 15-22. Cross-sections of leaf, x240. 23. Gemma, x120. 24. Cross-section of stem, x240. 25. Capsule, x25. 26. Peristome, x120. 27. Exothecial cells, x240. 28. Operculum, x25. 29. Calyptra, x25. (1-4, 7-17, 19, 20, 23-29: drawn from HIRO-Deguchi 12165; 5, 6, 21, 22: NICH-27390; 18: N.Iwasaki-9453 in MAK).

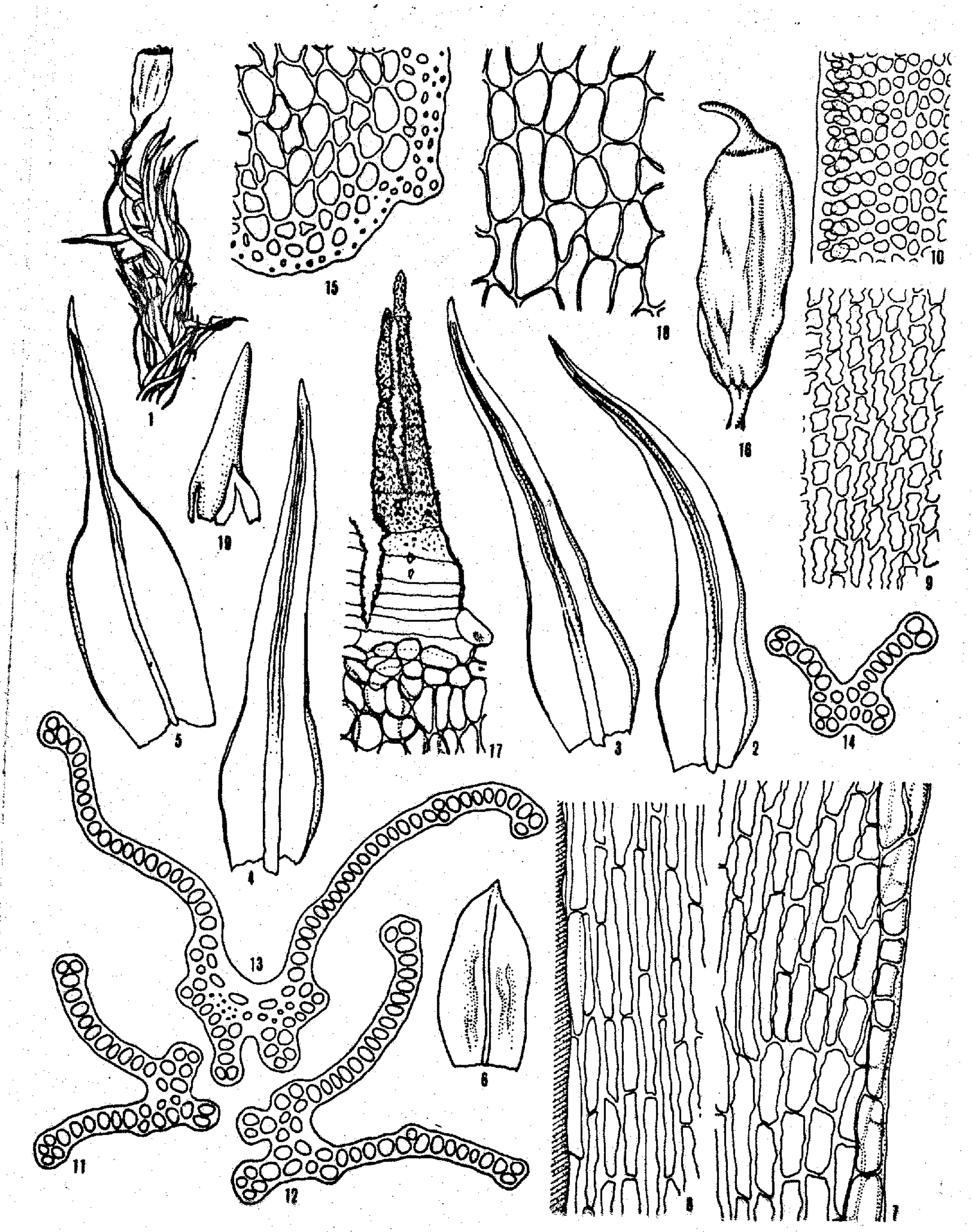


Fig. 19. *Grimmia curvata* (Brid.) De Sloov. 1. Plant, x9. 2-4. Leaves, x25. 5. Perichaetial leaf, x25. 6. Perigonial leaf, x25. 7-10. Laminal cells from upper (10), middle (9), angular (7), and basal paracostal (8) parts, x325. 11-14. Cross-sections of leaf, x240. 15. Cross-section of stem, x240. 16. Capsule, x25. 17. Peristome, x240. 18. Exothecial cells, x240. 19. Calyptra, x25. (Drawn from HIRO-Deguchi 13064).

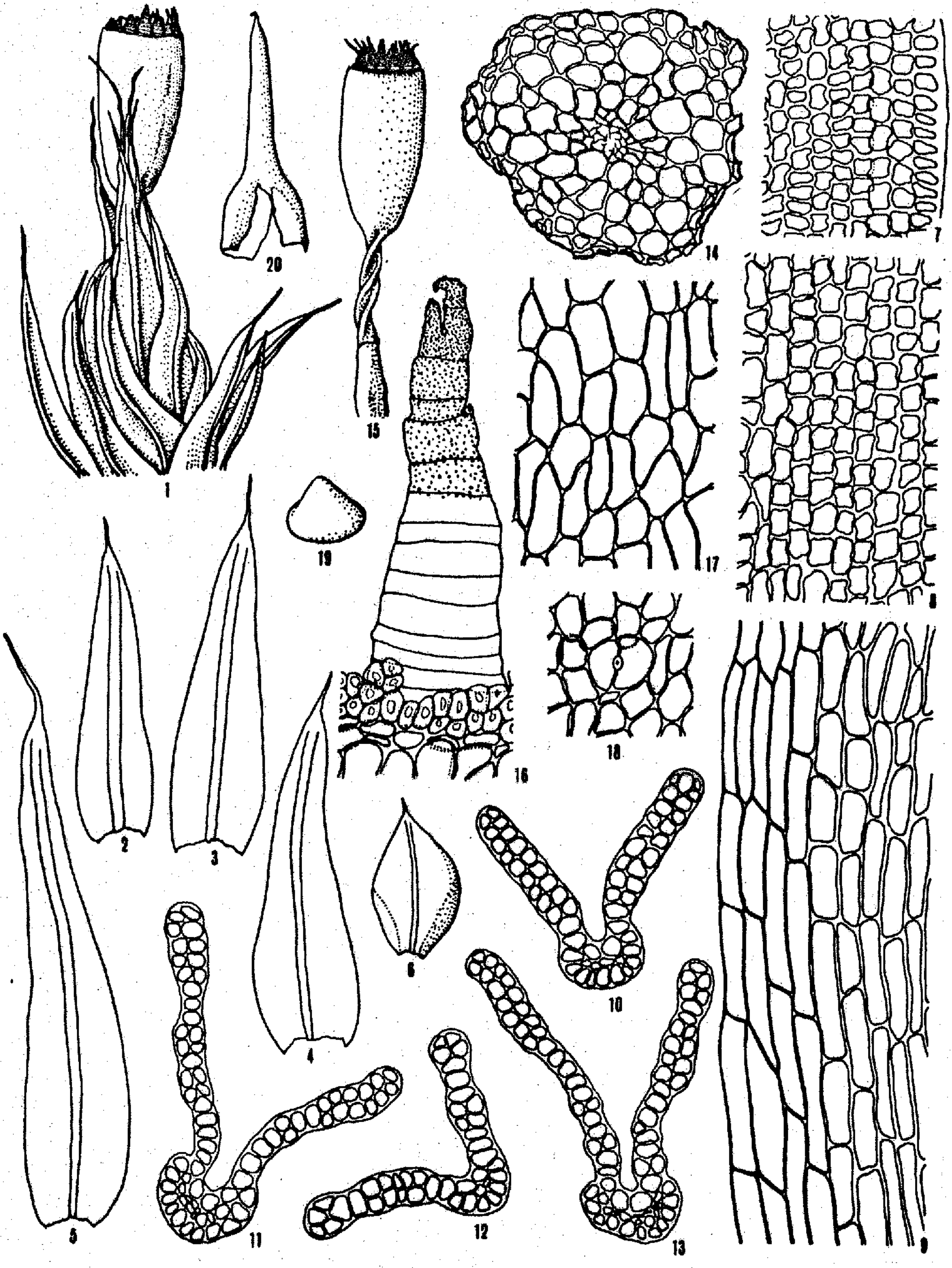


Fig. 20. Grimmia donniana Sm. 1. Plant, x25. 2-4. Leaves, x25. 5. Perichaetial leaf, x25. 6. Perigonial leaf, x25. 7-9. Laminal cells from upper (7), middle (8), and basal (9) parts, x325. 10-13. Cross-sections of leaf, x240. 14. Cross-section of stem, x240. 15. Capsule with seta and vaginula, x25. 16. Peristome and annulus, x240. 17. Exothecial cells, x240. 18. Stomata, x240. 19. Operculum, x25. 20. Calyptra, x25. (Drawn from HIRO-Deguchi 13023).

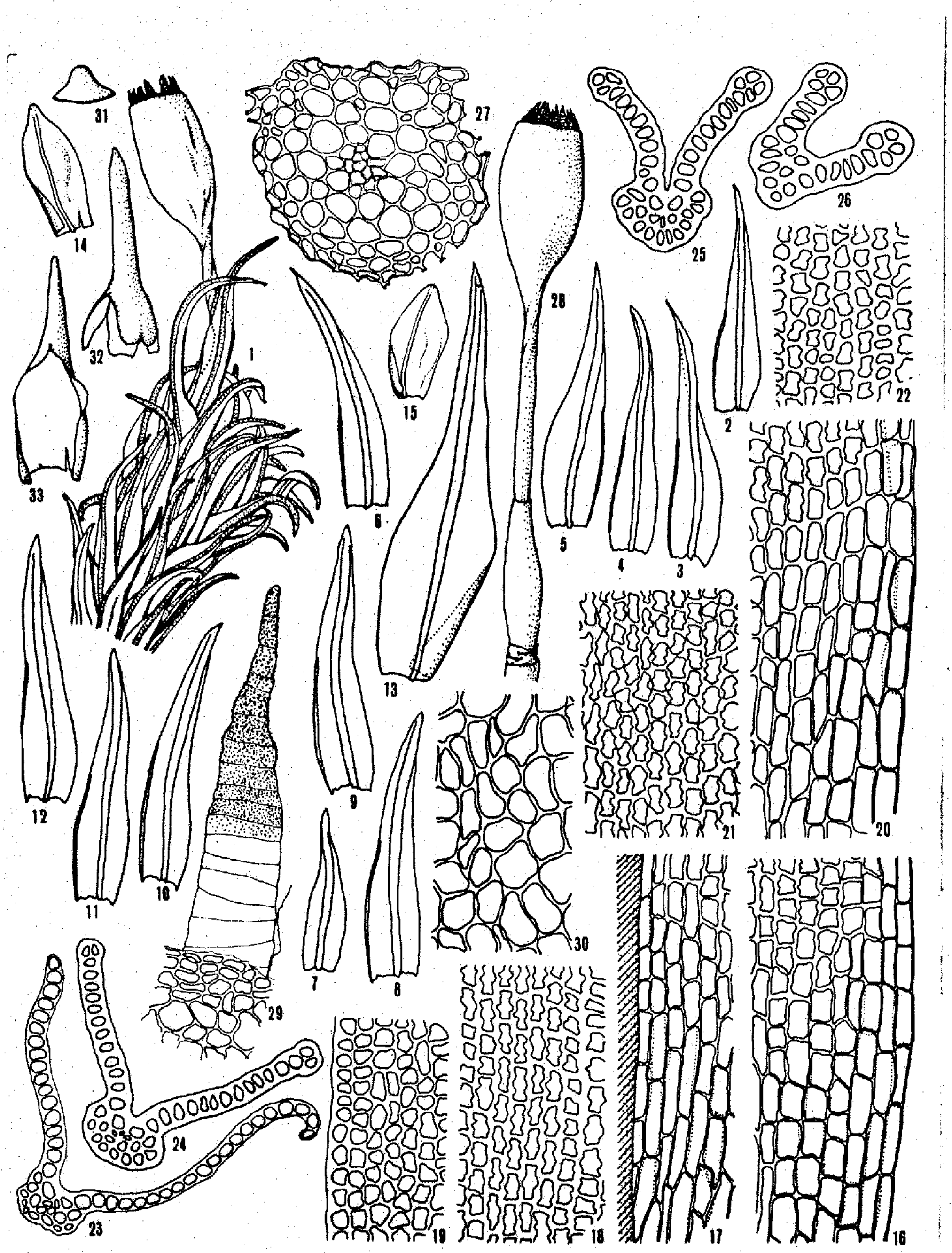


Fig. 21. *Grimmia elongata* Kaulf. 1. Plant, x25. 2-12. Leaves, x25. 13. Perichaetial leaf, x25. 14 & 15. Perigonial leaves, x25. 16-22. Laminal cells from upper (19, 22), middle (18, 21), angular (16, 20), and basal paracostal (17) parts, x325. 23-26. Cross-sections of leaf, x240. 27. Cross-section of stem, x240. 28. Capsule with seta and vaginula, x25. 29. Peristome, x240. 30. Exothecial cells, x240. 31. Operculum, x25. 32 & 33. Calyptra, x25. (1, 7-19, 23, 27-33: drawn from HIRO-Deguchi 13080; 2-6, 20-22, 24-26: isotype of *Grimmia decalvata* in H-BR).

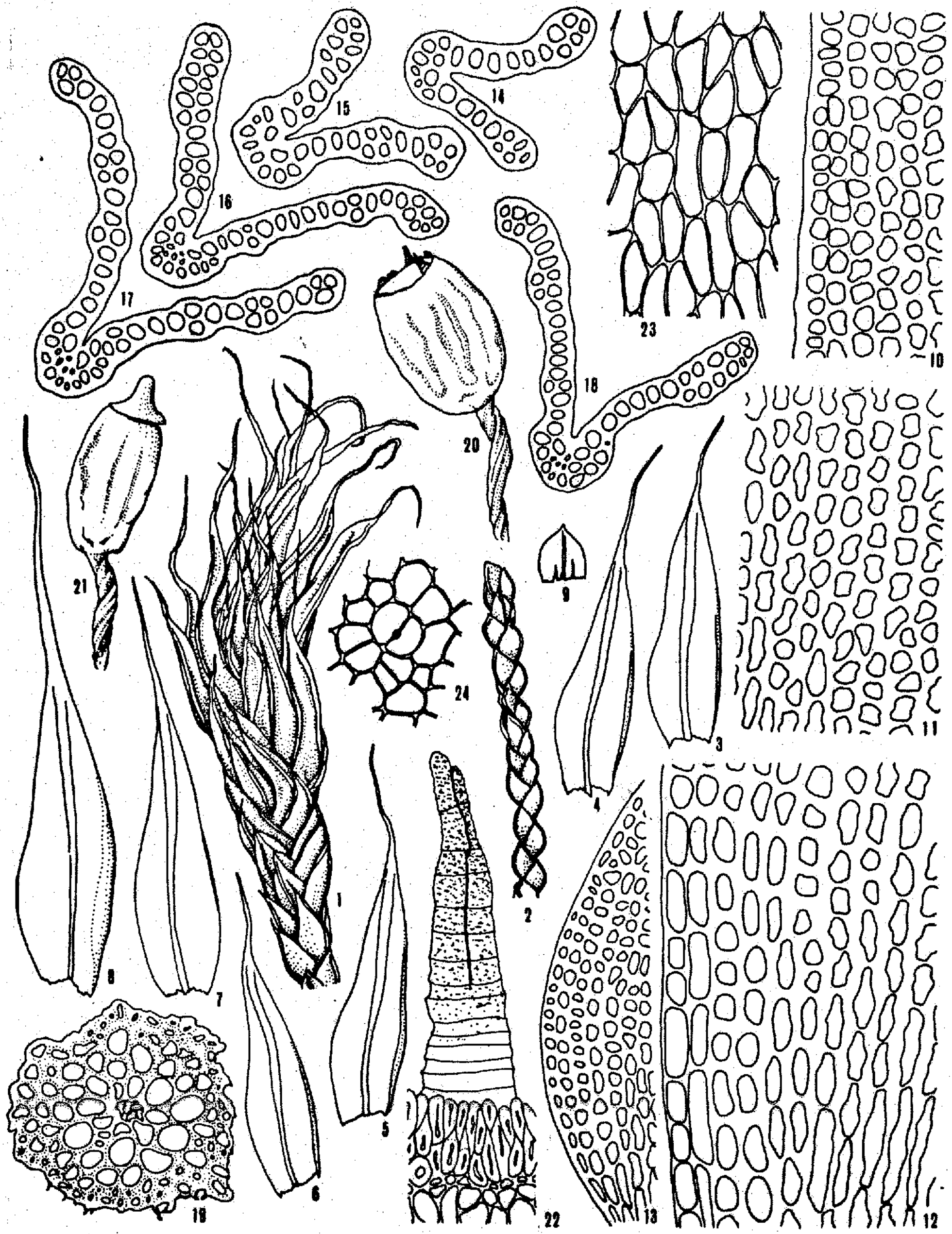


Fig. 22. <u>Grimmia funalis</u> (Schwaegr.) B.S.G. 1. Plant, x25. 2. Young filiform stem, x25. 3-7. Leaves, x25. 8. Perichaetial leaves, x25. 9. Leaf on young filiform stem, x25. 10-12. Laminal cells from upper (10), middle (11), and ang ular (12) parts, x325. 13. Angular cells of young filiform stem-leaf, x240. 14-18. Cross-sections of leaf, x240. 19. Cross-section of stem, x240. 20 & 21. Capsules, x25. 22. Peristome, x240. 23. Exothecial cells, x240. 24. Stomata, x240. (Drawn from TNS-F. 569).

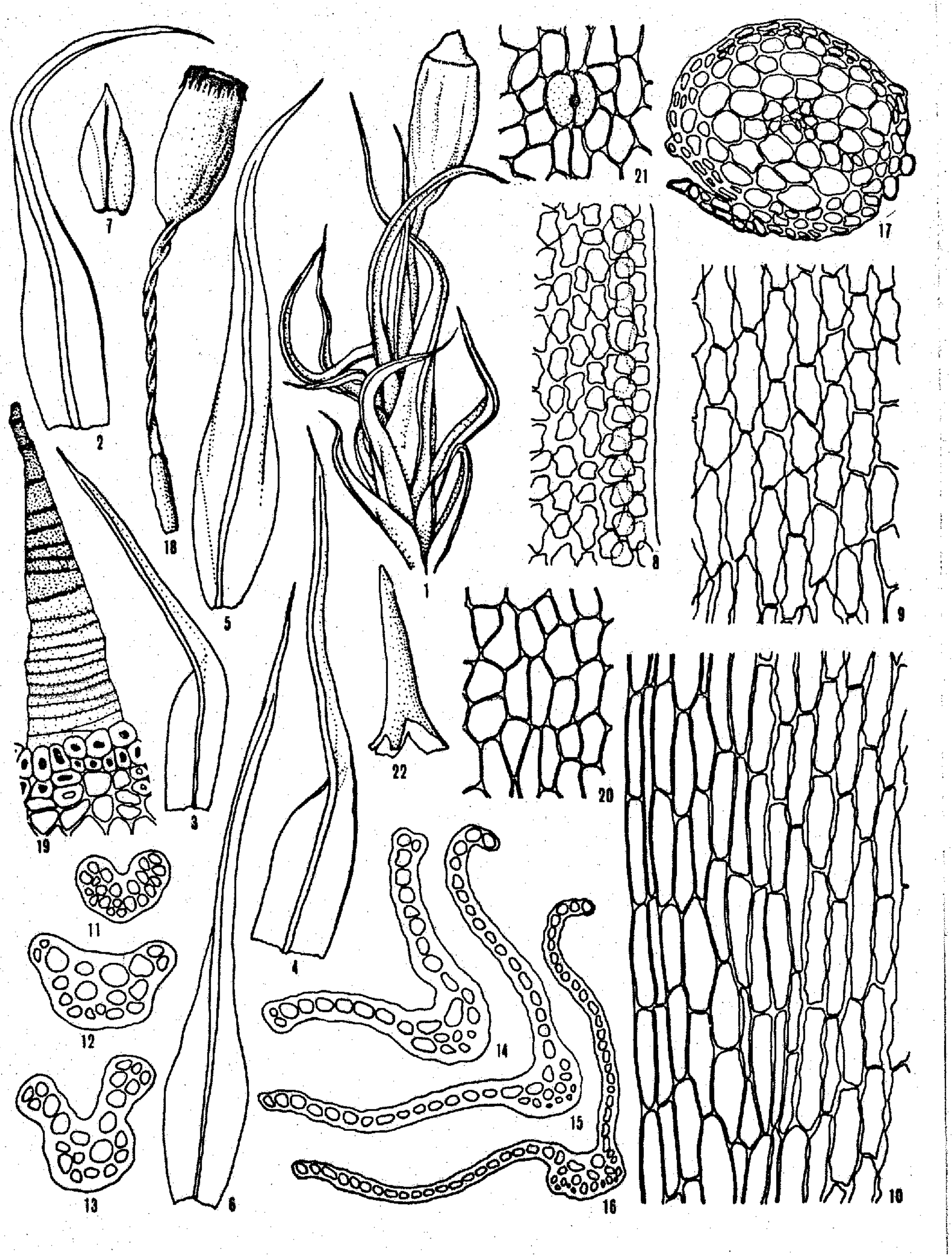


Fig. 23. Grimmia incurva Schwaegr. 1. Plant, x25. 2-4. Leaves, x25. 5-6. Perichaetial leaves, x25. 7. Perigonial leaf, x25. 8-10. Laminal cells from upper (8), middle (9), and basal (10) parts, x325. 11-16. Cross-sections of leaf, x240. 17. Cross-section of stem, x240. 18. Capsule with seta and vaginula, x25. 19. Peristome, x240. 20. Exothecail cells, x240. 21. Stomata, x240. 22. Calyptra, x25. (1, 5-7, 17-21: drawn from HIRO-Deguchi 13131; 2-4, 8-16: HIRO-Deguchi 13128).

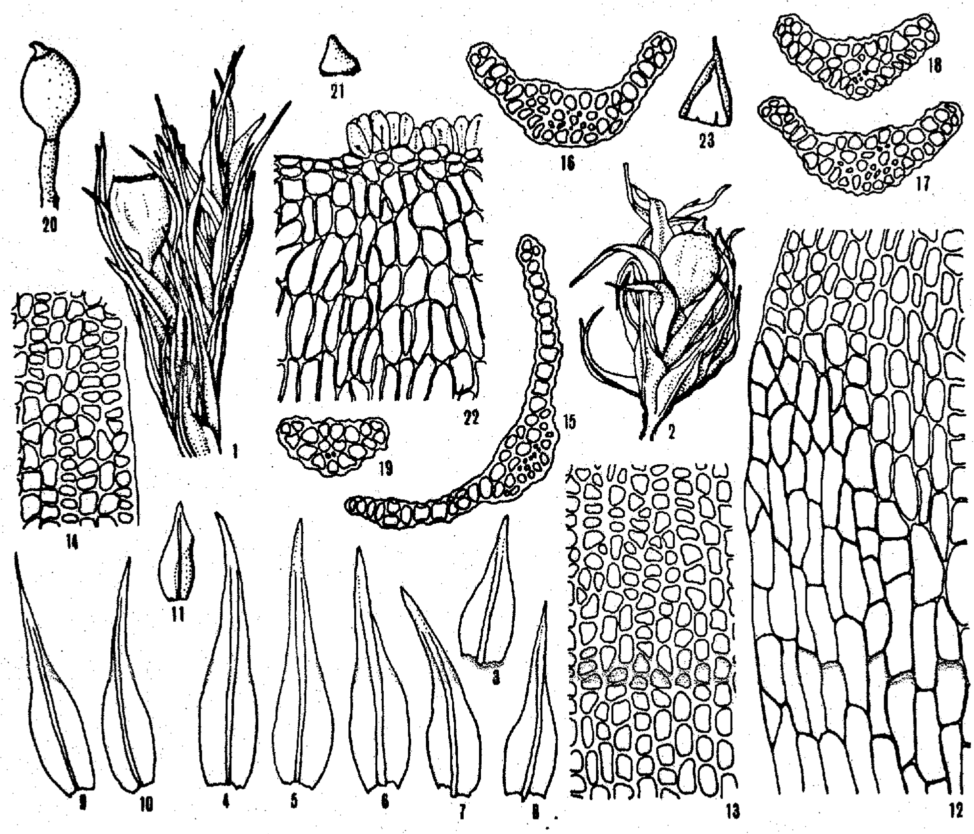


Fig. 24. _Grimmia_ _olympica_ E.G.Britt. 1 & 2. Plants, x25. 3-8. Leaves, x25. 9 & 10. Perichaetial leaves, x25. 11. Perigonial leaf, x25. 12-14. Laminal cells from upper (14), middle (13), and angular (12) parts, x325. 15-19. Cross-sections of leaf, x240. 20. Capsule, x25. 21. Operculum, x25. 22. Cells near the orifice of urn, x240. 23. Calyptra, x25. (Drawn from HIRO-Deguchi 12578).

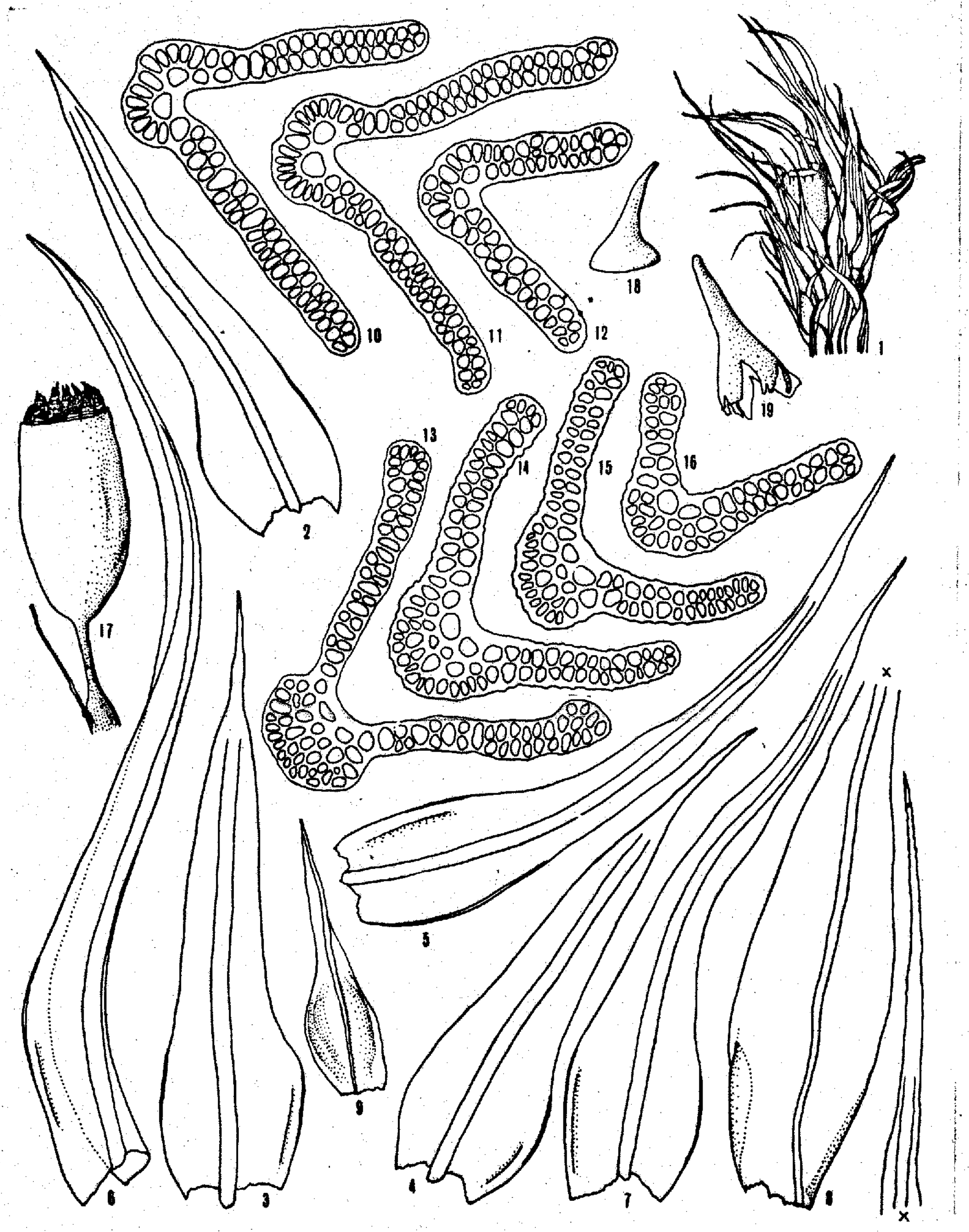


Fig. 25. *Grimmia pilifera* P.Beauv. 1. Plant, x9. 2-7. Leaves, x25. 8. Perichaetial leaf, x25. 9. Perigonial leaf, x25. 10-16. Cross-sections of leaf, x240. 17. Capsule with seta, vaginula, and aborted archegonium, x25. 18. Operculum, x25. 19. Calyptra, x25. (1, 8, 9, 17-19: drawn from HIRO-Deguchi 13212; 3 & $, 10-12: HIRO-Deguchi 11526; 5-7, 14-16: HIRO-Ando 7398; 2, 13: isotype of *Grimmia hisauchii* in TNS).

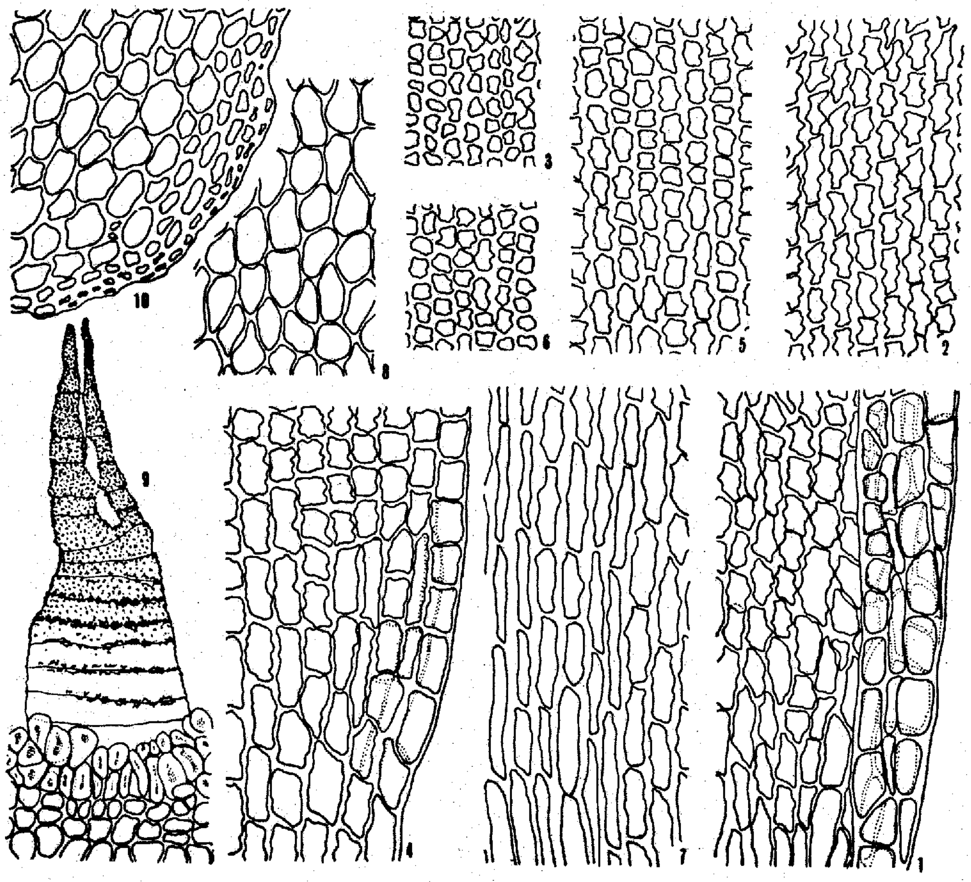


Fig. 26. Grimmia pilifera P.Beauv. 1-7. Laminal cells from upper (3, 6), middle (2, 5), angular (1, 4), and basal paracostal (7) parts, x325. 8. Exothecial cells, x240. 9. Peristome, x240. 10. Cross-section of stem, x240. (1-3, 7-10: drawn from HIRO-Deguchi 13212; 4-6: HIRO-Deguchi 11526).

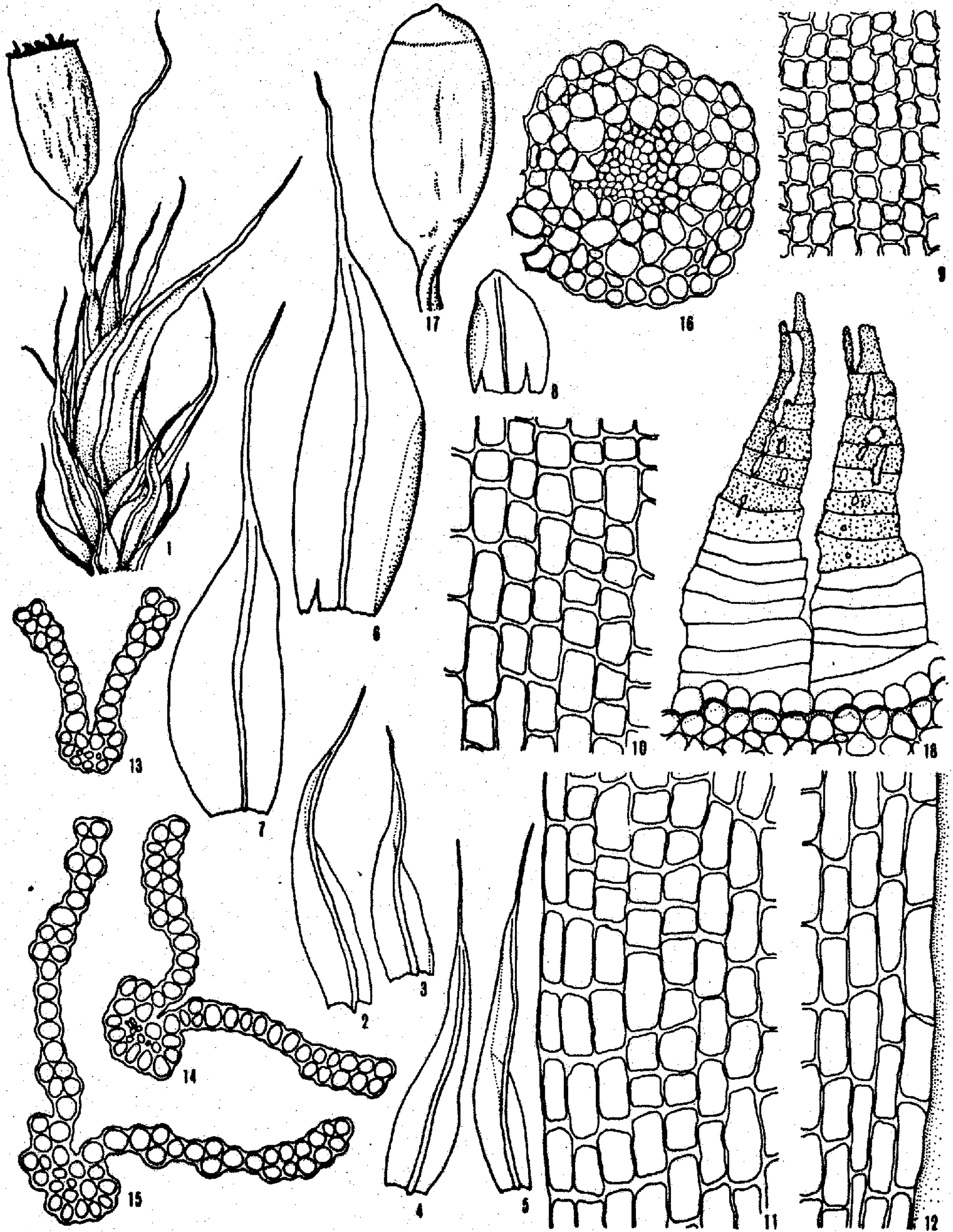


Fig. 27. Grimmia subsulcata Limpr. 1. Plant, x25. 2-5. Leaves, x25. 6 & 7. Perichaetial leaves, x25. 8. Perigonial leaf, x25. 9-12. Laminal cells from upper (9), middle (10), angular (11), and basal paracostal (12) parts, x325. 13-15. Cross-sections of leaf, x240. 16. Cross-section of stem, x240. 17. Capsule, x25. 18. Peristome, x240. (Drawn from HIRO-Deguchi 12950).

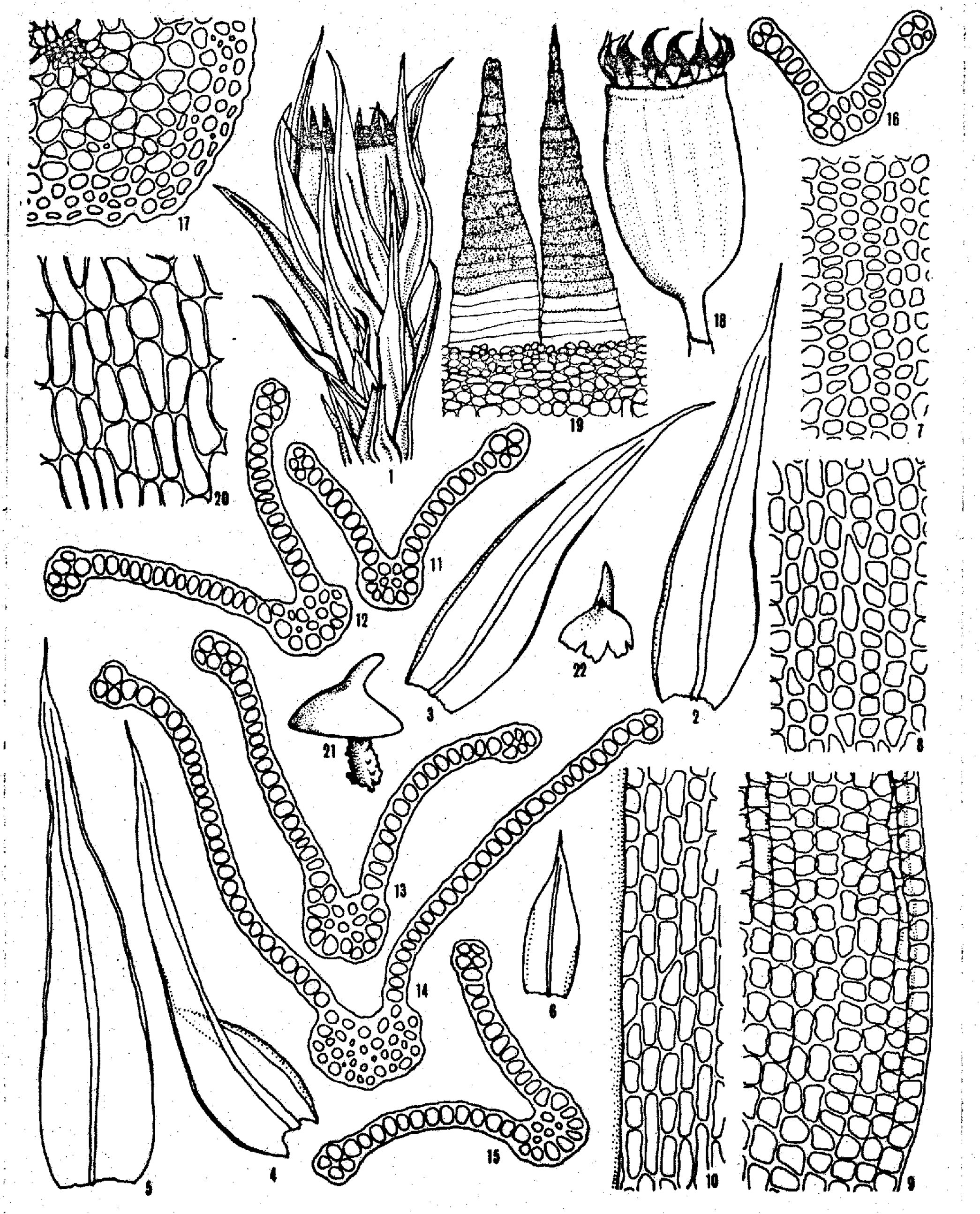


Fig. 28. Schistidium apocarpum (Hedw.) Bruch et Schimp. 1. Plant, x25. 2-4. Leaves, x25. 5. Perichaetial leaf, x25. 6. Perigonial leaf, x25. 7-10. Laminal cells from upper (7), middle (8), angular (9), and basal paracostal (10) parts, x325. 11-16. Cross-sections of leaf, x240. 17. Cross-section of stem, x240. 18. Capsule, x25. 19. Peristome, x120. 20. Exothecial cells, x240. 21. Operculum with columella, x25. 22. Calyptra, x25. (Drawn from HIRO-Deguchi 13337).

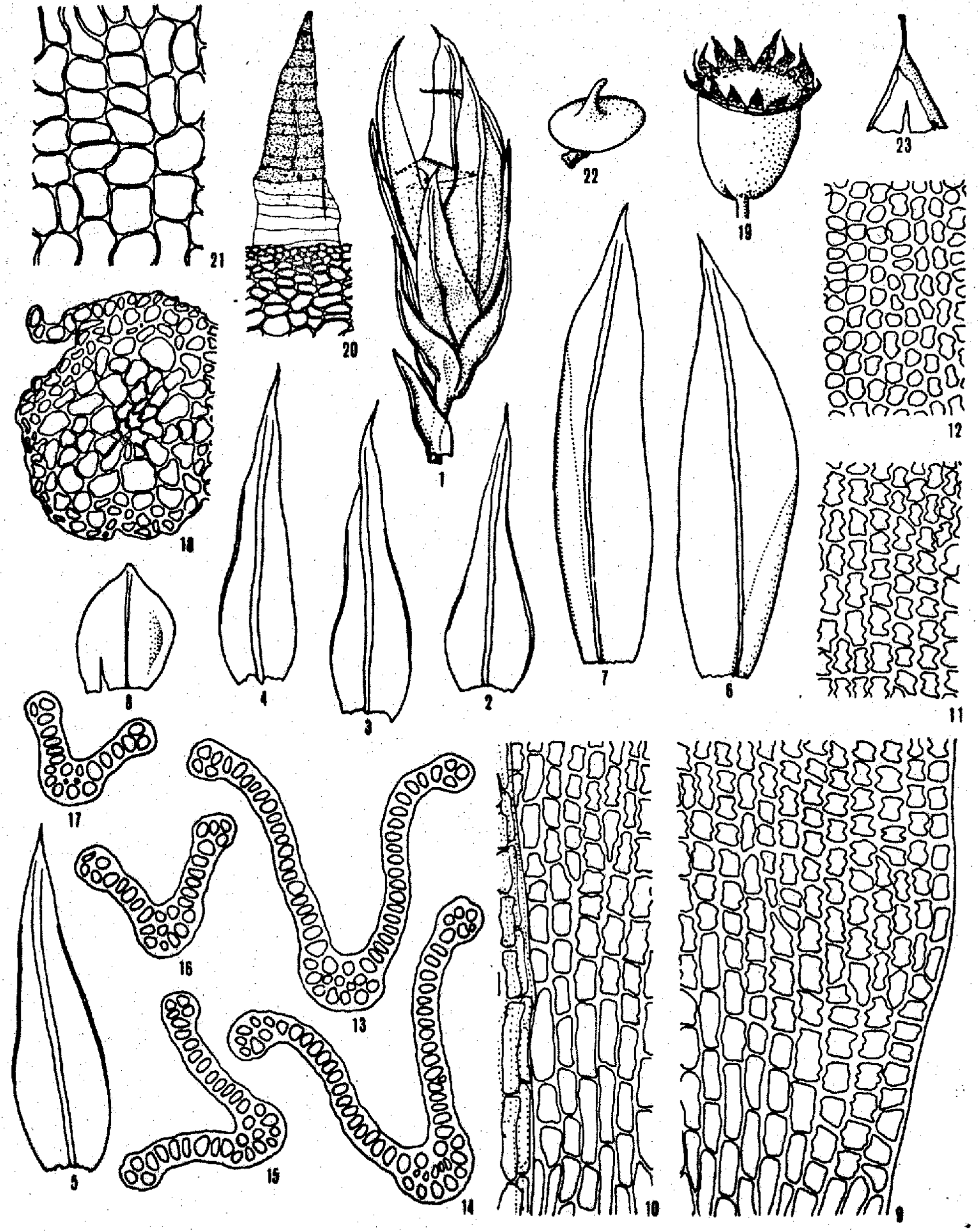


Fig. 29. Schistidium confertum (Funck) Bruch et Schimp. 1. Plant, x25. 2-5. Leaves, x25. 6 & 7. Perichaetial leaves, x25. 8. Perigonial leaf, x25. 9-12. Laminal cells from upper (12), middle (11), angular (9), and basal paracostal (10) parts, x325. 13-17. Cross-sections of leaf, x240. 18. Cross-section of stem, x240. 19. Capsule, x25. 20. Peristome, x120. 21. Exothecial cells, x240. 22. Operculum with columella, x25. 23. Calyptra, x25. (Drawn from Takaki-28931 in Takaki's private herbarium).

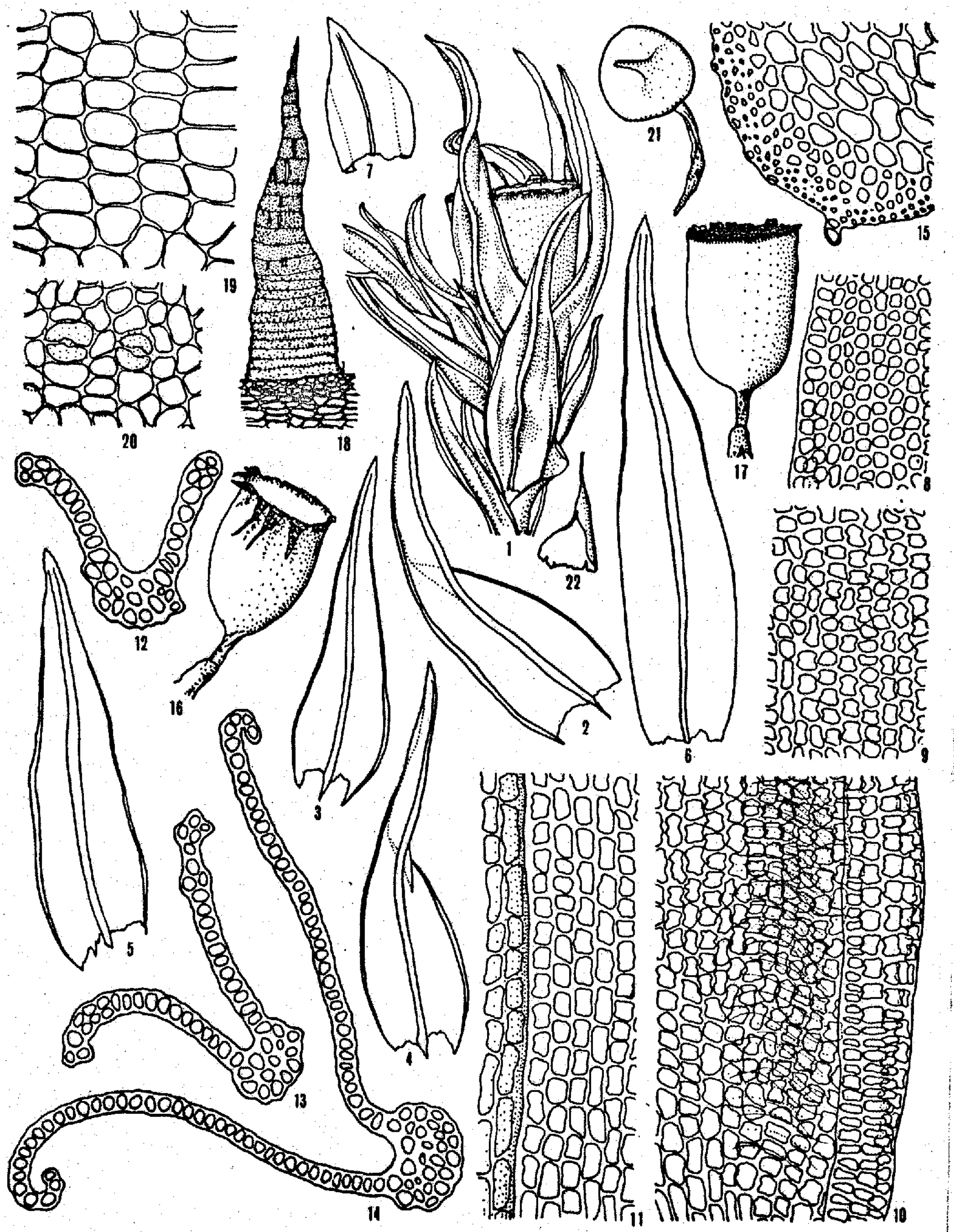


Fig. 30. *Schistidium gracile* (Roehl.) Limpr. (Mod. *commune*)
1. Plant, x25. 2-5. Leaves, x25. 6. Perichaetial leaf, x25. 7. Perigonial leaf, x25. 8-11. Laminal cells from upper (8), middle (9), angular (10), and basal paracostal (11) parts, x325. 12-14. Cross-sections of leaf, x240. 15. Cross-section of stem, x240. 16 & 17. Capsules, x25. 18. Peristome, x120. 19. Exothecial cells, x240. 20 Stomata, x240. 21. Operculum with columella, x25. 22. Calyptra, x25. (Drawn from HIRO-Deguchi 13209).

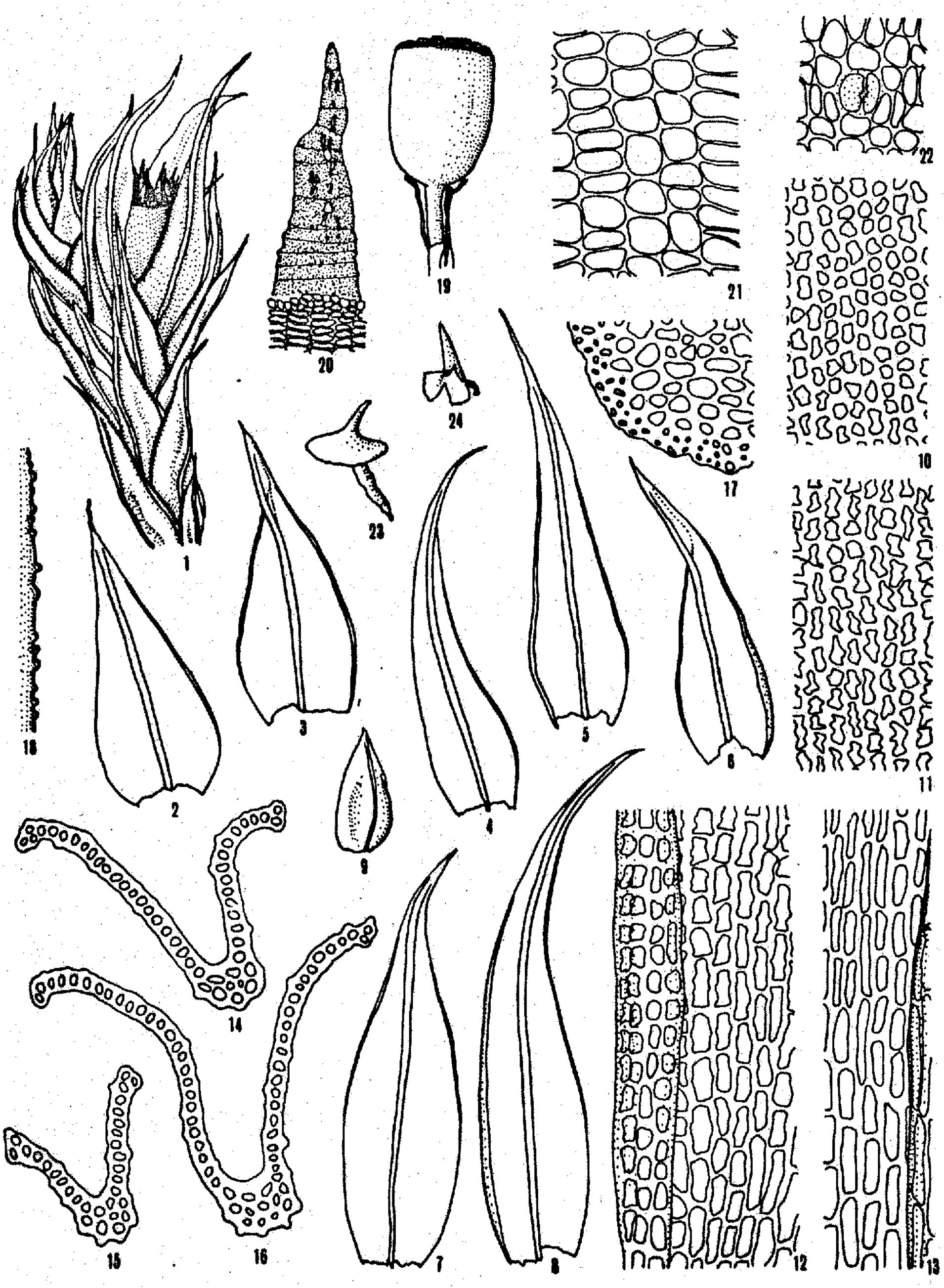


Fig. 31. Schistidium gracile (Roehl.) Limpr. (Mod. typicum) 1. Plant, x25. 2-6. Leaves, x25. 7-8. Perichaetial leaves, x25. 9. Perigonial leaf, x25. 10-13. Laminal cells from upper (10), middle (11), angular (12), and basal paracostal (13) parts, x325. 14-16. Cross-sections of leaf, x240. 17. Cross-section of stem, x240. 18. Profile of papillae in the upper part of costa, x240. 19. Capsule, x25. 20. Peristome, x120. 21. Exothecial cells, x240. 22. Stomata, x240. 23. Operculum with columella, x25. 24. Calyptra, x25. (1, 4-24: drawn from HIRO-Deguchi 11647; 2 & 3: HIRO-Deguchi 13309).

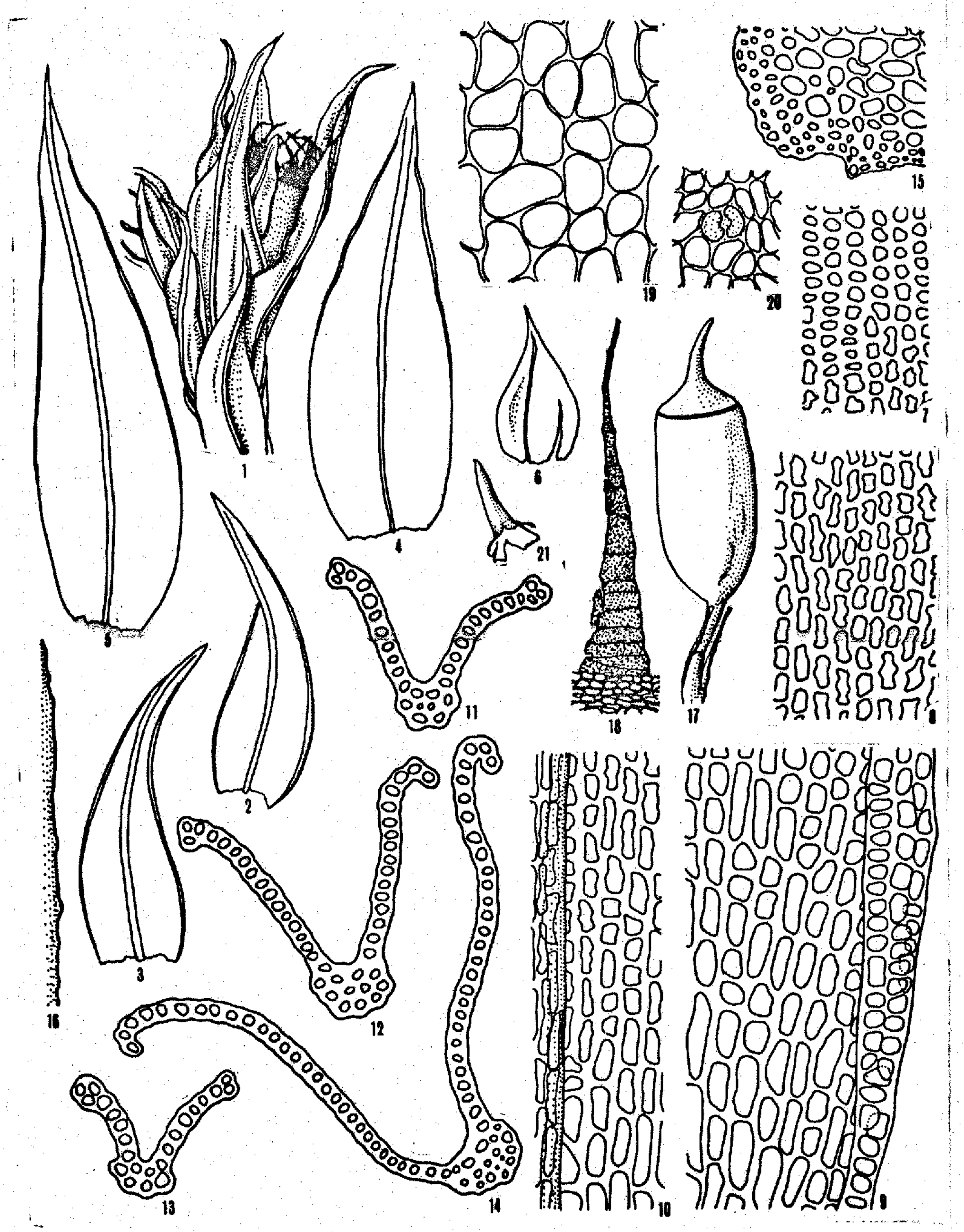


Fig. 32. Schistidium gracile (Roehl.) Limpr. (Mod. trichodon)
1. Plant, x25. 2 & 3. Leaves, x25. 4 & 5. Perichaetial leaves, x25. 6. Perigonial leaf, x25. 7-10. Laminal cells from upper (7), middle (8), angular (9), and basal paracostal (10) parts, x325. 11-14. Cross-sections of leaf, x240. 15. Cross-section of stem, x240. 16. Profile of papillae in the upper part of costa, x240. 17. Capsule, x25. 18. Peristome, x120. 19. Exothecial cells, x240. 20. Stomata, x240. 21. Calyptra, x25. (1-3, 5-21: drawn from Takaki-8525 in Takaki's private herbarium; 4: Saito-13046 in Saito's private herbarium).

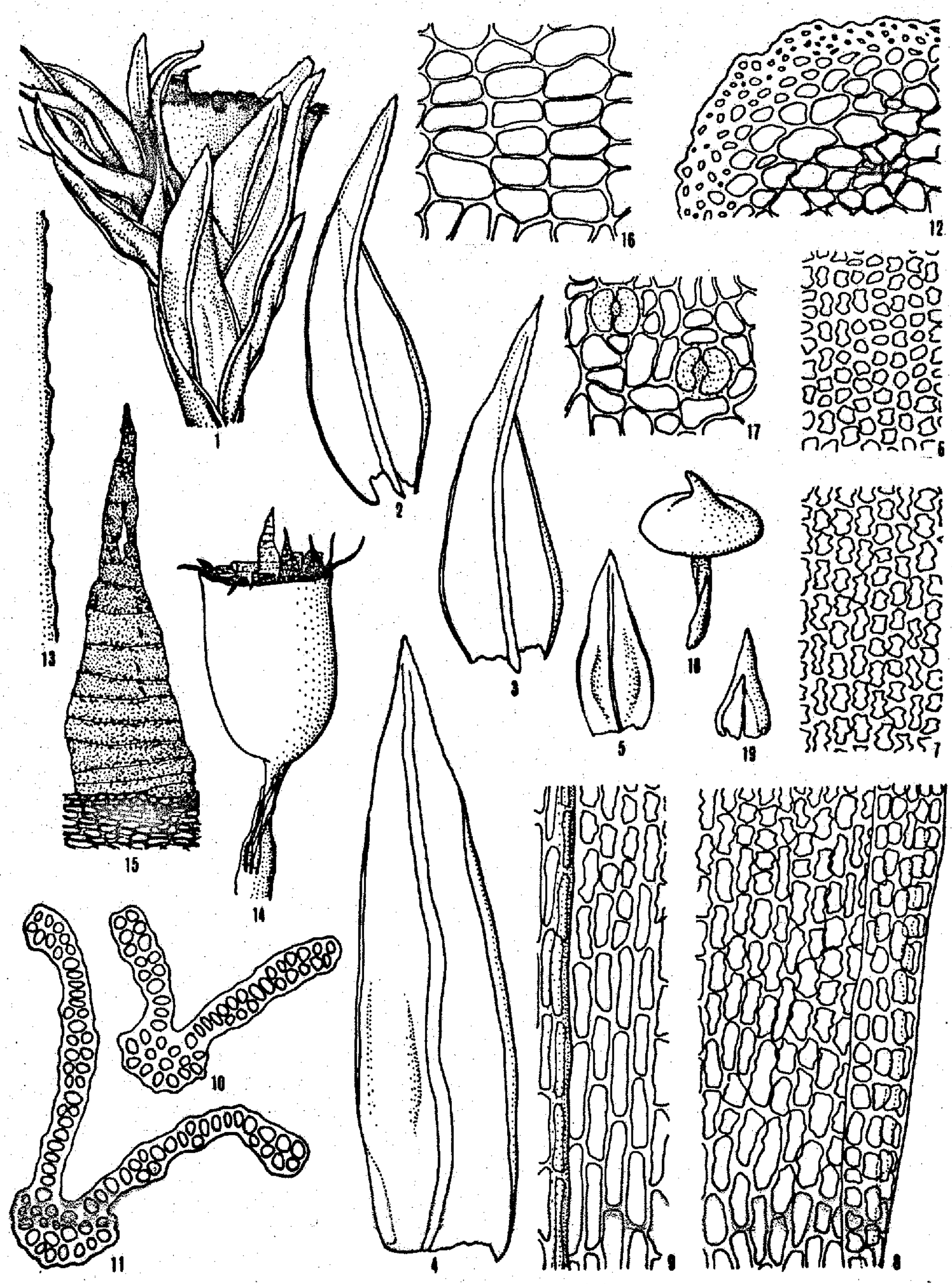


Fig. 33. Schistidium gracile (Roehl.) Limpr. (Mod. denticulatum) 1. Plant, x25. 2-3. Leaves, x25. 4. Perichaetial leaf, x25. 5. Perigonial leaf, x25. 6-9. Laminal cells from upper (6), middle (7), angular (8), and basal paracostal (9) parts, x325. 10-11. Cross-sections of leaf, x240. 12. Cross-section of stem, x240. 13. Profile of papillae in the upper part of costa, x240. 14. Capsule, x25. 15. Peristome, x120. 16. Exothecial cells, x240. 17. Stomata, x240. 18. Operculum with columella, x25. 19. Calyptra, x25. (Drawn from HIRO-Deguchi 15129).

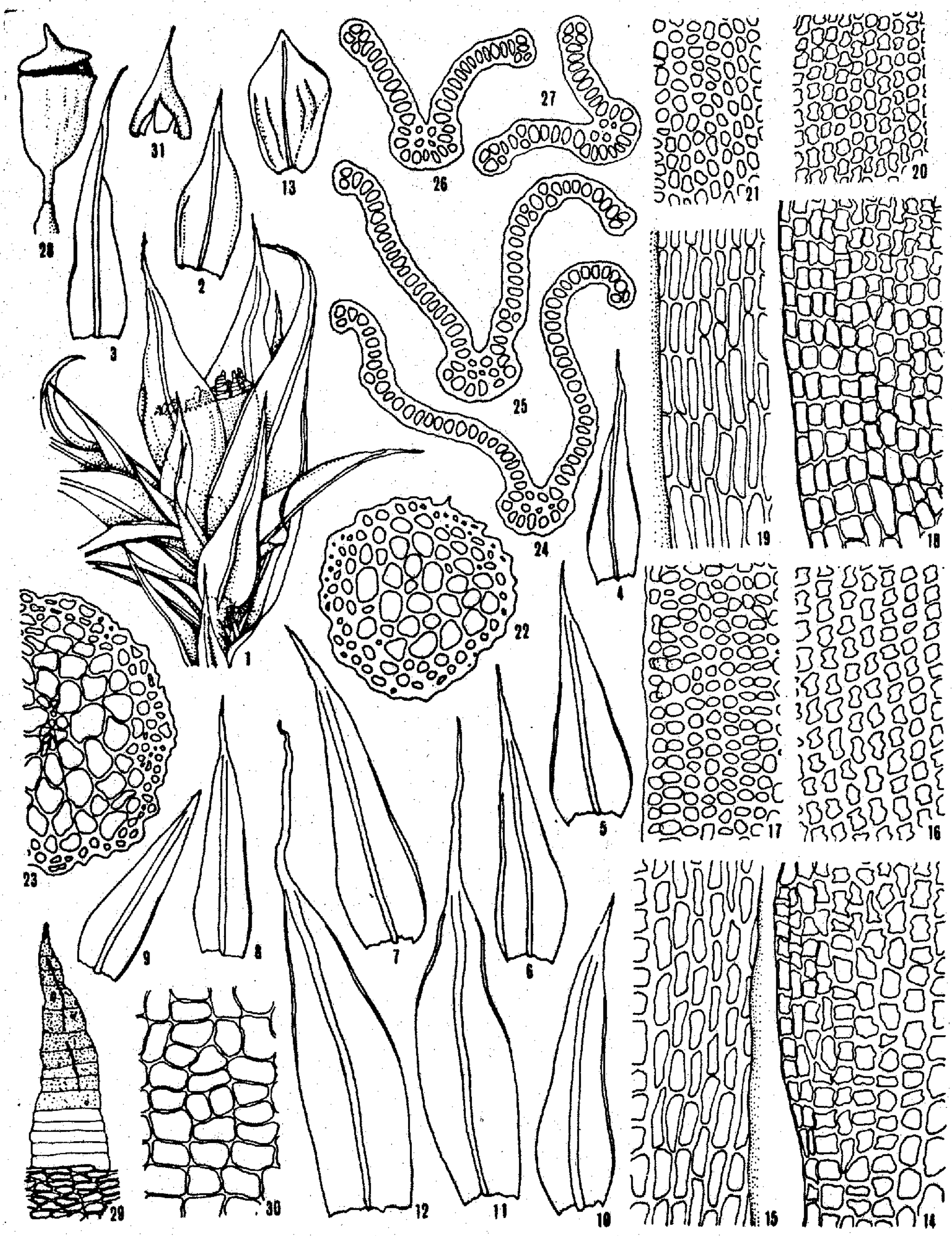


Fig. 34. Schistidium liliputanum (C.Müll.) Deguchi 1. Plant, x25. 2-10. Leaves, x25. 11 & 12. Perichaetial leaves, x25. 13. Perigonial leaf, x25. 14-21. Laminal cells from upper (20, 21), middle (16, 17), angular (14, 18), and basal paracostal (15, 19) parts, x325. 22 & 23. Cross-sections of stem, x240. 24-27. Cross-sections of leaf, x240. 28. Capsule, x25. 29. Peristome, x240. 30. Exothecial cells, x240. 31. Calyptra, x25. (1, 7-12, 14-17, 22, 23, 28: drawn from HIRO-Deguchi 12013; 2-6, 13, 18-21, 24-27: holotype of Grimmia apocarpa var. microphylla, Faurie-2287 in PC; 29-31: HIRO-Seki 15613).

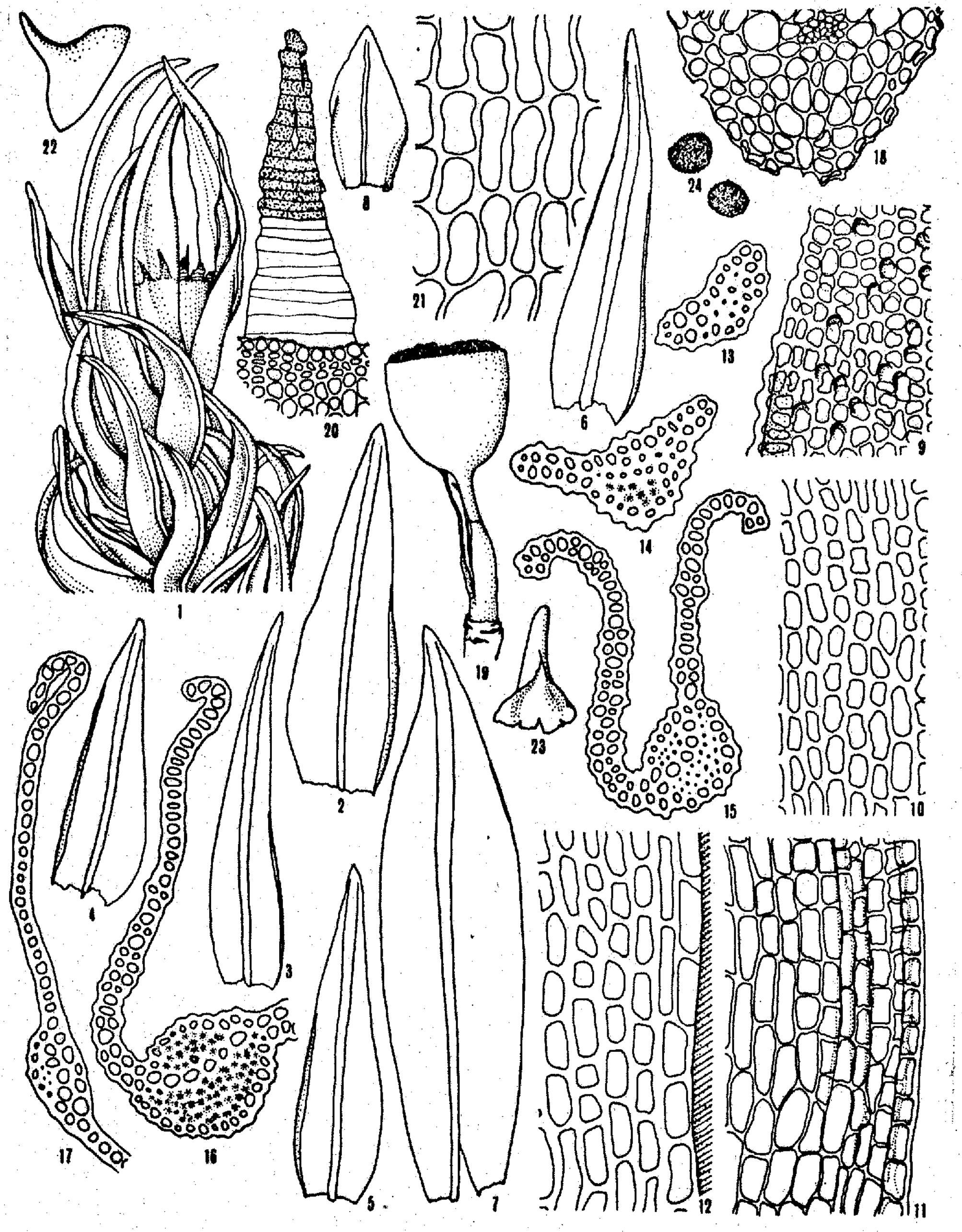


Fig. 35. *Schistidium maritimum* (Trun.) Bruch et Schimp. 1. Plant, x25. 2-6. Leaves, x25. 7. Perichaetial leaf, x25. 8. Perigonial leaf, x25. 9-12. Laminal cells from upper (9), middle (10), angular (11), and basal paracostal (12) parts, x325. 13-17. Cross-sections of leaf, x240. 18. Cross-section of stem, x240. 19. Capsule with vaginula and aborted archegonia, x25. 20 Peristome, x240. 21. Exothecial cells, x240. 22. Operculum, x25. 23. Calyptra, x25. 24. Spores, x240. (Drawn from HIRO-Deguchi 12027).

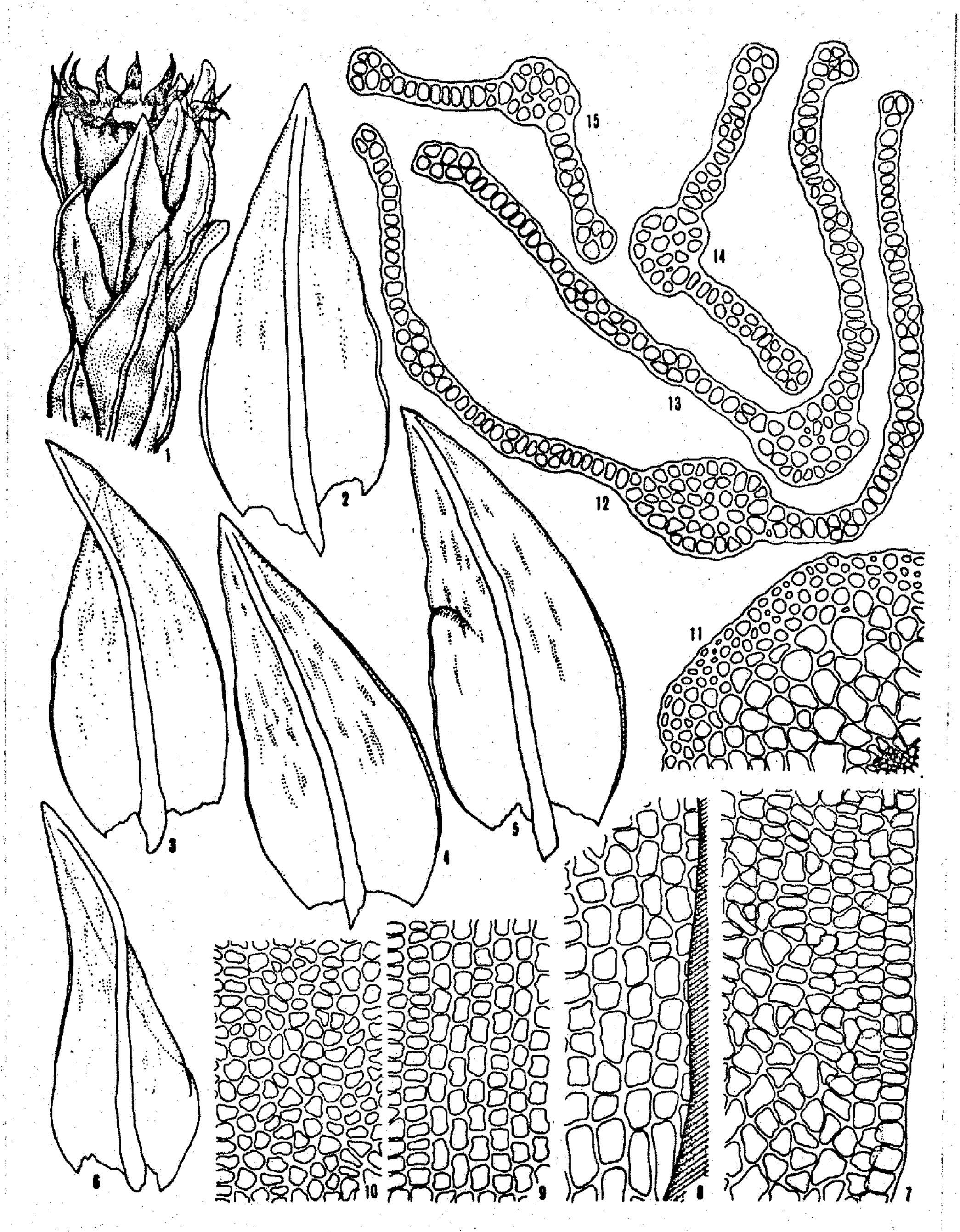


Fig. 36. Schistidium rivulare (Brid.) Limpr. 1. Plant, x25. 2-6. Leaves, x25. 7-10. Laminal cells from upper (10), middle (9), angular (7), and basal paracostal (8) parts, x325. 11. Cross-section of stem, x240. 12-15. Cross-sections of leaf, x240. (Drawn from HIRO-Deguchi 12945).

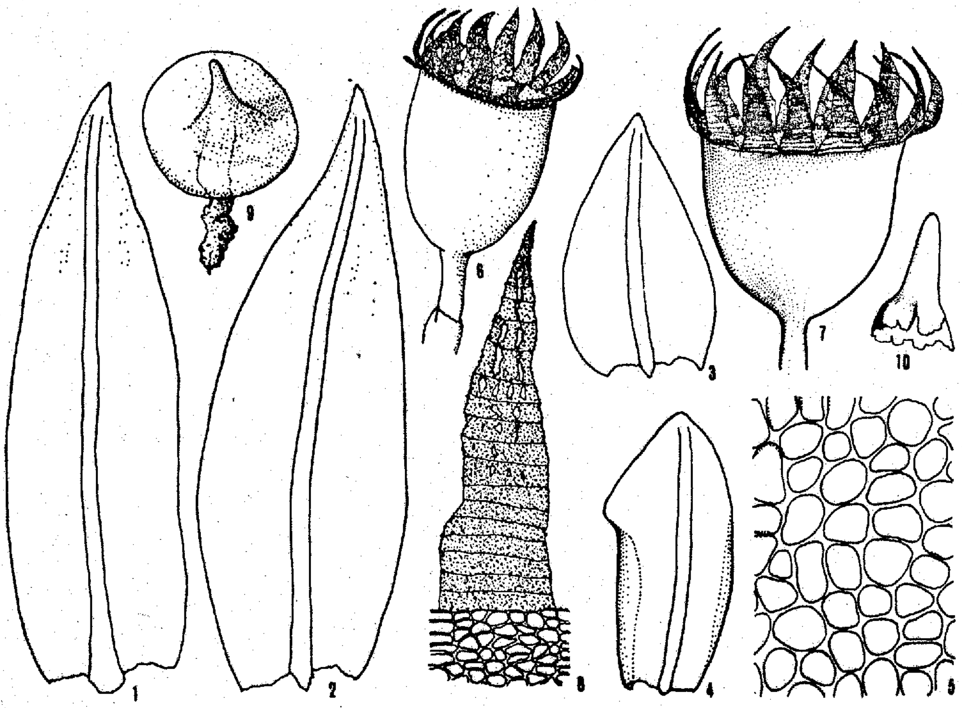


Fig. 37. Schistidium rivulare (Brid.) Limpr. 1 & 2. Perichaetial leaves, x25. 3 & 4. Perigonial leaves, x25. 5. Exothecial cells, x240. 6 & 7. Capsules, x25. 8. Peristome, x120. 9. Operculum with columella, x25. 10. Calyptra, x25. (Drawn from HIRO-Deguchi 12945).

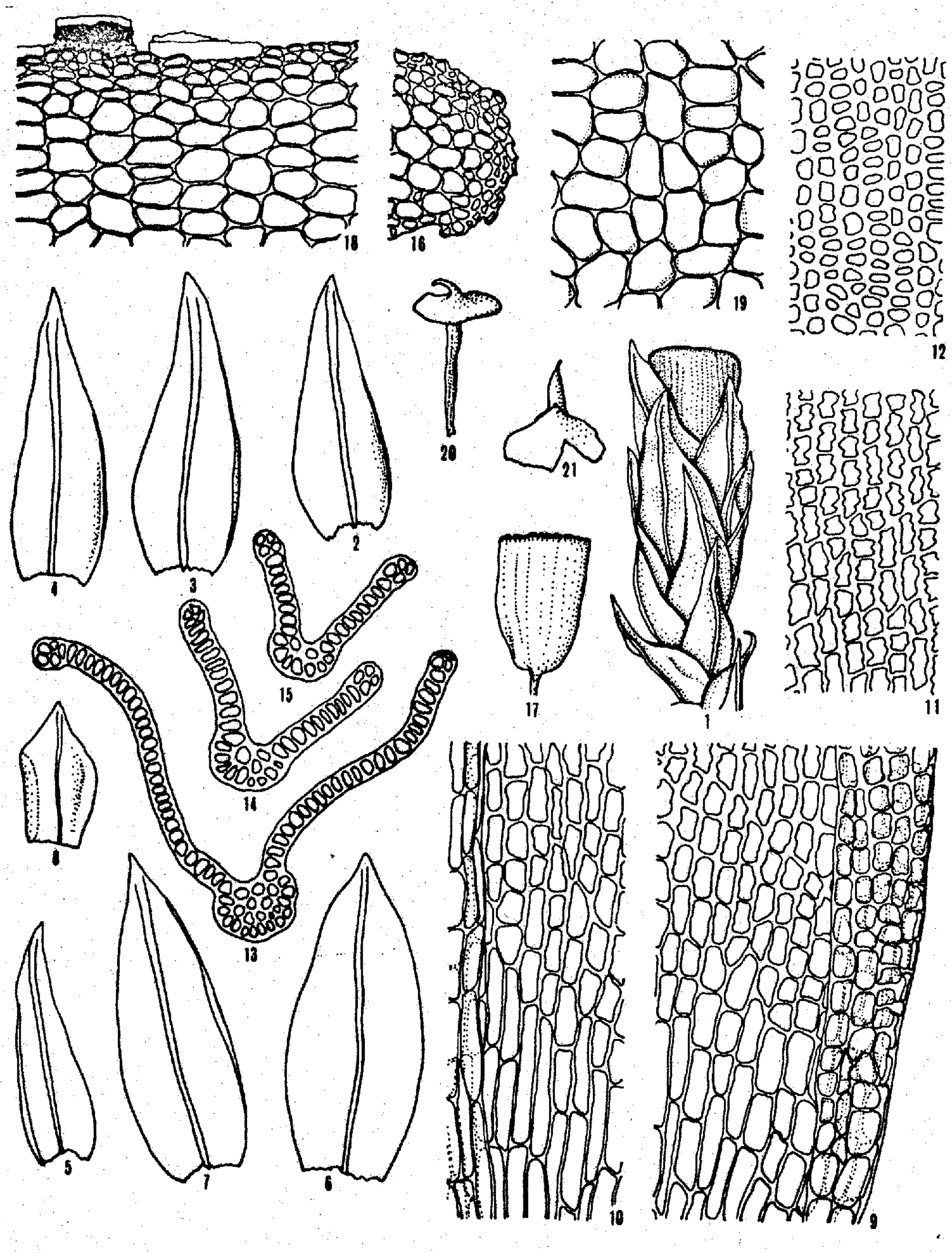


Fig. 38. Schistidium subconfertum (Broth.) Deguchi 1. Plant, x25. 2-5. Leaves, x25. 6 & 7. Perichaetial leaves, x25. 8. Perigonial leaf, x25. 9-12. Laminal cells from upper (12), middle (11), angular (9), and basal paracostal (10) parts, x325. 13-15. Cross-sections of leaf, x240. 16. Cross-section of stem, x240. 17. Capsule, x25. 18. Rudimentary peristome teeth and exothecial cells, x240. 20. Operculum with columella, x25. 21. Calyptra, x25. (Drawn from HIRO-Deguchi 13307).

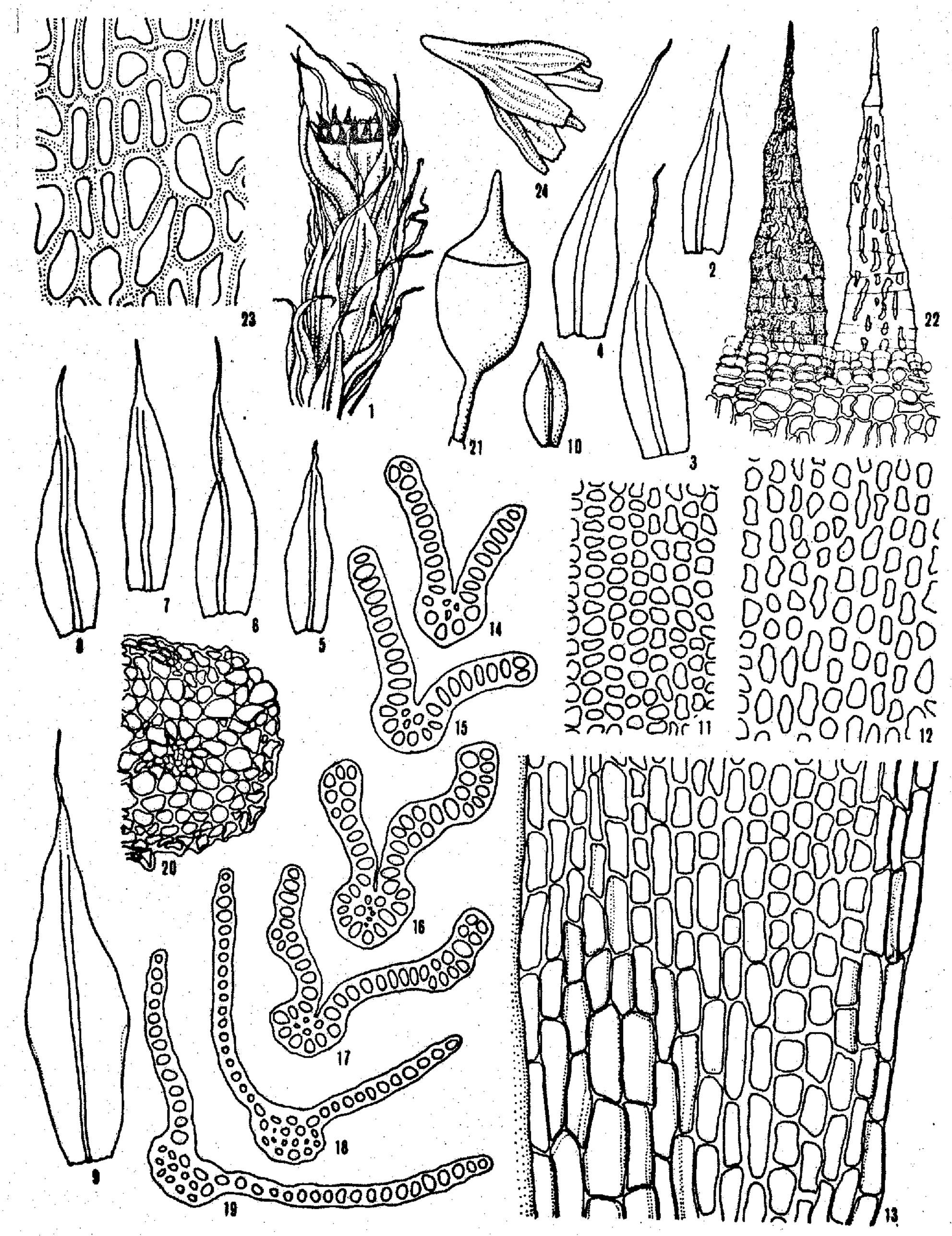
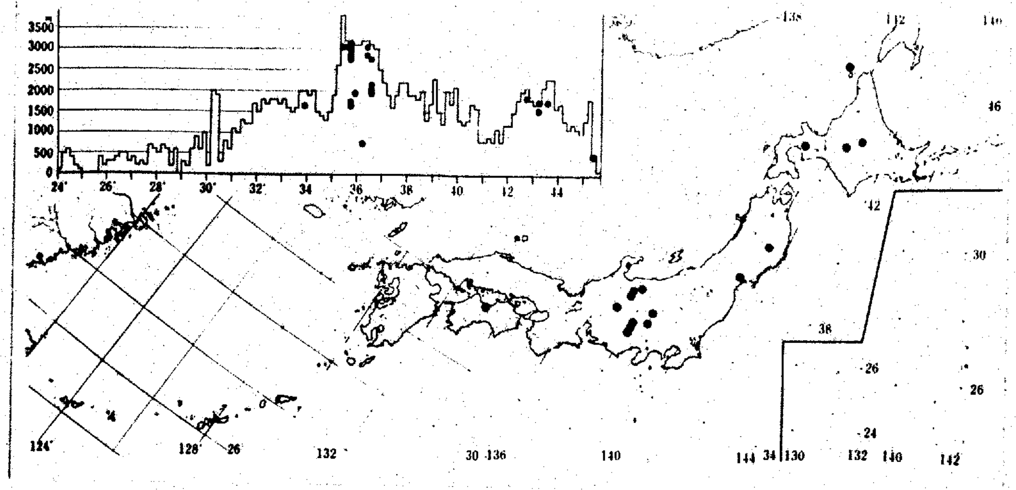
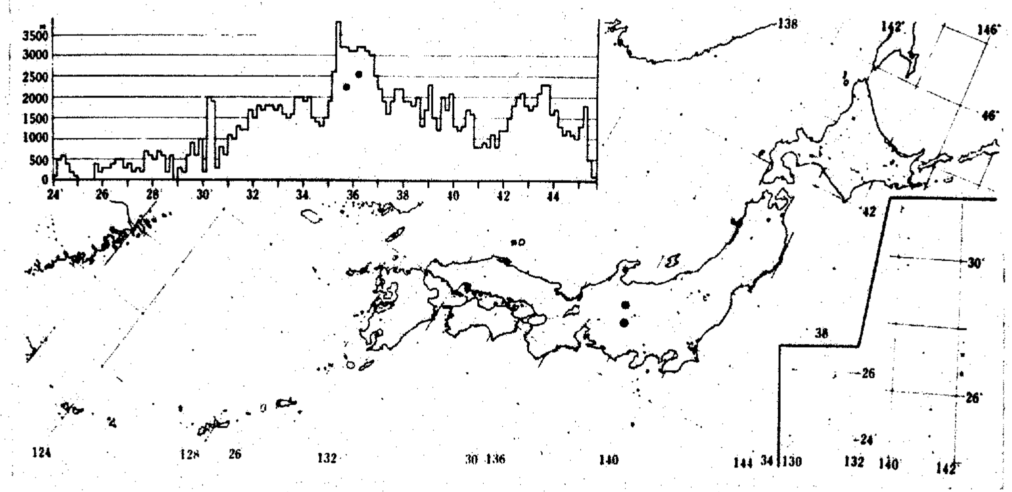


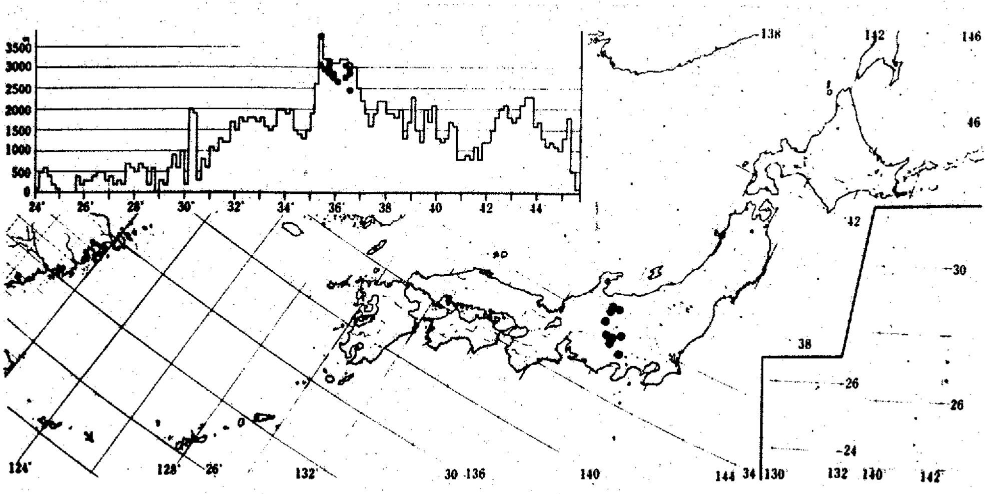
Fig. 39. Coscinodon cribrosus (Hedw.) Spruce 1. Plant, x25. 2-8. Leaves, x25. 9. Perichaetial leaf, x25. 10. Perigonial leaf, x25. 11-13. Laminal cells from upper (11), middle (12), and basal (13) parts, x325. 14-19. Cross-sections of leaf, x240. 20. Cross-section of stem, x240. 21. Capsule, x25. 22. Peristome, x240. 23. Exothecial cells, x240. 24. Calyptra, x25. (Drawn from HIRO-Deguchi 12301).



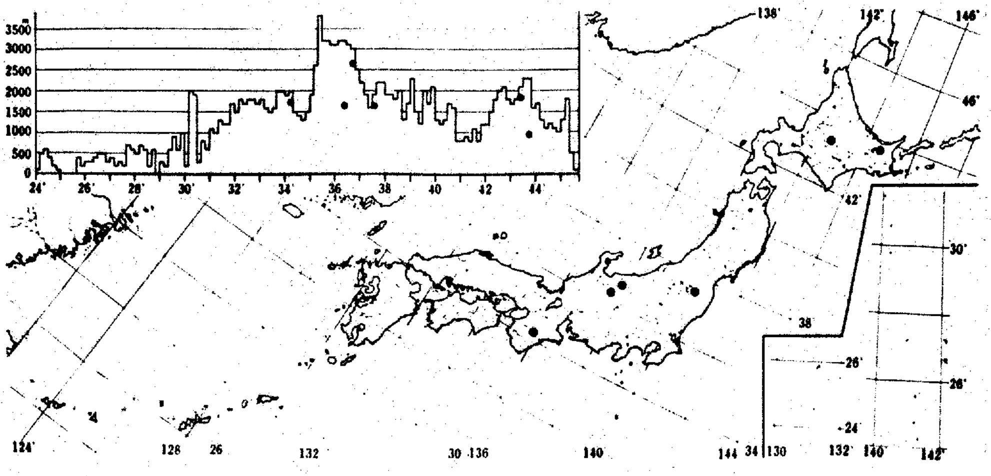
Map 1. Grimmia affinis Hornsch.



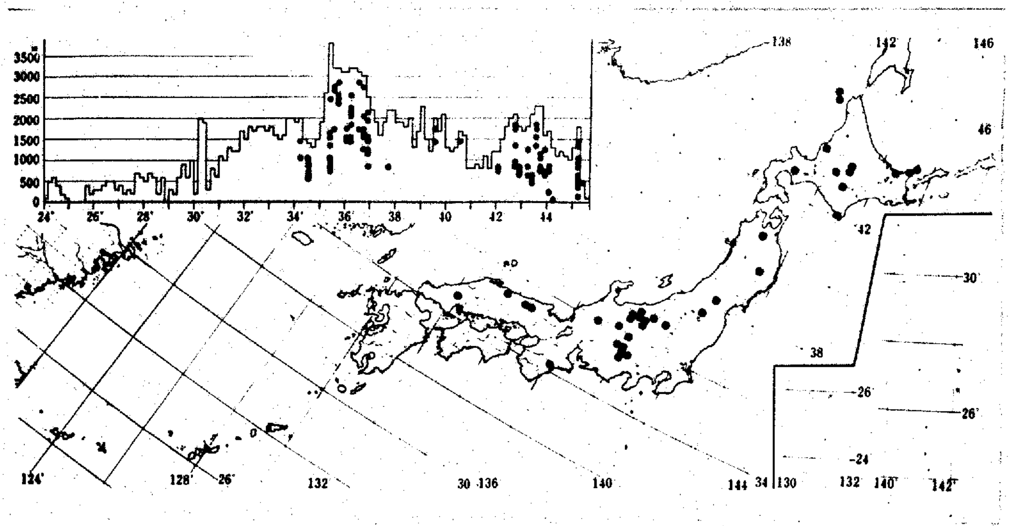
Map 2. Grimmia anomala Hampe ex Schimp.



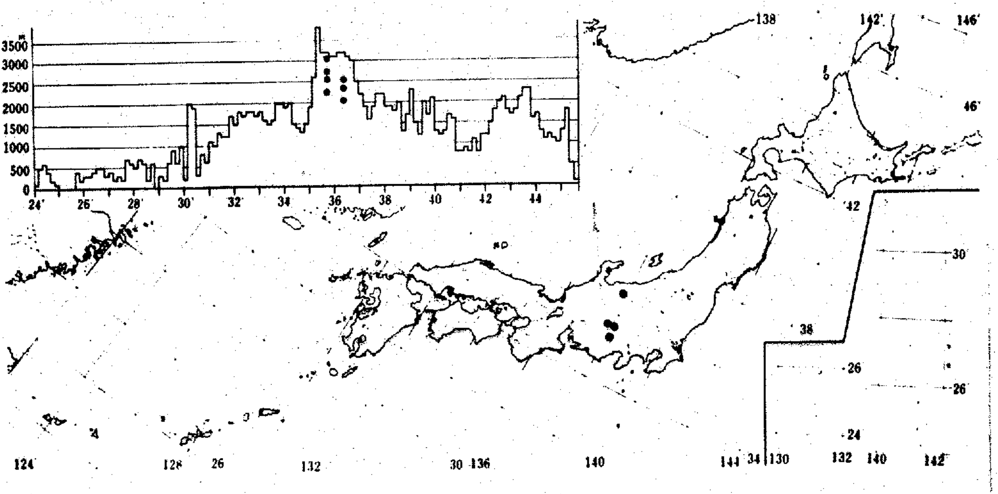
Map 3. Grimmia apiculata Hornsch.



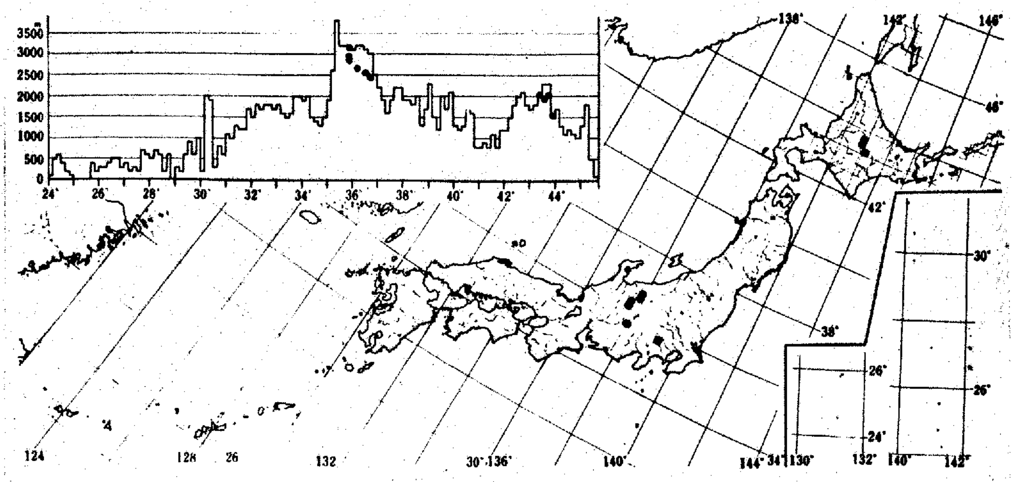
Map 4. Grimmia atrata Mielich. ex Hornsch.



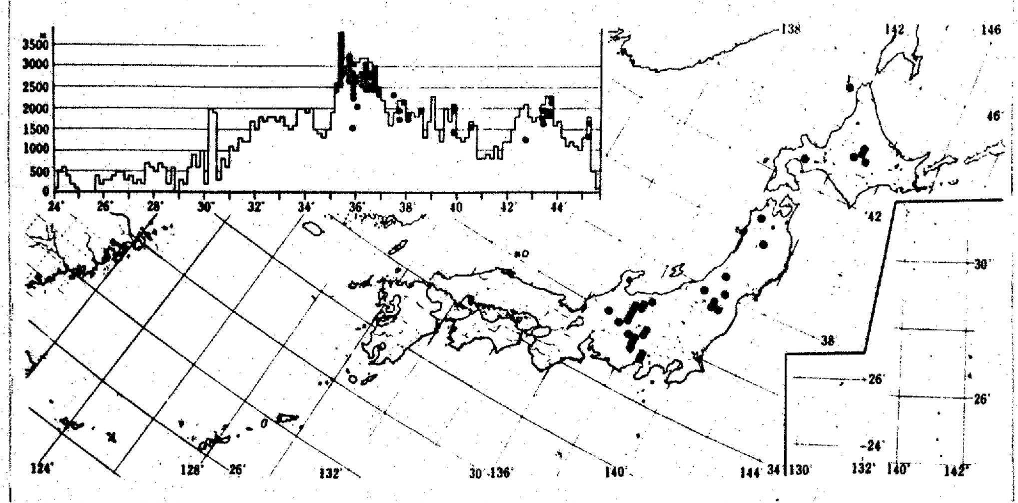
Map 5. Grimmia brachydictyon (Card.) Deguchi



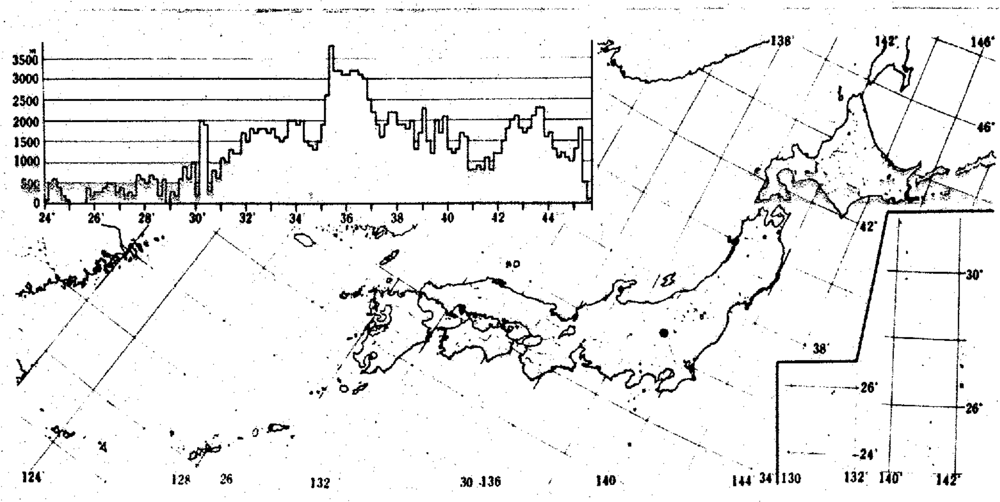
Map 6. Grimmia curvata (Brid.) De Sloov.



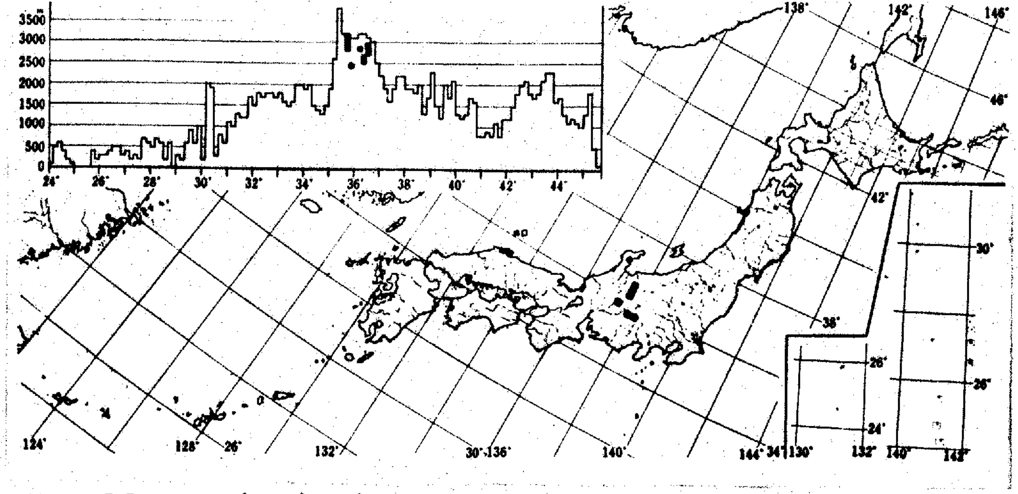
Map 7. Grimmia donniana Sm.



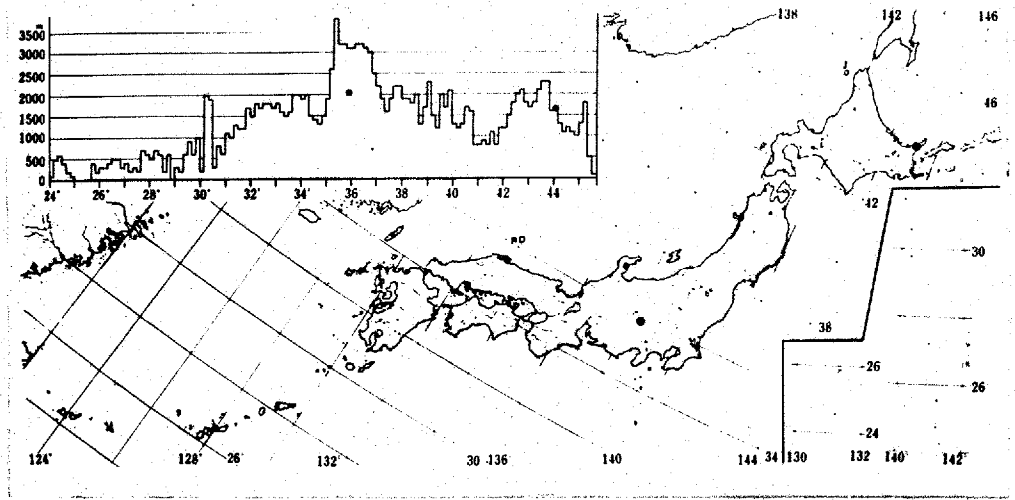
Map 8. Grimmia elongata Kaulf.



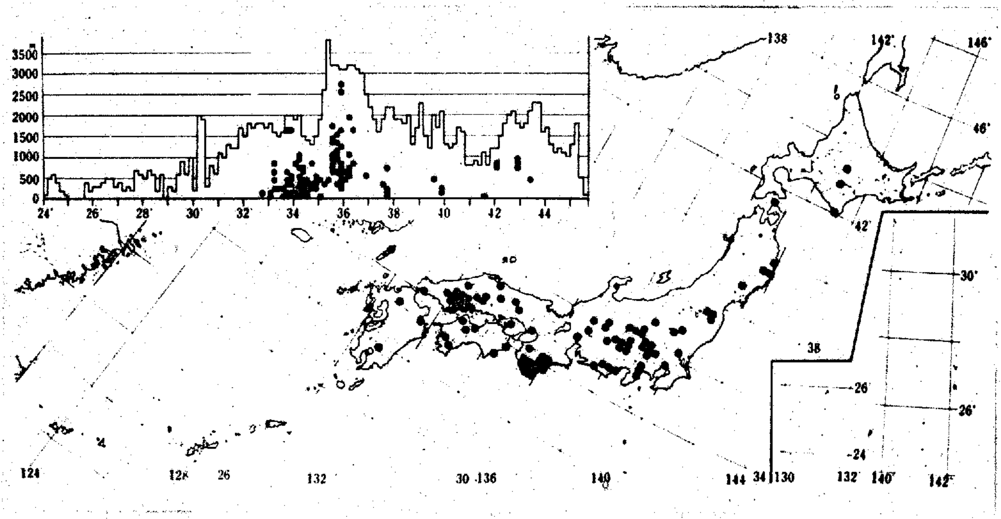
Map 9. Grimmia funalis (Schwaegr.) Bruch et Schimp.



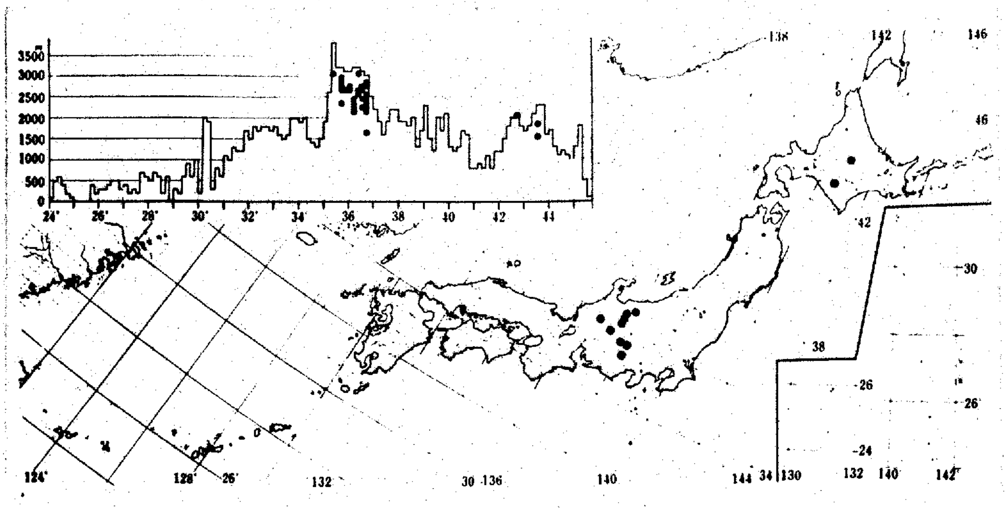
Map 10. Grimmia incurva Schwaegr.



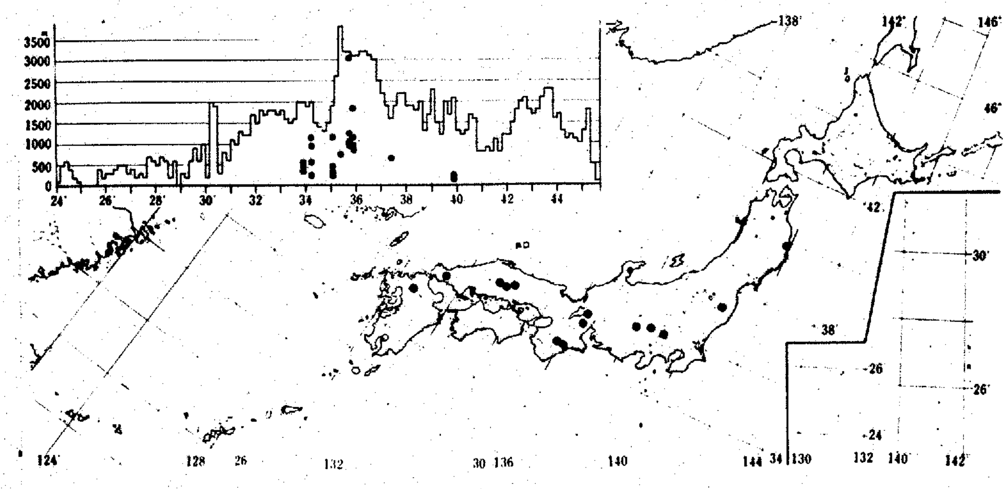
Map 11. Grimmia olympica E.G.Britt.



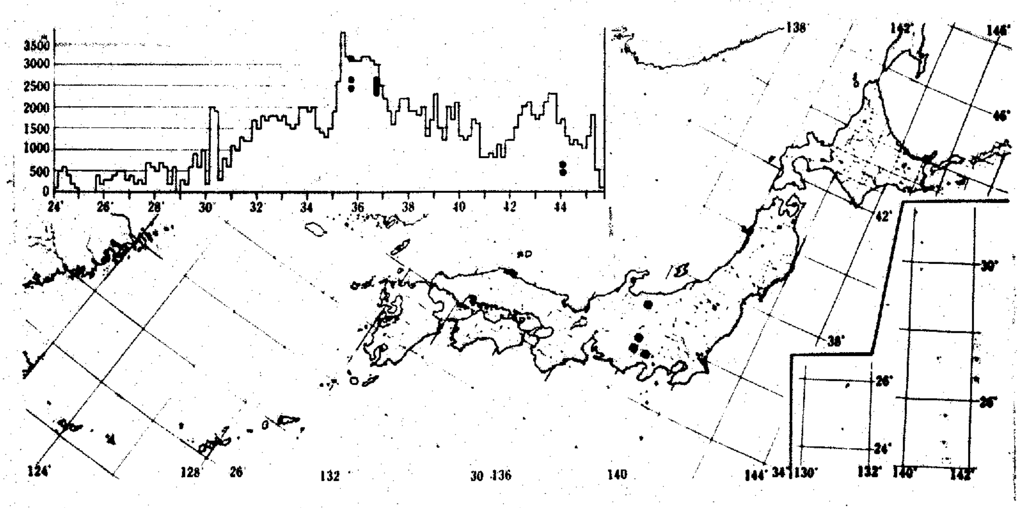
Map 12. Grimmia pilifera P.Beuv.



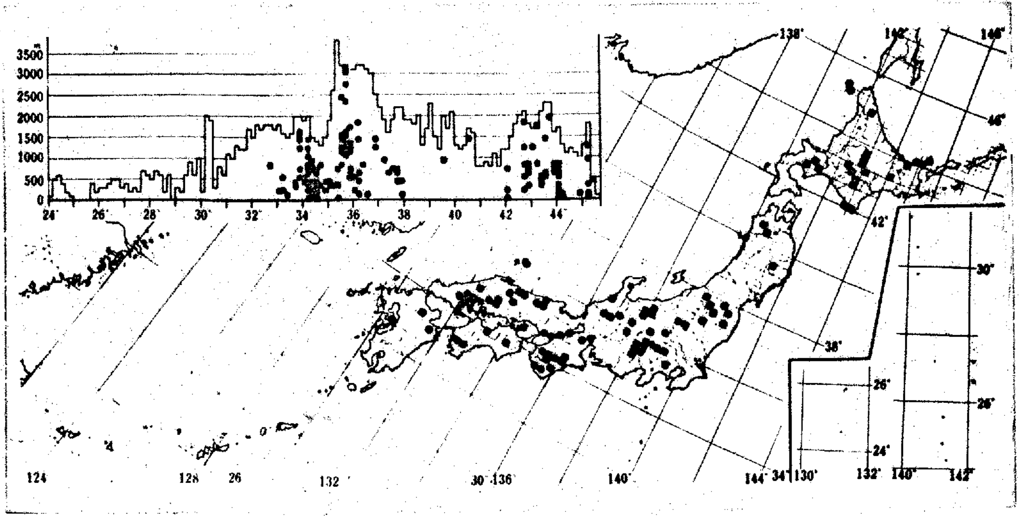
Map 13. Grimmia subsulcata Limpr.



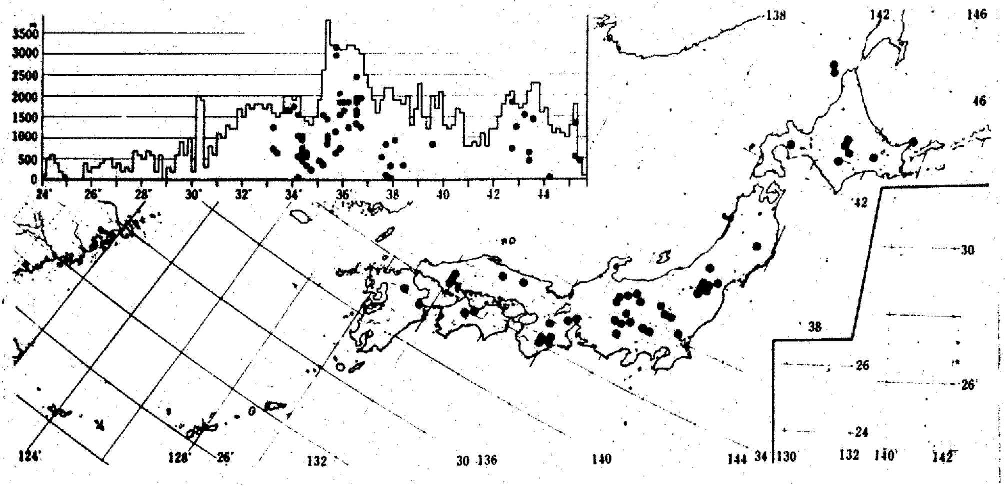
Map 14. Schistidium apocarpum (Hedw.) Bruch et Schimp.



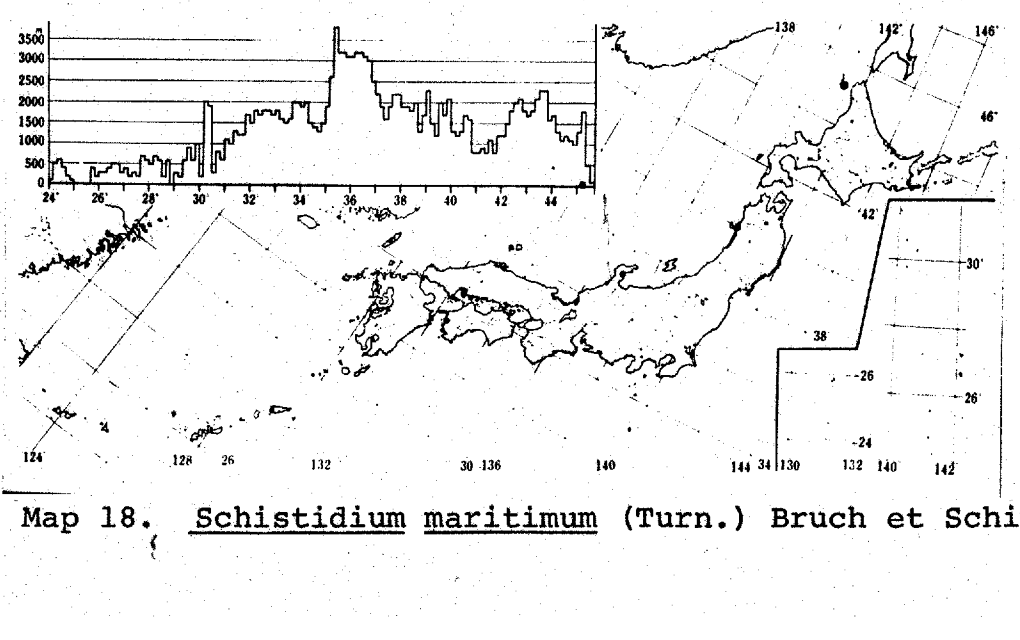
Map 15. Schistidium confertum (Funck) Bruch et Schimp.



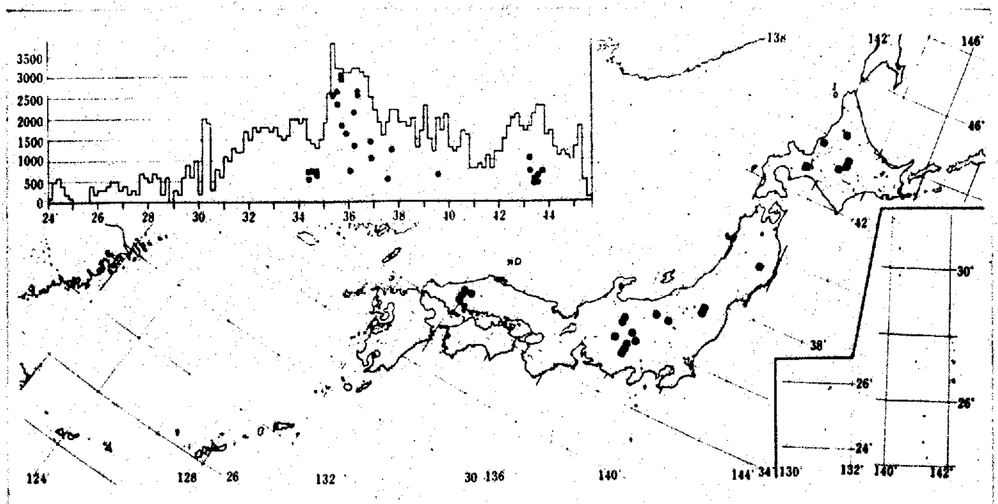
Map 16. Schistidium gracile (Roehl.) Limpr.



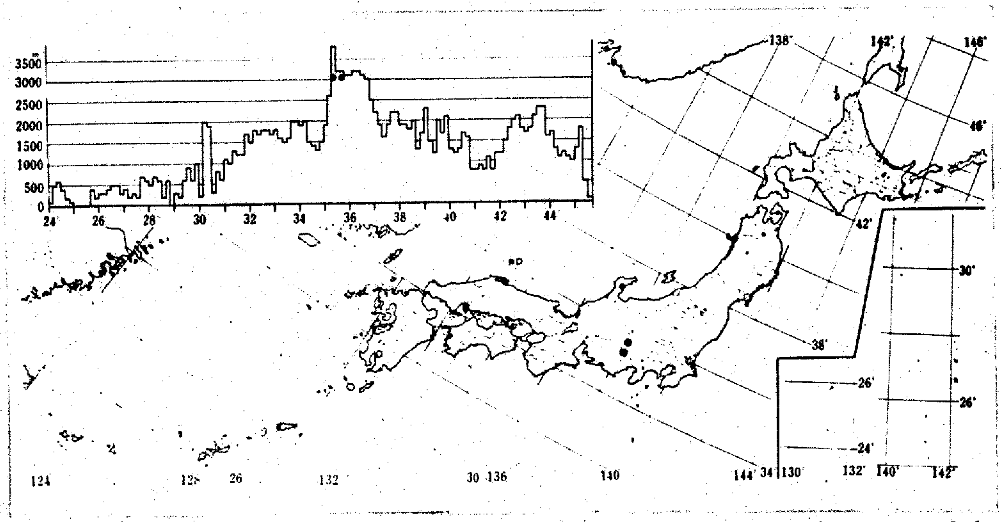
Map 17. Schistidium liliputanum (C.Müll.) Deguchi



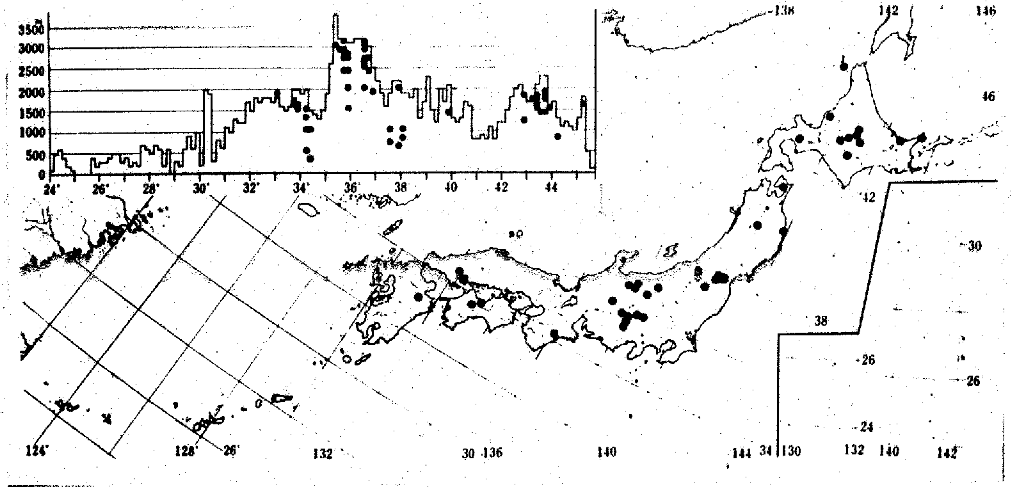
Map 18. Schistidium maritimum (Turn.) Bruch et Schimp.



Map 19. Schistidium rivulare (Brid.) Podp.



Map 20. Schistidium subconfertum (Broth.) Deguchi



Map 21. Coscinodon cribrosus (Hedw.) Spruce