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INVITED REVIEW

Great Discoveries in Bryology and Lichenology

In the Footsteps of Lantzius-Beninga: Investigating the Peristome Characters of Mosses

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Abstract. Lantzius-Beninga (1815–1871), influenced by the earlier work of Hedwig (1730–1799), investigated the capsules of mosses, and more specifically characteristics of the peristome. He was the first to show that longitudinal sections of the capsule and peristome teeth at the capsule mouth provided characters useful to distinguish species. Limpricht (1888–1903) integrated the findings of Lantzius-Beninga into his species descriptions in Kryptogamen-Flora von Deutschland, Österreich und der Schweiz. The ideas of Lantzius-Beninga were later taken up by S. Edwards; J. Shaw and H. Robinson; and J. Shaw, L. Anderson and B. Mishler for taxonomic research, although the technique of sectioning the capsule and peristome has not been widely adopted by bryologists. Drawings of longitudinal sections through peristome teeth of selected species of Grimmia are presented here to illustrate specific differences between them using the technique of Lantzius-Beninga. We show that it is possible to correlate some variable characters of the gametophyte with the characters of the sporophyte, specifically longitudinal sections of the peristome and capsule at the capsule mouth, and to clearly separate taxa on the basis of peristome differences. A paragraph concerning sectioning methods is included.

Keywords. Grimmia, Lantzius-Beninga, moss, peristome, peristome longitudinal section.

The evaluation of characters of peristomes from Lantzius-Beninga to the end of the 20th century: an abridged history.—Bojung Scato Georg Lantzius-Beninga was born into a wealthy family in Ostfriesland, Germany in 1815. After his secondary studies he attended the Universität Georgia Augusta (University of Göttingen) Germany. In 1844, he presented his doctoral dissertation studies “De evolutione sporidiorum in capsule muscorum” and in 1846 he was given the title Privat-Docent in the faculty of Philosophy in the University of Göttingen. In 1850, he was named Assistant in the university herbarium and in 1852 Assessor in the faculty of Philosophy. In 1850, in the Novorum Actorum Academiae Caesareae Leopoldinae-Caroliniae Naturae Curiosorum, his investigations on the capsules of the mosses were published under the title “Beiträge zur Kenntnis des innern Baues der ausgewachsenen Moos kapsel, insbesondere des Peristomes” (Lantzius-Beninga 1850). In the last ten years of his life Lantzius-Beninga was occupied with a work on vascular plants that was only partly completed before he died in 1871—Die unterscheidenden Merkmale der deutschen Pflanzenfamilien und-Geschlechter. As a teacher and a researcher he was highly regarded, but sometimes his freedom with criticisms created personal animosities among his colleagues. His character and the political situation within Germany at that time may explain why he did not advance to a higher academic level within the University hierarchy. In late 1870, only a few months before his death, he was finally awarded the title of ‘Professor’ (Bielefeld 1897).

Hedwig (1730–1799), considered to be the founder of the scientific study of mosses by Lantzius-Beninga, was very influential in his research, especially Hedwig’s 1801 publication Species Muscorum Frondosorum. Lantzius-Beninga made reference to Hedwig’s description of the capsules of mosses and adopted from Hedwig the notions of columella and outer and inner capsule membrane

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Lantzius-Beninga (1847, 1850). From Bruch and Schimper (1836–1855), he adopted the name spore sac. The capsule of mosses had become more important for researchers at the time and he deplored the lack of any detailed investigation on this relatively complex structure. He stated “Sogar das Peristom, worauf Hedwig das einzige bis jetzt brauchbare System zur Anordnung der Moose begründet hat, wurde nicht weiter untersucht,” translated as ‘even the peristome, on which Hedwig based the only useful system for the arrangement of the mosses, has not been deeply investigated.’ This reproach was essentially directed towards Bruch, Schimper, and Gümbel (1836–1855), the authors of Bryologia Europaea, whom he considered to have made a number of errors in their interpretation of peristome characters (Lantzius-Beninga 1850). For example, when we examine this text we can see that the illustration of the longitudinal section of a peristome tooth of Grimmia plagiopodia Hedw. (Fig. 1A), the type species of the genus Grimmia, is erroneously drawn. In reality, the trabeculae of G. plagiopodia are much less protruding than those shown in the illustration of Bruch, Schimper, and Gümbel (Fig. 5D).

When we take into account the history of the development of the microscope (Freund & Berg 1963) we find an explanation for such gaps in the understanding of capsule architecture and peristome structure. Hedwig, in his earlier years, had a very simple microscope that could enlarge objects just 50 times. He had received this microscope as a gift from his contemporary Schreber (Forschütz 1960). Hedwig personally augmented the system of lenses in this instrument in such a way that he could magnify objects up to 290 times. Following the Lexikon deutscher Bryologen (Frahm 1995), Bruch worked with a self-constructed microscope with low magnifying powers when he began his studies of mosses. In contrast, Lantzius-Beninga in 1840 already owned a microscope that magnified up to 700 times (Bielefeld 1897). His microscope had been constructed in Berlin by the famous microscope manufacturer Schiek. Two-hundred years ago microscopes were unique objects that were built on demand and were accordingly very expensive. It was not common for every laboratory to possess a microscope and rarer still to possess one for personal use.

By the end of the nineteenth century it became possible to produce microscopes of a high standard through the improvement of optical lenses by Abbe (1840–1905) and the production of optical glass by Schott (1851–1935). Abbe greatly contributed to the excellence of the instruments made in Jena, Germany by his understanding of the theory of light and through the augmentation of the mathematical precision of lens production. Jena became the center of the development of optical instruments at that time. Parallel to the evolution in microscope technology and quality was an increased knowledge of living tissues and an enormous advance in scientific understanding (Freund & Berg 1963). Innovations and developments in microscopes lead to new discoveries and developments in many areas of biology. For mosses, the availability of microscopes with higher magnifying powers enabled the closer examination of morphological and anatomical characters that in turn led to new interpretations of species concepts and systematic relationships.

With these increased technical possibilities, Lantzius-Beninga began to build on the knowledge that he had first elaborated in his dissertation. Once again he returned to the capsules of mosses with the intention of understanding the development and characters of peristomes. To do this he used capsules just before they were mature because the material was easier to manipulate and the peristome teeth were not damaged, as may happen after capsule dehiscence. He began his studies by investigating the simply constructed capsules of Phascum and Tetraphis before moving on to those of Weissia, Barbula, and Fissidens, and the more complicated constructions of Bartramia, Polytrichum, and Hynum. He was among the first to recognize the isolated position of the peristome of the Polytrichum species (Lantzius-Beninga 1847, 1850).

By means of longitudinal (Fig. 2A) and trans-
verse (Fig. 2B) sections of the developed capsule of *Anacalypta rubella* [= *Bryoerythrophyllum recurvirostrum* (Hedw.) P. C. Chen] Lantzius-Beninga (1847) explained the development of a tooth of a haplolepidous peristome. One can see two columns of cells (Fig. 2A, layers labeled ‘t’ and ‘p’) connected by the thickened vertical walls. The transverse walls of the cells, pointing to the margin of the operculum, are also partly reinforced. These walls are the protruding trabeculae in the fully developed tooth. The remaining thinner walls are destroyed upon deoperculation. Traces of them are occasionally visible on the peristome teeth of freshly deoperculate capsules. The transverse section of the capsule (Fig. 2B) shows that the outer dorsal side of a tooth consists of a column of one plate (p) (primary peristome layer or PPL) and the inner side of a column of two plates (t) (inner peristome layer or IPL). The surface view of a tooth of *Schistidium apocarpum* Bruch & Schimp. shows the construction pattern of these cell plates [from Edwards 1979, Fig. 2(b) and represented here in Fig. 2E]. On the outer side of the tooth appears one column (Fig. 2C) and on the inner side two columns are present (Fig. 2D). The schematic representation of Edwards (1979, Fig. 1) of the haplolepidous peristome makes this particularly clear.

The longitudinal section through a capsule of *Hypnum sylvaticum* Brid. [= *Plagiothecium nemorale* (Mitt.) A. Jaeger] (Fig. 3A) shows the formation of a diplolepidous peristome. Between ‘p’ and ‘t’ is a fine cell layer, the inner peristome layer (IPL).

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**Figure 3.** Development of a double rank of peristome teeth of *Hypnum sylvaticum* [= *Plagiothecium nemorale*]. — A. Capsule, longitudinal section. — B. Capsule, transverse section. From Lantzius-Beninga (1847).
The outer peristome layer (OPL) is formed by the thickening of the membrane between ‘p’ and ‘r’. The trabeculae are developed in the same way as in the haplolepidous peristomes. The transverse section of a capsule of the same species (Fig. 3B) shows that the outer side of the tooth of the outer rank is constituted of two cell plates and the inner side of one plate only. Between p and t arise the inner plicate peristome teeth (endostome).

Results of his investigations on different species of mosses led Lantzius-Beninga to conclude that “die Beschaffenheit der inneren Struktur der Kapsel ein wichtiges Moment zur Feststellung der Arten zu sein scheint. Bei allen guten Arten fand ich im Bau wesentliche Unterschiede von anderen verwandten, ebenfalls sichern Arten, wogegen ich bei einigen schwankenden Arten keine Abweichungen wahrnehmen konnte.” (Lantzius-Beninga 1850). This is translated as ‘it seems to me that the inner structure of the capsule is an important element for the identification of a species. In all good species I found in the construction essential differences to other related, clearly defined species, on the other hand in some varying species I could not recognize differences.’ The implications of the findings of Lantzius-Beninga are that peristome-capsule longitudinal sections may import useful additional information when attempting to distinguish species, and in interpreting species relationships. However, we see that his technique has not been widely applied in moss taxonomic or systematic studies. This was perhaps in part due to the method of carefully sectioning the capsule and peristome teeth to obtain suitable material for comparison.

In 1884, 34 years after the last publication of Lantzius-Beninga, Henri Philibert (1822–1901), published two articles under the same title “De l’importance du péristome pour les affinités naturelles des mousses” in Revue Bryologique (Philibert 1884a,b). From 1884 to 1902 followed a series of publications by Philibert entitled “Etudes sur le péristome” (Philibert 1884c, 1885a,b, 1886a,b, 1887a,b, 1888a–g, 1889a–c, 1890a–c, 1896a,b, 1901a,b, 1902). Edward Taylor (1962) translated this series into English and published them collectively as The Philibert Peristome Articles: An Abridged Translation. It may be possible that Philibert had known of Lantzius-Beninga’s work and had been stimulated by it, although he did not cite it in his later studies. Edwards (1984) wrote that Philibert recognized nothing that was not in concordance with the earlier work of Lantzius-Beninga. It is interesting to note that it is Philibert and not Lantzius-Beninga who is credited today as being at the base of the development of peristome studies.

Moss peristomes can be divided into two main types based on the architecture of the peristome teeth—a nematodontous type (e.g., the Polytrichales or Tetrphidiales) and an arthrodontous type. The teeth of the former (nematodontous peristome) are composed of bundles of whole cells and the latter (arthrodontous peristome) of articulated and fused cell plates. It was Mitten (1859) who first introduced the concepts of ‘Nematodonti’ and ‘Arthrodonti’ (Wagenitz 1996). Philibert later recognized two forms of the arthrodontous peristomes that he designated as “haplolepidous” and “diplolepidous” (see Taylor 1962).

Haplolepidous peristomes have teeth with only one column of cell plates on the outer dorsal side, as in Schistidium apocarpum [from Edwards, 1979, Fig. 7(d) and represented here in Fig. 4A] or the above cited Bryoerythrophyllum recurvirostrum (Fig. 2A). Diplolepidous peristomes are those that have teeth formed from two columns of cell plates on the outer (dorsal) side as in Orthotrichum striatum Hedw. [from Edwards, 1979, Fig. 10(d) and represented here in Fig. 4B], Leucodon maritimus (Hook.) Wijk & Margad. [from Edwards, 1979, Fig. 10(b) and represented here in Fig. 4C], or Plagiothecium nemorale (Fig. 3A). Only diplolepidous peristomes have a second, outer rank of peristome teeth (termed the exostome). These definitions correspond to the results of Lantzius-Beninga’s early investigations.
The illustrations made by Lantzius-Beninga were very detailed and scientifically precise works that evoked much admiration at the time. In textbooks for botany such as Sachs (1874) or Goebel (1915) one can find reference to and praise for Lantzius-Beninga’s work. In contemporary studies on peristomes such as in Edwards (1984) re-drawings from the originals of Lantzius-Beninga are included and some recent taxonomic studies Kienitz-Gerloff (1878a,b), Lorch (1931), Kreulen (1972), Shaw and Robinson (1984), and Shaw et al. (1987) also refer to his findings. A modern account of peristomes is given by Edwards (1979, 1984). Schwartz (1991), in a review of the developmental studies of peristomes, provided a comprehensive history of peristome research, including that of Lantzius-Beninga. He concluded that the peristome is generally considered to have conservative, and consequently informative, taxonomic characters. Iwatsuki (1982) stated that the architecture of a peristome tooth is useful to differentiate species of nearly all groups of mosses. This statement supports the conclusions made by Lantzius-Beninga over 130 years earlier.

Comparisons of longitudinal sections of the peristome and capsule mouth from selected species of Grimmia.—Limprricht, at the end of the 19th century, for the descriptions of moss species in Kryptogamen-Flora von Deutschland, Österreich und der Schweiz, made extensive use of the characters of the sporophyte. He based his work on the knowledge of Lantzius-Beninga. “Peristom einfach, die 16 Zähne allermeist bis zur Insertion gesondert, immer nach dem Typus der Apoolepidiace gebaut, beide Schichten ziemlich gleichmässig entwickelt und meist nur die aussere mit vortretenden Querleisten” (simple peristome, the 16 teeth mostly separated down to the insertion, always constructed as the type of the haplolepidae, both layers equally developed and mostly only the outer layer with protruding trabeculae). This is an extract of the list of characters given by Limpricht (1888–1889) for the Grimmiaeae in the first volume of the Kryptogamen-Flora von Deutschland, Österreich und der Schweiz. In the introductory chapters of this volume byrological terms are explained and drawings of morphological and anatomical features are given to support the explanations. It is here that Limpricht cited Lantzius-Beninga in relation to the use and importance of peristome characteristics, specifically peristome tooth-capsule sections, in the delineation of species; a technique he adopted in his work (Limpricht 1888–1889).

The application of Lantzius-Beninga’s methods of peristome-capsule sectioning leads to some convincing results when applied to the genus Grimmia. Studies on the peristome of several species of Grimmia reveal both the family characteristics, as described above by Limpricht, and some distinct differences between species. The assumption that the little varying features of the peristome (a strong specific character) can be correlated with the more variable morphological expression of a species can be tested using this method. Closely related species and questionable species can be identified and those with irregular morphology can be placed according to their less variable peristome characteristics.

**METHODS**

The capsules are gently heated in a basic solution of about 1% KOH to assist the softening, clearing, and the rewetting of the tissue. The heated capsules are then cut longitudinally into halves. The spore sac is carefully removed and the preparation is then cleaned with a fine brush (as used for watercolors) to remove any debris and excess spores. The rounded capsule base is cut off to permit the halves to lie flat on the slide. The capsule halves are secured with forceps and are then cut into longitudinal sections in the axis of the capsule with a sharp razor blade. The sections are made as finely as possible and a cover slip is placed over the preparation. The illustrations presented here are done from material mounted in water and all are based on preparations cut free-hand. Appendix 1 lists specimens utilized.

**RESULTS**

Peristome-capsule longitudinal sections in the genus Grimmia.—The compound microscope allows the taxonomically useful specific characters to be observed and measured accurately. The often variable characters of the gametophyte can thus be correlated with peristome characters. Results of peristome-capsule sectioning that permit comparative examination are obtained from completely developed capsules in the state of maturity just before the depercurlation.

Grimmia plagiopodia Hedw.—Drawings of G. plagiopodia (Figs. 5A–D), type of the genus Grimmia, summarize the characters that define members of the Grimmiaeae, translated from Limpricht (1888–1889) “costa with basal (ventral) guide cells (Fig. 5A) with leaf cells more or less sinuose, peristome in one rank, the 16 teeth almost separated down to the insertion, always constructed as the haplolepidous type, both layers rather regularly developed with dorsally protruding trabeculae” (Fig. 5D). Vitt (1984) describes the peristome of the suborder Grimmiiineae as follows: “Peristome with the inner and outer layers equally thickened, or the outer layer slightly thicker than the inner, transverse walls developed more strongly on the outer surface.” The haplolepidous peristome is of the arthrodonous type with a rank of 16 teeth composed of two layers of cell plates. On surface view 16 outer (dorsal) (Fig. 5B) and 24 inner (ventral) (Fig. 5C) columns of cell plates are seen.

Grimmia ovalis (Hedw.) Lindb. and G. affinis
Hornsch.—The long-lasting uncertainty over the identity of *G. longirostris* Hook. (= *G. affinis*) and *G. ovalis* may have been avoided if their peristome teeth had been studied in more detail. Both species are monocious and are commonly found with sporophytes. They have both been described by Limpich: *G. longirostris* (= *G. ovata* F. Weber & D. Mohr) translated as 'peristome teeth densely covered with long papillae, outer layer with distant trabeculae, no prostome'; and *G. ovalis* (= *G. commutata* Huebener) translated as 'outer layer strongly developed, trabeculae densely set, protruding, with fragments of a prostome.' The drawings of the outer surface of peristome teeth and longitudinal sections of the peristome teeth (Figs. 6A–F) show the marked difference between the peristome architecture of these two species. The peristome of *G. longirostris* is inserted just below the capsule orifice (Fig. 6B), a prostome is absent, the teeth in the upper half are strongly papillose, and the trabeculae are not protruding and are scarcely visible (Figs. 6A–B). In contrast, the peristome in *G. ovalis* is deeply inserted in the capsule orifice (Figs. 6D–E) and most of the time a prostome is present (visible on surface view at the rim of the capsule), the teeth in the upper half are ornamented with needle-like fine papillae, and the trabeculae are protruding in the upper part (Figs. 6C–D). The development of prostomes follows the same pattern as the normal teeth: they are formed by the cells of the column situated between the peristome and the capsule wall. The transverse section of the capsule rim at the insertion of the peristome for *G. ovalis* (Fig. 6F) shows the irregular development of the prostome.

*Grimmia* elongata *Kaulf.*, *G. incurva* Schwägr., and *G. donniana* Sm.—Three *Grimmia* species that can be difficult to distinguish from each other gametophytically; *G. elongata*, *G. incurva*, and *G. donniana*, share the characters of elongated narrowly rectangular hyaline cells at the margin of the leaf base and rounded thick-walled annulus cells with very small lumina that separate individually from the capsule rim. They are the only *Grimmia* species in the European moss flora with this combination of characters. However, their peristomes differ in the depth of the insertion of the teeth at the capsule rim, and by the papillae form and papillosity of the peristome teeth (Figs. 7A–H). The peristome of *G. elongata* is deeply inserted in the capsule rim, the trabeculae are protruding from the base to the apex of the teeth (Fig. 7A), and the papillae become gradually rough and pointed in the upper part of the teeth (Fig. 7B).

The peristomes of *G. donniana* (Figs. 7C–E) and *G. incurva* (Fig. 7G) are inserted near the capsule rim. The teeth of *G. donniana* are papillose from the very rim of the capsule and the papillae become rougher (larger and more developed) towards the apex (Fig. 7F). The teeth of *G. incurva* are smooth in the lower half and are ornamented with very fine, needle-like papillae in the upper half (Fig. 7H).

*Grimmia* donniana, *G. triforis* Carest. & *De Not.* and *G. arenaria* Hampe.—Three taxa that were

separated on the basis of seta-form; *G. donniana* (long, straight setae), *G. triformis* (short, straight setae), and *G. arenaria* (curved setae), have been found to have identical peristome characteristics, when comparing the outer surfaces and the longitudinal sections of the peristome teeth (Figs. 7C–E). The form of the seta should be understood as being variable and the age of the specimens should be considered because in unripe states setae may be bent but straighten as the sporophyte matures. Seta form, at least in the case of *G. donniana*, is not useful as a specific and separating character. Corley et al. (1981) accept only *G. donniana* as a species and place *G. arenaria* in synonym of it.

Grimmia crinita Brid. and *G. crinita var. elongata* Bruch & Schimp.—To investigate whether *G. crinita* and *G. crinita var. elongata* [= *G. crinita var. capillata* (De Not.) De Not.] are two separate entities, their peristomes can be compared (Figs. 8A–E). Figures 8A and B show the dorsal and ventral view of typical peristome teeth of *G. crinita* drawn from a specimen collected on a concrete wall in the wine growing region of western Switzerland. Figure 8D shows the dorsal view of a typical peristome of *G. crinita var. capillata* drawn from a specimen collected from a limestone wall in Montpellier, southern France. *Grimmia crinita* tends to grow in cushions on the vertical faces of walls and the stems are orientated downwards while the plants ascribed to *G. crinita var. capillata* have more erect stems and they are slightly more embedded in the substratum. They differ morphologically only by the hair-points of leaves in the comal region. In *G. crinita*, hair-points are present in these leaves while in *G. crinita var. capillata* the comal leaves lack hair-points, (only the perichaetial leaves have hair-points). The annulus cells and their position at the capsule mouth as well as the papillae and papillosity of the teeth (Figs. 8A–D) are identical in both entities, the longitudinal sections of teeth of *G. crinita* (Fig. 8C), and *G. crinita var. capillata* (Fig. 8E), reveal the same flat insertion and the curvature of the teeth directed to the capsule wall. The latter feature is found only once in the genus *Grimmia*. The perfect congruence of the capsule characters in both taxa makes separation of them into independent taxa questionable.

Grimmia atrata Hoppe & Hornsch.—Studies on teeth of only partially formed capsules may lead to errors in interpretation (Figs. 9A–D). To illustrate this, normally developed peristome teeth of *G. atrata* (Fig. 9A) can be compared to a malformed
peristome tooth (Fig. 9C). The inner ventral cell layer in the malformed tooth (Fig. 9C) is not complete. At least after careful examination of the inside of the operculum, fragments of the peristome can be seen. A longitudinal section (Fig. 9D) of the tooth shows the deterioration, but also the column of uniseriate cells that surpass the rim of the capsule (Fig. 9D). From a normally developed peristome of *G. atrata* (Fig. 9B) the insertion region and the development of the outer layer of the teeth of the aberrant peristome are not different.

Grimmia *pitardii* Corb. (= Campylostelium *pitardii* (Corb.) E. Maier).—The systematic placement of *Grimmia pitardii* (= *Campylostelium pitardii*) was problematic because it lacks some of the defining characters of *Grimmia*. *Campylostelium pitardii* has straight and smooth cell walls (walls are sinuose or nodulous in *Grimmia*) and its leaves are without hair-points throughout. A further difference between this species and *Grimmia* is also found in the costal architecture—the guide cells are in median position in *C. pitardii* while guide cells are ventral in *Grimmia*. Perhaps the most striking differences however are found in the peristome—the teeth of *C. pitardii* are not divided down to the insertion and are supported by a well-developed basal membrane (peristome teeth are divided to the base and lacking a basal membrane in *Grimmia*). In longitudinal section of the tooth of *C. pitardii* it can be seen that the outer layer is of nearly the same width as the inner layer and that protruding trabeculae are lacking. Such characters justify the transfer of this species to the genus *Campylostelium* Bruch & Schimp. as discussed in Maier (1998).

**Final Comments**

In a posthumously published work, Loeske (1935) wrote “dass grundsätzlich weder der Sporophyt noch der Gametophyt für die systematische Beurteilung ausschlaggebend ist und dass sämtliche Merkmale beider Generationen vergleichend und unter Berücksichtigung ihrer Veränderlichkeit zu prüfen sind,” translated as: ‘... that principally neither the sporophyte nor the gametophyte are preponderant for systematic judgement and that all characters of both generations should be taken into consideration.’ We have shown that peristome-capsule longitudinal sections in *Grimmia* can reveal specific characters that can be used taxonomically, in combination with gametophytic features, to define species. This method can also be applied to the clarification of certain taxonomic problems. At the beginning of the 21st century, bryological research now recognizes the fundamental contribution made by Lantzius-Beninga over a century and a half ago.

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APPENDIX 1. SPECIMENS USED

The specimens used in this study have not been compared to the type specimens; therefore the results of these comparisons presented in this paper are not an equivalent of a taxonomic change.

Grimmia longirostris Hook. [MAIER 31 g]
Grimmia atrae Hoppe & Hornsch. [LONG 20936 E, G].
Grimmia crinita Brid. [Maier 10424 g]
Grimmia crinita var. elongata Bruch & Schimp. = Grimmia capillata De Not. [Husnot, Musci Galliae n. 414 g]
Grimmia donniana Sm. [Maier 10250, 9025, 30 g]
Grimmia elongata Kaulf. [Maier 9138 g]

Grimmia incurva Schwägr. [Maier 2160–1 g]
Grimmia ovalis (Hedw.) Lindb. [Maier 8008 g]
Grimmia plagiopodia Hedw. [Schliephacke s.n. m]
Schistidium apocarpum (Hedw.) Bruch & Schimp. [Maier 5493 g]