



Studies on *Schistidium* (Grimmiaceae, Bryophyta) in Europe, with particular reference to the Alps: I. A description of *S. marginale* sp. nov.

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Abstract

Schistidium marginale is described as a new species from several European states including Austria, Georgia, Italy, Macedonia, Spain, Switzerland and Turkey. The species is fully illustrated, its affinities are discussed in detail and its current distribution is mapped. The new species is closely related to *S. confertum* and *S. echinatum* from which it differs in having a coarser and thicker costa which is 3–4-stratose in mid-leaf and 4-layered at the base; strongly thickened, 2–4-stratose and (1–)2–5-seriate leaf margins; and a thicker and stiffer leaf hair-point. It clearly belongs to *Schistidium* Bruch & Schimp. sect. *Conferta* (Vilh.) Ochyra on account of the distinct 3–6(–7)-seriate basal marginal border of quadrate to short-rectangular, often subhyaline cells with distinctly thickened transverse walls.

Key words: acidophile, distribution, Grimmiaceae, mosses, saxicole, *Schistidium*, taxonomy

Introduction

Schistidium Bruch & Schimper (*in* Bruch *et al.* 1845: 93) is one of the most complex and difficult of moss genera which, at the same time, is still poorly known and understudied taxonomically. Species of this genus are primarily saxicoles and only sometimes do they occur in epigeal or epiphytic habitats. The vast majority of *Schistidium* species are associated with dry habitats, although there is a fairly large group of species that thrive in wet habitats, including rheophytic sites (Ochyra & Bednarek-Ochyra 2015). The real number of species in *Schistidium* cannot be established at the moment, since it has not been critically revised in most regions of the globe. However, discoveries of a number of new species or reinstatement of some species from obscurity in recent decades in various parts of the globe, for example in Antarctica (Ochyra 1987, 1998a, 2003, 2004, Ochyra *et al.* 2003a), South America (Ochyra & Bednarek-Ochyra 2011), North America and Greenland (Mogensen & Blom, 1989; Allen 2005, Blom & Darigo 2009, McIntosh *et al.* 2015), China (Blom *et al.* 2011, Feng *et al.*, 2013), and Asiatic Russia (Ochyra & Afonina 1994, 1995, 2010; Ignatova *et al.* 2010) indicate that additional new species are likely to be found with progress in taxonomic work and exploration of underworked regions. The discovery of several new species of *Schistidium* in Europe (Poelt 1953, 1955, Blom 1996, 1998, Blom & Lüth 2002, Ignatova *et al.* 2010) is especially remarkable because this continent is considered to be the cradle of modern bryology and is the best explored bryologically.

As elsewhere, *Schistidium* exhibits in Europe the greatest diversity in mountainous regions. It was first observed by the authors of *Bryologia germanica* (Nees von Esenbeck *et al.* 1827) who described many new taxa from the Alps from collections made by such eminent contemporary bryologists as D.H. Hoppe and J.C. Schleicher. Unfortunately, many of their new taxa have never been taxonomically assessed (see Price & Maier 2011: 302–303), and for some of these no original material have been detected (Blom 1996).

When revising herbarium material of *Schistidium* from Central Europe, after having defined taxa occurring in Scandinavia, the first author was struck by two observations. Firstly, almost all the specimens collected in the lowlands and forest areas were already known to him, but secondly, he was unfamiliar with a large part of the material collected from above the tree line in the mountains. These observations were confirmed during his excursions to two alpine localities in Switzerland (Blom 1997), where three species unknown in Scandinavia occurred frequently. At the same

time he did not find *S. flexipile* (Brotherus 1892[1893]: 92) Roth (1904: 563), *S. scandicum* Blom (1996: 157), *S. poeltii* Blom (1996: 101) and *S. venetum* Blom (1996: 192) which are important constituents of the *Schistidium* flora of the Scandinavian mountain chain. Thus, there seems to be a considerable difference between the two mountainous areas in Europe and this strongly justifies the need for taxonomic work on *Schistidium* in the Alps and other mountain ranges in continental Europe.

Since the publication of a revision of *Schistidium* in Scandinavia (Blom 1996, 1998) in which also a number of taxa were recorded for the first time from the mountains in continental Europe, including the Alps, several alpine and montane species have been confirmed for or added to the flora of the Alps. These are: *S. atrichum* (Müller & Kindberg in Macoun & Kindberg 1892: 65) Weber (1976: 106) [syn. *S. tarentasiense* Seville (1909: 14); Chavoutier & Hugonnot 2013], *S. subflaccidum* (Kindberg 1900: 85) Blom (in Blom *et al.* 2006: 193, Fig. 3) (Köckinger *et al.* 2008), *S. sinensiapocarpum* (Müller 1898: 187) Ochyra (1998b: 107) (Blom *et al.* 2006: Fig. 2; Köckinger *et al.* 2008), *S. echinatum* Ignatova & Blom in Ignatova *et al.* (2010: 211, Figs 13–15), *S. obscurum* Blom, Köckinger & Ignatova in Ignatova *et al.* (2010: 207, Figs 10–11), *S. sordidum* Hagen (1901: 324) (Hofmann & Berney 2004, Skrzypczak 2009; Kiebacher & Köckinger 2015), and *S. venetum* (Köckinger *et al.* 2008). The last two species occur in both the Alps and Scandinavia.

The modern concept of *Schistidium* was outlined in *Bryologia europaea* (Bruch *et al.* 1845) and actually this generic name published in this opus was conserved with the conserved type (Ochyra & Isoviita 1990). This major work served for decades as the oracle as far as taxonomic and nomenclatural matters of European mosses were concerned and following it the vast majority of small alpine specimens of *Schistidium* were named *S. confertum* (Funck 1820: 18) Bruch & Schimper (in Bruch *et al.* 1845: 99, pl. 232). This species occupies a key position in understanding the diversity of *Schistidium* in the moss flora of the Alps, because it is actually an aggregate comprising several distinct species, including common and distantly related taxa such *S. dupretii* (Thériot 1907: 63) Weber (1976: 106). Even when such species are recognised, there remains great variation in morphological characters within the broadly conceived *S. confertum*. Recent studies have shown the existence of several distinct species within the *S. confertum* complex (Blom & Lüth 2002, Ignatova *et al.* 2010). They share several important morphological character states, and most of them grow on siliceous or weakly base-rich rocks. The next species of this complex is described in this paper.

Schistidium marginale has actually been known for nearly two decades. Blom (1997: Table 1) reported it as taxon ‘A’ and discussed its elevational distribution in the Göschenen valley in Uri canton, Switzerland. As a provisional and undescribed species, it was considered in a phylogenetic study of *Schistidium* (Milyutina *et al.* 2010) and was also included in a key to the Russian representatives of *Schistidium* (Ignatova *et al.* 2010). Köckinger *et al.* (2008) mapped the distribution of *S. marginale* in Carinthia, Austria and provided a short note on its ecology and morphological characters. The formal description of this species is thus long overdue, and should not be further deferred.

Material and Methods

This work is primarily based on the study of specimens sent on loan to the first author from several herbaria (see the Acknowledgements section), particularly those collected by Heribert Köckinger, Weißkirchen, Austria. The material was studied and described using standard anatomical and morphological methods applied within the Grimmiaceae (Frisvoll 1988; Blom 1996; Bednarek-Ochyra 2006). Microscopic examinations and measurements were taken with a Zeiss light microscope, selecting mature leaves from the region just below the perichaetial leaves. Illustrations were made with an aid of the Nikon drawing tube in pencil and subsequently inked and mounted in plates. The distribution map was generated on the outline map of Europe with use of CorelDraw 11 programme.

Taxonomic Treatment

Schistidium marginale H.H.Blom, Bednarek-Ochyra & Ochyra, *sp. nov.*, Figs 1–2

Nostra species nova Schistidio conferto et *S. echinato* similis, sed ab illa costis grossissimis crassissimisque, in sectione transversali superne et medio 3–4-stratosibus, basi 4-stratosibus et pilo hyalino rigidiori crassiorique distincta est; prior species a nostra capsulis ovoidis, obovoidis vel breviter obloidis, deinde frequenter cyathiformibus campanulatisque, 0.9–1.4(–1.7) longiori quam latiori, altera margine recurvo versus apice et dentibus pili longioribus plus protrudentibus bene distinguitur.

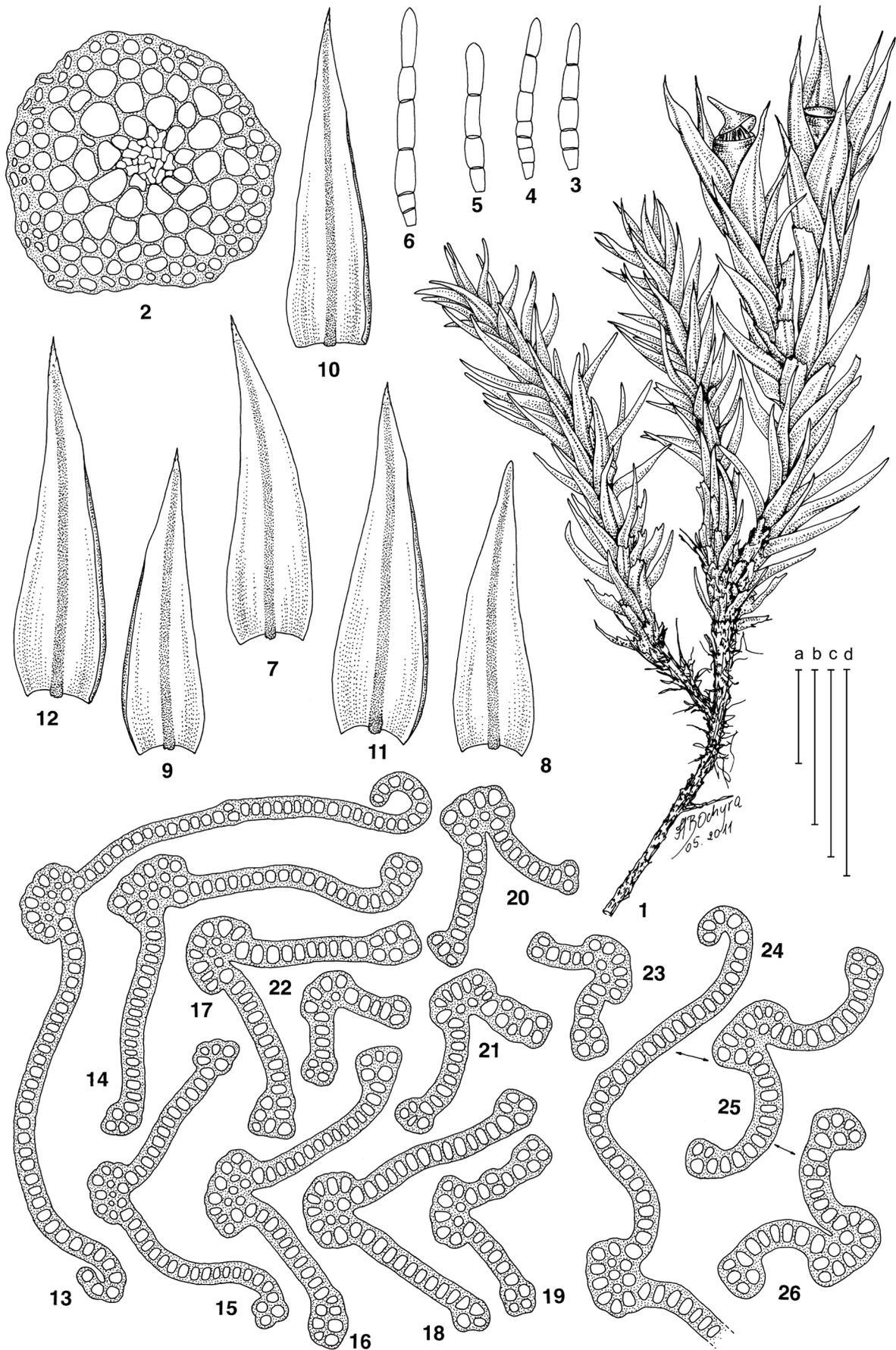


FIGURE 1. *Schistidium marginale*. 1. Habit, wet. 2. Transverse section of stem. 3–6. Axillary hairs. 7–12. Vegetative leaves. 13–26. Transverse sections of leaves, sequentially from base to apex. (1–2, 7–10, 13–23 from Köckinger 96-437, isotype; 3–6, 11–12, 24–26 from Köckinger 12239, paratype; both in KRAM.) Scale bars: a – 1 mm (1); b – 100 µm (3–6, 13–26); c – 100 µm (2); d – 1 mm (7–12).

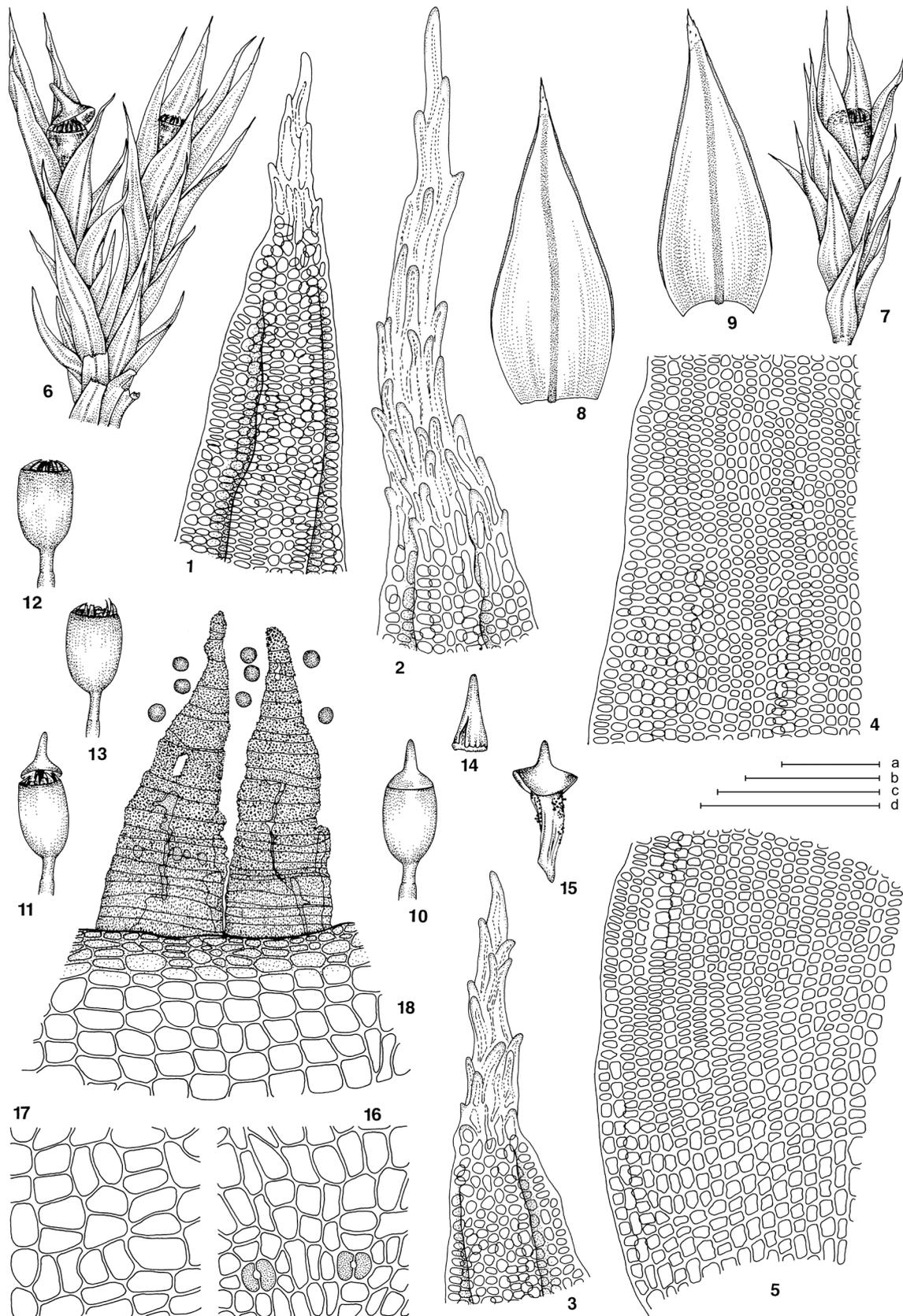


FIGURE 2. *Schistidium marginale*. 1–3. Leaf apices with hair-points. 4. Mid-leaf cells. 5. Basal cells. 6–7. Portions of branches with perichaetia, wet. 8–9. Perichaetial leaves. 10–11. Operculate capsules, wet. 12–13. Deoperculate capsules, wet. 14. Calyptra. 15. Operculum with attached columella. 16. Exothecial cells and stomata at base of urn. 17. Exothecial cells in middle of urn. 18. Exothecial cells at mouth, peristome and spores. (1–7, 10–14 from *Köckinger 96-437*, isotype; 8–9, 15–18 from *Köckinger 12239*, paratype; both in KRAM.) Scale bars: a – 1 mm (6–7, 10–14); b – 1 mm (15) and 100 µm (16–18); c – 100 µm (2–3); d – 1 mm (1, 4–5, 8–9).

Type: AUSTRIA. Steiermark, Gurktaler Alpen, Frauenalpe mountain south of Murau, alt. ca 1900 m a.s.l., [lat. ca 47°03'23"N, long. ca 14°08'18"E], on S-facing, base-rich schistose rock, 28 June 1996, *Köckinger 96-437* (holotype: TRH!, isotype: KRAM!).

Plants small, dull, olivaceous or brownish above, often with yellowish tones, brownish below, turning pale yellowish in old herbarium material, forming dense, sometimes extensive tufts or mats. *Stem* 0.9–2.5 cm, slender, irregularly branched, in transverse section with 2–3-stratose epidermis of cells with relatively large lumina and thin-walled medullary cells, with narrow central strand, consisting of about 10–15 or more cells. *Axillary hairs* filiform, hyaline throughout, uniseriate, 4–7-celled, with 1–4 short, quadrate basal cells and 3–4 elongate distal cells. *Leaves* densely set, shiny, erect, imbricate, straight, narrowly ovate-triangular, acute or rarely acuminate, keeled, 1.5–2.1 × 0.4–0.6 mm. *Hair-point* 0–0.7(–0.85) mm, straight and rather stiff, ± flattened in lower part, not decurrent, coarsely spinulose with short, erect to erecto-patent spinulae, dorsally densely spinulose. *Costa* smooth, robust, in upper and central parts 48–75 µm wide, about 1/3 leaf width in the narrow upper part of leaf, percurrent to shortly excurrent, dorsally high and ridge-like and making an acute angle with the lamina in transverse section, 2–3(–4) stratose in upper and central parts, trapezoid, subrectangular or irregularly angular in outline (sometimes forming a shallow furrow along the dorsal side), 3–4-stratose in lower part and subrectangular to hemispherical in outline. *Margins* smooth, mostly plane or very narrowly recurved for various lengths in the central part on one side and narrowly recurved in lower 1/3–2/3 or rarely almost throughout on the opposite side, often recurved almost to apex on one or both sides in larger subperichaetial leaves, in upper and central parts from bistratose for (1–)2–5 rows to 4-stratose, often subtriangular to clavate in outline, in lower part mostly bistratose for 1 row. *Lamina* smooth, in upper and central parts varying from unistratose with a few bistratose spots and strips to irregularly bistratose, in lower part unistratose. *Laminal cells* thick-walled, in upper part mostly isodiametric, rounded, ovate and elliptical mixed with a few oblong cells, esinuose, in central and lower parts predominantly shortly oblong, weakly to distinctly sinuose, 8–10 µm wide and up to 11–20 µm long; *basal cells* in a small juxtacostal group, (8–)10–12 µm wide and up to 22–33(–50) µm long; *basal marginal cells* quadrate or short rectangular, often subhyaline, with thickened transverse walls in 3–6(–7) rows. *Perichaetial leaves* ovate-elliptical, 2.1–3.0 × 0.7–1.0 mm, with margins broadly recurved in upper 1/3–2/3 of leaf and hair-points 0–0.7 mm. *Calyptra* small and narrow, fugacious, smooth, brownish, not extending to the margin of the urn rim, cucullate when young and becoming nearly mitriform with age (few studied).

Monoicous. *Sporophytes* almost always present, abundant, immersed. *Seta* pale yellowish, 0.1–0.3 mm. *Urn* greyish-brown to yellow-brown, ± shiny, obloid-cylindrical, becoming finely striate with age, 0.8–1.0 × 0.4–0.65 mm, with length/width ratio 1.6–1.9. *Exothecial cells* in upper part irregular, varying from quadrate to transversely elongate and mixed with oblong cells, in lower part predominantly oblong with slightly thickened walls, up to 20–30 µm wide and 55–65 µm long. *Stomata* large, surrounded by small differentiated thick-walled cells, 4–6 per urn. *Peristome teeth* 240–380 µm, orange-brown or dark reddish, straight, erect to erecto-patent but becoming squarrose with age, tapering to a fine, acute or obtuse point, varying from entire to much perforated with narrow slits along the median line, sometimes with split off prongs at upper margins, smooth in basal part, finely or rather coarsely and densely papillose above with narrow, short or rather long papillae in horizontal to oblique rows in central part. *Columella* long and narrow permanently attached to the conic-convex operculum with erect or oblique, straight rostrum, 0.15–0.3(–0.4) mm. *Spores* 8–10 µm in diameter, almost smooth.

Ecology and distribution:—*Schistidium marginale* grows on inclined, mostly south-facing rock ledges. It has been collected on acidophilous rocks such as granite and gneiss, but most frequently it grows on various types of hard schist. The species is known from the Alps of Austria and Switzerland, the Jura Mountains and Pyrenees, as well as from Macedonia, Turkey and the Caucasus (see list of cited specimens) (Fig. 3). Its distribution in Carinthia, Austria, was mapped by Köckinger *et al.* (2008: 231). The elevation range of *S. marginale* extends from 1100 to 2350 m.

Etymology:—The specific epithet refers to the distinctly bordered leaf margins with very strongly thickened limbidia.

Relationship and differentiation:—Based on molecular studies of the rDNA ITS region, *Schistidium marginale* appears as a sister group to a clade comprising *S. confertum* and *S. echinatum* (Ignatova *et al.* 2010: Figs 1–2). These two species are also thought to be the closest relatives of *S. marginale* based on morphological characters, and they are the most likely to be confused with it. These three species constitute a group of closely related species which may prove difficult to key out due to an overlap in quantitative characters. They are small mosses that share several important characters, including (a) short peristome teeth which are often much perforated, (b) a dorsally prominent, ridge-like costa, (c) small leaf cells which are esinuose or slightly sinuose in the upper and central parts of leaf, (d) a partly bistratose upper leaf lamina, (e) markedly thickened leaf margins, (f) basal leaf marginal cells with thickened transverse walls, (g) a flattened, distinctly dentate to spinulose hair-point, (h) leaf KOH + yellow reaction. All these

traits are diagnostic for *Schistidium* sect. *Conferta* (Vilhelm 1922: 53) Ochyra (in Ochyra *et al.* 2003b: 132) which was defined as the *Confertum* group within *Schistidium* (Blom 1996). Species of this section are widely distributed in mountainous areas in the Northern and Southern Hemispheres growing commonly on acidophilous rocks.



FIGURE 3. Distribution map for *Schistidium marginale*.

Plants of *Schistidium marginale* are slightly larger than those of the other two species. They possess longer leaves, 1.5–2.1 mm versus 1.0–1.8 mm in *S. confertum* and 0.8–1.8 in *S. echinatum*. In addition, this species has the coarsest and thickest costa in this complex which is 3–4-stratose in central and usually 4-stratose in lower part of leaf, whilst it is 2–3-stratose and 3-stratose, respectively, in the other species. The angled costa which in some specimens forms a shallow but distinct furrow along the dorsal side in upper part of the leaf, is a unique feature, not seen in any known *Schistidium* species. Likewise, the leaf margins of *S. marginale* are also the most heavily thickened in the group.

In *Schistidium marginale* the leaf hair-point is thicker and stiffer than in the other species. Its structure is more similar to that of *S. echinatum* than *S. confertum* (see Ignatova *et al.* 2010: Fig. 15) but the lateral and dorsal spinulae are distinctly shorter and less protruding in *S. marginale* and the hair-point of this species may appear quite smooth when inspected with the naked eye. The leaf margin of the vegetative leaves provides a further character distinguishing it from *S. echinatum*. In that species the margins are recurved towards the leaf apex on both sides of the leaf (Ignatova *et al.* 2010: Fig. 14), whereas they are plane or narrowly and mostly shortly recurved on one side only in *S. marginale* (Figs 1.17–23). The obloid-cylindrical urn of *S. marginale* is similar to that in *S. echinatum* and they share similar

length/width ratios—1.5–1.8 in *S. echinatum* and 1.6–1.9 in *S. marginale*. However, the urn shape in these species differs markedly from the ovoid, obovoid to shortly obloid urn in *S. confertum*, which becomes cyathiform to campanulate with age and has length/width ratio 0.9–1.4(–1.7).

Additional specimens studied (paratypes):—AUSTRIA. **Kärnten.** Hohe Tauern, Säuleck mountain east of Mallnitz, Seealm, *Köckinger 95-385* (GZU). Kreuzeck massif, north of Oberdrauberg, Zwickenberger Ochsenalm, *Köckinger 12343* (KL, TRH); Nockberge, Falkert mountain, *Köckinger 99-1233* (KL); Karnische Alpen, Rattendorfer Alm west of Nassfeld Pass, *Köckinger 12240* (KL, KRAM); Karnische Alpen, Weidenkopf mountain north-west of Hochweißsteinhaus, 2200 m, *Köckinger 12239* (KL, KRAM); Karnische Alpen, Runseck mountain, *Köckinger 12342* (KL); Lange Alm south-west of Murau, cirque above Hirschtaler Alm, *Köckinger 12344* (KL); Gurktaler Alpen, Zgarten-Alm east of Turracher Höhe, *Köckinger 96-523* (GZU); Gurktaler Alpen, Nockberge, north-east side of Klomnock above Windeben, 1920 m, *Köckinger 94-844* (GZU, TRH). **Steiermark.** Seetaler Alpen, Lindertal north-east of Zirbitzkogel, *Köckinger 95-321* (GZU, TRH); Seetaler Alpen, above Wildsee, *Köckinger 94-1607* (GZU); Seetaler Alpen, Zirbitzen near Obdach, August 1887, *Glowacki s.n.* (GJO); Triebener Tauern, Gr. Schober mountain, near Schoberpass, *Köckinger 97-350* (GZU, with *S. confertum*); Gurktaler Alpen, Frauenalpe mountain south of Murau, *Köckinger 96-433, 96-436, 96-438 & 96-439* (BCB, GZU, NY, Z). **Vorarlberg.** Silvretta Mountains, south-east of Gargellen, 1950–2000 m, *Köckinger 14889* (KRAM, TRH). **Tirol.** Hohe Tauern, Windischmatrei, Messe(r)ling mountain, 21 August 1873, *Gander s.n.* (S); Ochsental-Obertal, above Kühtai towards Finstertaler Seen, 19 August 1967, *Düll s.n.* (priv. herb., with *Bucklandiella macounii* subsp. *alpina*).

GEORGIA. **Svaneti.** Mamisson in the spring area of the Tskhenis-Tsquali river, 15 July 1877, *Brotherus s.n.* (H-Brotherus); Racha, Baraleti mountain near Uzeri, 3 July 1877, *Brotherus s.n.* (H-Brotherus).

ITALY. **Trentino-Alto Adige.** Adamello Mountains, Val de Genova, towards Mandronenhütte, 12 September 1903, *Baumgartner s.n.* (W); below Laresgletcher towards Val de Genova, 20 September 1903, *Baumgartner s.n.* (W). **Friuli-Venezia Giulia.** Alpi Carnici, Rudenspitze mountain north of Forni Avoltri, *Köckinger 12341* (GZU).

MACEDONIA. **Bitola.** Kaymakchalan (Voras) mountain above Kali Pediada, 1745 m, *Erzberger 14053* (B-Erzberger, KRAM, TRH); Pelister Mountains, from hotel Molika through Kopanki tourist house to the spring of Magarevska stream (Česma), 1625–1745 m, *Erzberger 124161, 14172 & 14178* (B-Erzberger, KRAM, TRH).

SPAIN. **Huesca.** Panticosa, Ordicuso, 24 August 1995, *Heras & Infante s.n.* (VIT, TRH).

SWITZERLAND. **Vaud.** Chasseron, *Lesquereux s.n.* (NEU); Yvorne (? , illegible) 17 August 1840 *Lesquereux s.n.* (NEU). **Bern.** Sustenpass, 11 September 1905, *Culmann s.n.* (Z); Bachalp above Grindelwald, 8 August 1905, *Culmann s.n.* (Z); Andermatt, 19 July 1956, *Casas s.n.* (BCB). **Uri.** Sidelhorn, Grimsel, August 1891, *Culmann s.n.* (Z); Göschener Tal, *Blom 6082, 6085, 6110* (TRH). **Valais.** Champex, 8 April 1961, *Albrecht s.n.* (Z); Ravoire, 8 April 1960, 9 April 1969, *Albrecht s.n.* (Z). **Graubünden.** Arosa, 3 August 1960, *Albrecht s.n.* (Z).

TURKEY. **Artvin.** Otingol, *Stainton & Henderson 5995C* (E).

Acknowledgments

Thanks are due to the Curator and Keepers of the herbaria at BCB, E, GJO, GZU, H, NEUCH, S, VIT, W and Z for kindly allowing us to study their herbarium holdings of *Schistidium*. We are very grateful to Heribert Köckinger, Weißkirchen, Austria, and Peter Erzberger, Berlin, for making available for study their specimens from Austria and Italy and Macedonia, respectively. Katarzyna Biłyk and Marian Wysocki, Kraków, generated the distribution map, Arthur Copping, Roydon, Diss, UK, kindly revised the English text and Heribert Köckinger provided a valuable comment on the manuscript and we gratefully acknowledge their assistance. Halina Bednarek-Ochyra and Ryszard Ochyra have gained financial support for this work from the Polish National Centre of Science through grants N N 303 796 940 and N N 303 469 338, respectively, and, partly, through the statutory fund of the W. Szafer Institute of Botany of the Polish Academy of Sciences.

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