

1 ***Schistidium convergens* (Grimmiaceae), a new species from southern Spain and**
2 **Morocco**

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10 With 4 figures and 2 tables

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12

13 **Abstract:** *Schistidium convergens* is described as a new species from southern Spain
14 and northern Morocco, based on morphological and molecular data. The species is fully
15 described and illustrated, its affinities are discussed in detail, and its current distribution
16 mapped. The species is distinguished morphologically by its usually smooth leaf
17 margins, sometimes with short papillae towards the leaf apex, recurved from the leaf
18 base to the apex on both sides, rectangular basal leaf cells, quadrate to short-rectangular,
19 subhyaline basal marginal cells with slightly thickened transverse walls, and irregular,
20 isodiametric, quadrate to short rectangular, sometime oblate distal and medial exothecial
21 cells. A table with characters to distinguish this species from *S. apocarpum*, the
22 morphologically most similar species, and a phylogenetic analysis in order to detect
23 relationships of the new species with nearby taxa based on the rDNA ITS region are
24 provided.

25 **Keywords:** Bryophyte, taxonomy, phylogeny, Europe, Africa, ITS.

26

Introduction

Schistidium Bruch & Schimper is not only one of the most taxonomically difficult moss genera, but also one of the least known and understood. The species concept within this genus has changed significantly in the last few decades, especially after the treatment of the *S. apocarpum* (Hedw.) Bruch & Schimp. complex in Norway and Sweden (Blom 1996). Other relevant studies include Goryunov et al. (2007), supporting the narrow species concept in *Schistidium* using DNA data, and the subsequent study of Milyutina et al. (2007). The narrow morphological species concept better fits patterns of nuclear ribosomal DNA spacer sequence variation within the group (Ignatova et al., 2009; Milyutina et al., 2010). DNA barcoding has also been used recently in studies of species complexes (Hofbauer et al. 2016) to determine their delimitation and identification, suggesting the presence of cryptic taxa in the genus. According to Frey & Stech (2009), the genus *Schistidium* includes around 110 species, but its real number remains unknown, mainly due to the lack of revisions in several regions of the globe. Following the research of Blom (1996), numerous species of *Schistidium* have been discovered and described from various parts of the world, for example: Allen (2005), Blom (1996), Blom & Darigo (2009), Blom & Lüth (2002), Blom et al. (2011), Blom et al. (2016), Feng et al. (2013), Ignatova et al. (2009, 2016) McIntosh et al. (2015, 2017), Mogensen & Blom (1989), Ochyra & Afonina (1994, 2010), Ochyra & Bednarek-Ochyra (2011). This allows us to suggest that the genus is not well known even in Europe and that many species probably remain undescribed.

Recently, a synthesis of *Schistidium* in Spain and Portugal has been published (Suárez & Muñoz 2015), comprising a total of 19 species from the Iberian Peninsula and Balearic Islands. However, some mountainous areas in the south of the Iberian Peninsula remain relatively poorly inventoried, as regards the distribution of several species. For more than 30 years, our research group has made numerous collections of *Schistidium* from southern Spain and northern Africa, increasing our knowledge of the diversity of this genus in these territories. Consequently, we noted that some specimens collected on acidic substrates (mica schists and gneiss) from Sierra Nevada and Sierra de los Filabres (Spain), and the Rif and Middle Atlas (Morocco), did not fit any of the described species from Europe, although their morphological similarity with some European species is evident.

61 The objective of this work is to provide a formal description of a new species, collected
62 over the past two decades, but remaining undescribed. The study is based on a
63 morphological analysis comparing it to the most similar Iberian species complemented
64 with a phylogenetic and systematic study based on the rDNA ITS region in order to
65 disentangle the relationships of the new species with nearby taxa of the Iberian and
66 European flora. The ITS region has been widely used to resolve phylogenetic
67 relationships in different bryophyte groups including *Amblystegium* Schimp.
68 (Vanderpoorten et al. 2001), *Campylopus* Brid. (Stech 2004), *Didymodon* Hedw.
69 (Werner et al. 2005), *Tortula* Hedw. (Cano et al. 2005), *Schistidium* (Goryunov et al.
70 2007), *Henediella* Paris (Cano et al. 2009), and *Hypnum* Hedw. s.l. (Câmara et al.
71 2018).

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Materials and Methods

74

75 MORPHOLOGICAL STUDY: This work is based on a revision of about 350 specimens from
76 the Iberian Peninsula and North Africa, which are deposited in MUB. The material was
77 studied and described using standard anatomical and morphological methods applied
78 within the Grimmiaceae (e.g., Blom 1996; Bednarek-Ochyra 2006). Microscopic
79 examinations and measurements were taken with an Olympus-BH2 light microscope,
80 selecting mature leaves from the portion of the stem just below the perichaetial leaves,
81 while microphotographs were obtained with a Spot insight QE camera mounted on this
82 microscope.

83

84 MOLECULAR TAXON SAMPLING: For the present study, we generated nine ITS sequences
85 (ITS1-5.8S-ITS2 nuclear ribosomal spacer); two samples of the new species plus seven
86 samples belonging to *Schistidium*: *S. apocarpum*, *S. brunnescens* Limpr., *S. confertum*
87 (Funk) Bruch & Schimp., *S. crassipilum* H. H. Blom and *S. helveticum* (Schkuhr)
88 Deguchi. These sequences were complemented with 50 Genbank sequences belonging
89 to 28 *Schistidium* species. Sampling selection was based on the phylogenetic
90 reconstruction of Ignatova et al. (2009) and Myliutina et al. (2010). Based on the
91 phylogeny recovered by Milyutina et al. (2010), *S. sordidum* I. Hagen (rather than
92 representatives of other genera) was used to root the tree in order to avoid exclusion of
93 many positions in the ITS alignment. The samples studied are listed in Table 1,
94 including GenBank accession numbers.

95

96 DNA EXTRACTION, PCR AMPLIFICATION, AND SEQUENCING: Total DNA from the distal
97 portion of a few gametophores from herbarium specimens or recent collections was
98 extracted using the CTAB method described by Doyle & Doyle (1987) and stored at -
99 20°C until the polymerase chain reaction (PCR) was carried out. The internal
100 transcribed spacer region (ITS1-5.8S-ITS2) of nuclear ribosomal DNA was amplified
101 with the primer pair pr1 and prB (Milyutina et al. 2010). The PCR reactions were
102 carried out in an Eppendorf Mastercycler thermocycler using the following program:
103 initial cycle of 94°C for 5 min, 35 cycles of 94°C for 30 s, 58°C for 45 s, 72°C for 1
104 min, and a final extension step of 72°C for 8 min to complete the PCR. The reactions
105 were conducted in a final volume of 50 µL using approximately 40 ng of DNA, 0.4 µM
106 of forward and reverse primers, 5 µL of polymerase buffer (provided by the supplier of
107 the enzyme), 0.2 mM of each of dNTPs, 2 mM of MgCl₂ and 2 U of Taq polymerase
108 (Biotools). Finally, 2 µL of each amplification product were visualized on 1.5% agarose
109 gels, and successful amplifications were cleaned using the GenElute PCR Clean-Up kit
110 (SIGMA). The amplicons were sequenced using the above forward and reverse primers
111 using the Big Dye sequencing kit and the products were separated on an automatic ABI
112 3700 sequencer following standard protocols.

113

114 Forward and reverse sequences were checked for inaccurate base calling with Chromas
115 Lite, v. 2.01 (Technelysium Pty. Ltd). Consensus sequences were aligned using default
116 parameters of MUSCLE in Geneious v.7.1.3 (Kearse et al. 2012). Minor manual
117 adjustments were done in order to avoid punctual alignment errors. Bayesian analyses
118 were performed by MrBayes, v. 3.2 (Ronquist et al. 2012). JModeltest (Darriba et al.
119 2012) retrieved GTR + I + G (general time reversible model of DNA substitution) as the
120 optimal model of evolution. Two simultaneous runs were initiated by starting from
121 random trees. To ensure that the two runs converged onto a stationary distribution,
122 analyses were run until the average standard deviation of the split frequencies was
123 below 0.01. Convergence was evaluated using the potential scale reduction factor
124 (PSRF), and 1000000 generations were run, sampling every 100th generation, at the
125 following settings: Nst = 6, rates = invgamma. Burnin (the number of starting
126 generations ruled out from further analyses) was set at 200 000 generations after
127 visually inspecting the likelihood values in Excel. A 50% majority rule consensus tree
128 was constructed using the 'sumt' command of MrBayes. A Maximum likelihood (ML)

129 phylogenetic tree was estimated with 1000 bootstrap replicates by the rapid Bootstrap
130 analysis in RAxMLGUI v.1.5b (Silvestro & Michalak 2012). Trees were edited with
131 Figtree, v.1.4.0 (Rambaut 2012). The best-scoring Maximum likelihood tree was chosen
132 as the final tree with bootstrap values (Bs) and posterior probabilities (PP) from
133 Bayesian inference added to nodes in Figure 1.

134

135

Results and Discussion

136

137 The final alignment of 59 sequences yielded 1251 nucleotide sites, of which 597
138 were constant, 244 variable but parsimony uninformative, and 410 parsimony
139 informative. Both the Maximum likelihood and the Bayesian inference searches resulted
140 in trees with a similar topology. Therefore, the ML bootstrap values (Bs) and Bayesian
141 posterior probability (PP) are provided for the single phylogenetic tree retained under
142 the ML analysis (Figure 1).

143

144 Using *Schistidium sordidum* as the outgroup species, *S. grandirete* H. H. Blom was
145 resolved as sister to *Schistidium pulchrum* H. H. Blom, which was located as the sister
146 species of *S. frisvollianum* H. H. Blom. And this taxon is sister to the remaining species,
147 which compose a clade with strong support (80% Bs, 100 PP) and are distributed in two
148 subclades. The first (SCI), showed no ML bootstrap but high posterior probability (PP
149 =100%), and it included *S. apocarpum* (Hedwig) Bruch & Schimper, *S. boreale* Poelt,
150 *S. lancifolium* (Kindb.) Blom, *S. papillosum* Culm, *S. pruinatum* (Wilson ex Schimp.)
151 G. Roth, , *S. strictum* (Turner) Loeske ex Mårtensson, *S. subjulaceum* H. H. Blom and
152 *S. trichodon* (Brid.) Poelt, and. The second subclade, with low support, was divided in
153 two branches (SCII + SCIII). *Schistidium convergens* (the species described here) was
154 located as basal species in one of these two branches (SCII) with no ML bootstrap
155 support but a high posterior probability (PP = 95%). Within that branch, the following
156 species are found: *S. confertum* (Funck) Bruch & Schimper, *S. dupretii* (Thé.) W. A.
157 Weber, *S. flaccidum* (De Not.) Ochyra, *S. flexipile* (Lindb. ex Broth.) G. Roth, *S.*
158 *frigidum* H. H. Blom, *S. marginale* H. H. Blom, Bedn.-Ochyra & Ochyra, *S. robustum*
159 (Nees & Hornsch.) H. H. Blom, *S. scandicum* H. H. Blom, *S. tenerum* (J. E. Zetterst.)
160 Nyholm, *S. umbrosum* (J. E. Zetterst.) H. H. Blom, and *S. submuticum* Zick. ex H. H.
161 Blom, . The other branch (SCIII) had strong support (Bs = 95%, PP = 100%) and

162 included *S. atrofusum* (Schimp.) Limpr., *S. brunnescens* Limpr., *S. crassipilum* H. H.
163 Blom, *S. elegantulum* H. H. Blom, and *S. helveticum*.

164

165 As expected, the topology recovered here is similar to that found by Ignatova et al.
166 (2009) and Milyutina et al. (2010). *Schistidium convergens* is placed into the group
167 named by Ignatova et al. (2009) as the Confertum+Frigidum-clade (SCII in Figure 1).
168 Most species in this group are characterized by short, smooth leaves, with long basal
169 cells, basal marginal cells more or less hyaline, forming a rectangular alar group and
170 with thickened cross-walls, and small olivaceous shoots (cf. Blom 1996). However, *S.*
171 *convergens* also possesses characteristics of the Atofusum-clade species (sensu
172 Ignatova et al. 2009) (SCIII in Figure 1), including the irregularly bistratose lamina in
173 the upper and median portions of the leaf and the more or less isodiametric, and smooth
174 to slightly sinuose-walls leaf of the upper and central parts of the leaf, but differs in its
175 quadrate exothecial cells, as they are usually oblong-rectangular in this group. Finally,
176 the new species also has characters in common with the Apocarpum-clade (Ignatova et
177 al. 2009; Blom 1996) (SCI in Figure 1), mainly the exothecial cells that are
178 predominantly isodiametric or transversely elongated. Both morphological and
179 molecular information support the recognition of a new species.

180

181 **Taxonomic treatment**

182

183 ***Schistidium convergens*** J. Guerra & M. J. Cano, **sp. nov.** Figs. 2, 3

184

185 TYPE: Spain. Granada, Laroles, Sierra Nevada, camino desde Laroles al castaño
186 centenario, 965 m, 31°1'N, 3°1'W, micaesquistos en lugares sombríos bajo *Quercus*
187 *rotundifolia*, 13/8/2017, *Guerra s.n.* (Holotype: MUB 55721, Isotype: MO).

188

189 DIAGNOSIS: The following combination of characters differentiates this species from
190 similar species: lamina in central and upper leaf portions varying from unistratose to
191 having bistratose spots and strips to irregularly tristratose; leaf margins sometimes with
192 short papillae towards leaf apex, recurved from leaf base to apex; basal laminal cells
193 rectangular, 18-45(50) x 5-7 µm; basal marginal cells quadrate to short rectangular,
194 subhyaline, with slightly thickened transverse walls; distal and medial exothecial cells
195 highly irregular, isodiametric, quadrate to short rectangular, and sometimes oblate.

196

197 ETYMOLOGY: The specific epithet refers to the morphological convergence with several
198 other species, notably, *Schistidium crassipilum* and *S. apocarpum*.

199

200 DESCRIPTION: Plants small, olivaceous to brownish above, forming small tufts or mats.

201 *Stem* 1–3 cm, slender, irregularly branched, in transverse section with 2–3-stratose

202 epidermis of small, thick-walled cells, thin-walled medullary cells with large lumina;

203 central strand distinct consisting of about 14–17(20) cells. *Axillary hairs* filiform,

204 hyaline, uniseriate, 4–6 cells long, with 1–4 short quadrate basal cells and 3–4 elongate

205 distal cells. *Leaves* dense, shiny, erect, imbricate, straight, occasionally curved, ovate to

206 triangular-ovate, acute, keeled, $1.5\text{--}2.2 \times 0.3\text{--}0.4$ mm. *Hair-point* 0–250(300) μm ,

207 straight, not decurrent, slightly spinulose, with short, erect to erect-patent spinulae.

208 *Costa* smooth, in upper and central parts 45–60(70) μm wide, percurrent to shortly

209 excurrent, sometimes forming a shallow furrow along dorsal side towards upper part, 2–

210 4(-5) stratose, subrectangular to circular in outline. *Margins* smooth, sometimes with

211 short papillae towards apex, sinuose, recurved throughout, reaching apex on both sides,

212 rarely plane in one side, in lower part mostly 1–2 stratose for one row, in upper and

213 central part (1)2–4 rows to 2–3-stratose. *Lamina* smooth, unistratose below, in central

214 and upper part varying from unistratose to bistratose in spots and strips, to irregularly

215 bi-tristratose. *Laminal cells* rounded, ovate or elliptical above, smooth-walled or

216 sometimes sinuose, in central part oblong and distinctly sinuose, $(3.5)4\text{--}8 \times 4\text{--}5(8)$ μm ;

217 *basal cells* rectangular, $18\text{--}45(50) \times 5\text{--}7$ μm ; *basal marginal cells* quadrate to short

218 rectangular, subhyaline, with slightly thickened transverse walls, $(4)5\text{--}12 \times 5\text{--}6(7)$ μm .

219 *Perichaetial leaves* ovate-elliptical, from middle part markedly narrowed, $2.2\text{--}2.3 \times$

220 $0.5\text{--}0.6$ mm, margins recurved in upper 2/3 of leaf, hair point 200–350 μm long.

221 *Monoicous*. *Sporophytes* almost always present but scarce, immersed. *Seta* yellowish,

222 $0.1\text{--}0.25$ mm. *Urn* brown to red-brown, not shiny, obloid-cylindrical, slightly urceolate

223 with age, $1\text{--}1.2(1.3)$ mm long. *Exothecial cells* in upper and central part irregular,

224 isodiametric, quadrate to short rectangular, sometimes oblate, $25\text{--}38(40) \times (20)25\text{--}40$

225 μm , in lower part, surrounding stomata, isodiametric, predominantly quadrate, $(10)12\text{--}$

226 $17 \times 12\text{--}17(18)$ μm . *Stomata* large, $37.5\text{--}42.5$ μm in diameter, 2–4(5) per urn.

227 *Peristome teeth* $245\text{--}345$ μm , brown to orange-brown, straight, erect to erect-patent,

228 tapering to an acute, rarely obtuse point, from entire to perforate with 1–2 narrow slits

229 along median line in upper part, finely to coarsely and densely papillose from base to

230 apex. *Columella* permanently attached to operculum. *Operculum* (0.5)0.6–0.7 mm long,
231 with straight or oblique rostrum. *Calyptra* small, fugacious, smooth, cucullate to
232 mitriform, ca. 0.3 mm long. *Spores* 7–10 µm in diameter, almost smooth.

233

234 HABITAT AND DISTRIBUTION: *Schistidium convergens* grows on vertical or inclined
235 rocks (gneiss and mica schists), usually in exposed and sunny places, and accompanied
236 usually by *Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr, *Schistidium flaccidum*,
237 *Grimmia decipiens* (Schultz) Lindb., *G. dissimulata* E. Maier, *G. orbicularis* Bruch ex
238 Wilson, *Orthotrichum cupulatum* Brid., and *O. rupestre* Schwägr. In the Iberian
239 Peninsula the rocks where this species grows are found in forests of *Quercus*
240 *rotundifolia* Lam., and *Q. pyrenaica* Willd. with *Adenocarpus decorticans* Boiss. In
241 Africa, it is usually found in *Cedrus atlantica* (Endl.) Carrière forests or in areas
242 adjacent to these. The elevational distribution ranges from 965 to 2520 m. The species
243 is known from Sierra Nevada (Granada, Spain), Sierra de los Filabres (Almería,
244 España), and Rif mountain range and Middle Atlas in Morocco (Figure 4).

245

246 RELATIONSHIP AND DIFFERENTIATION: Morphologically the new species is similar to
247 *Schistidium apocarpum* with which it shares some features. Nevertheless, they have
248 distinctly different ecologies. *Schistidium apocarpum* usually grows on siliceous rocks
249 or limestone near watercourses, while *S. convergens* occurs on exposed and sunny
250 siliceous rocks. The main morphological differences between these two species are
251 summarized in Table 2.

252

253 Because its leaf margins are recurved almost to the leaf apex on both sides, *S.*
254 *convergens* may be confused with *S. pulchrum*. However, the latter is a larger plant with
255 a unistratose leaf lamina, only exceptionally bistratose, entire upper leaf margins and
256 leaf apices with hyaline, white, and shining hair-points. In addition, *S. pulchrum* is
257 known only from Scandinavia, Finland, Switzerland, Austria, Ukraine, Russia, USA
258 and Canada (Blom 1996). In contrast, *S. convergens* has a leaf lamina with bistratose
259 spots and strips or is irregularly bi-tristratose from near the leaf apex to near the leaf
260 base, papillose upper leaf margins, and the hair-point is not particularly white or
261 shining. This combination of characters excludes *S. pulchrum* (Blom, pers. comm.
262 2018). *Schistidium pulchrum* has been cited from the south of Spain (Almería) based on
263 a small, damaged sample, and with a single capsule mounted in a microscopic slide

264 (Suárez & Muñoz 2015). An examination of this specimen (MUB 8818) showed that it
265 had been misidentified since it clearly belonged to *S. convergens*. Therefore, *S.*
266 *pulchrum* should be excluded from the moss flora of the Iberian Peninsula.
267
268 *Schistidium convergens* shares the overall appearance of *S. crassipilum* but there are
269 numerous characters that distinguish the two species. *Schistidium crassipilum* may have
270 recurved leaf margins although this recurvature usually occurs only on one side of the
271 leaf. Exceptionally, *S. crassipilum* may have 1 or 2 stomata at the base of the capsule,
272 but they are usually small, malformed, or inconspicuous (Blom 1996), but stomata have
273 never been seen on material from south of the Iberian Peninsula. In addition, the
274 exothecial cells in *S. crassipilum* are typically elongate and oblong-rectangular and
275 rarely quadrate, a cellular pattern very different from that in *S. convergens*.
276
277 ADDITIONAL SPECIMENS STUDIED (PARATYPES): Spain: Almería, Sierra de los Filabres,
278 barranco Verruga, 1800 m, 37°13'15''N, 2°35'8''W, base de roca, micaesquistos, sine
279 data, García-Zamora & Ros (MUB 8818). Granada, Güejar Sierra, Sierra Nevada, entre
280 la estación de Maitena y el comienzo de la vereda de la Estrella, 1230 m, 37°8'N,
281 3°24'W, micaesquistos, 2 August 2018, Guerra (MUB 57128). Granada, Güejar Sierra,
282 vereda de la Estrella, 1341 m, 37°8'N, 3°23'W, 2 August 2018, Guerra (MUB 57382).
283 Granada, Güejar-Sierra, Sierra Nevada, Peñones de San Francisco, 2520 m,
284 30SVG6506, fisura de roca silícea, 22 August 2012, Rams (MUB 25041). Granada,
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293 (MUB 12351, 12353).
294

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300

301

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397 LEGENDS OF THE FIGURES AND TABLES

398

399 Fig. 1. Maximum likelihood phylogenetic tree inferred for a sampling of select species
400 of *Schistidium*, from variation in the nuclear locus recovered for the nuclear ITS.

401 Maximum likelihood bootstrap values (Bs) followed by Bayesian posterior probabilities
402 (PP) are shown above the branches.

403

404 Fig. 2. *Schistidium convergens*. A & B. Vegetative leaves. C & D. Perichaetial leaves.

405 E. Leaf margin towards the apex. F. Leaf dorsal surface towards the apex. G & H.

406 Hyaline hairpoints. I. Transverse sections of the lamina. J. Basal cells. K. Transition

407 from upper to central laminal cells. L. Exothecial cells in middle portions of the urn. M

408 & N. Peristome teeth. (All from the holotype). Scale bars: A, B, C, D = 0.5 mm; E, F,

409 G, H = 30 μ m; I = 25 μ m; J = 37 μ m; K = 15 μ m; L = 40 μ m; M, N = 85 μ m.

410

411 Fig. 3. *Schistidium convergens*. A. Habit, dry. B. Perichaetial leaves. C. Vegetative

412 leaves. D. Leaf apices with hair-points. E. Central laminal cells. F. Upper laminal cells.

413 G. Basal cells. H. Basal marginal cells. I. Transverse sections of lamina. J. Transverse

414 sections of stem. K. Urn. L. Operculum with columella. M. Calyptra. N. Exothecial

415 cells and stomata at base of urn. O. Exothecial cells in upper and middle portions of the

416 urn. P. Portion of peristome. (All from the holotype). Scale bars: A = 1.8 mm; B, C =

417 0.6 mm; D = 68 μ m; E, F = 30 μ m; G, H = 70 μ m; I = 64 μ m; J = 80 μ m; K, L, M = 1.3

418 mm; N, O = 60 μ m; P = 125 μ m.

419

420 Fig. 4. Current distribution of *Schistidium convergens*.

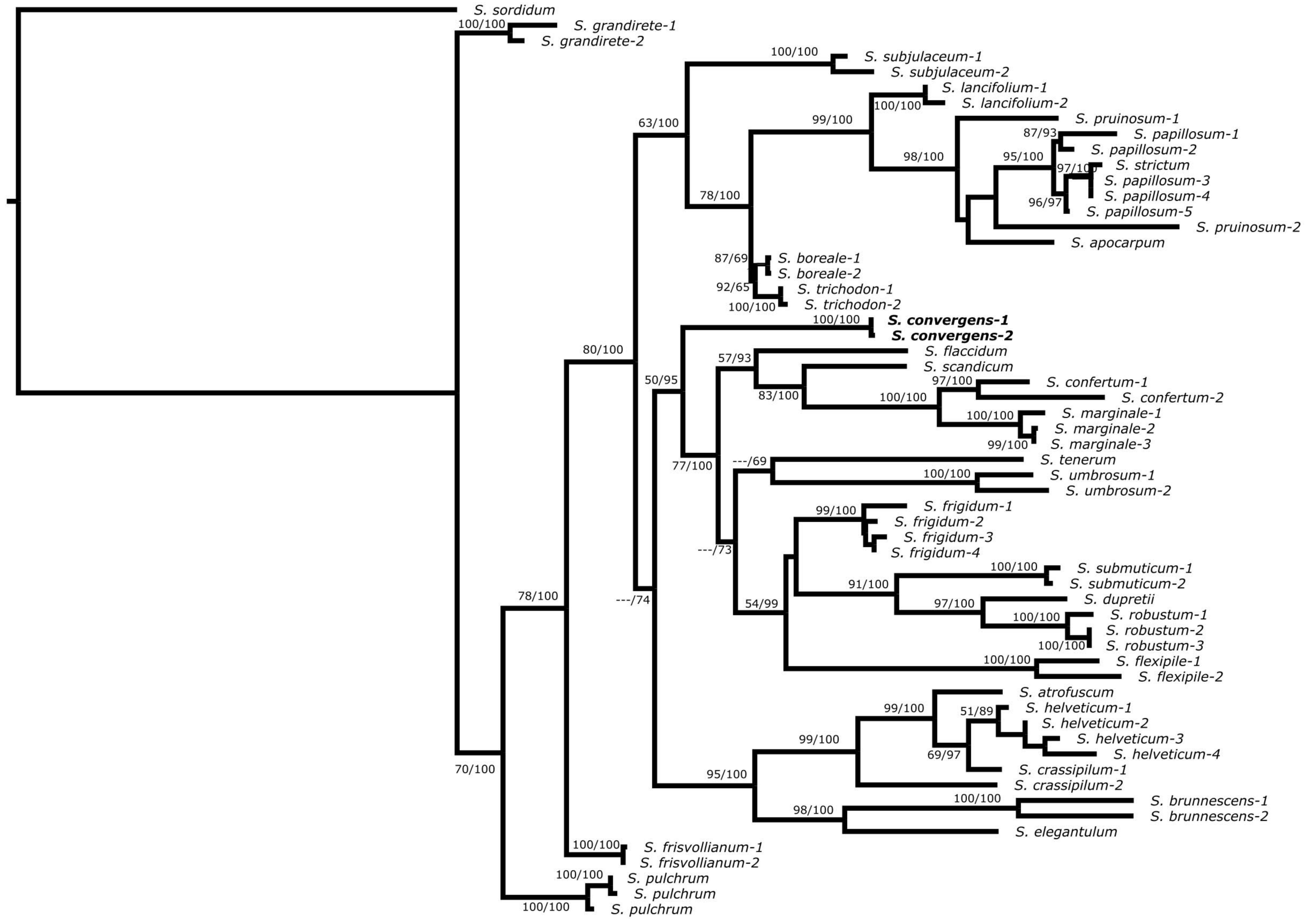
421

422 Table 1. Voucher information and GenBank accession numbers of the specimen used in
423 the molecular study.

424

425 Table 2. Comparison of characters of *Schistidium convergens* and *S. apocarpum*. Data

426 from Bloom (1966) and our own study.

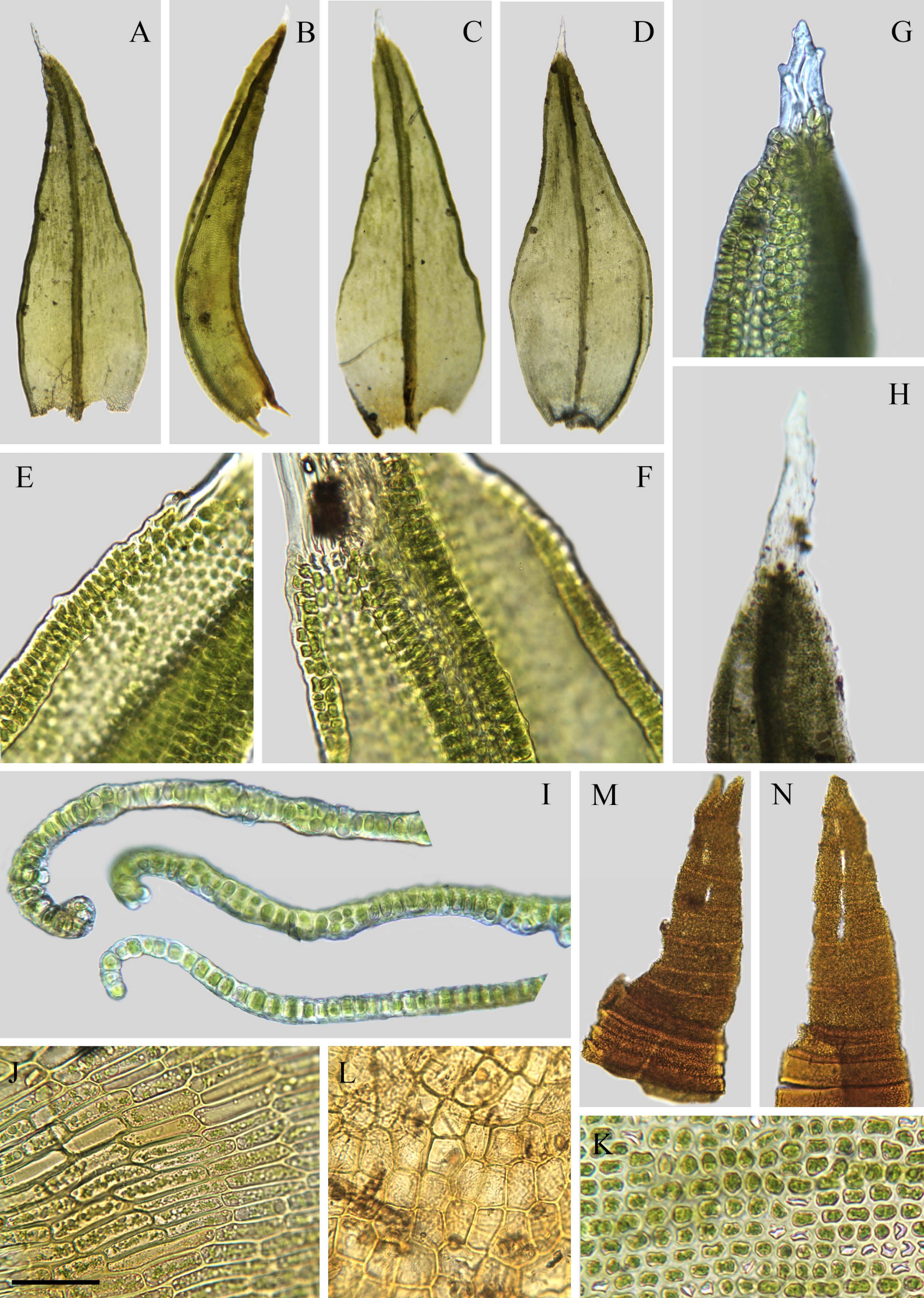


SC I

SC II

SC III

0.05



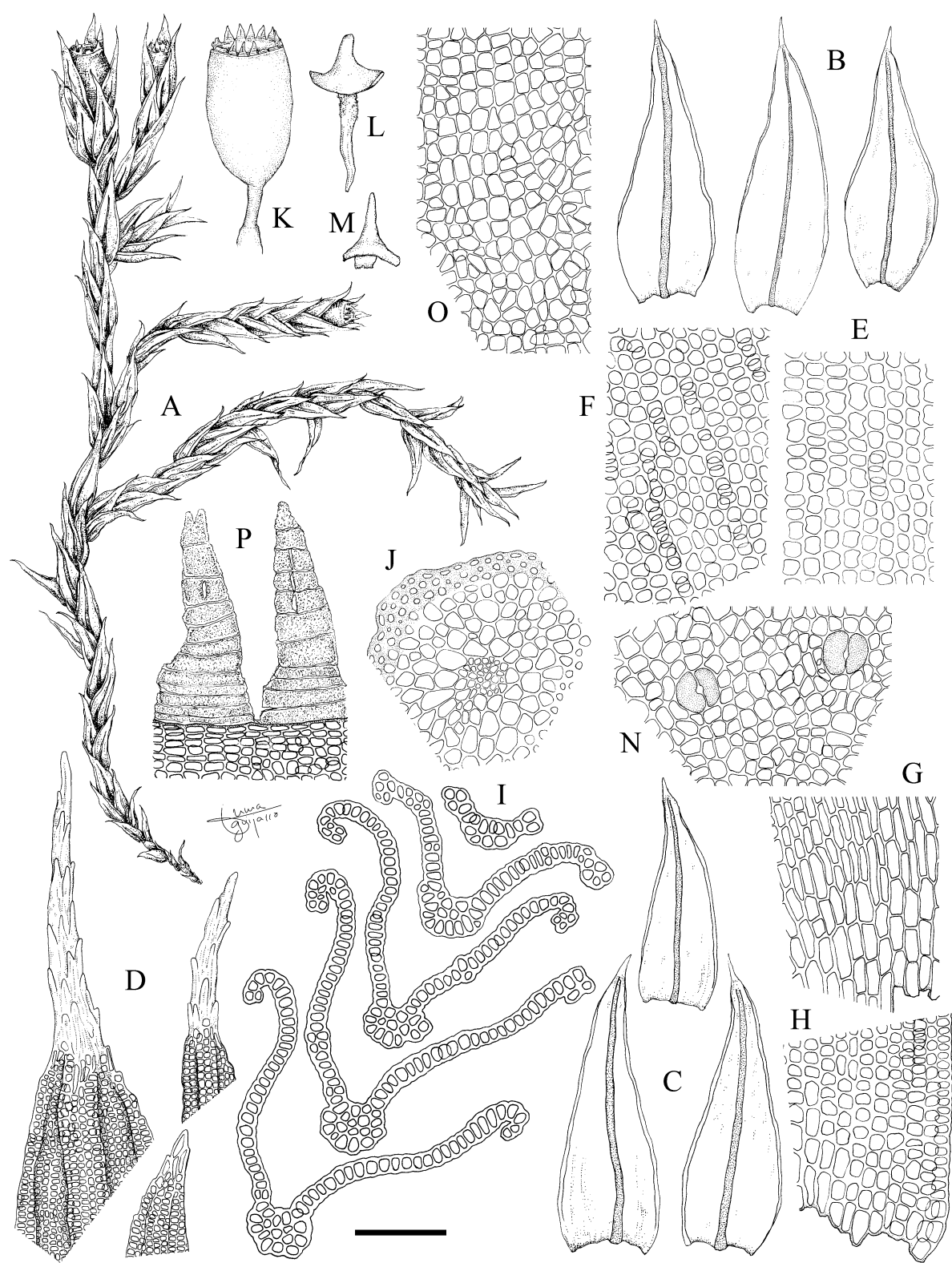




Table 1

Species	Voucher information	GenBank accession number
<i>Schistidium apocarpum</i>	Spain: Gerona, Setcases, <i>Cano</i> (MUB 55587)	MK030010
<i>S. atrofuscum</i>	Russia: Karachaevo-Cherkessiya, <i>Ignatov & Ignatova 05-3313</i> (MW)	HM053887
<i>S. boreale-1</i>	Russia: Anabar Plateau, <i>Fedosov 06-208</i> (MW)	HM053888
<i>S. boreale-2</i>	Russia: Anabar Plateau, <i>Fedosov 06696</i> (MW)	MH053889
<i>S. brunnescens-1</i>	Austria: Steiermark, Eisenerzer Alpen, <i>Köckinger 14980</i> (Herbarium Köckinger)	KT715464
<i>S. brunnescens-2</i>	Spain: Murcia, Moratalla, Sierra de Taibilla, <i>Cano</i> (MUB 36519)	MK030011
<i>S. convergens-1</i>	Spain: Granada, Sierra Nevada, Lanteira, <i>Guerra</i> (MUB 56966)	MK030013
<i>S. convergens-2</i>	Spain: Sierra Nevada, Laroles, <i>Guerra</i> (MUB 55721)	MK030014
<i>S. confertum-1</i>	Sweden: <i>Hedenäs s.n.</i> (S)	HM053892
<i>S. confertum-2</i>	Spain: Granada, Sierra Nevada, Barranco Soria, <i>Cano</i> (MUB 324190)	MK030012
<i>S. crassipilum-1</i>	Germany: Baden-Württemberg, Bodenseegebiet, <i>Schäfer-Verwimp 30679</i> (STU)	KY715462
<i>S. crassipilum-2</i>	Spain: Guadalajara, Checa, <i>Guerra</i> (MUB 20931)	MK030015
<i>S. dupretii</i>	Russia: Perm Province, <i>Bezgodov 630</i> (MW)	HM053895
<i>S. elegantulum</i>	Germany: Niedersachsen, Harz, <i>Preußing MP04414</i> (STU)	KT715473
<i>S. flexipile-1</i>	Russia: Anabar Plateau, <i>Fedosov 06-683</i> (MW)	HM053900
<i>S. flexipile-2</i>	Norway: Spitsbergen, <i>Belkina B128/1-06</i> (KPABK)	HM053903
<i>S. flaccidum</i>	Austria: <i>Köckinger 14897</i> (MW)	HQ890511
<i>S. frigidum-1</i>	Russia: Taymir, <i>Fedodov Sch25</i> (MW)	HM053907
<i>S. frigidum-2</i>	Russia: Anabar Plateau, <i>Fedosov 07-1-8</i> (MW)	HM053905
<i>S. frigidum-3</i>	Russia: Anabar Plateau, <i>Fedosov 07-2-28</i> (MW)	HM053904
<i>S. frigidum-4</i>	Russia: Anabar Plateau, <i>Fedosov 06-771</i> (MW)	HM053906
<i>S. frisvolianum-1</i>	Russia: Taymir, <i>Fedosov Sch 14</i> (MW)	HM053909
<i>S. frisvolianum-2</i>	Russia: Anabar Plateau, <i>Fedosov Sch06-295</i> (MW)	HM053908
<i>S. grandirete-1</i>	Russia: Putorana Mts., <i>Matveeva s.n.</i> (LE)	HM053910
<i>S. grandirete-2</i>	Russia: Severnaya Zemlya, <i>Matveeva s.n.</i> (LE)	HM053911
<i>S. helveticum-1</i>	Germany: Baden-Württemberg, Neckarbecken, <i>Nebel MNI32170</i> (STU)	KT715463
<i>S. helveticum-2</i>	Spain: Málaga, Yunquera, Sierra de las Nieves, El Saucillo, <i>Cabezudo et al.</i> (MUB 56120)	MK030016
<i>S. helveticum-3</i>	Spain: Granada, Sierra de Baza, <i>Guerra</i> (MUB 56096)	MK030017

<i>S. helveticum-4</i>	Spain: Málaga, Yunquera, Sierra de las Nieves, cañada de los Hornillos, <i>Cabezudo et al.</i> (MUB 56093)	MK030018
<i>S. lancifolium-1</i>	USA: Maine, <i>Allen 16385</i> (MO)	HM053915
<i>S. lancifolium-2</i>	USA: Maine, <i>Allen 27860</i> (MO)	HM053917
<i>S. marginale-1</i>	Russia, Karachaevo-Cherkessiya, <i>Ignatov & Ignatova 05-1092</i> (MW)	HM053921
<i>S. marginale-2</i>	Austria: <i>Köckinger 12240</i> (MW)	HM053920
<i>S. marginale-3</i>	Austria: <i>Köckinger 12239</i> (MW)	HM053919
<i>S. papillosum-1</i>	Russia: Kara Sea, Nordensheld Archipelago, <i>Melnikov s.n.</i> (LE)	HM053925
<i>S. papillosum-2</i>	Russia: Kommander Island, Bering Island, <i>Fedosov 1-3-177</i> (MW)	HQ890520
<i>S. papillosum-3</i>	Germany: Baden-Württemberg, Schwarzwald, <i>Nebel & Sauer NS97133</i> (STU)	KT715461
<i>S. papillosum-4</i>	Germany: Baden-Württemberg, Randen, <i>Nebel et al. IH97059</i> (STU)	KT715459
<i>S. papillosum-5</i>	Germany: Baden-Württemberg, Schwarzwald, <i>Holz & Lüth IH98039</i> (STU)	KT715460
<i>S. pruinosum-1</i>	Russia: Kabardino-Balkaria, <i>Ignatov & Ignatova s.n.</i> (MW)	HM053933
<i>S. pruinosum-2</i>	Russia Adygeya, <i>Akatova s.n.</i> (MW)	HM053932
<i>S. pulchrum-1</i>	Russia: Transbaikalia, <i>Afonina 7312</i> (MW)	KX443492
<i>S. pulchrum-2</i>	Russia: Taymir, <i>Fedosov HK-9</i> (MW)	HQ890521
<i>S. pulchrum-3</i>	Russia: Transbaikalia, <i>Afonina 3812/2</i> (MW)	KX443495
<i>S. robustum-1</i>	Sweden: Gotland, <i>Hedenäs s.n.</i> (S)	HM053938
<i>S. robustum-2</i>	Austria: Kärnten, Südwestlich Villach, <i>Schütt, Koperski</i> (STU)	KT715471
<i>S. robustum-3</i>	Germany: Baden-Württemberg, Schwäbische Alb, Wental, <i>Nebel MN1012</i> (STU)	KT715472
<i>S. scandicum</i>	Russia: Bashkortostan, <i>Zolotov 07-38</i> (MHA)	DQ822027
<i>S. sordidum</i>	Russia: Yakutia, <i>Ivanova s.n.</i> (MW ex SASY)	HM053943
<i>S. strictum</i>	Norway: <i>Blom s.n.</i> (MW)	HM053944
<i>S. subjulaceum-1</i>	Russia: Buryatia, <i>Tubanova 1(V)</i> (MW ex UUH)	HM053947
<i>S. subjulaceum-2</i>	Russia: Altai, <i>Ignatov s.n.</i> (MHA)	HQ890522
<i>S. submuticum-1</i>	Russia: Yakutia, <i>Filin s.n.</i> (MW)	HM053950
<i>S. submuticum-2</i>	Russia: Anabar Plateau, <i>Fedosov 06-443</i> (MW)	HM053949
<i>S. tenerum</i>	Russia: Chukotka, <i>s.r.</i> (LE)	HM053952
<i>S. trichodon-1</i>	Austria: <i>Köckinger 12261</i> (MW)	HM053953
<i>S. trichodon-2</i>	Russia: Kabardino-Balkaria, <i>Kharzinov 1721</i> (MW)	HM053954
<i>S. umbrosum-1</i>	Russia: Murmansk Province, <i>Kucera 11499</i> (MW)	HM053955
<i>S. umbrosum-2</i>	Norway: <i>Hedenäs s.n.</i> (S)	HM053956

Species	Plant size	Leaves	Leaves margin	Leaves apex margin	Dorsal costa surface	Central strand	Lamina	Hair point	Central laminal cells	Basal marginal cells	Exothelial cells	Peristome teeth
<i>S. convergens</i>	1–3 cm	Straight, occasionally curved, 1.5–2.2 × 0.3–0.4 mm	Recurved throughout, reaching the apex, on both sides of leaf, very rarely plane in one side	Smooth or papillose-sinuose	Smooth	Present and very distinct	With many bi-tristratose spots and strips up to half or more	0–250(300) μm	(3.5)4–8 × 4–5(8) μm, distinctly sinuose	Quadrate to short rectangular, subhyaline	Irregular, isodiametric, quadrate to short rectangular, sometime oblate, 25–38(40) × (20)25–40 μm	Entire to perforate with 1–2 narrow slits along the median line in the upper part
<i>S. apocarpum</i>	1,3–10(12) cm	Curved to falcate-secund, (1.7)2–3 (3.2) × 0.6–0.95 mm	Recurved throughout, reaching the apex. Occasionally almost plane on one side of leaf	Denticulate-papillose, rare smooth	Papillose	Absent or indistinct	Unistratose but often with bistratose spots	0–750(800) μm	(5)8–10 × 8–10 μm, strongly sinuose	Transversely elongate, chlorophyllose	Isodiametric or short rectangular, with patches of oblong and rectangular cells near the base. 37–60 × 30–47(50) μm	Semiperforate in lower part, entire to perforate in central and upper part

	Urna size	Stomata	Habitat
<i>S. convergens</i>	1–1.2(1.3) mm long	2–4(5) per urn	Dry siliceous rock
<i>S. apocarpum</i>	0.9–1.5 mm long	(4)8–12(18) per urn	Humid siliceous or calcareous rock

Table 2