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ON *POHLIA SAPROPHILA* (MIELICHHOFERIACEAE, BRYOPHYTA)

О *POHLIA SAPROPHILA* (MIELICHHOFERIACEAE, BRYOPHYTA)

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Abstract

The status and distribution of *Pohlia saprophila* (Müll. Hal.) Broth. remained vague, as this species was not specially studied. Being described from the Central China, Gansu Province, it was treated as doubtful in the last edition of the Moss Flora of China. This species is closely related to *P. elongata*, and its distinction from it in dioicous sexual condition could be considered ambiguus, as dioicous plants occasionally occur in some populations of *P. elongata* as well. However, dioicous sexuality in *Pohlia saprophila* is stable and consistent with very dense growth of plants due to numerous rhizoids, and also is well supported by ITS sequence data. In addition to China, *Pohlia saprophylla* occurs in Mongolia, Kazakhstan, Kyrgyzstan, South Siberia (Altai and Transbaikalia) and extends eastward to Kamchatka. Another species, which was described as dioicous in this groups, *P. viridis* Lindb. & Arnell, is synonymized with *P. elongata*.

Резюме

Таксономический статус и распространение *Pohlia saprophila* (Müll. Hal.) Broth. оставались до последнего времени не вполне понятными, поскольку специального изучения его не предпринималось. Описанный из провинции Ганьсу, Центральный Китай, вид в последнем издании Флоры мхов Китая был отнесет к сомнительным. *Pohlia saprophila* является близкородственным видом к *P. elongata*, и ее отличия, касающиеся, в первую очередь, двудомности могли расцениваться как недостаточные для выделения вида, тем более что двудомные и многодомные растения изредка встречаются и у самой *P. elongata*. Однако двудомность у *Pohlia saprophila* является константным признаком, и особенности ее роста в обширных, густых, сильно войлочных дерновинках указывает на самостоятельность этого вида, что поддерживается и данными анализа ITS последовательностей ДНК. Помимо Китая, вид встречается также в Монголии, Киргизии, Казахстане, а в России выявлен в Южной Сибири (Алтай и Забайкалье) и на Камчатке. Другой вид из группы *P. elongata*, *P. viridis* Lindb. & Arnell, описанный как двудомный, отнесен в синонимы к *P. elongata*.

KEYWORDS: mosses, *Pohlia saprophila*, new records, Russia

INTRODUCTION

Pohlia saprophila (Müll. Hal.) Broth. was originally described (as *Bryum*) from Gansu (Kansu, Gangsu) Province of China from collections of Potatin (Müller, 1896). Subsequently it was transferred to *Pohlia* by Brotherus (1903). *Pohlia saprophila* was included in the Checklist of mosses of China (Redfearn *et al*., 1996), however, in the Moss flora of China it was referred to doubtful species (Zhang *et al*., 2007).

The original description of *P. saprophila* was very short (Müller, 1896). Savicz-Lyubitskaya & Smirnova (1970) published their own illustrations of this species and its full-length description, in Russian. According to their description, the species is characterized by dioicous sexual condition, lanceolate leaves with recurved margins, long laminal cells, narrow, inclined capsules with endostome with rather long cilia, and growth on rotten logs in mountain forests of Cental Asia.

The shape of capsules of *P. saprophila* is very similar to that of *P. elongata* Hedw., and most other characters also fit the latter species as well, especially because *P. elongata* is a very polymorphic and, being typically paroicous, is occasionally dioicous (Shaw, 2014). Therefore, the doubts in the clear distinction of plants with *P. saprophila*-phenotype from *P. elongata* are quite natural.

This our preliminary opinion, however, was overturned by observations in the field. The abundant rhizoid tomentum makes tufts of *P. saprophila* very dense, and it often grows in expanded mats. Sometimes *P. saprophila* covers a considerable parts of fallen logs, not in a way common to *P. nutans* (Hedw.) Lindb., which forms tufts, but not so extensive; moreover, it is not similar to

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P. elongata in growth pattern, as the latter species grows almost always on soil or rocks, in a rather loose tufts. The sexual condition of such plants is always dioicous, with both sexes represented in most populations.

Original test with ITS sequences revealed almost complete identity of Siberian specimen of *Pohlia saprophila* with two accessions of *P. crudoides* (Sull. & Lesq.) Broth. from GenBank, based on Chinese collections. To understand the case, we expanded the set of specimens, including few putatively related species.

MATERIAL AND METHODS

Species selection, in addition to *P. saprophila*, which was sampled from three distant areas, includes *P. elongata* var. *elongata, P. elongata* var. *greenii* (Brid.) A.J. Shaw*, P. longicollis* (Hedw.) Lindb.*, P. cruda* (Hedw.) Lindb.*, P. crudoides, P. obtusifolia* (Vill. ex Brid.) L.F. Koch*, P. nutans* (different phenotypes), and *P. drummondii* (Müll. Hal.) A.L. Andrews.

DNA extraction and amplification were done according to the laboratory protocols described in Gardiner *et al.* (2005). The newly obtained data for 24 specimens were supplemented with five sequences available in GenBank. Voucher specimens and GenBank accession list is in Appendix 1 (supplementary materials). Sequences were aligned using BioEdit (Hall, 1999). Bayesian analysis was conducted in MrBayes 3.1.2 (Ronquist *et al.*, 2012) using the GTR+G model, for 10,000,000 generations with sampling every 1000 generations. Three simultaneous runs were used. The first 25% of sampled trees were discarded for the burn-in. Mamimum parsimony analysis was completed with Nona (Goloboff, 1994) within the Winclada shell (Nixon, 1999), with bootstrap calculation with 2000 replications.

RESULTS

ITS region was found very variable in the studied group of *Pohlia*, so even a simple inclusion of a sequenced specimen in alignment provided a sufficient evidence of its specimen identity for most taxa (Fig. 1).

The identical sequences of all samples of *P. saprophila* from populations at 5000 km one from another confirm the separate status of this species.

Bayesian and maximum parsimony analyses were rooted on *Pohlia longicollis,* a taxon maximally dissimilar to other studied species, as it is seen from the alignment. An attempt to include a more distant species of the same genus, *Pohlia drummondii,* has failed, as the sequence is so different that it is almost impossible to align.

Bayesian analysis (Fig. 2) found the clade of *P. cruda* (PP=1/BS=100) to be sister to the clade of all other species. The latter clade (PP=1/BS=0.96) includes *P. crudoides* (PP=0.95), and another clade (PP=1/BS=84), which is subdivided into two terminal clades. One of these terminal clades (PP=1/BS=99) includes *P. nutans*+*P. obtusifolia*, another one (PP=1/BS=98) accomodates *P. elongata* and *P. saprophila*. The first clade is subdivided into *P. obtusifolia* (PP=0.84/BS=68) and *P. nutans* (PP=1/BS=96).

The second terminal clade includes *P. elogata* var. *elongata*-clade (PP=1/BS=100), sister to clade (PP=1/BS=94) with two subclades: *P. elongata* var. *greenii* (PP=1/BS=99) and *P. saprophila* (PP=1/BS=99). The latter includes two sequences from one Chinese specimen kept in GenBank under *P. crudoides* name, but their identity with *P. saprophila* and difference from *P. crudoides* is obvious. Most probably, this misnaming was caused by underestimation of *P. sarphophila* and by similarity between these two species in having narrow lanceolate leaves with recurved margins and only slightly inclined narrowly cylindrical capsules.

Interestingly, *P. saprophila* appeared to be most closely related to *P. elongata* var. *greenii,* despite the latter is more distinct from *P. saprophila* than *P. elongata* var. *elongata*, especially in capsule shape: in *P. elongata* var. *greenii* it is short and more similar to that of *P. nutans* than of *P. elongata.* The 'typical' phenotype of the latter species with narrowly cylindrical capsules was sampled from four localities situated at considerable distance (ca. 2000 km) from each other, and their sequences were found to be almost identical. At the same time, two samples of *P. elongata* var. *greenii* considerably differ from each other, suggesting a complex situation in this group. Certainly, an expanded sampling of *P. elongata* var. *greenii* may reveal either more taxa in this group and/or phylogeographically interesting patterns.

Although *P. nutans* was not in the main focus of the paper, we selected few medium-sized forest phenotypes and some slender, high mountain, *P. drummondii*-like phenotypes. No stable genetic differentiation was noticed between them.

TAXONOMY

Pohlia saprophila (Müll. Hal.) Broth., Nat. Pflanzenfam. 1(3): 548. 1903. — *Bryum saprophilum* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s. 3: 97. 1896. Fig. 3.

Lectotype (selected here): China borealis, province Kansu occidental, vallin flum. Baga-Rhudonsug, 5.V.1885, *Potanin* (LE!).

Isolectotype: **MO**: http://www.tropicos.org/Image/100147243. Numerous syntypes with other collection dates were seen in LE, H, S, BM.

Description. *Plants* robust, in silky yellowish green to light green, very dense tufts with brown or rusty tomentum. *Stems* 0.5–1.5(–4) cm long, densely foliate, generally simple, near the base sometimes forking and dark-brown, red to blackish, with dense rhizoids. *Leaves* appressed when dry, erecto-patent when moist, often more or less twisted around the stem*,* 1.3–2.4(–2.8)×0.3–0.5 mm, ovate-lanceolate to linear-lanceolate, gradually tapering to acute apex; margins narrowly recurved, denticulate at apex; *costa* stout, ending shortly below apex, 60–120 μm wide at base, 1/6–1/4 of leaf width at base; *laminal cells* thick-walled, rectangular to linear, 35–75 (–100)×7–13 μm, at base shorter and wider and often pinkish. *Brood branches* often present in leaf axils in

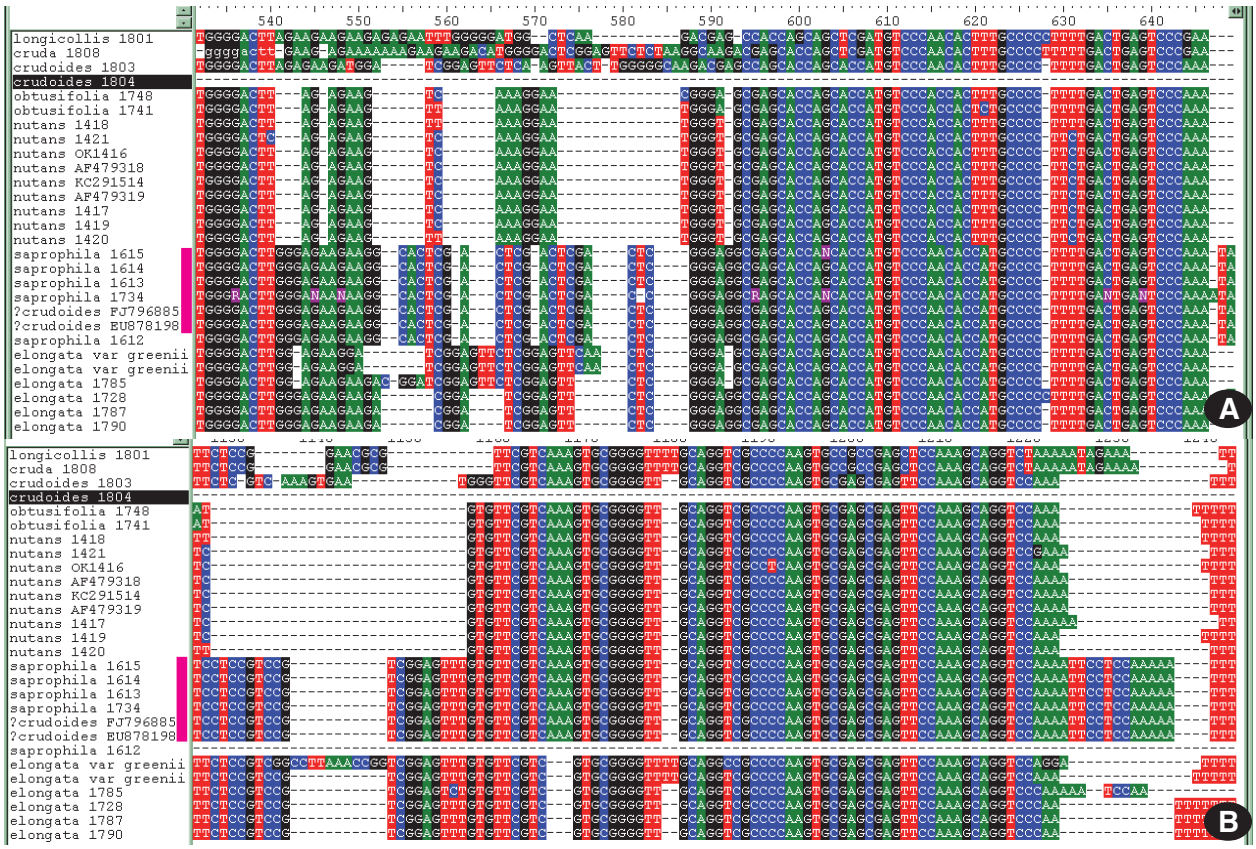

Fig. 1. Fragments of ITS alignment of *Pohlia*, showing unique motifs in ITS1 (A) and ITS2 (B) of *Pohlia saprophila* (marked by magenta vertical bar). Note two GenBank sequences labelled "*P. crudoides*" that are identical with *P. saprophila* and different from two speciemens of *P. crudoides*.

subapical part of the vegetative stems, 1–3 per axil, erect. *Dioicous*. Perichaetial leaves narrowly linear-lanceolate. Perigonia terminal, perigonial bracts acuminate. *Setae* 0.7–2(–3) cm, yellow to reddish-brown. *Capsules* inclined to horizontal, 2–3.5 mm long, 0.5–0.7 mm wide, narrowly cylindrical, yellow to brown when mature, slightly constricted below mouth when empty, neck 1/4–1/3, rarely 1/2 of capsule length; exothecial cells rectangular to elongate, with straight, thick walls, stomata superficial. *Operculum* conic, acute. *Annulus* of one cell row, revoluble. *Exostome teeth* yellow, acute-triangular, narrowly bordered, finely papillose proximally, coarsely papillose distally. *Endostome* hyaline, densely papillose, basal membrane low, segments keeled, narrowly perforate, cilia long, nodulose, rarely short. *Spores* light yellow, 12–15 µm, finely papillose.

Differentiation. *Pohlia saprophila* is recognized by a compact tufts with dense rhizoids, narrowly cylindrical capsules in combination with dioicous sexual condition, long lanceolate, light green leaves with narrowly recurved margins and endostome with long cilia. Propaguliferous flagelliform branches often present on top of vegetative stems. The other species of the genus with narrowly cylindrical capsules from Asia are *P. longicollis* and *P. elongata*. *Pohlia saprophila* differs from them in compact tufts with dense rhizoids, dioicous sexual condition and long, nodulose cilia of endostome. Laminal cells in *P. saprophila* are rectangular to linear, thick-walled, unlike cells of *P. elongata,* which are thick-walled but short-rectangular, and unlike cells of *P. longicollis*, which are rectangular to linear but thin-walled. There are two Chinese species with narrowly cylindrical capsules, *i.e*., *Pohlia macrocarpa* D.-C. Zhang, X.-J. Li & Higuchi and *P. hyaloperistoma* D.-C. Zang, X.-J. Li & Higuchi (Zhang *et al*., 2007). *Pohlia saprophila* differ from them by compact tufts with dense rhizoids and long vs. absent cilia of endostome; furthermore, it differ from *P. hyaloperistoma* in dioicous vs. autoicous sexual condition, and from *P. macrocarpa* in recurved vs. plane leaf margins. *Pohlia saprophila* differs from dioicous *P. sphagnicola* in compact tufts with dense rhizoids, narrowly cylindrical capsules and ecology.

Middle Asian and Chinese plants of *Pohlia saprophila* differ from the South Siberian and Kamchatkan plants in somewhat longer setae and occasionally longer capsules, up to 6 mm (Savich-Lyubitskaya & Smirnova, 1970). Flagelliform branches are more common in Kamchatkan plants, where they were seen on many shoots in most specimens, and occasionally two to three such branches occur on one shoot.

Distribution (Fig. 4). *Pohlia saprophila* is known from Kansu (Gansu), Xinjiang and Hebei Provinces of China (Müller, 1896; Zhao, 1993; herbarium specimens in LE). The species was reported from Mongolia (Abra-

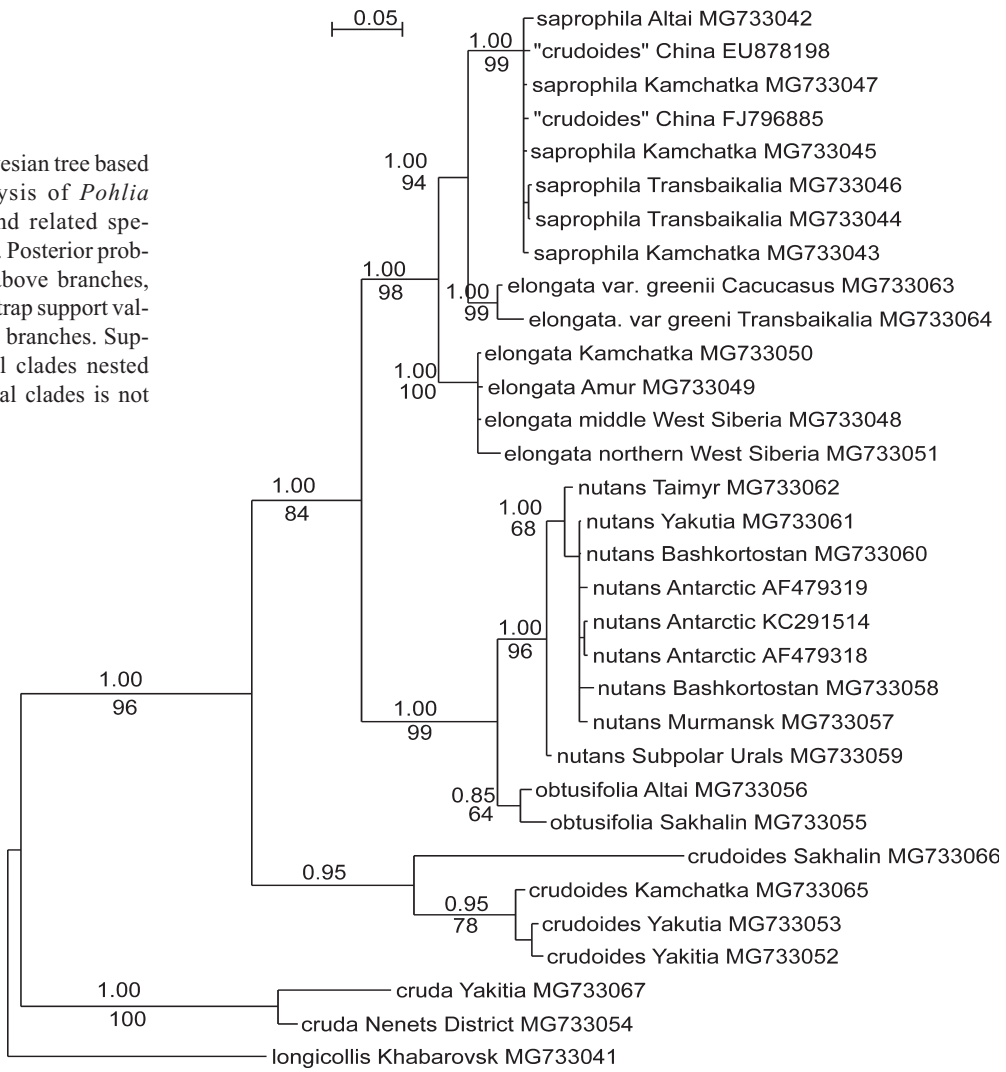

Fig. 2. Bayesian tree based on ITS analysis of *Pohlia saprophila* and related species of *Pohlia*. Posterior probabilities are above branches, and MP boorstrap support values are below branches. Support for small clades nested within terminal clades is not shown.

mova & Tsegmed, 1979; Abramov & Abramova, 1983) and Tsegmed (2010) cited it for five physiographic regions of Mongolia: Prikhubsugul, Khentei, Khangai, Khobdoss and Mongolian Altai, which cover most territory of the country. Savich-Lyunitskaya & Smirnova (1970) reported *P. saprophila* for the Middle Asia within the former USSR, where it occurs in Kazakhstan and Kyrgyzstan (Ignatov *et al*., 2006; Eremina, 1965; Sakauova, 1992; Mamatkulov *et al.*, 1998; specimens in LE). The species was also reported from NE European Russia (Zheleznova, 1994), but the specimen appeared to belong to *P. longicollis*. Then, it was collected in Altai and presented into database of Moss Flora of Russia (cf. Ivanov *et al*., 2017), but not published formally. Revising material for the Moss flora of Russia project, we found more localities of *P. saprophila* in southern Siberia and Kamchatka.

Ecology. *Pohlia saprophila* grows on rotten wood in spruce, birch and larch forests; rarely it is found at bases of trunks and on the bark of old trees. In Mongolia, this species was also collected on soil and rocks (Tsegmed, 2010). In Middle Asia, China, Mongolia and South Siberia, *Pohlia saprophila* grows at 1100–3000 m a.s.l. In Kamchatka Territory, it occurs at alstitudes 500–900 m. *Pohlia saprophila* forms pure dense tufts or occasionally grows with minor admixture of *Cynodontium asperifolium* (Lindb. & Arnell) Paris, *Flexitrichum flexicaule* (Schwägr.) Fedosov & Ignatov, *Pylaisia polyantha* (Hedw.) Bruch, Schimp. & W.Gümbel, *Sanionia uncinata* (Hedw.) Loeske, and *Oncophorus* spp.

*Specimens examined***:** (specimens in LE, if not otherwise mentioned); S+ – with capsule, Pr+ – with propaguliferous flagelliform branches): CHINA: **Xinjiang Province**: Tianshan Mt., N slope, Da-niou, 17.VII.1957, *Guan 1497,* S+; Mt. Bogda, 19.VIII.1931, *Liu,* S+, P+. **Hebei Province**, Weichang, X.1899, *Palibin,* S+, Pr+. **Gansu Province**, Nanshan Range, vicinity Edzin-Gol River, valley Bardun River, ~3000 m alt., 15.V.1886 and 17.V.1886 17.V.1886 23.V.1885, *Potanin*, S+: and 17.V.1886 23.V.1885, *Potanin*, S+. MONGOLIA: **Prikhubsugul Province**, circa lacus Ubsa, 16.VII.1879 and 17.VII.1879, *Potanin*, S+, Pr+. **Khangai Province**, Arakhangaiski Aimak, Taryat somon, 2135 m alt., 22.VI.1977, *Tsegmed 3045*, S+, Pr+. **Khentei Province**, vicinity Ulan-Bator, 10.IX.1974, *Tsegmed 2417*, Pr+. MIDDLE ASIA: Inter Turkestanicum, Kungei, *Regel 3457*, S+; Inter Turkestanicum, Borgasy, 5-6000’ (=1830 m

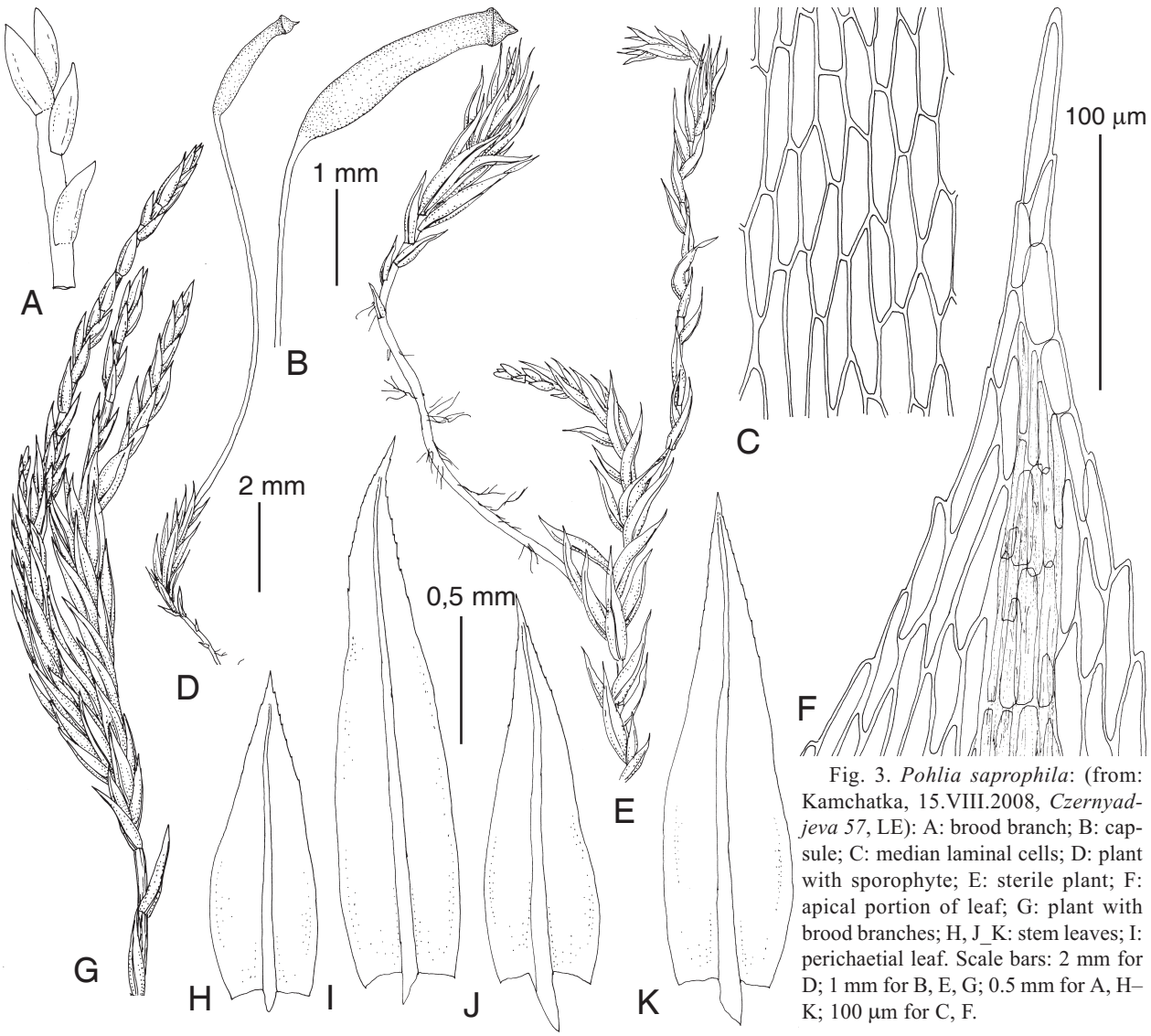

Fig. 3. *Pohlia saprophila*: (from: Kamchatka, 15.VIII.2008, *Czernyadjeva 57*, LE): A: brood branch; B: capsule; C: median laminal cells; D: plant with sporophyte; E: sterile plant; F: apical portion of leaf; G: plant with brood branches; H, J_K: stem leaves; I: perichaetial leaf. Scale bars: 2 mm for D; 1 mm for B, E, G; 0.5 mm for A, H–K; 100 μm for C, F.

alt.), 4.VII.1879, *Regel 3141*, S+. KAZAKHSTAN: **Almatinakaya Province**: valley Levyi Talgar River, ~2700 m alt., 1.IX.1958, *Lisowski, S*+; Ketmen' Range, ~2800 m alt., 6.VIII.1946, *Rubtsov 16*, S+, Pr+. KIRGIZSTAN: Issukkul Lake, 9000' (=3130 m alt.), 19.VIII.1877, *Regel 888*, S+. RUSSUA: **Republic of Altai**, Taldura River, 49°57'N, 87°50'E, 2360 m alt., 11.VII.2012, *Ignatov & Ignatova 12-382,* S+. **Republic of Buryatia**, East Sayan, upper of Oka River, vicinity Orlik Settl., 52°30'N, 99°50'E, 1412 m alt., 1.VII.2008, *Afonina 00408*, S+, Pr+. **Zabaikalsky Territory**: Sokhondinsky State Reserve: vicinity Enda River, 49°27'N, 110°51'E, ~1070 m alt., 8.VII.2010, *Czernyadjeva 2-10*, Pr+; vicinity Agutsa River, 49°40'N, 111°26'E, ~1100 m alt., 20.VII.2010, *Czernyadjeva 33-10*, Pr+. **Kamchatka Territory**: Shiveluch Volcano, 56°33'N, 161°11'E, 514 m alt., 20.VII.2001, *Czernyadjeva 24, 25, 26,* S+, Pr+; Kluchevskaya group of volcano, vicinity of Kopyto Mt.: 55°57'N, 160°11'E, 660 m alt., 13.VIII.2004, *Czernyadjeva 69,* S+, Pr+; 55°57'N, 160°14'E, 933 m alt., 13.VIII.2004, *Czernyadjeva 71,* S+, Pr+; Kluchevskaya group of volcano, Ostryy Tolbatchick Volcano: 55°46'N, 160°16'E, 910 m alt., 16.VIII.2006, *Czernyadjeva 961*, S+, Pr+; 55°46'N, 160°13'E, 880 m alt., 15.VIII.2008, *Dulin 57,* S+, Pr+.

Pohlia elongata Hedw., Sp. Musc. Frond. 171. 1801. Lectotype in BM (Shaw, 1982), not seen.

Pohlia viridis Lindb. & Arnell, Kongl. Svenska Vetensk. Acad. Handl., n.s. 23(10): 55. 1890. syn. nov.

Lectotype S-B170418 (selected here): Partly printed label: "Pohlia viridis Lindb. et Arn., Sibiria: Jenisei, Antsiferove, 59 10 n. lat., i [mycelklädd] klippspringa, 27/6/1876." On small envelope inside bigger envelope: "Aoter! Pohlia (n.sp.) viridis!, Sibiria: Jenisei, Antsiferovo, 59 n. lat., i hÍla i urberg, 27/6/1876".

Notes on lectotypification: Stockholm herbarium possesses 3 syntypes, all from the same locality, Anziferova 59° n. lat., and principally all of them could be chosen. We select the least problematic specmen, as two other ones have the followings disagreements with the protologue. The species is described as dioicous, while B170419 is annotated "polyoica!", and B170420 (from Herbarium Forstrer, Dr. Georg Roth. Herb. Hj. Möller) has less complete locality information.

We found paroicous plants in the lectotype, as well as in one of syntypes. Therefore we see no difference be-

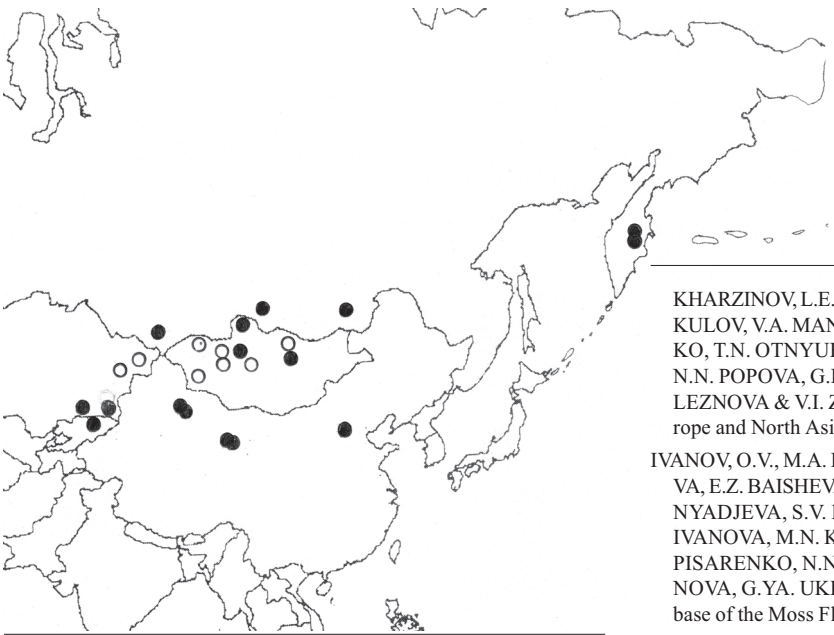

Fig. 4. Distribution of *Pohlia saprophila.* Solid circles – specimens examined from herbarium collections; hollow circles – literature data.

tween *P. viridis* and *P. elongata* sufficient for the taxonomic recognition of the former.

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LITERATURE CITED

[ABRAMOV, I.I. & A.L. ABRAMOVA]. АБРАМОВ И.И., А.Л. АБРАМОВА. 1983. Конспект флоры мхов Монгольской народной республики. – [Konspekt flory mhov Mongolskoj Narodnoj Respubliki] *Л., Наука* [*Leningrad, Nauka*]*, 221 pp*.

[ABRAMOVA, A.L. & TS. TSEGMED] АБРАМОВА А.Л., Ц. ЦЭГМЭД. 1979. Редкие и интересные виды мхов Монголии. – [Rare and interesting mosses of Mongolia] *Новости систематики низших растений* [*Novosti Sistematiki Nizshikh Rastenij*] **16**: *169–175*.

BROTHERUS, V.F. 1903. Bryales. – *In: H.G.A. Engler & K. Prantl (eds.) Die Natürlichen Pflanzenfamilien. I(3). Leipzig, 481–576*.

[EREMINA, N.KH.] ЕРЕМИНА Н.Х. 1965В. Материалы к флоре акрокарпных мхов Заилийского Алатау. – [Materials on flora of acrocarpous mosses of Zailiisky Alatau] *Ботанические материалы Гербария института ботаники АН Каз ССР* [*Botanicheskie Materialy Herbaria Institita Botaniki Akademii Nauk Kazakhskoj SSR*] **3**: *115–125*.

GARDINER, A., M. IGNATOV, S. HUTTUNEN & A. TROITSKY. 2005. On resurrection of the families Pseudoleskeaceae Schimp. and Pylaisiaceae Schimp. (Musci, Hypnales). – *Taxon* **54**: *651–663*.

GOLOBOFF, P.A. 1994. NONA: A Tree Searching Program. – *Program and documentation, published by the author, Tucumán, Argentina.*

HALL, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. – *Nucleic Acids Symposium Series* **41**: *95–98*.

IGNATOV, M.S., O.M. AFONINA, E.A. IGNATOVA, A. ABOLINA, T.V. AKATOVA, E.Z. BAISHEVA, L.V. BARDUNOV, E.A. BARYAKINA, O.A. BELKINA, A.G. BEZGODOV, M.A.BOYCHUK, V.YA. CHERDANTSEVA, I.V. CZERNYADJEVA, G.YA. DOROSHINA, A.P. DYACHENKO, V.E. FEDOSOV, I.L. GOLDBERG, E.I. IVANOVA, I. JUKONIENE, L. KANNUKENE, S.G.KAZANOVSKY, Z.KH. KHARZINOV, L.E. KURBATOVA, A.I. MAKSIMOV, U.K. MAMATKULOV, V.A. MANAKYAN, O.M. MASLOVSKY, M.G. NAPREENKO, T.N. OTNYUKOVA, L.YA. PARTYKA, O.YU. PISARENKO, N.N. POPOVA, G.F. RYKOVSKY, D.YA. TUBANOVA, G.V. ZHELEZNOVA & V.I. ZOLOTOV. 2006. Check-list of mosses of East Europe and North Asia. – *Arctoa* **15**: *1–130*.

IVANOV, O.V., M.A. KOLESNIKOVA, O.M. AFONINA, T.V. AKATOVA, E.Z. BAISHEVA, O.A. BELKINA, A.G. BEZGODOV, I.V. CZERNYADJEVA, S.V. DUDOV, V.E. FEDOSOV, E.A. IGNATOVA, E.I. IVANOVA, M.N. KOZHIN, E.D. LAPSHINA, A.A. NOTOV, O.YU. PISARENKO, N.N. POPOVA, A.N. SAVCHENKO, V.V. TELEGANOVA, G.YA. UKRAINSKAYA & M.S. IGNATOV. 2017. The database of the Moss Flora of Russia. – *Arctoa* **26**(1): *1–10.*

[MAMATKULOV, U.K., I.O. BAITULIN & S.G. NESTEROVA] МАМАТКУЛОВ У.К., И.О. БАЙТУЛИН, С.Г. НЕСТЕРОВА. 1998. Мохообразные Средней Азии и Казахстана. – [Bryophytes of the Middle Asia and Kazakhstan] *Алматы* [*Almaty*], *232 pp*.

MÜLLER, C. 1896. Bryologia provinciae Schensi sinensis I. – *Nuovo giornale botanico italiano, n.s.* **3**: *89–129*.

REDFEARN, P.L., B.C. TAN & S. HE. 1996. A newly updated and annotated checklist of Chinese mosses. – *Journal of the Hattori Botanical Laboratory* **79**: *163–357*.

RONQUIST, F., M. TESLENKO, P. VAN DER MARK, D.L. AYRES, A. DARLING, S. HÖHNA, B. LARGET, L. LIU, M.A. SUCHARD & J.P. HUELSENBECK. 2012. MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. – *Systematic Biology* **61**: *539–542*.

[SAKAUOVA, G.B.] САКАУОВА Г.Б. 1992. Мохообразные Южного Алтая. – [Bryophytes of South Altai] *Автореф. дисс... канд. биол. наук Душанбе, АН Респ. Таджикистан, Инст. Бот*. [*Thesis Ph. D.. Dushanbe, Akad. Nauk. Resp. Tadjikistan, Inst. Bot*.], *22 p*.

[SAVICZ-LYUBITSKAYA, L.I. & Z.N. SMIRNOVA] САВИЧ-ЛЮБИЦКАЯ Л.И., З.Н. СМИРНОВА 1970. Определитель листостебельных мхов СССР. Верхоплодные мхи. – [Handbook of mosses of the USSR. The acrocarpous mosses] *Л., Наука* [*Leningrad, Nauka*]*, 822.*

SHAW, J. 1982. *Pohlia* Hedw. (Musci) in North and Central America and the West Indies. – *Contributions from the University of Michigan Herbarium* **15**: *219–295.*

SHAW, J. 2014. Mielichhoferiaceae. – *In: Flora of North America Editorial Committee (eds.) Flora of North America North of Mexico* **28**: *189–214*.

[TSEGMED, TS.] ЦЭГМЭД Ц. 2010. Флора мхов Монголии. – [Moss flora of Mongolia] *М. Труды совместной российско-монгольской комплексной биологической экспедиции* [*Moscow, Trudy Sovmestnoi Rossiisko-Mongolskoi Kompleksnoi Biologicheskoi Ekspeditsii*]*, 635 pp*.

[ZHELEZNOVA, G.V.] ЖЕЛЕЗНОВА Г.В. 1994. Флора листостебельных мхов Европейского Северо-Востока. – [Moss flora of European North-East] *СПб., Наука* [*St.- Petersburg, Nauka*], *148 pp*.

ZHANG, D., X. LI & S. HE. 2007. Bryaceae. – *In: Moss Flora of China. English Version. Vol. 4. Beijing, New York and St.-Louis, Science Press and Missouri Botanical Garden*: *3–92*.

ZHAO, J.-C. 1993. A preliminary study on the bryophytes of eastern section of Tianshan Mountains, Northwest China. – *Chenia* **1**: *99–112*.