

SEVEN SPECIES OF FRESHWATER LICHEN-FORMING FUNGI NEWLY RECORDED FROM POLAND

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Abstract. This paper presents seven freshwater lichen species from Western Carpathian streams: *Bryobilimbia ahlesii* (Körb.) Fryday *et al.*, *Rhizocarpon sublavatum* Fryday, *Thelidium circumspersellum* (Nyl.) Zschacke, *T. klementii* Servít, *T. pluvium* Orange, *T. rehmi* Zschacke and *Verrucaria devensis* (G. Salisbury) Orange. All of them are first records for Poland. *Thelidium klementii* is new for the Carpathians and was previously known only from the type locality in Germany. Morphological descriptions based on Polish specimens are presented, and the ecology and geographical distribution of these lichens are briefly discussed.

Key words: amphibious lichens, biodiversity, Carpathians, distribution, lichenized fungi, new records

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INTRODUCTION

The vast majority of lichens are restricted to terrestrial environments and their thalli do not tolerate long periods of submersion, but there is a small group of lichens whose proper development depends on constant or recurrent inundation (Thüs *et al.* 2014). These freshwater (amphibious) lichens are a widely distributed but still insufficiently studied component of freshwater habitats. Among the 1642 species of lichens known from Poland (Fałtynowicz & Kossowska 2016) only 56 are freshwater lichens. This paper reports seven freshwater lichen species newly recorded from the Western Carpathians in Poland.

MATERIAL AND METHODS

The study is based on material collected by the first author during field work in 2012–2016 for research focused on the lichen biota of freshwater habitats in the Polish Western Carpathians. The lichen material was analyzed by standard morphological and anatomical methods using Nikon SMZ 800N and Nikon Eclipse E200 microscopes. The pigments *Atra*-brown (*sensu* Meyer & Printzen 2000) and *Macrocarpa*-green (*sensu* Fryday 2002) were identified. Lichen substances were

studied by thin-layer chromatography (TLC) using the methods described by Orange *et al.* (2001). Voucher specimens are in the herbarium of the W. Szafer Institute of Botany, Polish Academy of Sciences (KRAM).

RESULTS AND DISCUSSION

Bryobilimbia ahlesii (Körb.) Fryday, Printzen & S. Ekman

Thallus thin, continuous or irregularly rimose, pale grey or grey-green. *Apothecia* 0.45–0.6 mm diam., sessile. *Disc* reddish-brown to brown-black, concave to slightly convex. *Apothecial margin* usually prominent and persistent. *Exciple* dark reddish brown in section at outer edge and almost colorless to pale reddish brown in inner part. *Epihymenium* colorless or yellowish brown to pale reddishbrown, K–. *Hymenium* colorless, 60–80 µm high, often with scattered blue-violet (K+ green) granules. *Hypothecium* brown to brownish black, usually with blue-violet (K+ green) granules. *Asci* *Porpidia*-type. *Ascospores* simple, colorless, ellipsoid, 12–16(–17.5) × (4–)5–6 µm, with or without gelatinous coat.

CHEMISTRY: lichen substances not detected by TLC; thallus K–, C–, KC–, Pd–.

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NOTES. The new generic name *Bryobilimbia* was proposed by Fryday *et al.* (2014) for *Lecidea hypnorum* and its closely related taxa. *Bryobilimbia* can be distinguished from *Lecidea* and *Mycobilimbia* by its *Porpidia*-type ascus. It differs from *Clauzadea* and *Porpidia* in having ascospores with a finely warted perispore and/or thin gelatinous coat, whereas *Porpidia* has ascospores with a well-developed gelatinous coat and *Clauzadea* has ascospores with only a thin gelatinous coat when young. *Bryobilimbia* is also distinguished by the presence of scattered blue-violet (K⁺ green) granules in the hymenium, and mostly simple paraphyses. It differs from *Lecidoma* and *Romularia* in having a thinner, membranaceous thallus and darker hypothecium. Both *Bryobilimbia ahlesii* and *Bryobilimbia sanguineoatra* (Wulfen) Fryday, Printzen & S. Ekman grow on rocks and thus can be easily confused, but the latter differs in having a pale yellow thallus and smaller ascospores [(9–)11–14 × 3.5–5(–6) μm] (Fryday *et al.* 2014; Hu *et al.* 2014).

Bryobilimbia ahlesii occurs at shaded sites with high air humidity, where it grows usually on siliceous rocks. It is a typical riparian species which usually occurs in the upper splash water zone but avoids long periods of inundation. In the study area this species was found on damp sandstone on the bank of Młodowski Potok stream in the Beskid Sądecki Mts.

It is a rather rare species, known from scattered localities throughout Europe (Czech Republic, Finland, Germany, Great Britain, Lithuania, Russia, Sweden), North America (USA) and Asia (China) (Arup 2004; Coppins & Fryday 2006; Urbanavichus 2010; Halda *et al.* 2011; Fryday *et al.* 2014; Hu *et al.* 2014; Motiejūnaitė & Grochowski 2014; Paukov *et al.* 2017).

SPECIMEN EXAMINED. POLAND. BESKID SĄDECKI MTS: Pasma Radziejowej range, Młodowski Potok stream, above forest road, on damp sandstone, 49°27'3"N, 20°40'33"E, 526 m, 12 June 2014, *N. Matura* (KRAM L-69161).

Rhizocarpon sublavatum Fryday

Thallus thin, cracked and areolate, grey or brown. *Prothallus* usually distinct and black. *Apothecia* flat, epruinose. *Disc* black, 0,3–0,5(–0,6) mm

in diam., irregularly arranged, innate when young, becoming sessile when mature. *Apothecial margin* thin, the same color as disc. *Exciple* brownish in section (*Atra*-brown pigment), K[–] or K⁺ intensifying, N and HCl± intensifying, sometimes with *Macrocarpa*-green (K[–], N⁺ red, HCl⁺ bright blue) patch in upper part. *Epihymenium* olive-green to olive-brown (*Atra*-brown and *Macrocarpa*-green pigments intermixed). *Hymenium* colorless, I⁺ blue, 120–140 μm high. *Hypothecium* medium brown to dark brown. *Asci* 8-spored, *Rhizocarpon*-type. *Ascospores* muriform, colorless, occasionally almost black when mature, narrowly ellipsoid to ellipsoid, 17–38 × 11–25 μm.

CHEMISTRY: lichen substances not detected by TLC; thallus K[–], C[–], KC[–], Pd[–].

NOTES. *Rhizocarpon sublavatum* can be confused with several species of the genus on account of its hyaline and muriform ascospores. The most similar species is *R. lavatum* (Fr.) Hazsl., which differs from *R. sublavatum* in having a paler thallus and larger and narrower ascospores (34–44 × 14–18 μm). *Rhizocarpon reductum* Th. Fr. differs in the presence of stictic acid in the thallus and apothecia, which give spot test reactions K⁺ yellow and Pd⁺ orange. *Rhizocarpon anaperum* (Vain.) Vain. has a darker *Macrocarpa*-green pigment in the epihymenium and browner and slightly convex areoles, whereas *R. sublavatum* has flat areoles (Ihlen 2004).

Rhizocarpon sublavatum grows mostly on siliceous rocks in damp places. It prefers moderately shady habitats. In the study area this species was found at two localities in the Polish Tatra Mts, on temporarily inundated and splashed siliceous rocks.

This species is widely distributed in Great Britain, Norway, Sweden, Finland and Austria (Fryday 1996, 2000; Ihlen 2004; Berger & Prietmetzhofer 2014).

SPECIMENS EXAMINED. POLAND. TATRY MTS: High Tatra Mts, black hiking trail from Murowaniec mountain shelter to Świnicka Przełęcz pass, Litworowy Staw Lake, on temporarily inundated siliceous rock, 49°13'54"N, 19°59'49"E, 1586 m, 20 July 2015, *N. Matura* (KRAM L-69162); Biały Żleb gully, blue hiking trail from Morskie Oko lake to Dolina Pięciu Stawów Polskich valley, small stream near trail, on splashed

siliceous rock, 49°12'39"N, 20°4'8"E, 1568 m, 19 July 2015, *N. Matura* (KRAM L-69163).

Thelidium circumspersellum (Nyl.) Zschacke

Thallus inconspicuous, very thin to vanishing, brown, without cortex. *Photobiont* chlorococcoid alga, 3–6 µm in diam., arranged in small groups or irregularly dispersed. *Perithecia* sessile to semi-immersed. *Involucrellum* absent. *Exciple* black-brown, reaching up to 200 µm in diam. *Asci* 8-spored, 64–75 × 17–25 µm. *Ascospores* 3-septate, colorless, 18–27 × 7–10 µm.

CHEMISTRY: lichen substances not studied by TLC; thallus K–, C–, KC–, Pd–.

NOTES. *Thelidium circumspersellum* is very similar to *T. zwackhii* (Hepp) A. Massal.; basically *T. zwackhii* can be distinguished by its thicker thallus, larger asci (90–120 × 29–40 µm), larger ascospores (20–36 × 9–15 µm) and transparent exciple in its lower part (Thüs & Schultz 2009). The two species are very similar in morphology and are sometimes difficult to determine. It may be a complex of species or one species with high phenotypic variation. Further molecular analysis will help in determining their relationship.

This species occurs on periodically inundated limestone. It prefers moderately shady habitats. During this study, *Thelidium circumspersellum* was found at a single locality in Uhryński Potok stream in the Beskid Sądecki Mts on a frequently inundated rock.

Previously this species was reported from Romania (Thüs & Nascimbene 2008) and Austria (Berger & Priemetzhofer 2014; Hafellner & Türk 2016).

SPECIMEN EXAMINED. POLAND. BESKID SĄDECKI MTS: Pasma Jaworzyny Krynickiej range, Uhryński Potok stream, lower part of Uhryń village, near nature trail, on limestone rock often inundated, 49°29'44"N, 20°51'38"E, 576 m, 24 Aug. 2013, *N. Matura* (KRAM L-69166).

Thelidium klementii Servít

Thallus semi-endolithic, rather thick (120–230 µm), finely rimose to areolate, predominantly whitish grey; cortex colorless. *Photobiont* coccoid green alga, 4–9 µm in diam., dispersed.

Perithecia semi-immersed in thallus, naked. *Involucrellum* apical or absent. *Exciple* dark brown, up to ca 200 µm in diam. *Asci* 8-spored, 70–80 × 25–28 µm. *Ascospores* mostly (0–)1-septate, colorless, 17–30 × 10–15 µm.

CHEMISTRY: lichen substances not studied by TLC; thallus K–, C–, KC–, Pd–.

NOTES. *Thelidium rivulicolum* (Nyl.) Migula is similar in having a thick thallus and 1-septate ascospores, but differs in having an almost twice-larger exciple (300–450 µm diam.) and slightly longer asci (90 × 30 µm) and ascospores (23–42 × 7–15 µm) (Thüs & Schultz 2009).

Thelidium klementii occurs on temporarily inundated calcareous rocks with high content of silica (Thüs & Schultz 2009). During this study it was collected from submerged and splashed sandstone rocks. It prefers moderately shaded habitats. In the study area this species was recorded at a few localities in the Beskid Sądecki Mts and at one locality in the Beskid Żywiecki Mts.

Outside Poland, *Thelidium klementii* is known only from the type locality in Germany which was destroyed when a large reservoir was constructed, and the species is now threatened with extinction (Thüs & Nascimbene 2008).

SPECIMENS EXAMINED. POLAND. BESKID SĄDECKI MTS: Pasma Jaworzyny Krynickiej range, Baraniecki stream, upper part of stream, in forest, on submerged sandstone rock, 49°24'20"N, 20°48'16"E, 750 m, 2 July 2013, *N. Matura* (KRAM L-69165); Pasma Radziejowej range, Potok Bliszczce stream, near site of tree-felling and human settlements, on splashed sandstone rock, 49°29'17"N, 20°25'24"E, 415 m, 5 June 2014, *N. Matura* (KRAM L-69167); Góry Leluchowskie Mts, Wojkowski Potok stream, behind asphalt road, near clearing and forest in upper part of Wojkowa village, on splashed sandstone rock, 49°20'13"N, 20°59'22"E, 689 m, 4 Sept. 2013, *N. Matura* (KRAM L-69168); BESKID ŻYWIECKI MTS: Danielka stream, near mountain shelter, on submerged sandstone rock, 49°28'29"N, 19°7'37"E, 620 m, 1 Aug. 2015, *N. Matura* (KRAM L-69164).

Thelidium pluvium Orange

Thallus epilithic, thin to moderately thick (35–85 µm), continuous or slightly cracked, greyish, brown or greenish. *Photobiont* coccoid

green alga, reaching up to 8 μm in diam. *Perithecia* immersed in prominent thallus warts, 250–450 μm in diam. *Involucrellum* thin (up to 30 μm), apical to reaching thallus base, often laterally spreading, leaving transparent area between exciple and involucrellum, \pm covered by layer of thallus. *Exciple* 100–320 μm in diam. *Asci* 8-spored, 75–100 \times 25–35 μm . *Ascospores* 1-septate, colorless, 19–36 \times 8–17 μm .

CHEMISTRY: lichen substances not studied by TLC; thallus K–, C–, KC–, Pd–.

NOTES. *Thelidium pluvium* is similar to *T. methorium* (Nyl.) Hellb., which differs in having larger perithecia (0.43–1.60 mm in diam.) which are usually not covered by a thallus layer, larger ascospores (24–46 \times 13–21 μm) and a well-developed, thicker involucrellum. *Thelidium minutulum* Körb. is also similar but it has an apical involucrellum (or none) and smaller ascospores (13–32 \times 4–15 μm) than *T. pluvium* (Thüs & Schultz 2009).

Thelidium pluvium occurs on temporarily inundated or splashed siliceous rocks. It prefers shady habitats. During this study it was found at a single locality in Potok Rusnaków stream in the Beskid Makowski Mts on a small splashed stone at a moderately sunny site.

This species was previously known from a few scattered localities. Probably it is mistaken in the field for *Verrucaria hydrophila* Orange. It has been reported from mountain regions in Central European mountains (Germany and Austria), Northern Europe (Norway) and the British Isles (UK) (Orange 1991; Wirth 1999; Berger & Prietzhofer 2000; Keller 2000; Cezanne *et al.* 2008; Thüs & Nascimbene 2008). Outside Europe it was found in Tasmania (McCarthy 1994).

SPECIMEN EXAMINED. POLAND. BESKID MAKOWSKI MTS: Potok Rusnaków stream, in forest, on splashed siliceous stone, 49°45'41"N, 19°54'25"E, 585 m, 8 July 2014, *N. Matura* (KRAM L-69172).

Thelidium rehmii Zschacke

Thallus thin to moderately thick, 15–110 μm , slightly cracked, greenish grey. *Photobiont* chlorococcoid alga, 3–10 μm in diam., irregularly arranged in thallus. *Perithecia* semi-immersed in

thallus to almost sessile. *Involucrellum* absent or apical but never laterally spreading. *Exciple* 200–300 μm in diam. *Asci* 8-spored, 67–93 \times 26–40 μm . *Ascospores* 1-septate, colorless, 19–30 \times 8–15 μm .

CHEMISTRY: lichen substances not studied by TLC; thallus K–, C–, KC–, Pd–.

NOTES. *Thelidium rehmii* can be easily confused with *T. minutulum* on account of their very similar morphology, but *T. minutulum* appears to be restricted to calcareous or basic siliceous rocks (limestone, metamorphic rocks) and its photobiont cells are arranged in distinct groups (Thüs & Schultz 2009).

Thelidium rehmii grows on temporarily inundated and splashed siliceous rocks in the vicinity of streams. It prefers more or less shaded places. In the study area it was found at scattered localities.

In Europe this species is known from a few localities in southern Germany (Thüs & Nascimbene 2008) and the Czech Republic (Servít 1954). Recently it was also found in Japan (Harada 2013).

SPECIMENS EXAMINED. POLAND. BESKID MAKOWSKI MTS: Potok Rusnaków stream, in forest, below forest road, on rock often inundated, 49°45'41"N, 19°54'25"E, 585 m, 8 July 2014, *N. Matura* (KRAM L-69171); BESKID NISKI MTS: Bielcza stream, near clearing and entrance to Kamień Reserve, on stone often inundated, 49°23'34"N, 21°47'55"E, 577 m, 14 Aug. 2015, *N. Matura* (KRAM L-69178); BESKID SADECKI MTS: Pasma Jaworzyny Krynickiej range, Baraniecki stream, upper part of stream, in forest, on splashed rock, 49°24'20"N, 20°48'16"E, 750 m, 2 July 2013, *N. Matura* (KRAM L-69182); Szczawniczek stream, near road, among human settlements, on splashed rock, 49°23'14"N, 20°53'6"E, 597 m, 10 Sept. 2013, *N. Matura* (KRAM L-69170); Uhryński Potok stream, middle part of Uhryń village, open habitat near road, bridge and human settlements, on temporarily inundated rock, 49°28'36"N, 20°51'35"E, 641 m, 23 Aug. 2013, *N. Matura* (KRAM L-69175); Uhryński Potok stream, lower part of Uhryń village, near nature trail, on splashed stone, 49°29'44"N, 20°51'38"E, 576 m, 24 Aug. 2013, *N. Matura* (KRAM L-69173); Pasma Radziejowej range, Kozłeczki stream, in forest, above human settlements, on splashed rock, 49°27'27"N, 20°27'39"E, 663 m, 30 May 2014, *N. Matura* (KRAM L-69179); Przysietnica stream, along road between bridge and small dam, near chapel, on splashed

rock, 49°28'45"N, 20°34'31"E, 816 m, 5 June 2014, *N. Matura* (KRAM L-69183); GORCE MTS: Lubański stream, behind last house on road, below bridge, on rock often inundated, 49°30'34"N, 20°20'16"E, 621 m, 30 Aug. 2015, *N. Matura* (KRAM L-69181); PIENINY MTS: Zagórny Potok stream, near human settlements, on rocks often inundated and splashed, 49°24'19"N, 20°21'57"E, 520 m, 9 Sept. 2015, *N. Matura* (KRAM L-69176).

Verrucaria devensis (G. Salisbury) Orange

Thallus superficial, 40–140 µm thick, pale grey-green to greyish brown or medium brown, smooth, almost subgelatinous, continuous or usually locally or extensively cracked (cracks partially or sometimes completely delimiting areoles); black basal layer either locally or extensively present. *Prothallus* white. *Perithecia* immersed in thallus, forming very low projections. *Involucrellum* conical at first, then becoming very wide-spreading and confluent in between. *Exciple* colorless, 120–210 µm in diam. *Asci* 8-spored. *Ascospores* simple, colorless, oblong ellipsoid, (16–)18–23 × 8–10 µm.

CHEMISTRY: lichen substances not studied by TLC; thallus K–, C–, KC–, Pd–.

NOTES. *Verrucaria devensis* was recently described by Orange (2014). It can be easily confused with *V. praetermissa* (Trevisan) Anzi, but *V. devensis* differs in having a strongly pigmented, thinner and almost subgelatinous thallus. Another similar species, *V. elaeina* Borrer, can be distinguished from *V. devensis* because the former lacks a black basal thalline layer and has a weakly developed involucrellum, more exposed perithecia, and paler, non-gelatinous thallus.

Verrucaria devensis occurs on inundated rocks and stones in shady and sunny habitats. During this study it was found at a few localities.

Outside Poland, *Verrucaria devensis* has been reported only from Wales and Scotland so far (Orange 2014).

SPECIMENS EXAMINED. POLAND. BESKID MAKOWSKI MTS: Rusnaków stream, near human settlements, on submerged rock, 49°44'35"N, 19°54'39"E, 407 m, 9 July 2014, *N. Matura* (KRAM L-69174); BESKID MAŁY MTS: Zebrutnica stream, in forest, by roadside, on submerged rock, 49°46'8"N, 19°25'44"E, 569 m, 5 July

2014, *N. Matura* (KRAM L-69177); BESKID SADECKI MTS: Pasma Radziejowej range, Przysietnica stream, along forest road, below bridge, on submerged stone, 49°29'9"N, 20°34'33"E, 712 m, 6 June 2014, *N. Matura* (KRAM L-69180); Góry Leluchowskie Mts, Wojkowski Potok stream, lower part of Wojkowa village, open habitat near road, on submerged stone, 49°21'48"N, 20°58'56"E, 555 m, 4 Sept. 2013, *N. Matura* (KRAM L-69169).

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REFERENCES

- ARUP U. 2004. Three overlooked *Lecidea* species in Sweden. *Symb. Bot. Upsal.* **34**(1): 39–48.
- BERGER F. & PRIEMETZHOFFER F. 2000. Neue und seltene Flechten und lichenicole Pilze aus Oberösterreich, Österreich III. *Herzogia* **14**: 59–84.
- BERGER F. & PRIEMETZHOFFER F. 2014. Erläuterungen und Erstnachweise von Flechten in Oberösterreich, sowie weitere erwähnenswerte Beobachtungen. 1. Update des Flechtenatlas. *Stappia* **101**: 53–65.
- CEZANNE R., EICHLER M., HOHMAN M. L. & WIRTH V. 2008. Die Flechten des Odenwaldes. *Andrias* **17**: 1–520.
- COPPINS B. J. & FRYDAY A. 2006. Reassessment of some lichen species described by Josiah Lowe, and notes on some other North American lecodeoid lichens. *Bryologist* **109**(1): 9–17.
- FALTYNOWICZ W. & KOSSOWSKA M. 2016. The lichens of Poland. A fourth checklist. *Acta Botanica Silesiaca, Monographiae* **8**: 3–122.
- FRYDAY A. 1996. The lichen vegetation of some previously overlooked high-level habitats in North Wales. *Lichenologist* **28**(6): 521–541.
- FRYDAY A. 2000. On *Rhizocarpon obscuratum* (Ach.) Massal., with notes on some related species in the British Isles. *Lichenologist* **32**(3): 207–224.
- FRYDAY A. 2002. A revision of the species of the *Rhizocarpon hochstetteri* group occurring in the British Isles. *Lichenologist* **34**: 451–477.
- FRYDAY A. & PRINTZEN CH. & EKMAN S. 2014. *Bryobilimbia*, a new generic name for *Lecidea hypnorum* and closely related species. *Lichenologist* **46**(1): 25–37.
- HAFELLNER J. & TÜRK R. 2016. Die lichenisierten Pilze Österreichs – eine neue Checkliste der bisher nachgewiesenen

- Taxa mit Angaben zu Verbreitung und Substratökologie. *Stapfia* **104**(1): 2–216.
- HALDA J. P., BOUDA F., FESSOVÁ A., KOCOURKOVÁ J., MALÍČEK J., MÜLLER A., PEKSA O., SVOBODA D., ŠOUN J. & VONDRÁK J. 2011. Lichens recorded during the autumnal bryo-lichenological meeting in Železné hory Mts (Czech Republic), September 2009. *Bryonora* **47**: 40–51.
- HARADA H. 2013. The lichen genus *Thelidium* (Verrucariaceae) in Japan. *Lichenology* **11**(2): 53–66.
- HU L., ZHAO X., SUN L. Y., ZHAO Z. T. & ZHANG L. L. 2014. Four lecideoid lichens new to China. *Mycotaxon* **128**: 83–91.
- IHLEN P. G. 2004. Taxonomy of the non-yellow species of *Rhizocarpon* (Rhizocarpaceae, lichenized Ascomycota) in the Nordic countries, with hyaline and muriform ascospores. *Mycol. Res.* **108**: 533–570.
- KELLER C. 2000. Die Wasserflechten der Teigitsch zwischen der Langmannsperre und dem Kraftwerk Amstein (Steiermark, Österreich). *Herzogia* **14**: 49–58.
- MCCARTHY P. M. 1994. Additional lichen records for Australia 19. *Austral. Lichen. Newslett.* **35**: 17.
- MEYER B. & PRINTZEN C. 2000. Proposal for a standardized nomenclature and characterization of insoluble lichen pigments. *Lichenologist* **32**: 571–583.
- MOTIEJŪNAITĖ J. & GROCHOWSKI P. 2014. Miscellaneous new records of lichens and lichenicolous fungi. *Herzogia* **27**(1): 193–198.
- ORANGE A. 1991. *Thelidium pluvium* (Verrucariales), a new lichenized species from north-west Europe. *Lichenologist* **23**: 99–106.
- ORANGE A. 2014. Two new or misunderstood species related to *Verrucaria praetermissa* (Verrucariaceae, lichenized Ascomycota). *Lichenologist* **46**(5): 605–615.
- ORANGE A., JAMES P. W. & WHITE F. J. 2001. *Microchemical Methods for the Identification of Lichens*. British Lichen Society, London.
- PAUKOV A. G., GAGARINA L. V. & FROLOV I. V. 2017. New and interesting lichen records from the Ural Mountains, Russia. *Folia Cryptog. Estonica* **54**: 25–30.
- SERVIT M. 1954. *Československé lišejníky celedi Verrucariaceae*. Nakladatelství Československé Akademie Věd, Praha.
- SMITH C. W., APTROOT A., COPPINS B. J., FLETCHER A., GILBERT O. L., JAMES P. W. & WOLSELEY P. A. (eds) 2009. *The Lichens of Great Britain and Ireland*. British Lichen Society, London.
- THÜS H. & NASCIBENE J. 2008. Contributions toward a new taxonomy of central European freshwater species of the lichen genus *Thelidium* (Verrucariales/Ascomycota). *Lichenologist* **40**: 499–521.
- THÜS H. & SCHULTZ M. 2009. Süßwasserflora von Mitteleuropa – Freshwater Flora of Central Europe. In: B. BÜDEL, G. GÄRTNER, L. KRIENITZ, H.-R. PREISIG & M. SCHAGERL (eds), *Fungi, Lichens* **1**: 1–223. Spektrum Akademischer Verlag, Heidelberg.
- THÜS H., APTROOT A. & SEAWARD M. R. D. 2014. Freshwater fungi and fungal-like organisms. In: E. B. G. JONES, K. D. HYDE & K.-L. PANG (eds), *Freshwater fungi*, pp. 335–358. Walter de Gruyter GmbH, Boston.
- URBANAVICHUS G. 2010. *A checklist of the lichen flora of Russia*. Nauka, St. Petersburg.
- WIRTH V. 1999. Neu- und Wiederfunde von Flechten und flechtenbewohnenden Pilzen in Deutschland. *Jahresh. Vereins Vaterl. Naturk. Württemberg* **155**: 227–236.