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Lichenicolous fungi from the Holarctic. Part III: New reports and a key to species on *Hypogymnia*

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ABSTRACT. – *Cercidospora parva* and *Feltgeniomyces mongolicus* are reported for the first time from North America, the latter is also first documented from the Arctic. *Micarea inquinans* is newly reported for Russia, and *Epithamnolia xanthoriae* is reported as new to European Russia. *Baeomyces* and *Dibaeis* are reported as new host genera for *Epithamnolia xanthoriae*, and *Dibaeis* for *Merismatium nigritellum*. A key to the species of lichenicolous fungi growing on *Hypogymnia* is provided.

KEYWORDS. – Biodiversity discovery, biogeography, floristics, lichen-dwelling fungi, United States of America.

INTRODUCTION

This paper continues the author's publications (Zhurbenko 2009a, b) on noteworthy finds of lichenicolous fungi from the Holarctic. It is based on collections from the American and Russian Arctic and supplements the panarctic checklist of lichenicolous fungi published by Kristinsson et al. (2010). In addition to providing new reports and range extensions, the first key to the lichenicolous fungi growing on species of *Hypogymnia* is provided.

MATERIALS AND METHODS

Microscopy was carried out, and photographs taken, using a Zeiss Axio Zoom.V16 microscope and a Zeiss Axio Imager.A1 microscope equipped with Nomarski differential interference contrast optics, fitted with an AxioCam MRc5 digital camera. Cross-sections of reproductive structures were prepared by hand with a razor blade and mounted in water, 10% potassium hydroxide (K), Lugol's iodine (I) directly or after a K pre-treatment (K/I), or phloxine. Measurements were taken from water mounts. The length, width and length/width ratio (L/W) of the conidia are given as: (min–){X−SD}–{X+SD}(–max), where "min" and "max" are the extreme values observed, X the arithmetic mean and SD the corresponding standard deviation. Voucher specimens are deposited in the mycological herbarium of the V. L. Komarov Botanical Institute in St. Petersburg, Russia (LE).

NEW REPORTS

***Cercidospora parva* Hafellner & Ihlen**

NOTES. – This fungus is characterized by immersed to semi-immersed perithecioid ascomata (0.2–0.3 mm in diameter) with a wall that is hyaline below and greenish above, branched and anastomosed paraphysoids, fissitunicate, cylindrical to elongate-clavate, 4–8-spored asci, and hyaline, 1-septate, ellipsoid, with the upper cell broader than the lower one, halonate ascospores, measuring 12–15(–16) × 4–5(–5) µm (Ihlen 1998). It grows on *Baeomyces* and was previously known from Asia (Russia; Zhurbenko & Santesson 1996; Zhurbenko 2009a, b) and Europe (Germany, Iceland, Norway, Scotland, Sweden;

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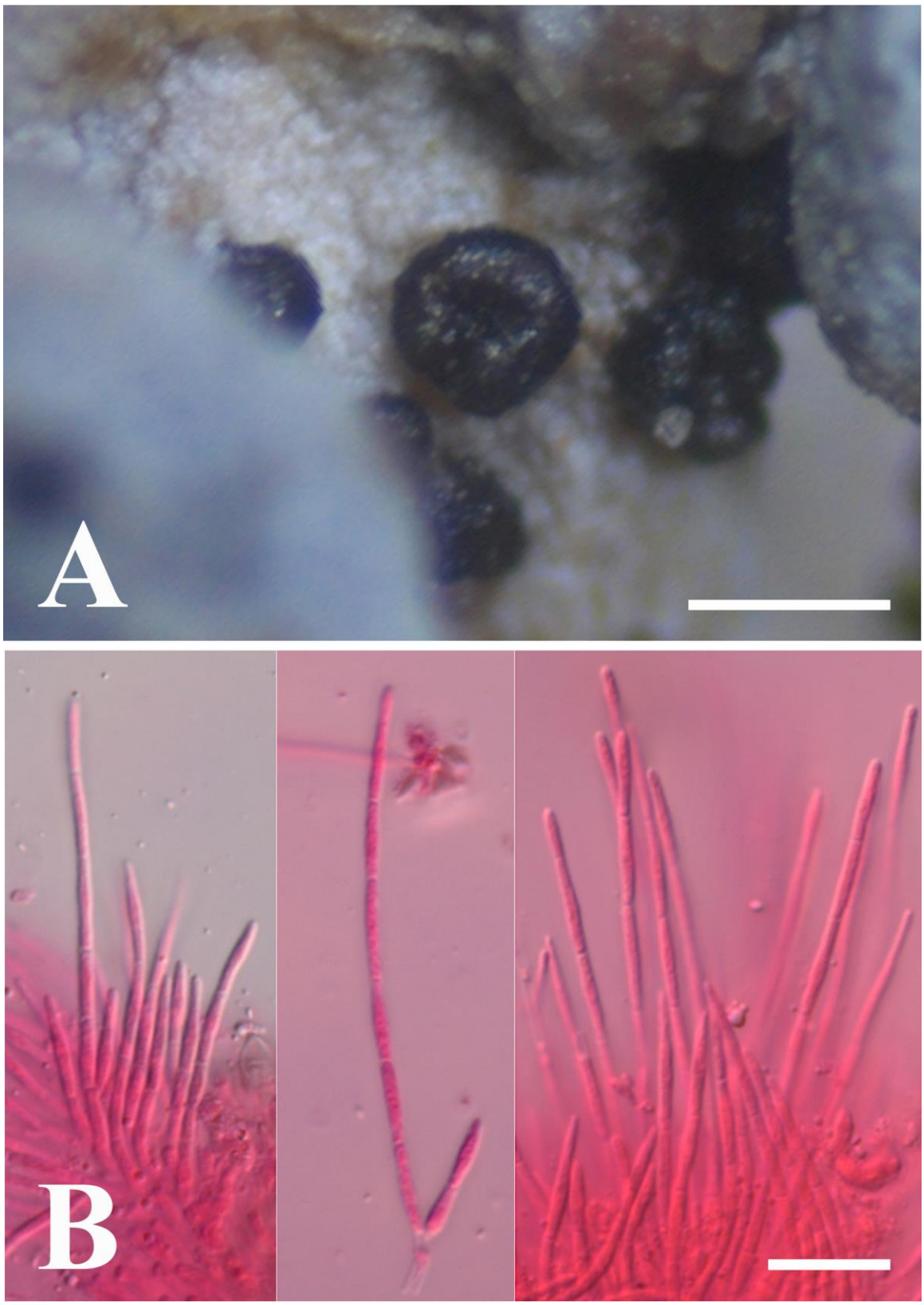

Figure 1. *Epithamnolia xanthoriae* growing on *Dibaeis baeomyces* (*Zhurbenko 0777)*. A, habitus of wet conidiomata. B, conidia and conidiogenous cells in phloxine. Scale bars: A = 200 µm, B = 10 µm.

Brackel 2010, 2014; Gilbert & Coppins 1992; Ihlen 1998; Santesson et al. 2004). It is here newly reported for the U.S.A. and North America.

Specimen examined. – **USA. ALASKA.** NORTHWEST ARCTIC BOROUGH: Kobuk Valley Wilderness, ca. 140 km E of Kotzebue, left bank of Kobuk River near its junction with Kavet Creek, 67°07′N, 159°03′W, elev. 40 m, *Betula-Juniperus-Rosa*-dwarf shrub-moss-lichen vegetation on sandy soil, 9.viii.2000, on *Baeomyces placophyllus* (thallus), *M.P. Zhurbenko 00182* (LE 310177).

***Epithamnolia xanthoriae* (Brackel) Diederich & Suija s. lat.**

FIGURE 1.

NOTES. – This species, in its broad sense, is characterized by superficial, brown, initially pycnidioid, later broadly cupuliform conidiomata 100–250 µm in diameter, occasionally branched conidiophores, composed of 1–3 elongate filiform cells, enteroblastic, phialidic, integrated, acropleurogenous conidiogenous cells, and hyaline, filiform, attenuated towards both ends, mostly straight, 0–5(–8)-septate, smooth-walled conidia, measuring (25–)40–84 × (1.8–)2–3(–4) µm (Brackel 2009, Suija et al. 2018). It is known from Austria, Belgium, France, Germany, Greenland, Iceland, Italy, Luxembourg, the Netherlands and Russia where it has been found on many different lichens (e.g., *Candelaria*, *Hypogymnia*, *Lecanora*, *Melanohalea*, *Ochrolechia*, *Parmelia*, *Phaeophyscia*, *Physcia*, *Platismatia*, *Polycauliona*, *Protoparmeliopsis*, *Pseudevernia*, *Punctelia*, *Rusavskia* and *Xanthoria*; Brackel 2009, 2014; Suija et al. 2018, Zhurbenko 2017). It was previously reported in Russia only from the Karachayevo-Circassian Republic and Krasnodar Territory (Zhurbenko 2017, Zhurbenko & Kobzeva 2014) and is here newly documented for the Nenets Autonomous Area (which is the first report from European Russia) and Krasnoyarsk Territory (which is only the second report from Asia). *Baeomyces* and *Dibaeis* are new host genera for this species.

Specimens examined. – **RUSSIA. KRASNOYARSK TERRITORY.** Putorana Plateau, Kapchuk Lake, Nikita-Yuryakh River mouth, 69°28′N, 91°02′E, *Salix* shrubs, 6.viii.1983, on *Baeomyces placophyllus* (apothecia, apothecial stipes), *M.P. Zhurbenko 83234* (LE 233757). **NENETS AUTONOMOUS AREA.** Bol'shezemel'skaya Tundra, vicinities of Khar'yaga oilfield, 67°11′07″N, 56°29′37″E, elev. 70 m, *Betula nana*-dwarf shrub-moss-lichen tundra, 25.vii.2007, on *Dibaeis baeomyces* (apothecia, apothecial stipes), *M.P. Zhurbenko 0777* (LE 310174).

***Feltgeniomyces mongolicus* Zhurb.**

FIGURE 2.

NOTES. – This fungus is characterized by more or less superficial, subglobose, stromatic, pycnidioid conidiomata, 40–95 µm in diameter, with wide, often splitted opening, sometimes eventually collapsed exciple (which makes the conidiomata look like sporodochia), conidiophores similar to stromatic cells, enteroblastic, terminal, discrete, ampulliform to obpyriform, sometimes percurrently proliferating, olivaceous brown conidiogenous cells, and olivaceous brown, solitary, subglobose, ellipsoid, oblong, narrowly obovate, occasionally cuneiform, reniform or irregular in shape, sometimes truncated at the base, aseptate, rough but not distinctly verruculose conidia. In the type material a distinct exciple was not observed apparently due to destruction in the later stages of development and the conidiomata were charactrized as sporodochial (Zhurbenko et al. 2019). Additionally, the specimen cited here differs from the protologue in having somewhat longer conidia, (6.7–)7.8–10.6(–13.0) × (4.2–)4.4–5.2(–5.9) µm, L/B = (1.4–)1.6–2.1(–2.9) (n = 50) versus (5.4–)6.3–8.1(–9.3) × (4.0–)4.3–5.1(–5.5) µm, L/B = (1.1–)1.3–1.7(–2.1). In some respects, *Feltgeniomyces mongolicus* morphologically resembles *Katherinomyces cetrariae* Khodos. found on species of *Cetraria* (the type host), *Flavocetraria*, *Lecidea* and *Rhizoplaca* (Darmostuk & Khodosovtsev 2019, Khodosovtsev et al. 2016, Zhurbenko et al. 2020). However, *K. cetrariae* can be distinguished by its holoblastic conidiogenesis and brown, not basally truncated, finally verruculose conidia (Khodosovtsev et al. 2016, Zhurbenko et al. 2019). This species was recently described from Mongolia where it was found on *Hypogymnia bitteri* (Zhurbenko et al. 2019) and previously known only from the type collection. This is the first report from the Arctic, U.S.A. and North America. *Hypogymnia subobscura* is also a new host species. Based on the author's extensive studies of lichenicolous fungi, it appears that although many foliose Parmeliaceae are commonly infected with such fungi, the occurrence of lichenicolous fungi on *Hypogymnia* is comparatively rare. Therefore, to draw the attention to them, the first comprehensive identification key to the species reported from this host genus is provided here (see the Appendix).

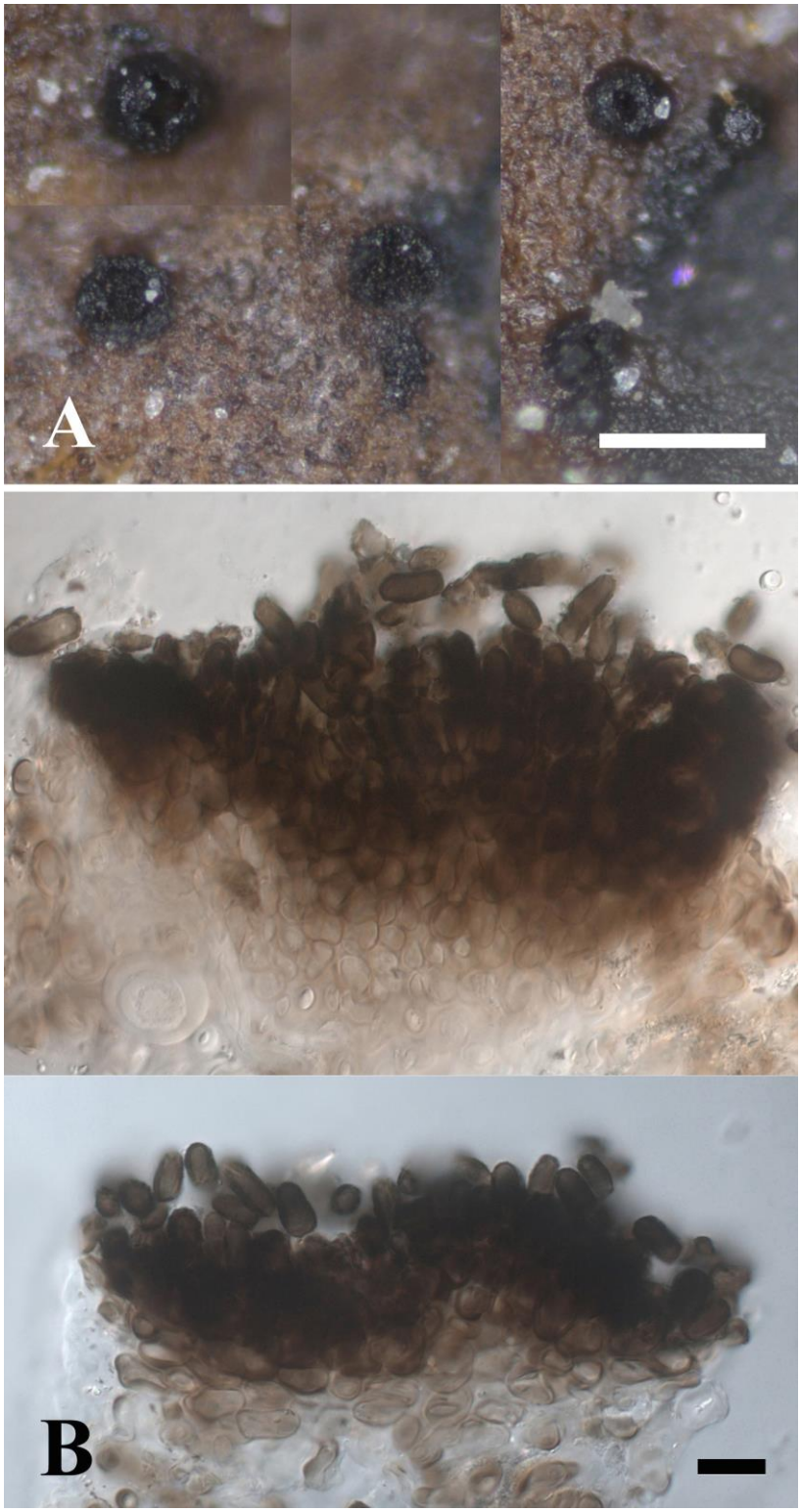

Figure 2. *Feltgeniomyces mongolicus* growing on *Hypogymnia subobscura* (*Zhurbenko 01624*). A, habitus of dry conidiomata. B, conidiomata with collapsed exciple in cross-section in water. Scale bars: A = 100 µm, B = 10 µm.

Specimen examined. – **USA. ALASKA.** NORTH SLOPE BOROUGH: Brooks Range, upper stream of Atigun River near mile 248 Dalton Highway, 68°07′N, 149°28′W, elev. 1400 m, dwarf shrub-moss-lichen tundra, 31.vii.2001, on *Hypogymnia subobscura* (thallus), *M.P. Zhurbenko 01624* (LE 310180).

***Merismatium nigritellum* (Nyl.) Vouaux**

NOTES. – This fungus is characterized by mostly superficial, perithecioid ascomata 150–300 µm in diameter, branched periphysoids, I+ red hymenial gel, subcylindrical to narrowly clavate, thick-walled, 8-spored asci, and brown, ellipsoid to broadly ovoid, (sub)muriform ascospores, measuring (14–)15–24.5(–32) × (6.5–)8–12(–15) µm (Triebel 1989). It has been reported on a wide range of distantly related lichen host genera from Asia, Europe and North America (see for instance: Brackel 2014, Zhurbenko 2009a) and possibly also from South America due to an uncertain report of Etayo and Sancho (2008). *Dibaeis* is a new host genus.

Specimen examined. – **RUSSIA. NENETS AUTONOMOUS AREA.** Bol'shezemel'skaya Tundra, vicinities of Khar'yaga oilfield, 67°08′22″N, 56°47′06″E, elev. 70 m, *Betula nana*-dwarf shrub-moss-lichen tundra, 22.vii.2007, on *Dibaeis baeomyces* (apothecia), *M.P. Zhurbenko 0779* (LE 310179).

***Micarea inquinans* (Tul.) Coppins**

NOTES. – This fungus is characterized by black, aggregated apothecia 0.2–0.6 mm in diameter, with a usually indistinct exciple, brown hypothecium, greenish black epihymenium, hyaline to greenish, K/I+ blue hymenium, branched, apically swollen paraphyses, clavate to broadly clavate, 6–8-spored asci with K/I+ deep blue tholus and fuzzy outer coat, and hyaline, ellipsoid, aseptate, smooth-walled ascospores, measuring 7–12 × 5–6 µm (Ihlen 1998). It is currently known from Asia (Zhurbenko et al. 2015), Europe (Brackel 2014) and North America (Fryday 2017) where it grows on *Dibaeis* and *Baeomyces*. It is here newly reported from Russia, and for the second time from North America, where it has been recently documented from Alaska (Fryday 2017).

Specimens examined. – **RUSSIA. NENETS AUTONOMOUS AREA.** Bol'shezemel'skaya Tundra, vicinities of Khar'yaga oilfield, 67°12′N, 56°41′E, elev. 70 m, *Betula nana*-dwarf shrub-moss-lichen tundra, 21.vii.2007, on *Dibaeis baeomyces* (thallus), *M.P. Zhurbenko 0780* (LE 310173). **USA. ALASKA.** DENALI BOROUGH: Denali Highway near Denali National Park, foot of unnamed mountain, 64°04′N, 147°27′W, elev. 850 m, *Betula-Salix*-dwarf shrub-moss-lichen mountain tundra, 3.ix.2000, on *Dibaeis baeomyces* (thallus), *M.P. Zhurbenko 00274c* (LE 310175).

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APPENDIX – KEY TO THE LICHENICOLOUS FUNGI GROWING ON *HYPOGYMNIA*

This key has been compiled from the literature cited under each species below under "Lit.". References to taxonomic descriptions of the species are given in bold font, references to the occurrence of the species on *Hypogymnia* are given in regular font. The names of species that are host specific to *Hypogymnia* are given in bold. The sizes of diaspores are rounded to the nearest 0.5 µm. The facultatively lichenicolous fungus *Acremonium persicinum* (Nicot) W. Gams and an asexual stage of *Trichonectria anisospora* (Lowen) van den Boom & Diederich described as *Acremonium pedatum* Lowen, which are both known only from cultures isolated from *Hypogymnia* species (Diederich & Sérusiaux 2000, Lowen 1989) are not included in the key. A report of *Biatoropsis usnearum* Räsänen from *H. physodes* (Obermayer 1993), which is otherwise a well-known species confined to *Usnea*, is evidently based on a misidentification and the species is not included here. A report of *Echinothecium reticulatum* Zopf from *H. tubulosa* (Halıcı et al. 2007), which otherwise typically grows on *Parmelia*, most probably refers to the morphologically similar *E. hypogymniae* Zhurb., the latter of which is included in the key.

1. Spores produced in asci 2

2. Ascomata entirely composed of agglomerations of globose yeast-like cells, dark brown to blackish; asci developing between the cells, (4–)8-spored; ascospores initially hyaline, dark brown when old, ellipsoid, 1-septate, 9–12 × 4.5–6 µm. Lit.: **Ertz et al. (2014),** Brackel (2014) ..... *Lichenostigma maureri* Hafellner

2. Ascomata not composed of agglomerations of globose yeast-like cells.....3

3. Ascomata cleistohymenial, subglobose, immersed to finally slightly protruding, opening by a wide pore surrounded by radially fissured margin of the exciple. Lit.: **Zhurbenko & Zheludeva (2015)**..... '***Sphaeropezia***' **sp.**

3. Ascomata not cleistohymenial.....4

4. Ascomata stromatic, multilocular, superficial, with a labyrinthiform or lirellate ornamentation; paraphyses branched and anastomosing; asci (5–)8-spored; ascospores hyaline, 3-septate, (12–)13–15.5(–17) × (3–)3.5–4(–4.5) µm. Lit.: **Zhurbenko et al. (2008)**..... ***Plectocarpon hypogymniae* Zhurb. & Diederich**

4. Ascomata not stromatic and multilocular.....5

5. Ascomata catathecia, without ostiolar setae; asci 8-spored; ascospores hyaline, 1-septate, with two pairs of setulae, 14–16 × 3–4 µm. Lit.: **Aptroot et al. (1997)**..... ***Lichenopeltella hypogymniae* Diederich**

5. Ascomata not catathecia 6

6. Ascomata apothecia 7

7. Apothecia arising singly, not associated with galls, with black, strongly convex disc; ascospores olivaceous to brown, 1-septate, somewhat macrocephalic, verrucose, (10.5–)12–14.5(–16.5) × (4.5–)5.5–6.5(–7) µm. Lit.: **Diederich (1990)** ..... ***Abrothallus prodiens* (Harm.) Diederich & Hafellner**

7. Apothecia aggregated on galls, with brownish black, flat to strongly convex disc; ascospores hyaline, aseptate, not macrocephalic, smooth 8

8. Apothecia up to 0.5 mm in diameter, with flat to slightly convex disc; ascospores ellipsoid to fusiform, with rather acute ends, (11–)14–18.5(–23) × (5–)5.5–6(–6.5) µm. Lit.: Diederich (2003), Hafellner & Türk (1995), **Triebel & Rambold (1988)** ..... *Nesolechia oxyspora* (Tul.) A. Massal.

8. Apothecia up to 2 mm in diameter, with strongly convex disc; ascospores ovoid to subglobose, 9–11(–12) × (4–)5–7(–8) µm. Lit.: **Triebel & Rambold (1988)** ..... ***Phacopsis cephalodioides* (Nyl.) Triebel & Rambold**

6. Ascomata perithecia 9

9. Perithecia bright orange; asci 8-spored; ascospores hyaline, 1-septate, 14.5–17 × 4–6.5 µm. Lit.: **Lowen (1989)** ..... ***Trichonectria anisospora* (Lowen) van den Boom & Diederich**

9. Perithecia black 10

10. Ascospores hyaline, 1-septate, (9.5–)10.5–12.5(–13.5) × (4–)4.5–5.5(–6) µm; vegetative hyphae forming distinct dark reticulate net on the host surface; perithecia with hyphal outgrowths; asci 8-spored. Lit.: **Zhurbenko et al. (2019)** ..... ***Echinothecium hypogymniae* Zhurb.**

10. Ascospores brown or grey 11

11. Perithecia with hyphal outgrowths; paraphyses present; asci 8-spored; ascospores brown, 0(–1)-septate, 17–29 × 9–14 µm. Lit.: Etayo (2002), **Matzer & Hafellner (1990)** ..... *Roselliniella atlantica* Matzer & Hafellner

11. Perithecia without hyphal outgrowths; paraphyses absent; asci multispored; ascospores grey, 1-septate, 4–6.5 × 1.5–2 µm. Lit.: **Etayo & Sancho (2008)** ..... *Muellerella antarctica* Etayo

1. Spores not produced in asci 12

12. Spores produced on basidia, hyphae with clamp connections 13

13. Mature basidia consist of a lower ellipsoid, thick-walled probasidium and an upper cylindrical, thin-walled, 3-septate meiosporangium with four subulate epibasidia up to 8.5 µm long, refractive at the apex; galls constricted at the base. Lit.: **Diederich (1996)** ..... ***Cyphobasidium hypogymniicola* (Diederich & Ahti) Millanes, Diederich & Wedin**

13. Mature basidia 2-celled; probasidia thin-walled; epibasidia cylindrical, at least 30 µm long, not refractive at the apex; galls not constricted at the base or absent 14

14. Basidia with a longitudinal or slightly oblique septum, basidiospores 3.5–6 µm wide, basidiomata up to 0.5 mm in diameter, galls absent, on *Hypogymnia pseudobitteriana*. Lit.: **Diederich (1996)** ..... ***Tremella papuana* Diederich**

14. Basidia with a longitudinal, oblique or transverse septum; basidiospores wider; galls up to 1.8 mm in diameter; on different species of *Hypogymnia* 15

15. Basidiospores 7–10 × 5.5–7 µm; galls pale brown, orange or pinkish; on *Hypogymnia physodes*. Lit.: **Diederich (1996)** ..... ***Tremella hypogymniae* Diederich & M.S. Christ.**

15. Basidiospores 6–8.5 × 5–8 µm, galls pale to dark brown or blackish, on *Hypogymnia tubulosa*. Lit.: **Diederich et al. (2020)** ..... ***Tremella tubulosae* Diederich, Coppins, J.C. Zamora, Millanes & Wedin**

12. Spores produced on conidiogenous cells, hyphae without clamp connections 16

16. Conidiomata true pycnidia, conidia aseptate 17

17. Conidia brown 18

18. Pycnidia mainly 100–175 µm in diameter, conidia mainly 5–7 × 3.5–5 µm. Lit.: Etayo & Sancho (2008), **Hawksworth (1977)** ..... *Lichenoconium cargillianum* (Linds.) D. Hawksw.

18. Pycnidia and conidia much smaller 19

19. Pycnidia mainly 30–50 µm in diameter, conidia mainly 2–3.5 µm in diameter. Lit.: **Hawksworth (1977)** ..... *Lichenoconium erodens* M.S. Christ. & D. Hawksw.

19. Pycnidia mainly 50–80 µm in diameter, conidia mainly 3–4 µm in diameter. Lit.: **Hawksworth (1977)** ..... *Lichenoconium usneae* (Anzi) D. Hawksw.

17. Conidia hyaline 20

20. Conidia elongate ellipsoid, often slightly curved. Lit.: **Diederich et al. (2012)** ..... *Briancoppinsia cytospora* (Vouaux) Diederich, Ertz, Lawrey & van den Boom

20. Conidia Y-shaped, consisting of main body and two divergent arms 21

21. Conidial arms with bulbous bases and very narrow apices. Lit.: Diederich & Sérusiaux (2000), **Gierl & Kalb (1993)** ..... *Spirographa ciliata* (Kalb) Flakus, Etayo & Miadlikowska

21. Conidial arms without bulbous bases, gradually narrowed at the apex. Lit.: Diederich & Sérusiaux (2000), **Hawksworth (1976)** ..... *Spirographa lichenicola* (D. Hawksw. & B. Sutton) Flakus et al.

16. Conidiomata not true pycnidia, conidia aseptate to multicelled 22

22. Conidiomata initially pycnidioid, later sometimes broadly cupuliform 23

22. Conidiomata never pycnidioid 24

23. Conidia hyaline, filiform, 0–5(–8)-septate, 25–84 × 2–4 µm. Lit.: **Brackel (2009)**, **Suija et al. (2018)** ..... *Epithamnolia xanthoriae* (Brackel) Diederich & Suija s. lat.

23. Conidia olivaceous brown, subglobose, ellipsoid, oblong, narrowly obovate, occasionally cuneiform, reniform or irregular in shape, aseptate, (5.5–)6.5–9.5(–13) × (4–)4.5–5(–6) µm. Lit.: **Zhurbenko et al. (2019)** ..... ***Feltgeniomyces mongolicus* Zhurb.**

24. Conidiomata entirely composed of agglomerations of globose yeast-like cells; conidia multicellular, subspherical to ellipsoid, brown 25

25. Conidia mainly 10–15 × 8.5–11 µm, in optical section mainly composed of 6–10 cells. Lit.: **Ertz et al. (2014)**, Zhurbenko (2009a) ..... *Lichenostigma alpinum* (R. Sant., Alstrup & D. Hawksw.) Ertz & Diederich

25. Conidia mainly 14–23 × 10–16 µm, in optical section mainly composed of 10–21 cells. Lit.: **Ertz et al. (2014)**, Brackel (2014) ..... *Lichenostigma maureri* Hafellner

24. Conidiomata not composed of agglomerations of globose yeast-like cells 26

26. Conidiophores arising in the tissues of the host, conidia brown 27

27. Conidia 2-celled, 5–8(–9) × 4–6 µm. Lit.: Halici & Aksoy (2009), **Hawksworth (1979)** ..... *Intralichen christiansenii* (D. Hawksw.) D. Hawksw. & M.S. Cole

27. Conidia 3- to multi-celled, mainly 18–25 × 6–12 µm. Lit.: Brackel (2009), **Hawksworth (1979)** ..... *Intralichen lichenicola* (M.S.Christ. & D.Hawksw.) D.Hawksw. & M.S.Cole

26. Conidiophores arising on the surface of the host, conidia hyaline or pigmented 28

28. Conidiomata sporodochial 29

29. Basal stromatic tissue and exciple-like structures absent; sporodochia loose, grey or pale brown; conidiogenous cells monoblastic; conidia (0–)1(–2)-septate, grey to brown. Lit.: **Etayo & Diederich (1996)**, Kocourkova & Knudsen (2009) ....*Cladophialophora parmeliae* (Etayo & Diederich) Diederich & Unter.

29. Basal stromatic tissue and exciple-like structures present; sporodochia compact, dark brown to black; conidiogenous cells enteroblastic; conidia 1-septate, brown. Lit.: **Atienza (2002)** ....***Minutoexcipula calatayudii* V. Atienza**

28. Conidiomata not sporodochial 30

30. Conidia hyaline, aseptate, 4–5.5(–6) × 1.5–2.5(–3) µm; facultatively lichenicolous. Lit.: Diederich & Sérusiaux (2000), **Hawksworth (1979)**, Kukwa & Flakus (2009)..... .....*Acremonium antarcticum* (Speg.) D. Hawksw.

30. Conidia brown, septate 31

31. Conidia arising in strongly branched chains, 0–39-septate, up to 162 µm long; facultatively lichenicolous. Lit.: Brackel (2009), **Heuchert et al. (2018)**..... *Taeniolina scripta* (P. Karst) P.M. Kirk

31. Conidia solitary, 1(–2)-septate, (7.5–)8.5–10.5(–11) × (5–)5.5–7(–8.5) µm. Lit.: **Brackel & Markovskaja (2009)** ....*Endophragmiella franconica* Brackel & Markovskaja