

New and interesting lichenicolous hypocrealean fungi from the Northern Hemisphere

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Two lichenicolous fungi of the family *Bionectriaceae* (*Hypocreales*) are described: *Paranectria alstrupii* (on *Psoroma* from Greenland) and *Pronectria lecideicola* (on *Lecidea* from Svalbard). *Neobarya peltigerae* is recorded as new for North America, *Pronectria walkerorum* and *Xenonectriella lutescens* for Russia and Asia. A revised description of the latter species is also provided, and *Peltigera* is reported as its new host. A key to all hypocrealean fungi growing on *Peltigera* is included.

Keywords: *Neobarya*, *Paranectria*, *Pronectria*, *Xenonectriella*, taxonomy, distribution.

Not less than 77 of over one thousand species of *Hypocreales* obligately grow on lichens. Most of them belong to *Bionectriaceae*, and especially to the genus *Pronectria*. The majority of the species (70 %) are known from one host lichen genus; though some like *Paranectria oropensis* and *Trichonectria hirta* have diverse host spectra. The aim of this paper is to describe two new lichenicolous hypocrealean species, and to provide additional reports on another three rare species.

Materials and Methods

The material was examined by standard microscopic techniques using LOMO microscopes MBS-1, Mikromed-2 and Zeiss microscope Axio Imager A1 equipped with Nomarski differential interference contrast optics. Photographs were taken by a Nikon Coolpix 5000 camera and an Axio Imager microscope. Microscopical measurements were made in water. Colour reactions were examined in lactic acid, 10% KOH (K), 1% Lugol's iodine solution, directly (I) and after a KOH pre-treatment (K/I). The estimated values of the size of asci and ascospores and length/breadth ratio (Q) of the ascospores have been given as follows: (minimum) mean \pm standard deviation (max-

imum). Sizes of asci were rounded to the nearest 1 μm , those of the ascospores to the nearest 0.5 μm . The difference in ascospore length between *Pronectria lecideicola* and *P. walkerorum* was tested by an unpaired t-test with Welch correction. Terms for ascospore shapes and colors follow Stearn (1992: 539) and Petersen (1996). Classification of the phylum *Ascomycota* is adopted from Lumbsch & Huhndorf (2007). Examined specimens are deposited in LE or the private herbarium of P. Diederich (herb. Diederich).

Taxonomy

Neobarya peltigerae Lowen, Boqueras & Gomez-Bolea in Candoussau *et al.*, *Sydowia* 59(2): 206 (2007)

The fungus was previously known from two finds in Europe (Candoussau *et al.* 2007). New to North America.

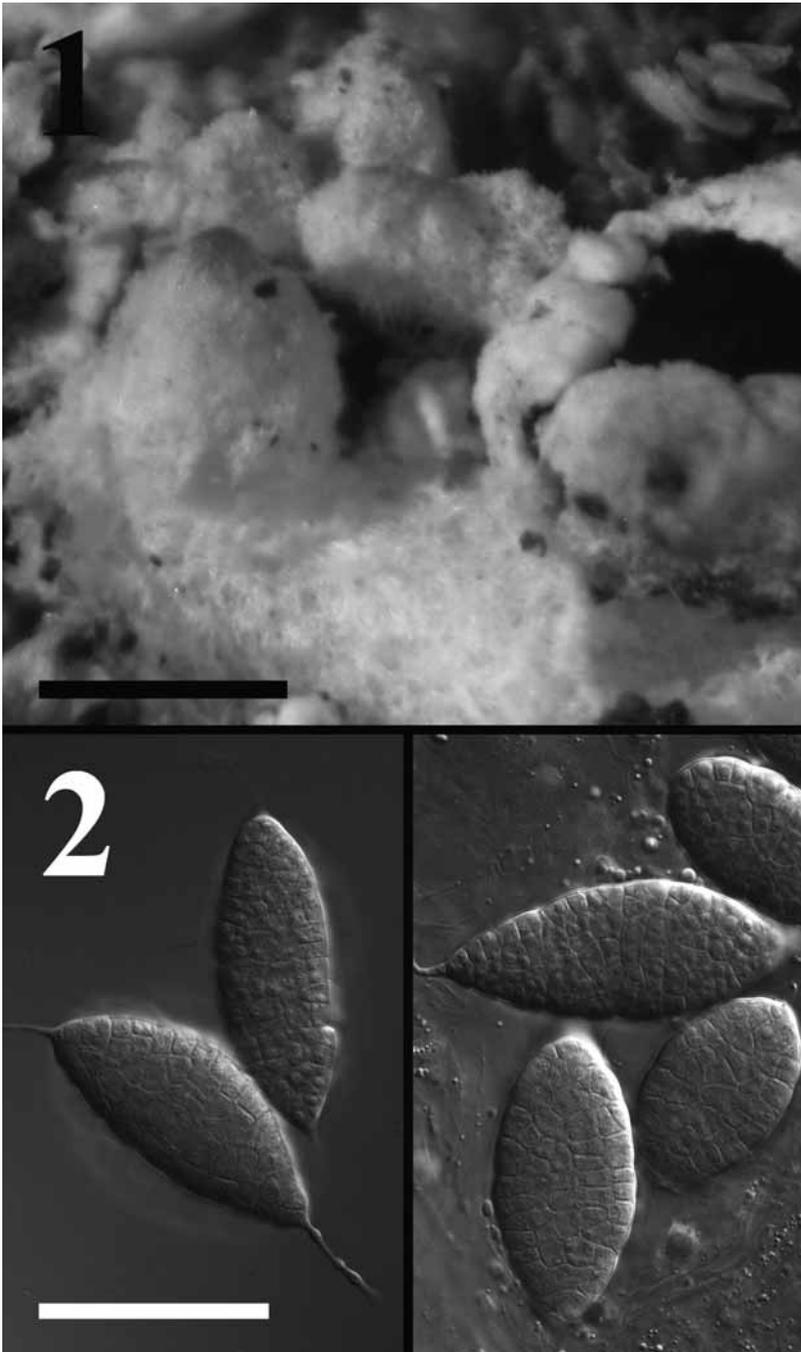
Material examined. USA, South-Central Alaska, Kenai Peninsula near Seward, by the road to the Chugach National Forest and Exit Glacier, 60° 10' N, 149° 27' W, alt. 30 m, *Picea sitchensis* dominated forest, on thallus of *Peltigera* sp., 1 Sep 2000, M. Zhurbenko 00297 (herb. Diederich).

Paranectria alstrupii Zhurb., *sp. nov.* Figs. 1, 2.
Mycobank no: MB 512230

Fungus lichenicola in thallis lichenum generis *Psoromatis* crescit. Similis *Paranectriae superbae*, sed ab ea imprimis differt ascosporis majoribus et hospite diverso.

Holotypus. GREENLAND, SW of Narssaq, Tugtugtoooq Is., Sildefjord, 3 km SW of Blue Moon Lake, 60° 51' 28" N, 46° 25' 10" W, alt. 15 m, coastal hill with *Betula nana*-lichen-moss tundra, on thallus of *Psoroma hypnorum*, 30 Jul 2005, M. Zhurbenko 05284 (LE 232839).

Perithecia superficial, often sitting on a well-developed cottony white subiculum to 1 mm thick, dispersed or more often aggregated in groups of up to 15 and infrequently fused; ovate, broadly ovate to broadly pyriform in longitudinal section, constricted at the base, 400–750 μm high and 250–600 μm wide, collapsing laterally; ostiole distinct, sometimes with a small non-setose papilla 50–70 μm wide; orange-pink throughout, coloration appearing pale except in the ostiolar area due to a dense white tomentum which completely covers the perithecia; tomentum and subiculum composed of hyaline, intertwined, sparsely branched and septate hyphae about 3 μm wide. Peridium about 50 μm thick throughout, in cross section composed of two layers: inner layer 5–10 μm thick, pale yellow-brown, of thin-walled, elongate cells without visible lumina; outer layer ca 40 μm thick, colourless, of angular-elongate cells with walls 1–3 μm thick



Figs. 1, 2. – *Paranectria alstrupii* (holotype): 1. Perithecia and subiculum, bar = 0.5 mm; 2. Ascospores, bar = 50 µm.

and lumina $3\text{--}20 \times 2\text{--}6 \mu\text{m}$; peridium and centrum slightly bleaching in K, not changing colour in lactic acid and iodine. Hamathecium of numerous straight, filiform ostiolar filaments $1\text{--}2 \mu\text{m}$ wide. Ascii unitunicate, (sub)cylindrical, the wall apically not thickened and without a distinct apical apparatus, ca $140\text{--}220 \times 25\text{--}50 \mu\text{m}$, 4-spored, I-, K/I-; asci with healthy ascospores often intermingled with numerous poorly developed asci of irregular form with many orange-yellow lipid guttules. Ascospores elliptic to narrowly elliptic, occasionally broadly elliptic, with acute to attenuated or occasionally rounded ends, both ends with straight, flexible, non-septate cauda $10\text{--}40 \times 0.5\text{--}(1) \mu\text{m}$, which can disappear in overmature ascospores, first submuriform then muriform with $3\text{--}6$ longisepta and $5\text{--}20$ transsepta, when old often with bulging marginal cells, wall smooth, at first colourless, then pale salmon to yellow brown, guttulate, $(45\text{--}) 54\text{--}75\text{--}(92) \times (17\text{--}) 23.5\text{--}32.5\text{--}(40) \mu\text{m}$, $Q = (1.4\text{--}) 2.0\text{--}2.7\text{--}(3.3)$ ($n = 45$; only mature spores measured, excluding cauda), diagonally uniseriate in the asci. Anamorph not found.

Etymology. Dedicated to Vagn Alstrup, the foremost explorer of the lichenicolous fungi of Greenland.

Matrix and biology. In the type collection the fungus grows on squamules, sometimes contiguous to the thalline margins of apothecia, of strongly damaged *Psoroma hypnorum*. In the collection the host is also heavily infected by *Arthonia* and *Sphaerellothecium* species, so it is unclear whether *Paranectria alstrupii* is a pathogen or opportunist saprobe.

Distribution. Known from southern Greenland within the tundra zone of the Arctic.

Discussion. Due to its pallid, tomentose ascomata not reacting in K or lactic acid, the characteristic bicaudate ascospores and the lichenicolous habit the new species clearly belongs to *Paranectria*, *Bionectriaceae* (Rossmann *et al.* 1999). It slightly modifies the generic concept given in Rossmann *et al.* (1999) in having a peridium thicker than $30 \mu\text{m}$. The genus *Paranectria* has hitherto included three lichenicolous species: *P. affinis*, *P. oropensis*, and *P. superba*. In the tomentose perithecia, muriform ascospores, and 4-spored asci, *Paranectria alstrupii* is most similar to *P. superba* (Hawksworth 1982). However, it clearly differs from all other known species of the genus in the at least twice bigger ascospores.

Paul Diederich (pers. comm.) informed me that he collected a similar *Paranectria* species in Papua New Guinea: Simbu Province, Mount Wilhelm, Pindaunde valley, along track to the summit, $5^\circ 47'$ S, $145^\circ 3'$ E, alt. 4200 m, on *Stereocaulon* sp. over granitic rocks and soil, 7 Aug 1992, *P. Diederich 11213* (herb. Diederich). Perithecia in that specimen are $0.5\text{--}0.7$ mm diam and ascospores $41\text{--}72 \times 21\text{--}31 \mu\text{m}$.

***Pronectria lecideicola* Zhurb., sp. nov.** – Figs. 3, 4.

MycoBank no: MB 512232

Fungus lichenicola in thallis lichenum generis *Lecideae* crescit. Similis *Pronectriae walkeris*, sed ab ea imprimis differt ascosporis longioribus et hospite diverso.

Holotypus. SVALBARD, North-East Land, Murchison fjord, NW coast of Nord Bay, 80° 02' 57" N, 18° 54' 29" E, alt. 30 m, nival vegetation, on thallus of *Lecidea ramulosa* growing on mosses, 19 Aug 2007, N. Matveeva (LE 232878).

Perithecia entirely pale to medium coral-orange, broadly elliptic, ovate or rounded in longitudinal section, 175–250 µm tall, 150–200 µm wide, sometimes with a papilla to 125 µm diam and an ostiole to 40 µm diam, wall smooth, without hairs, immersed in the host thallus with only the ostiolar area exposed to occasionally almost sessile, dispersed or occasionally contiguous to fused by a few. Peridium orange-yellow throughout, 30–50 µm thick, in cross section composed of radially compressed elongate cells, K-, not changing colour with lactic acid. Hamathecium of numerous filiform ostiolar filaments 1–2 µm diam. Asci unitunicate, cylindrical to subcylindrical, apex truncated, wall not thickened, without apical apparatus, (80–) 87–103 (–105) × (9–) 10–12 (–13) µm ($n = 10$), (6–) 8-spored, I-, K/I-. Ascospores narrowly elliptic to elliptic, occasionally very narrowly elliptic or exceptionally circular, ends more or less rounded to acute, (0–) 1-transseptate, not constricted at the septa, (9–) 15–19 (–21) × (4–) 5.5–7.5 (–9) µm, $Q = (1.0–) 2.2–3.3 (–4.6)$ ($n = 135$), colourless, conspicuously guttulate, wall granulate, without halo, diagonally uniseriate to partly biseriate in an ascus. Anamorph not observed.

Etymology. Dwelling on *Lecidea*.

Matrix and biology. The fungus grows in healthy-looking verrucae of *Lecidea ramulosa*, and hence is regarded as a commensal.

Distribution. Known only from the type locality (northernmost part of Svalbard) in the polar desert zone of the Arctic.

Discussion. *Pronectria lecideicola* is the first species of the genus found growing on a member of *Lecideaceae* (*Lecanoromycetidae*, *Lecanoromycetes*). The new species is close to *P. walkerorum* and *P. verrucariae* (Rossman *et al.* 1999, Zhurbenko *et al.* 2005). However, the former species has somewhat shorter ascospores of (8–) 12–17 (–20) × (4–) 5–7.5 (–10) µm, $Q = (0.9–) 1.7–2.9 (–5.0)$ ($n = 218$; measurements from LE 210371, LE 210391, LE 210381, LE 232888, LE 232898 and the specimens mentioned below). An unpaired t-test with Welch correction showed that the difference between means of their ascospore length is statistically extremely

significant (Welch's approximate $t = 11.8$ with 319 degrees of freedom). Additionally, *P. walkerorum* grows on *Ochrolechia* or *Ochrolechia*-like sterile terricolous lichens from another subclass (*Ostropomycetidae*) of the *Lecanoromycetes*. *Pronectria verrucariae* is separated from *P. lecideicola* by 2–4-spored asci, occasionally pale colored ascospores, often with one pointed end, and different hosts (*Verrucaria* species, *Eurotiomycetes*).

Pronectria walkerorum Zhurb. in Zhurbenko *et al.*, *Mycotaxon* 92: 206 (2005)

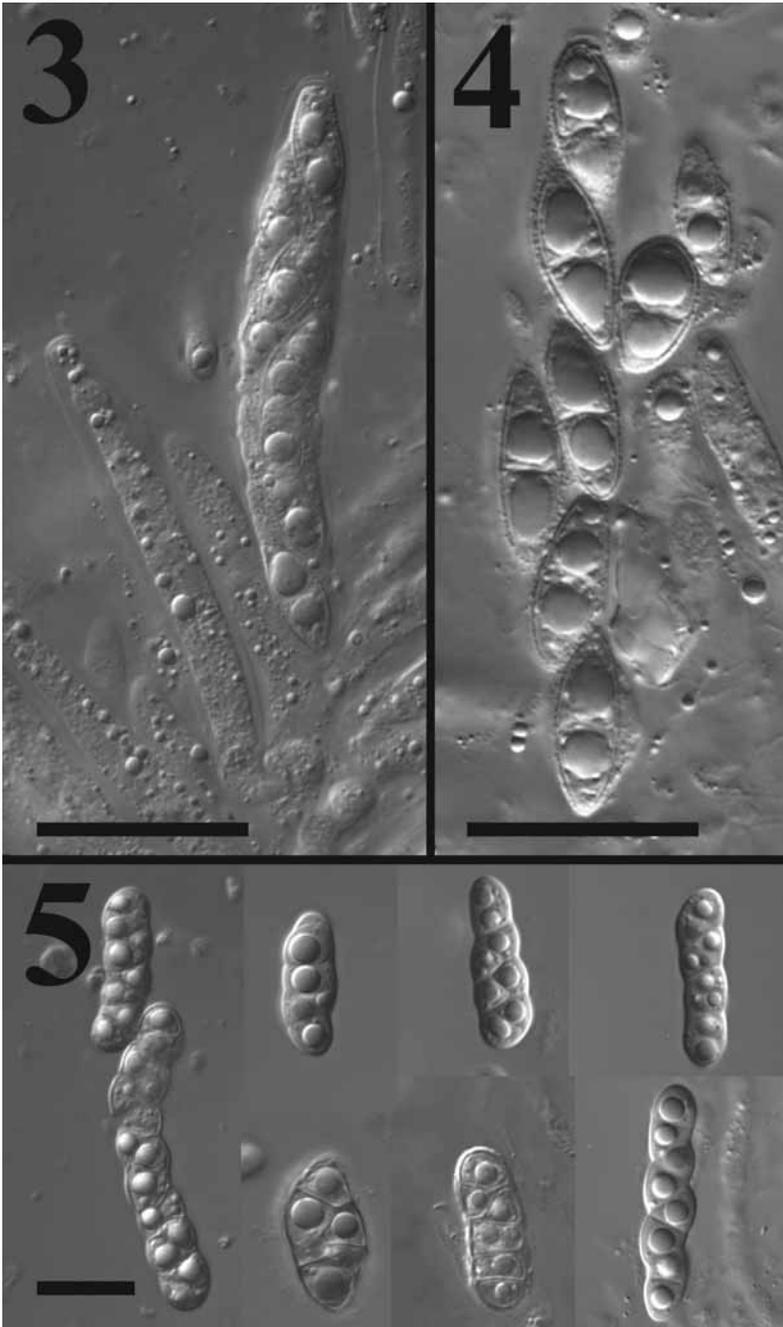
Previously known from Alaska, Canadian Arctic and Svalbard on *Ochrolechia* species (Zhurbenko *et al.* 2005), this fungus is newly recorded for Russia and Asia.

Material examined (all on thalli of *Ochrolechia* sp. or sterile *Ochrolechia*-like lichens on soil). CANADA, Canadian Arctic Archipelago, Victoria Island, Tuktu River, 70° 46' N, 109° 09' W, alt. 150 m, 1999, *D. Walker* (LE 232538). – RUSSIA, Severnaya Zemlya Archipelago, Bol'shevik Island, 5 km SSW of the Bazovaya River mouth, 79° 04' N, 102° 45' E, alt. 20 m, *Dryas-Salix polaris*-lichen-bryophyte community, 17 Jul 1996, *M. Zhurbenko* 96870 (LE 232665). – Yakutiya, Lena River delta, 30 km NW of Krest-Tumsa Cape, 72° 35' N, 126° 18' E, alt. 50 m, tundra, 30 Jul 1998, *M. Zhurbenko* 98244 (LE 232175); same delta, 3 km E of Krest-Tumsa Cape, 72° 22' N, 126° 42' E, alt. 50 m, *Dryas* tundra, 4 Aug 1998, *M. Zhurbenko* 98243 (LE 232191); same delta, Novyi Chai-Tumus, 72° 20' N, 125° 40' E, alt. 20 m, dwarf shrub-lichen-moss tundra, 6 Aug 1998, *M. Zhurbenko* 98242 (LE 232199). – Wrangel' Island, Neizvestnaya River basin, Kholodnyi Brook, 71° 16' N, 179° 41' W, alt. 90 m, *Salix glauca* community, 1995, S. Kholod (LE 232645).

Xenonectriella lutescens (Arnold) Weese in Weese, *Sitzungsber. Kaiserl. Akad. Wiss. Wien, Math.-Naturwiss. Kl., Abt. 1* 128: 749 (1919)

This fungus is most comprehensively described and illustrated in Rossman *et al.* (1999: 168, 169, Plate 36), Keissler (1930: 291, 292, Fig. 60) and Diederich (2003: 74, 75). However, there are essential discrepancies between these sources. In Rossman *et al.* (*op. cit.*) the ascospores are said to be muriform and 2 per ascus, while they are, at least initially, 1-septate and 8 per ascus, which is consistent with Plate 36 in the same paper and data of Keissler (*op. cit.*) and Diederich (*op. cit.*). Reports on asci and ascospore sizes and reactions of peridium with K and lactic acid also differ in the cited papers. Due to these reasons we consider worthwhile to describe and depict (Fig. 5) new material of this rare fungus with unusual ascospore ontogeny.

Perithecia intensively red throughout, ovate to pyriform in longitudinal section, with truncate apex and sometimes with a small papilla, ostiolate, 200–300 μm tall, 150–200 μm wide, immersed in lichen thalli with only the ostiolar areas visible as red spots, dis-



Figs. 3, 4. – *Pronectria lecideicola* (holotype): **3.** Asci, bar = 20 μm ; **4.** Ascospores, bar = 20 μm ; **5.** *Xenonectriella lutescens* (Zhurbenko 05131): fused ascospores, bar = 15 μm .

persed to contiguous. Peridium 40–50 μm thick near the ostiole, 20–35 μm thick below, in surface view paraplectenchymatous, formed of angular rounded cells 5–9 μm across, in cross section composed of two layers; inner layer *ca* 5 μm thick, colourless, of more or less radially compressed cells, outer layer orange red throughout, of parallel, elongate cells with thicker walls of 1–2 μm thick and lumina 5–8 \times 2–3 μm ; becoming intensively yellow with lactic acid, K+ strongly violet. Hamathecium of numerous straight, filiform ostiolar filaments, 1–2 μm wide; occasional, sparsely branched, septate, constricted at the septa filaments 2–6 μm wide were also observed between the asci. Asci unitunicate, cylindrical, with a long foot, apex without evident apical apparatus, wall not distinctly thickened, (70–) 72–92 (–100) \times 8–10 (–11) μm ($n = 15$), originally with 8 (0–) 1-septate ascospores, later usually with (1–) 2 (–4) fused pluriseptate ascospores, I-, K/I-. Ascospores originally (0–) 1-septate, elliptic to round, (7–) 10–16 (–20) \times (6–) 7–10 (–12) μm , $Q = (1.1–) 1.3–1.8 (–1.9)$ ($n = 30$), later usually fused by (2–) 4 (–8), narrowly oblong, occasionally broadly oblong, oblong or lorate, sometimes irregular in form, with more or less rounded ends, transversely pluriseptate (septa up to at least 12, often oblique and sometimes forming zigzag) to occasionally submuriform, (19–) 22–38 (–65) \times (7–) 9–11 (–13) μm , $Q = (1.5–) 2.2–3.8 (–6.5)$ ($n = 89$), often markedly constricted and sometimes slightly bent at the septa; colourless to sometimes pale yellow-brown (mainly the walls) when old, without an halo, usually with one large and many small lipid drops in each cell; wall smooth (but due to numerous small lipid guttules often appearing tuberculate) to somewhat wrinkled in old spores; simple or 1-septate ascospores usually diagonally uniseriate, fused spores strictly uniseriate and often laterally bulging. Anamorph not observed. The fungus grows commensalistically on healthy-looking thalli of *Peltigera didactyla* var. *didactyla*.

The fungus was previously known from a few finds in Europe, dwelling on *Collema fasciculare*, *Solorina bispora* and *S. saccata* (type host) (Rossman *et al.* 1999, Hafellner *et al.* 2004, Santesson *et al.* 2004). New to Russia and Asia; *Peltigera* is its new host genus.

Material examined – RUSSIA, Siberia, Buryatiya Republic, Tunka District, Eastern Sayan Mts., 10 km SW of Arshan, Malyy Bugatai River, 51° 52' N, 102° 21' E, alt. 750 m, dry river bed with sparse *Pinus*-, *Larix*-, *Populus*-dominated forest, in the thallus of *Peltigera didactyla* var. *didactyla*, associated with lichenicolous *Neolamya peltigerae*, 10 Jun 2005, M. Zhurbenko 05131 (LE 232849).

The lichen genus *Peltigera* is probably the richest host for lichenicolous fungi (Hawksworth 1980, Hawksworth & Miadlikowska 1997). About 90 species of non-lichenized obligately lichenicolous fungi occur on *Peltigera*, including eight hypocrealean species (see below).

Key to the hypocrealean fungi growing on *Peltigera*

Based on data in Hawksworth (1978, 1980, 1982, 1983), Hafellner (1994, 1996, 1999, 2002), Alstrup & Elvebakk (1996), Etayo & Diederich 1996, Aptroot *et al.* (1997), Alstrup & Cole (1998), Martinez & Hafellner (1998), Rossman *et al.* (1999), Zhurbenko & Davydov (2000), Hafellner *et al.* (2002), Zhurbenko & Himelbrant (2002), Triebel (2003), Zhurbenko & Laursen (2003), Alstrup (2004), Ertz (2004), Hafellner *et al.* (2004), Santesson *et al.* (2004), Zhurbenko (2004, 2008), Suija (2005), Candoussau *et al.* (2007), Motiejūnaitė (2007), Urbanavichus *et al.* (2007), and the present publication. Anamorphs are not included.

1. Ascospores filiform, 0-1-septate, $35-75 \times 1.5-3.5 \mu\text{m}$; asci 130-185 \times (4.5-) 5-6 (-6.5) μm , up to 15-transseptate when discharged; ascomata superficial, in clusters of up to 20; on thalli of *Peltigera membranacea*, *P. sp.*; known from Scotland, Spain and USA *Neobarya peltigerae* Lowen, Boqueras & Gomez-Bolea (2007)
- 1*. Ascospores not filiform; ascomata immersed to superficial 2
2. Ascomata K+ 3
- 2*. Ascomata K- 4
3. Ascomata K+ violet; ascospores at first mostly 1-septate, elliptic, (7-) 10-16 (-20) \times (6-) 7-10 (-12) μm ,8 per ascus, later usually fused by (2-) 4 (-8), narrowly oblong, transversely pluriseptate to occasionally submuriform, (19-) 22-38 (-65) \times (7-) 9-11 (-13) μm , (4-) 2 (-1) per ascus; on thalli of *Collema fasciculare*, *Peltigera didactyla*, *Solorina bispora* and *S. saccata*; known from Norway, Germany, Austria and Asian Russia
..... *Xenonectriella lutescens* (Arnold) Weese (1919)
- 3*. Ascomata K+ red; ascospores ellipsoid, 1-septate, (19-)25-31(-33) \times 7-9(-10) μm ; asci 4(-8)-spored; on thalli of *Peltigera aphthosa*, *P. didactyla* and *P. lepidophora*; known from Greenland, Iceland, Sweden, Finland, Russia (Karelia), Luxembourg, Switzerland and Spain
..... *Xenonectriella ornamentata* (D. Hawksw.) Rossman (1999)
4. Ascospores bicaudate, muriform, (23-) 30-46 \times (10-) 13-18 (-21) μm ; on thalli of *Peltigera elisabethae* and *P. rufescens*; known from England and Austria *Paranectria superba* D. Hawksw. (1982)
- 4*. Ascospores without cauda, 1-septate, smaller 5
5. Ascomata superficial; ascospores ellipsoid to narrowly ellipsoid, hyaline, 8-12 \times 3-4.5 μm ; on thalli of species of *Collema*, *Degelia*, *Leptogium*, *Lobaria*, *Nephroma*, *Pseudocypbellaria* and *Peltigera aphthosa*, *P. austroamericana*, *P. britannica*, *P. canina*, *P. collina*, *P. didactyla*, *P. dolichorhiza*, *P. horizontalis*, *P. leucophlebia*, *P. malacea*, *P. membranacea*, *P. neckeri*, *P. polydactylon*, *P. prae-*

- textata*; widely distributed in Europe, also known from Canary Islands, Asia (Russia), Melanesia (Papua New Guinea) and North and Central Americas (Canada, USA, Mexico, Costa Rica)
 *Nectriopsis lecanodes* (Ces.) Diederich & Schroers (1999)
- 5*. Ascospores more or less immersed 6
6. Ascospores 22–28 (–33) × 3.5–4 (–4.5) μm, fusiform to oblong, hyaline; asci 60–90 μm long; on thalli of *Peltigera polydactylon* and *P. rufescens*; known from Scotland, Finland and Russia (N. Siberia); also an uncertain report on *Collema cristatum* from Spain *Pronectria tenuispora* (D. Hawksw.) Lowen (1990)
- 6*. Ascospores (17–) 18–20 (–30) × (4–) 5.5–6 (–8) μm, ellipsoid-fusiform, at first hyaline, then pale orange; asci 72–90 μm long; on thalli of *Peltigera canina*, *P. didactyla*, *P. leucophlebia*, *P. malacea*, *P. polydactylon*, *P. rufescens*; known from Greenland, Norway, Sweden, Finland, Estonia, Lithuania, Czech Republic, Austria, Russia, Canada and USA
 *Pronectria erythrinella* (Nyl.) Lowen (1990)
- 6**. Ascospores 8–16 × (3–) 4–8 μm, ovoid to ellipsoid, hyaline; asci 40–70 μm long; on thalli of *Peltigera aphthosa*, *P. canina*, *P. didactyla*, *P. elisabethae*, *P. horizontalis*, *P. lepidophora*, *P. leucophlebia*, *P. polydactylon*, *P. praetextata* and *P. rufescens*; also reported on *Ochrolechia frigida*, *Solorina bispora* and *S. crocea*; widely distributed in Europe, also known from Greenland, Asia (Russia), North and South Americas (Canada, USA, Chile)
 *Pronectria robergei* (Mont. & Desm.) Lowen (1990)

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