



New species and new records of lichenicolous fungi from South Korea

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Abstract

One new species of lichenicolous fungus (*Endococcus xanthoparmeliae*) along with four new records (*Cercidospora caudata*, *Clypeococcum cladonema*, *Epicladonia simplex* and *Lichenostigma cosmopolites*) are described based on floristic work on lichens and lichenicolous fungi in the Bogil, Chuja and Jeju Islands of South Korea, bringing the total number of lichenicolous fungi species recognized in South Korea to nineteen. The new species grows on the epilithic foliose lichen *Xanthoparmelia coreana*, while *Cercidospora caudata*, *Clypeococcum cladonema*, *Epicladonia simplex* and *Lichenostigma cosmopolites* grow on *Caloplaca bogilana*, *Xanthoparmelia coreana*, *Cladonia* sp. and *Xanthoparmelia coreana*, respectively. The new species is described in detail and compared with the morphologically most similar species of the genus, while brief description and ecology is being provided for the new records. Furthermore, presence of *Endococcus verrucosus* in South Korea is also being confirmed and a brief description of that too is also provided.

Key words – Flora – island – Lichens – Lichenicolous fungi – mycobiota

Introduction

Lichenicolous fungi have received increasing attention within the last decades and the number of known species is growing considerably (Etayo & Breuss 1998, Lawrey & Diederich 2003, 2011). However, the distribution of these fungi in South Korea is poorly known. Since the publication of checklist of lichens of South Korea (Hur et al. 2005), numerous species have been added to the lichen biota of the country, including some new to science (e.g. Y. Joshi et al. 2010abc, Lü et al. 2011, Moon 2011, Y. Joshi et al. 2011, Moon et al. 2012, Kondratyuk et al. 2013ab, S. Joshi et al. 2013, Y. Joshi & Hur 2013ab), but very few work have been done on lichenicolous fungi. The first contribution regarding lichenicolous fungi of South Korea came from Thor et al. (2008), when they reported *Sphinctrina leucopoda* Nyl. colonizing *Pertusaria* sp. Later Y. Joshi et al. (2010a) added one more species for the lichenicolous flora of South Korea – *Dactylospora glaucomarioides* (Tuck.) Hafellner parasitizing *Ochrolechia* sp., but the most remarkable contribution on the lichenicolous flora of South Korea came from Kondratyuk et al.

(2013a), who published 12 species, including 3 new to science, and mentioned many other yet unidentified specimens that mostly appear to represent additional, undescribed taxa.

In the course of examining collections of lichenicolous fungi collected during lichenological research in Bogil, Chuja and Jeju Islands of South Korea in June 2011, 2012 and 2014, the authors recognized 4 new species for the country (*Cercidospora caudata* Kernst., *Clypeococcum cladonema* (Wedd.) D. Hawksw., *Epicladonia simplex* D. Hawksw. and *Lichenostigma cosmopolites* Hafellner & Calat.) and 1 species new to science (*Endococcus xanthoparmeliae*), thus raising the number of lichenicolous fungi to 19 (Table 1). Besides this, presence of *Endococcus verrucosus* Hafellner in South Korea is also being confirmed. This paper provides information on the taxonomy, occurrence and ecology of the new species and new records of lichenicolous fungi in South Korea.

Materials & Methods

All species of lichenicolous fungi were recorded from Bogil, Chuja and Jeju Islands of South Korea. The specimens were examined and deposited at Korean Lichen Research Institute, Sunchon National University (KoLRI). Macroscopical characters were studied using a Motic SMZ-168 stereomicroscope, while microscopical characters were studied in hand sections mounted in water, using Olympus BX-50 compound microscope. The anatomical features were investigated by preparing sections of thalli and ascomata, and mounting them in water and 10% KOH. Only free ascospores lying outside the asci were measured. Images of anatomical and morphological characters were taken by HD-Measure LTHS-300 (Leetech Co., Seoul, South Korea) microscope connected to computer.

Results and Discussion

Cercidospora caudata Kernst., Verh. zool.-bot. Ges., Wien 44: 212 (1895).

Pseudothecia globose, immersed in the host thallus. Ascomatal wall colorless in its lower part and intensely greenish blue around the ostiole. Paraphysoids abundant. Asci 6–8 spored. Ascospores hyaline, narrowly ellipsoid or fusiform, 1–2-septate, 17–21 × 4–5 µm, strongly heteropolar, both cells very different in shape and size, the lower cell curved and attenuated as a tail. Pycnidia not seen. (For detailed description and illustrations see Kernstock 1894, Hafellner 1987).

Known distribution – It is a widely distributed species known from arid and Mediterranean regions to boreal and arctic regions and is mostly parasymbiont on different species of *Teloschistaceae* (Navarro-Rosinés et al. 2004).

Materials examined – SOUTH KOREA, Jeju-do province, Jeju-si, Hangyeong-myeon, between Sinchang-ri and Yongsu-ri, seashore road, 33°20'31.6" N, 126°10'12.1" E, alt. 2 m asl., on rock, on thalli of *Caloplaca bogilana*, 18 June 2014, S.-O. Oh and party, 140120, 140168, 140187 (KoLRI 022416, 022299, respectively); *ibid.*, 18 June 2014, L. Gagarina, 140170-1 (KoLRI 022417); Chuja-do island, Chuja-myeon, Sinyang-1-ri, seashore of Mojini-mongdol, 33°56'44.9" N, 126°20'03.0" E, alt. 2 m asl., on rock, on thalli of *Caloplaca bogilana*, 21 June 2014, L. Gagarina, 140863, 140864-2, 140871, 140872 (KoLRI 022418, 022419, 022420, 022421, respectively).

Clypeococcum cladonema (Wedd.) D. Hawksw., Bot. J. Linn. Soc. 75: 197 (1977).

Ascomata pseudothecia, black, globose, ostiolate, numerous (6–12) and united in groups by a common clypeus, immersed; clypeus forming a rounded, black and raised patch on the surface of the host lichen to 1–2 mm diam.; pseudothecial walls brown to dark brown pigmented; hymenium I–, K/I–. Asci 8-spored. Ascospores 1-septate, olivaceous brown to brown, (15–) 17–20 × (6–) 7–8 µm, with a thin perispore. Conidia hyaline, simple, bacilliform, (4–) 4.5–5 × 0.8–1 µm. (For detailed description and illustrations see Hawksworth 1977).

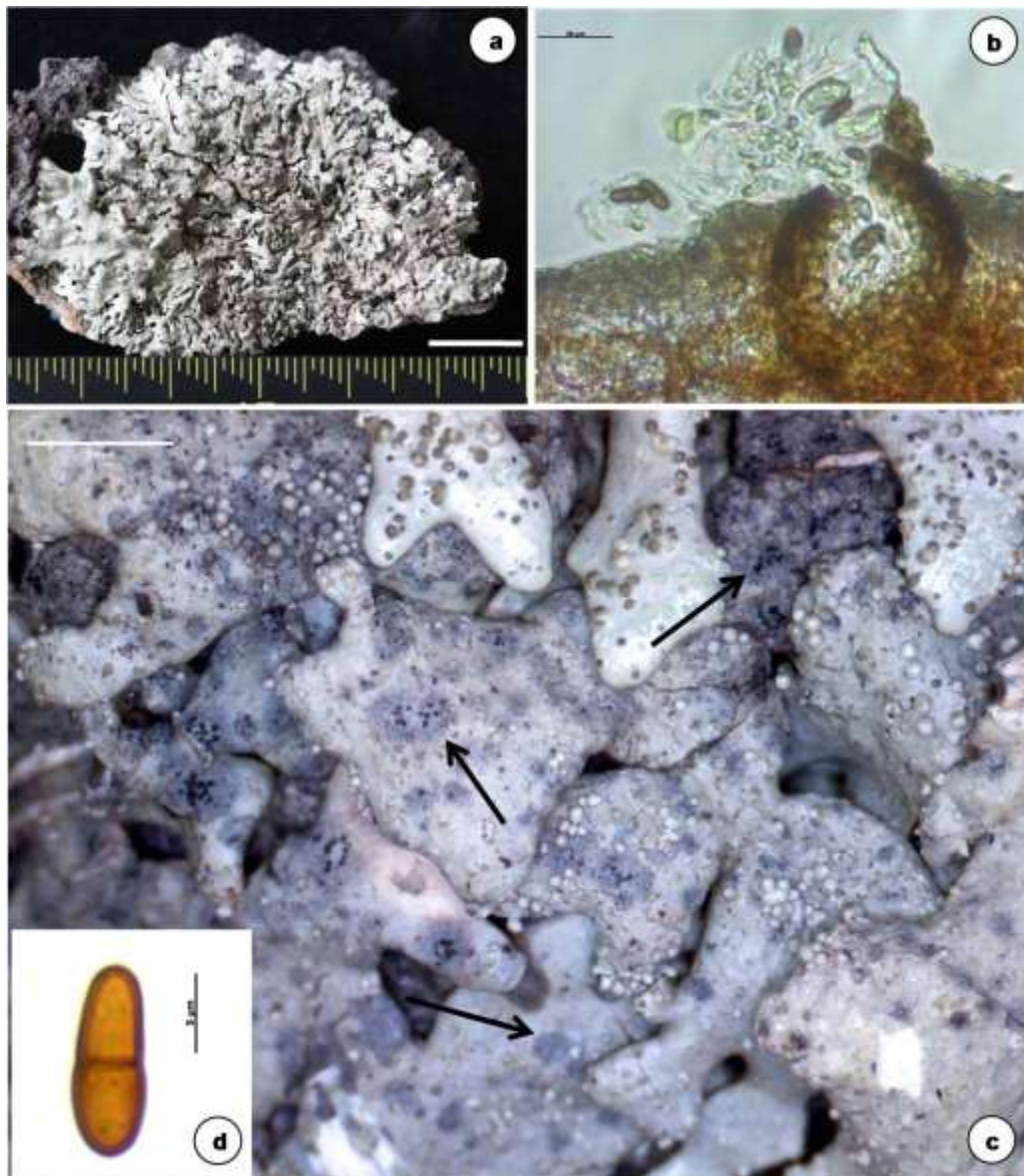


Fig. 1 – a: Thallus of *Xanthoparmelia coreana*, b: Cross section of perithecia, c: Magnified view of *Xanthoparmelia coreana* thallus infected by *Endococcus xanthoparmeliae* (arrows indicating the infected portions), d: Inset image of spore. Scale Bars: a 10 mm; b 20 µm; c 3 mm; d 5 µm.

Known distribution – The species is reported from Western Europe, Macaronesia and has its extensions up to Antarctic. It is new for South Korea and is found colonizing thallus of *Xanthoparmelia coreana*.

Materials examined – SOUTH KOREA, Jeju-do province, Jeju-si, Hangeong-myeon, between Sinchang-ri and Yongsu-ri, seashore road, 33°20'31.6" N, 126°10'12.08" E, alt. 2 m, on rocks, on *Xanthoparmelia* thalli, 18 June 2014, S.-O. Oh & party 140210, 140235 (KoLRI 021321, 021330).

Endococcus verrucosus Hafellner, Herzogia 10: 8 (1994).

Pseudothecia black, globose, immersed in the host thallus. Ascumatal wall colorless in its lower part and brown around the ostiole. Paraphysoids absent. Periphyses septate. Asci 8-spored. Ascospores pale brown to brown, ellipsoid to broadly fusiform, 1-septate, 12.5–15 × 7–8 µm, spore wall thick and smooth. Pycnidia not seen. (For detailed description and illustrations see Hafellner 1994).

Known distribution – In South Korea, the species is growing on the thallus and apothecia of *Aspicilia* sp. Previously, Kondratyuk et al. (2013a) reported *Endococcus* cf. *verrucosus* from Sinuido Island of South Korea colonizing gray crustose thallus (probably *Aspicilia*). At that time they were not quite sure whether it was *Endococcus verrucosus*, since the ascospores were quite small and the host was also not identified. In the present study, we found a fertile specimen of *Aspicilia* which is heavily infected by *Endococcus* sp., which on its examination revealed to be *E. verrucosus*, thus confirming its presence and range extension in South Korea. The species was previously reported from Europe and North America (Kainz & Triebel 2004).

Material examined – SOUTH KOREA, Jeollanam province, Shinan Co., Bogil Island, 34°07'30.7" N, 126°31'15.1" E, alt. 2 m asl., on rock, on thalli of *Aspicilia* sp., 23 June 2011, X. Y. Wang and J. A. Ryu, 110685 (KoLRI 013713).

Endococcus xanthoparmeliae Y. Joshi, S.Y. Kondr., L. Lökös & Hur, **sp. nov.** (Fig 1a-d)
MYCOBANK NO.: MB 814049

Type: South Korea, Jeju-do province, Jeju-si, Hangyeong-myeon, between Sinchang-ri and Yongsu-ri, seashore road, 33°20'31.6" N, 126°10'12.1" E, alt. 2 m asl., on rock, on thalli of *Xanthoparmelia coreana*, 18 June 2014, S.-O. Oh and party, Holotype KoLRI 021331, Isotype KoLRI 021325.

Etymology: The species epithet refers to the host name, i.e. lichen genus *Xanthoparmelia* (Vain.) Hale.

Similar to *Endococcus parmeliarum* but differs in having longer and wider ascospores and different host.

Thallus absent, non-lichenized, lichenicolous on *Xanthoparmelia coreana* (Fig. 1a), forming regularly rounded grayish to dark gray spots to (0.2–) 0.3–0.4 mm diam. with (1–) 4–7 (–11) perithecia (Fig. 1c), but often forming much larger patches to 1–2 (3) cm or covering the whole host thalline lobe.

Ascomata perithecioid, immersed or semi-immersed into host thallus, 45–55(–60) µm diam. and to 60 µm high, brownish hyphae of parasite can be seen as brown layer below host thalline cortex. *Exciple wall* dark brown to 6 (–8) µm thick in the upper portion, and to 4–5 µm thick in the lower half, (3–) 5–6 (–8) × 1–1.5 (–2) µm (Fig. 1b). *Paraphyses* absent. *Asci* clavate, 8-spored, 22–26 × 10–12 µm. *Ascospores* dark brown, 2-celled, oblong to ovoid, both cells almost the same, (8–) 10–12 × 4–5 (–6) µm (Fig. 1d).

Conidiomata not seen.

Distribution and host: The species is so far known only from two localities in South Korea – i.e. Jeju and Chuja Islands, where it is growing luxuriantly on the thallus of *Xanthoparmelia coreana*, which was often damaged by *Clypeococcum cladonema* and *Lichenostigma cosmopolites*.

Taxonomic notes: *Endococcus xanthoparmeliae* is similar to *E. parmeliarum* Etayo in Etayo & Sancho, described from Chile colonizing *Parmelia saxatilis*, but differs in having longer and wider ascospores [(8–) 10–12 × 4–5 (–6) µm vs. 6.5–9.5 × 3–3.8 µm] and different host (Etayo and Sancho 2008). *Endococcus propinquus* (Körb.) D. Hawksw. and *E. exerrans* Nyl. are other species having similar spore length and often confused with the new species. *E. propinquus* has a much wider host preference and wider spores (6.5–7 µm), while *E. exerrans* has narrower spores (3–4 µm) and is confined to *Rhizocarpon* sp. *E. verrucosus* Hafellner, another known species of the genus in South Korea, differs from the new species in having bigger and wider spores (12.5–15 × 7–8 µm) and different host (*Aspicilia*).

In brownish coloration of the spores, *Endococcus xanthoparmeliae* is sometimes mistaken with *Sphaerellothecium parmeliae* Etayo, which however differs from the new taxon in having smaller and narrower spores (8.5–10 × 3–4 µm), different hosts [*Parmelia saxatilis* (L.) Ach. and *P. sulcata* Taylor] and presence of large black stroma-like necrotic surfaces on host thallus from which arises parasitic ascomata (Etayo & Diederich 1998).

Table 1 List of so far known lichenicolous fungi colonizing various lichens in South Korea.

S. No.	Lichenicolous fungi	Host	Reference (s)
1.	<i>Abrothallus microspermus</i> Tul.	<i>Parmotrema reticulatum</i>	Kondratyuk et al. (2013a)
2.	<i>Arthonia epiphyscia</i> Nyl.	<i>Hyperphyscia</i> sp., <i>Phaeophyscia orbicularis</i>	Kondratyuk et al. (2013a)
3.	<i>Cercidospora caudata</i> Kernst.	<i>Caloplaca bogilana</i>	this paper
4.	<i>Clypeococcum cladonema</i> (Wedd.) D. Hawksw.	<i>Xanthoparmelia coreana</i>	this paper
5.	<i>Dactylospora glaucomarioides</i> (Tuck.) Hafellner	<i>Ochrolechia</i> sp.	Joshi et al. (2010a)
6.	<i>Endococcus verrucosus</i> Hafellner	<i>Aspicilia</i> sp.	Kondratyuk et al. (2013a); this paper
7.	<i>Endococcus xanthoparmeliae</i> Y. Kondr., L. Lököš & Hur	<i>Xanthoparmelia coreana</i>	this paper
8.	<i>Epicladonia simplex</i> D. Hawksw.	<i>Cladonia</i> sp.	this paper
9.	<i>Lichenochora obscuroides</i> (Linds.) Triebel & Rambold	<i>Phaeophyscia adiastrata</i> , <i>P. exornatula</i> , <i>P. hispidula</i>	P. Kondratyuk et al. (2013a)
10.	<i>Lichenodiplis lecanorae</i> (Vouaux) Duko & D. Hawksw.	<i>Lecanora</i> sp.	Kondratyuk et al. (2013a)
11.	<i>Lichenostigma cosmopolites</i> Hafellner & Calat.	<i>Xanthoparmelia coreana</i>	this paper
12.	<i>Lichenostigma heterodermiae</i> S.Y. Kondr., L. Lököš & J.S. Hur	<i>Heterodermia diademata</i> , <i>H. dissecta</i> , <i>H. hypoleuca</i> , <i>H. japonica</i> , <i>H. microphylla</i>	H. Kondratyuk et al. (2013a)
13.	<i>Opegrapha phaeophysciae</i> R. Sant.	<i>Phaeophyscia adiastrata</i> , <i>P. exornatula</i> , <i>P. aff. Squarrosa</i>	P. Kondratyuk et al. (2013a)
14.	<i>Phoma heterodermiae</i> S.Y. Kondr., L. Lököš & J.-S. Hur	<i>Heterodermia hypoleuca</i>	Kondratyuk et al. (2013a)
15.	<i>Roselliniopsis phaeophysciae</i> S.Y. Kondr., L. Lököš & J. S. Hur	<i>Phaeophyscia adiastrata</i> , <i>P. exornatula</i> , <i>P. cf. limbata</i>	P. cf. Kondratyuk et al. (2013a)
16.	<i>Sphinctrina leucopoda</i> Nyl.	<i>Pertusaria</i> sp.	Thor et al. (2008)
17.	<i>Sphinctrina tubaeformis</i> A. Massal.	<i>Pertusaria</i> sp.	Kondratyuk et al. (2013a)
18.	<i>Stigmatidium fuscatae</i> (Arnold) R. Sant.	<i>Acarospora</i> subg. <i>Phaeothallia</i>	Kondratyuk et al. (2013a)
19.	<i>Taeniolella phaeophysciae</i> D. Hawksw.	<i>Phaeophyscia adiastrata</i> , <i>P. exornatula</i> , <i>P. limbata</i> , <i>P. orbicularis</i> , <i>P. rubropulchra</i>	P. Kondratyuk et al. (2013a)

Materials examined – SOUTH KOREA, Jeju-do province, Jeju-si, Hallim-eup, Gwideok-ri, coast near the Chorok village, 33°26'33.3" N, 126°17'00.1" E, alt. 02 m asl., on rock, on thalli of *Xanthoparmelia coreana* growing together with *Diploschistes euganeus*, 05 July 2012, S. Kondratyuk and party, 121368 (KoLRI 016425 sub *Diploschistes euganeus*); Jeju-do province, Jeju-si, Hangyeong-myeon, between Sinchang-ri and Yongsu-ri, seashore road, 33°20'31.6" N, 126°10'12.1" E, alt. 2 m asl., on rock, on thalli of *Xanthoparmelia coreana* damaged by *Lichenostigma* and *Endococcus*, 18 June 2014, S.-O. Oh and party, 140215, 140217, 140223, 140226, 140233 (KoLRI 021323, 021324, 021326, 021328, 021329, respectively); *ibid.*, on thalli of *Xanthoparmelia coreana* damaged by *Clypeococcum*, 18 June 2014, S.-O. Oh and party, 140210 (KoLRI 021321); *ibid.*, on thalli of *Xanthoparmelia coreana* damaged by *Clypeococcum* and *Lichenostigma*, 18 June 2014, Y. Joshi and party, 140168, 140187 (KoLRI 022299, 022300, respectively); *ibid.*, on thalli of *Xanthoparmelia coreana* damaged by *Endococcus*, 18 June 2014, Y. Joshi and party, 140216, 140221 (KoLRI 022412, 022301, respectively); *ibid.*, on rock, on thalli of *Xanthoparmelia coreana*, 18 June 2014, S. Kondratyuk and L. Lököš, 140265 (KoLRI 022422); Jeju-do province, Jeju-si, Seogwipo-si, Pyoseon-myeon, Pyoseon-ri, seashore rocks, 33°19'23.25" N, 126°50'48.45" E, alt. 2 m asl., on thalli of *Xanthoparmelia coreana* damaged by *Endococcus* growing together with *Pyxine endochrysin*, 19 June 2014, Y. Joshi and party, 140495, 140517

(KoLRI 022302, 022413, respectively); Chuja-do island, Yecho-ri, Mt. Donda, 33°24'40.7" N, 126°29'35.9" E, alt. 661 m asl., on thalli of *Xanthoparmelia coreana* damaged by *Endococcus*, 21 June 2014, Y. Joshi and party, 140761, 140762 (KoLRI 022414, 022415, respectively).

Epicladonia simplex D. Hawksw., Bull. Br. Mus. Nat. Hist. 9: 19 (1981).

Conidiomata pycnidia, usually on galls formed on squamules of *Cladonia* sp., galls convex. Pycnidia immersed at first, but superficial at maturity, scattered, dark brown, subglobose to cupuliform, 100–150 µm diam. Pycnidial wall light olivaceous green to brown. Conidiogenous cells holoblastic. Conidia arising singly, rounded at the apex and truncated at the base, simple, non-septate, 10.5–13 × 2–3 µm diam. (For detailed description and illustrations see Hawksworth 1981).

Known distribution – It is probably a parasymbiont growing on *Cladonia* sp. and is being reported from Denmark (Alstrup 1994), Finland (Hawksworth 1981, Santesson et al. 2004), Sweden (Ihlen & Wedin 2006), North America (Esslinger & Egan 1995) and Russia (Zhurbenko 2004). The present study extends its distribution in Asia.

Material examined – SOUTH KOREA, Jeju-do province, Jeju-si, Nohyeong-dong, near Cheonwang Temple, 33°24'39.4" N, 126°29'38.1" E, 681 m asl., on *Pinus* bark, on thalli of *Cladonia* sp., 18 June 2014, S. Kondratyuk and L. Lökös, 140662-2 (KoLRI 022422).

Lichenostigma cosmopolites Hafellner & Calat., Mycotaxon 72: 108 (1999).

Hyphal strands superficial, dark brown, spreading over the host thallus, septate, ramified to net-like. Ascomata dark brown to black, scattered, subglobose. Centrum I+ orange-red, K/I+ blue. Asci 8-spored. Ascospores hyaline, 1-septate, narrowly obovate, halonate, 8–10 × 3–5 µm. Pycnidia not seen. (For detailed descriptions and illustrations see Hafellner & Calatayud 1999).

Known distribution – It is a widely distributed lichenicolous fungus known from all the continents except Antarctica colonizing *Xanthoparmelia* species (Calatayud et al. 2004).

Materials examined – SOUTH KOREA, Jeju-do province, Jeju-si, Hangeong-myeon, between Sinchang-ri and Yongsu-ri, seashore road, 33°20'31.6" N, 126°10'12.1" E, alt. 2 m asl., on rock, on thalli of *Xanthoparmelia coreana* damaged also by *Endococcus xanthoparmeliae*, 18 June 2014, S.-O. Oh and party, 140215, 140223, 140226, 140233 (KoLRI 021323, 021326, 021328, 021329, respectively); *ibid.*, on thalli of *Xanthoparmelia coreana* damaged also by *Clypeococcus*, 18 June 2014, S.-O. Oh and party, 140168, 140187 (KoLRI 022299, 022300, respectively).

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