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New or additional cladoniicolous fungi for Turkey

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Abstract: This study reports twelve species of cladoniicolous fungi from Turkey. Nine of these taxa, i.e. *Abrothallus cladoniae* R.Sant. & D.Hawksw., *Epicladonia stenospora* (Harm.) D.Hawksw., *Lichenosticta alcicornaria* (Linds.) D.Hawksw., *Lichenocodium aeruginosum* Diederich, M.Brand, van den Boom & Lawrey, *Phoma foliaceiphila* Diederich, Kocourk. & Etayo, *Scutula cladoniicola* Alstrup & D.Hawksw., *Sphaerellothecium cladoniicola* E.S. Hansen & Alstrup, *Syzygospora bachmannii* Diederich & M.S.Christ., and *Taeniolella beschiana* Diederich, are new records for Turkey. A key to these 12 species of lichenicolous fungi on *Cladonia* species is provided.

Key words: Cladoniicolous fungi, *Cladonia*, biodiversity, Turkey

1. Introduction

The knowledge of lichenicolous fungi in Turkey is relatively good when compared with other regions of the world, with 183 reported taxa (Halıcı et al., 2012, 2013, 2014). Halıcı (2008) reported 117 infrageneric taxa of lichenicolous fungi from Turkey and provided an identification key for those taxa.

Cladonia is a large genus of lichenized fungi with more than 450 species recognized worldwide (Litterski and Ahti, 2004). It is also one of the most preferred lichenized fungus genera by lichenicolous fungi because of its relatively large thalli. So far about 85 species of lichenicolous fungi (including several slightly lichenized ones) have been reported to grow on this genus (Zhurbenko and Alstrup, 2004). However, only four cladoniicolous fungi species have been reported from Turkey: *Dacampia cladoniicola* Halıcı and A.O.Türk, *Lichenocodium pyxidatae* (Oudem.) Petr. and Syd., *Roselliniella cladoniae* (Anzi) Matzer and Hafellner, and *Sphaerellothecium cladoniae* (Alstrup and Zhurb.) Hafellner (Halıcı, 2008). Therefore, more lichenicolous taxa on *Cladonia* species are expected from Turkey. Starting in 2012, we have been conducting a project to determine the biodiversity of the lichenized fungus genus *Cladonia* in Turkey and the lichenicolous fungi on collected *Cladonia* specimens as well. The aim of this paper is to report the additions of new lichenicolous fungi growing on *Cladonia* in Turkey.

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2. Materials and methods

All the lichenicolous fungi specimens detailed here are stored in the herbarium of Bozok University (Faculty of Science and Arts, Yozgat, Turkey). Their accession numbers are given in parentheses after the locality information. In addition, the specimens from Erciyes University herbarium were also examined. Specimens were examined in water, and 10% KOH and Lugol's iodine (MERCK 9261) solutions. Ascospore and conidia measurements were taken in water. The descriptive notes provided below are based on the Turkish specimens examined. Locality details of examined species are given in the Appendix.

3. Results

Twelve species of cladoniicolous fungi from Turkey reports in this study. Nine of these taxa, *Abrothallus cladoniae* R.Sant. & D.Hawksw., *Epicladonia stenospora* (Harm.) D.Hawksw., *Lichenosticta alcicornaria* (Linds.) D.Hawksw., *Lichenocodium aeruginosum* Diederich, M.Brand, van den Boom & Lawrey, *Phoma foliaceiphila* Diederich, Kocourk. & Etayo, *Scutula cladoniicola* Alstrup & D.Hawksw., *Sphaerellothecium cladoniicola* E.S. Hansen & Alstrup, *Syzygospora bachmannii* Diederich & M.S.Christ., and *Taeniolella beschiana* Diederich, are new records for Turkey. Short ecological data and comparisons with related species are given under the species.

Species Recorded

The new records for Turkey are indicated by an asterisk.

3.1. **Abrothallus cladoniae* R.Sant. and D.Hawksw.

Host lichen: *Cladonia coniocrea* (Flörke) Spreng.

A detailed description is provided by Hawksworth (1990).

This species differs from *Abrothallus pezizicola* Diederich & R.C. Harris, which also grows on *Cladonia*, by its distinctly verrucose and dark brown ascospores, whereas *A. pezizicola* has pale brown ascospores and often indistinct verrucose surface (Diederich, 2003).

This species has been reported on several *Cladonia* species, but this is the second record on *Cladonia coniocraea* new to Europe and Asia. Recently, Lendemer (2006) reported this host species in North America.

3.2. *Arthonia epiclادonia* (Nyl.) Alstrup and Zhurb.

Host lichen: *Cladonia pocillum* (Ach.) O.J.Rich.

A detailed description is provided by Zhurbenko and Alstrup (2004).

Arthonia epiclادonia was collected on the squamules of *Cladonia pocillum*. Turkish specimen characters agree well with the description given by Zhurbenko and Alstrup (2004). This species was previously reported from Turkey by Halıcı et al. (2010) on *Cladonia pyxidata*. (L.) Hoffm.

3.3. **Epiclادonia stenospora* (Harm.) D.Hawksw.

Host lichens: *Cladonia fimbriata* (L.) Fr., *C. pyxidata*

A detailed description is provided by Hawksworth (1981).

This species seems to have a wide distribution in Europe and also the Arctic on the *Cladonia pyxidata* group and *Cladonia* cf. *coniocraea*. Hawksworth (1981) mentioned that this species differs from *E. simplex* by the absence of gall formation in the host lichen, but Zhurbenko and Alstrup (2004) reported that *E. stenospora* grows on the upper side of basal squamules mostly in globose gall-like swellings. In the Turkish *Cladonia* specimens that were infected by *E. stenospora*, no gall-like swellings were observed. Moreover, *E. simplex* has nonseptate conidia, whereas *E. stenospora* usually has 0-1-septate conidia (Hawksworth, 1981; Zhurbenko and Alstrup, 2004).

3.4. *Lichenocodium pyxidatae* (Oudem.) Petr. and Syd.

Host lichens: *Cladonia coniocrea*, *C. pyxidata*

A detailed description is provided by Hawksworth (1977) and Zhurbenko and Alstrup (2004).

This species was previously reported from 2 different localities on the *Cladonia pyxidata* group (Halıcı and Cansaran Duman, 2007; Halıcı, 2008), and is probably very common. As the fungus causes bleaching on the host lichen, it can be considered pathogenic.

3.5. **Lichenocodium aeruginosum* Diederich, M.Brand, van den Boom and Lawrey

Host lichens: *Cladonia hammerii* Ahti s. lat., *Cladonia furcata* (Huds.) Schrad.

A detailed description is provided by Lawrey et al. (2011).

The Turkish specimens have black and superficial pycnidia, 90–140 µm in diam., growing on the primary

thallus, podetia, and apothecia. The conidia are subglobose, pale brown, fine verrucose, 3–4 × 2.5–3 µm. This species is easy to distinguish from *L. pyxidatae* because the pycnidial wall has a K+ blue reaction. *Cladonia furcata* is a new host for this species.

3.6. **Lichenosticta alcicornaria* (Linds.) D.Hawksw.

Host lichens: *Cladonia pyxidata*

A detailed description is provided by Hawksworth (1981).

This common lichenicolous coelomycete on various *Cladonia* spp. (Diederich 2003; Zhurbenko and Alstrup, 2004) is reported from Turkey for the first time. Although Zhurbenko and Alstrup (2004) stated that no pathogenic effect on the host lichen was observed, Turkish specimens affected by this lichenicolous fungus had bleaching on the infected parts of the squamules. The pycnidia were observed on both sides of basal squamules.

3.7. **Phoma* aff. *foliaceiphila* Diederich, Kocourk. and Etayo

Host lichen: *Cladonia pyxidata*

A detailed description is provided by Diederich et al. (2007).

The specimen examined has brown to black pycnidia, 100–150 µm diam., immersed in the primary thallus. Conidia colorless, bacilliform, with rounded apices, 7–8 × 3–4 µm, with two guttules. In the Turkish material the conidia are bigger than in the original description (Diederich et al., 2007).

3.8. *Roselliniella cladoniae* (Anzi) Matzer and Hafellner

Host lichens: *Cladonia pyxidata*

A detailed description is provided by Matzer and Hafellner (1990).

This species was previously reported from the Turkey by Halıcı (2008) on *Cladonia pyxidata* and it has a worldwide distribution (Diederich, 2003; Zhurbenko and Alstrup, 2004).

3.9. **Scutula cladoniicola* Alstrup & D.Hawksw.

Host lichen: *Cladonia pyxidata*

A detailed description is provided by Alstrup and Hawksworth (1990).

This species was described on squamules and podetia of *Cladonia stricta* (Nyl.) Nyl. from Greenland (Alstrup and Hawksworth, 1990). *C. pyxidata* is a new host for this species. The Turkish specimen has large (0.4–0.7 mm) black apothecia.

3.10. **Sphaerellothecium cladoniicola* E.S. Hansen and Alstrup

Host lichen: *Cladonia pocillum*

A detailed description is provided by Hansen and Alstrup (1995).

This species can easily be recognized in the field by mycelial strands of vegetative hyphae on the host *Cladonia* species. The related species, *Sphaerellothecium cladoniae*, which was previously reported on *Cladonia pyxidata* from Turkey by Hafellner and John (2006), differs from *S.*

cladoniicola by its mostly immersed perithecia, whereas *S. cladoniicola* has apparently superficial perithecia (Hansen and Alstrup, 1995; Zhurbenko and Alstrup, 2004).

3.11. **Syzygospora bachmannii* Diederich and M.S.Christ.
Host lichens: *Cladonia coniocrea*, *C. furcata*, *C. pyxidata*.
A detailed description is provided by Diederich (1996).

Syzygospora bachmannii, a common lichenicolous basidiomycetes species on *Cladonia* spp., is reported from Turkey. It is easily recognized in the field by blackish gall formations in the host.

3.12. **Taeniolella beschiana* Diederich

Host lichens: *Cladonia ochrochlora* Flörke, *C. pyxidata*

A detailed description is provided by Diederich (1992).

Although Diederich (1992) stated that this species is parasymbiotic or weakly parasitic on the thallus of *Cladonia* spp., Turkish specimens seem to be very pathogenic as the infected basal squamules of the host *Cladonia* species turn to black.

4. Key to Turkish cladoniicolous fungi

1. Fungus a basidiomycete, basidiomata adnate to gall inducing, often elongate and bent, or tuberculate to irregular, waxy to gelatinous reddish brown; basidiospores $7-9 \times 4.5-6 \mu\text{m}$; On podetia of *C. coniocrea*, *C. furcata*, and *C. pyxidata*
.....*Syzygospora bachmannii*
- Fungus an ascomycete or deuteromycete2
2. Fungus an ascomycete.....3
- Fungus a deuteromycete7
3. Ascumata perithecium.....4
- Ascumata apothecium or arthonioid.....5
4. Ascospores colored at maturity, usually simple, occasionally 1-4-septate, ellipsoidal, fusiform, narrowly citriform or occasionally subglobose, at first colorless, dark brown at maturity, with verruculose and finally scaling wall, $15-52 \times 6-17 \mu\text{m}$; asci 2-8-spored, unitunicate; perithecia to 0.7 mm in diam. and to 0.7 mm tall, ovoid, sometimes papillate, black, with rugose surface, often sessile; on the squamules of *Cladonia pocillum*.....*Roselliniella cladoniae*
- Perithecia associated with superficial dark brown mycelial network; ascospores 1-septate; interascal filaments absent; mycelial strands of both single and a few parallel, agglutinated hyphae; perithecia superficial; asci c. $20 \times 10 \mu\text{m}$; ascospores $8-12 \times 5 \mu\text{m}$, colorless; on the squamules of *Cladonia pocillum*
.....*Sphaerellothecium cladoniicola*
5. Ascumata without exciple, sometimes irregular6
- Ascumata with exciple, Spores 1-septate, $13-15(-16) \times 5-6.5 \mu\text{m}$; apothecia concave, becoming plane to convex with age, strongly constricted at base, to 0.7 mm in diam., sessile; on the squamules of *Cladonia pyxidata*
.....*Scutula cladoniicola*

6. Ascospores medium to dark brown, upper cell slightly thicker and longer than the lower cell, distinctly verruculose, readily breaking into two semispores along the septum, $6.5-8.5(-11) \times 3-3.5(-4.5) \mu\text{m}$, hymenium colorless, K+ bluish green; apothecia $150-270 \mu\text{m}$ in diam.; on squamules of *C. coniocrea*
.....*Abrothallus cladoniae*
- Ascospores colorless, 1-septate; $(10-14)-17.5(-20) \times 5-5.5(-6) \mu\text{m}$, on squamules of *C. pocillum*
.....*Arthonia epicladonia*
7. Conidia formed in pycnidia7
- Conidia not enclosed in pycnidia, formed directly from mycelium conidiophores and conidia dark brown; mycelial hyphae $2-3.5 \mu\text{m}$ thick; conidiophores $40-50 \times 3-5.5 \mu\text{m}$, with rough wall; conidia solitary or occasionally catenate by 2, 0-1-septate, weakly verruculose, $(7-7.5)-9-10.5(-13) \times 3.5-4-4.5(-5) \mu\text{m}$; colonies exhibit conspicuous blackish bristles; on squamules of *C. ochrochlora* and *C. pyxidata*
.....*Taeniolella beschiana*
8. Conidia colorless9
- Conidia brown.....11
9. Pycnidia brown to black, $100-150 \mu\text{m}$ diam., immersed in the primary thallus. Conidia colorless, bacilliform, with rounded apices, $7-8 \times 3-4 \mu\text{m}$, with two guttules, on squamules of *C. pyxidata*.....*Phoma foliaceiphila*
- Conidia often apically attenuated or truncated10
10. Conidia borne only at the apices of conidiogenous cells, simple or exceptionally 1-septate, subcylindrical to cymbiform, not curved, narrowed and abruptly truncated at the base by a scar, $7.5-11 \times 3-3.5 \mu\text{m}$; pycnidia immersed, possibly sometimes induce galls; on squamules of *C. fimbriata* and *C. pyxidata*.....*Epicladonia stenospora*
- Conidia born both apically and laterally, simple, lacrimiform, often slightly curved, distinctly attenuated and pointed at the base, $(6-6.5)-10(-11.5) \times (2-3)-4.5(-6) \mu\text{m}$; pycnidia often semiimmersed; on squamules of *C. pyxidata**Lichenosticta alcornaria*
11. Conidia subglobose to ovoid, truncated at the base, almost smooth-walled, $(2-2.5)-3.5(-4) \times 2-3 \mu\text{m}$; pycnidia mainly superficial, $50-80(-100) \mu\text{m}$ in diam., conidiogenous cells $(5-6)-9(-11) \times 1.5-2.5(-3) \mu\text{m}$; on squamules of *C. coniocrea* and *C. pyxidata*
.....*Lichenconium pyxidatae*
- Conidia subglobose, pale brown, fine verruculose, $3-4 \times 2.5-3 \mu\text{m}$; pycnidia black and superficial; $90-140 \mu\text{m}$ in diam., growing on the primary thallus, podetia, and apothecia on squamules of *C. furcata* and *C. hammerii*
.....*Lichenconium aeruginosum*

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Appendix

Abrothallus cladoniae R.Sant. and D.Hawksw.

Specimens Examined: **Bursa**, Karacabey, south of Yarış village, *Quercus* sp. forest, 19.09.2013, 40°17'925"N, 28°22'494"E, alt. 360 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 333].

Arthonia epicladonia (Nyl.) Alstrup and Zhurb.

Specimen Examined: **Çankırı**, Ilgaz Mountain, South of the Derbent Hotel, *Pinus nigra* Arnold. subsp. *pallasiana* and *Populus* sp. mixed forest, 07.07.2014, 41°02'488"N, 33°44'150"E, alt. 1550 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 754].

Epicladonia stenospora (Harm.) D.Hawksw.

Specimens Examined: **Çankırı**, Ilgaz Mountain, South of the Derbent Hotel, *Pinus nigra* and *Populus* sp. mixed forest, 07.07.2014, 41°02'488"N, 33°44'150"E, alt. 1550 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 719b]. **Kastamonu**, Azdavay–Pınarbaşı road, calcareous rocks, *Quercus* communities, 08.07.2014, 41°37'107"N, 33°15'219"E, alt. 825 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 742b]. **Kars**, Sarıkamış–Kars main road, East of Şehit Halit, *Pinus sylvestris* L. forest, 13.08.2014, 40°11'352"N, 42°38'154"E, alt. 1590 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 485b].

Lichenocodium pyxidatae (Oudem.) Petr. and Syd.

Specimens Examined: **Kastamonu**, Küre district, Kuşca village, 09.07.2014, 41°47'926"N, 33°43'560"E, alt. 1185 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 759b]. **Gümüşhane**, Köse, Köse–Gümüşhane road, North of Köse, *Pinus sylvestris* forest, 11.08.2014, 40°15'829"N, 39°37'224"E, alt. 1700 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 465b].

Lichenocodium aeruginosum Diederich, M.Brand, van den Boom and Lawrey

Specimens Examined: **Ardahan**, Posof, Asmakonak village, *Pinus sylvestris*, *Picea orientalis* L., and *Quercus* forest, 14.08.2014, 41°29'159"N, 42°43'962"E, 1750 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 438b]. **Ordu**, Çambaşı district, Çambaşı plateau road, *Picea orientalis* and *Pinus nigra* forest, 24.9.2014, 40°44'06"N, 37°56'19"E, alt. 1560 m, Leg.: R. Pino-Bodas.

Lichenosticta alcornaria (Linds.) D.Hawksw.

Specimens Examined: **Rize**, İkizdere district, Anzer plateau, East of Çataltepe, *Picea orientalis* forest, 17.08.2014, 40°38'184"N, 40°31'591"E, alt. 1685 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 397b]. **Trabzon**, Maçka district, around the Sümela monastery, *Quercus* community, 19.08.2014, 40°45'560"N, 39°36'718"E, alt. 570 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 606b]. **Ordu**, Çambaşı

district, Çambaşı plateau road, 40°44'06"N, 37°56'19"E, *Picea orientalis* and *Pinus nigra* forest, 24.09.2014, alt. 1560 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 1258].

Phoma aff. *foliaceiphila* Diederich, Kocourk. and Etayo

Specimens Examined: **Eskişehir**, Seyitgazi–Kırka road, Sandıközü village, *Pinus nigra* forest, 22.07.2014, 39°23'32"N, 30°23'16"E, alt. 1520 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 653b].

Roselliniella cladoniae (Anzi) Matzer and Hafellner

Specimens Examined: **Rize**, Çamlıhemşin, Kaçkar Mountain National Park, North of Ayder plateau, 15.08.2014, 40°55'860"N, 41°08'580"E, alt. 1660 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 496b].

Scutula cladoniicola Alstrup & D.Hawksw.

Specimens Examined: **Çanakkale**, Bayramiç, Kazdağı Mollahasanlar village, 17/09/2013, 39°47'166"N, 26°43'265"E, alt. 170 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 1296].

Sphaerellothecium cladoniicola E.S. Hansen and Alstrup

Specimens Examined: **Bitlis**, Tatvan–Gevaş road, calcareous rocks, 26.05.2014, 38°26'57"N, 42°22'23"E, alt. 1785 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 573b]. **Erzincan**, İmranlı–Refahiye road, calcareous rocks, 23.05.2014, 39°56'19"N, 38°44'02"E, alt. 1510 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 526b]. **Sivas**, Zara, Kızıldağ, gypseous rocks, 23.05.2014, 39°52'49"N, 37°58'35"E, 1660 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 566b].

Syzygospora bachmannii Diederich and M.S.Christ.

Specimens Examined: **Kastamonu**, Pınarbaşı district, *Abies nordmanniana* (Stev.) subsp. *bornmuelleriana* (Mattf.) Coode & Cullen and *Pinus nigra* mixed forest, 08.07.2014, 41°34'647"N, 33°12'320"E, alt. 1170 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 748b]. **Rize**–İkizdere, Anzer, east of Çataltepe, *Picea orientalis* forest, calcareous rocks, 17.08.2014, 40°38'184"N, 40°31'591"E, 1685 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 428b, CLAD 443b, CLAD 838b, CLAD 872b].

Taeniolella beschiana Diederich

Specimens Examined: **Kastamonu**, Pınarbaşı district, *Abies nordmanniana* and *Pinus nigra* mixed forest, 08.07.2014, 41°34'647"N, 33°12'320"E, alt. 1170 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 752b]. **Kastamonu**, Şenpazar district, southeast of Şenpazar, *Pinus nigra* forest, 09.07.2014, 41°49'493"N, 33°14'999"E, alt. 460 m, Leg.: M. Kocakaya and M.G. Halıcı [CLAD 807b].