

## Two Lichenicolous Fungi, *Illosporium carneum* and *Ovicuculispora parmeliae* (Bionectriaceae, Ascomycota), New to Japan

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**Abstract** Two lichenicolous fungi, *Illosporium carneum* and *Ovicuculispora parmeliae*, are reported as new to Japan. *Illosporium carneum* was found on *Peltigera didactyla* growing on rock in Nagano Prefecture, central Honshu, at an elevation of 2,300 m. *Ovicuculispora parmeliae* was found on *Heterodermia japonica* growing on rock in Saitama Prefecture, central Honshu, at an elevation of 1330 m.

**Key words:** anamorph, Asia, distribution, *Heterodermia japonica*, lichen, mycota, parasite, *Peltigera didactyla*, *Pronectria robergei*, taxonomy.

### Introduction

Lichenicolous fungi are parasitic or parasymbiotic fungi growing on lichens and over 1,800 species have been described in the world (Lawrey and Diederich, 2018). In Japan, ca. 150 species have been reported (Zhurbenko *et al.*, 2015, 2017; Tadome *et al.*, 2018; Zhurbenko and Ohmura, 2019). However, only about 30% of Japanese lichenicolous fungi is estimated to be found (Zhurbenko *et al.*, 2015).

During the course of our research on the diversity of lichenicolous fungi in Japan, *Illosporium carneum* Fr. and *Ovicuculispora parmeliae* (Berk. & M.A.Curtis) Etayo were newly found in Japan based on morphological and chemical examinations.

The genus *Illosporium* is an anamorph of the genus *Pronectria* (Bionectriaceae, Ascomycota), and characterized by the pink irregular-shaped sporodochial conidiomata and globose to subglobose conidia (Hawksworth, 1979). Most species

of *Illosporium* are non-lichenicolous parasitic fungi found usually on vascular plants, but *I. carneum* is only known as lichenicolous species within the genus (Diederich *et al.*, 2018). *Illosporium carneum* is an anamorph of *Pronectria robergei*. It was proved that *P. robergei* was developed from *I. carneum* on infected *Peltigera* by long-term observation in the field (Killian and Erner, 1925).

The genus *Ovicuculispora* is characterized by the ascus producing two types of ascospores, i.e., macrospores and microspores, and currently two accepted taxa have been known in the world (Etayo, 2010).

This paper aims to describe the morphological and anatomical features of these two species based on the Japanese materials.

### Materials and Methods

This study is based on the examinations of herbarium specimens housed in the herbarium of the National Museum of Nature and Science (TNS), Tsukuba, Japan.

Morphological observations were made using a dissecting microscope (Olympus SZX12, Tokyo, Japan) and a differential interference contrast microscope (Olympus BX51, Tokyo, Japan). Anatomical examinations were made on hand-cut sections mounted in water. Measurements of ascospores and conidia are given as (minimum–) range including mean  $\pm$  standard deviation (–maximum) ( $n$  = number of measurements).

Chemical reactions of the epihymenium were observed by the use of 10% KOH (K). The amyloidity of the hymenial gels was observed in 1.5% Lugol's iodine solution directly (I) or after a 10% KOH pretreatment (K/I).

### Results and Discussion

***Illosporium carneum*** Fr., Syst. Mycol. (Lundae) 3(1): 259. 1829.

[Fig. 1A–B]

**Colonies** formed by sporodochial conidiomata, usually discrete, sometimes confluent each other to form irregular mass in shape, erumpent through the upper cortex of the host thallus, 200–300  $\mu$ m wide, 80–100  $\mu$ m tall, pink to orange, K–, K/I–. **Conidiophores** micronematous, subglobose to ellipsoid or irregular in shape, densely compacted with adjacent cells. **Conidiogenous cells** ellipsoid to irregular in shape, hyaline. **Conidia** subglobose but often rather angular due to compression by adjacent conidia, connected, (4.7–)5.3–6.7(–7.7)  $\times$  (4.7–)4.3–6.1(–7.0)  $\mu$ m ( $n$  = 40), hyaline to pale pink.

This species is characterized by the pink irregular-shaped sporodochial conidiomata and subglobose conidia. Morphological and anatomical features of the Japanese material mentioned above agree well with the protologue and the description provided by Hawksworth (1979) as well as those of exsiccae of *Illosporium carneum* [Santesson: Fungi Lichenicoli Exs. 13, 265, 354 (TNS!); conidia size (4.5–)5.2–6.6(–7.3)  $\times$  (4.0–)4.8–6.2(–6.9)  $\mu$ m ( $n$  = 45)].

In Japan, the teleomorph of *I. carneum*, i.e., *Pronectria robergei*, has not been found so far.

However, it will be expected to be found in further investigation as it is common lichenicolous fungus parasitized on various *Peltigera* genera around the world (Vondrák and Liška, 2013; Moisejevs, 2017; Maloles *et al.*, 2018; Suija and Jüriado, 2020).

This species was reported in Asia (Turkey) (Volker *et al.*, 2020), Europe (Austria, England, Finland, Greenland, Latvia, Norway, Poland, Russia, Romania, and Spain) (Elvebakk and Prestrud, 1996; Urbanavichus *et al.*, 2007; Hansen, 2008; Kukwa and Flakus, 2009; Hawksworth *et al.*, 2010; Vondrák and Liška, 2013; van den Boom and Etayo, 2014; Hafellner, 2015; Moisejevs, 2017; Suija and Jüriado, 2020), North America (Canada) (Maloles *et al.*, 2018), and Oceania (New Zealand) (Galloway, 2007). The distribution is now extended to Japan.

Specimen examined. JAPAN. Nagano Pref.: Mt. Akadake, 2300 m elev., on *Peltigera didactyla* on rock, 13 September 2017, K. Tadome 496 (TNS).

*Exsiccate examined.* SWEDEN. Uppland: Estuna par., 0.5 km of Kullsta, on a sandy road side, on *Peltigera spuria* (= *P. didactyla*) (thallus), 7 July 1940 (Santesson: Fungi Lichenicoli Exs. 13, TNS); Torne Lappmark Prov., the Torne-trask area, Abisko, near the Tourist Station, 68°20'N 18°51'E, alt. 385 m, on the railway bank, on *Peltigera didactyla* (thallus), 16 August 1947 (Santesson: Fungi Lichenicoli Exs. 265, TNS). AUSTRIA. Salzburg Prov., Pinzgau, Hohe Tauern, Glockner-group, Stubachtal, Enzingerboden, on the W lowermost slope of Rotenkogel, 47°10'20"N 12°37'40"E, alt. 1500 m, slope with boulders and open *Pinus mugo* grove, on *Peltigera polydactylon* (thallus), 31 August 1996 (Santesson: Fungi Lichenicoli Exs. 354, TNS).

***Oviculisporea parmeliae*** (Berk. & M.A.Curtis) Etayo, Bull. Soc. Linn. Provence 61: 112. 2010.

[Fig. 1C–G]

**Ascomata** occur on upper surface of thallus of the host lichen, scattered or grouped, globose to subglobose, with brighter colored small papilla, surface covered with long hair, pink to red, 200–

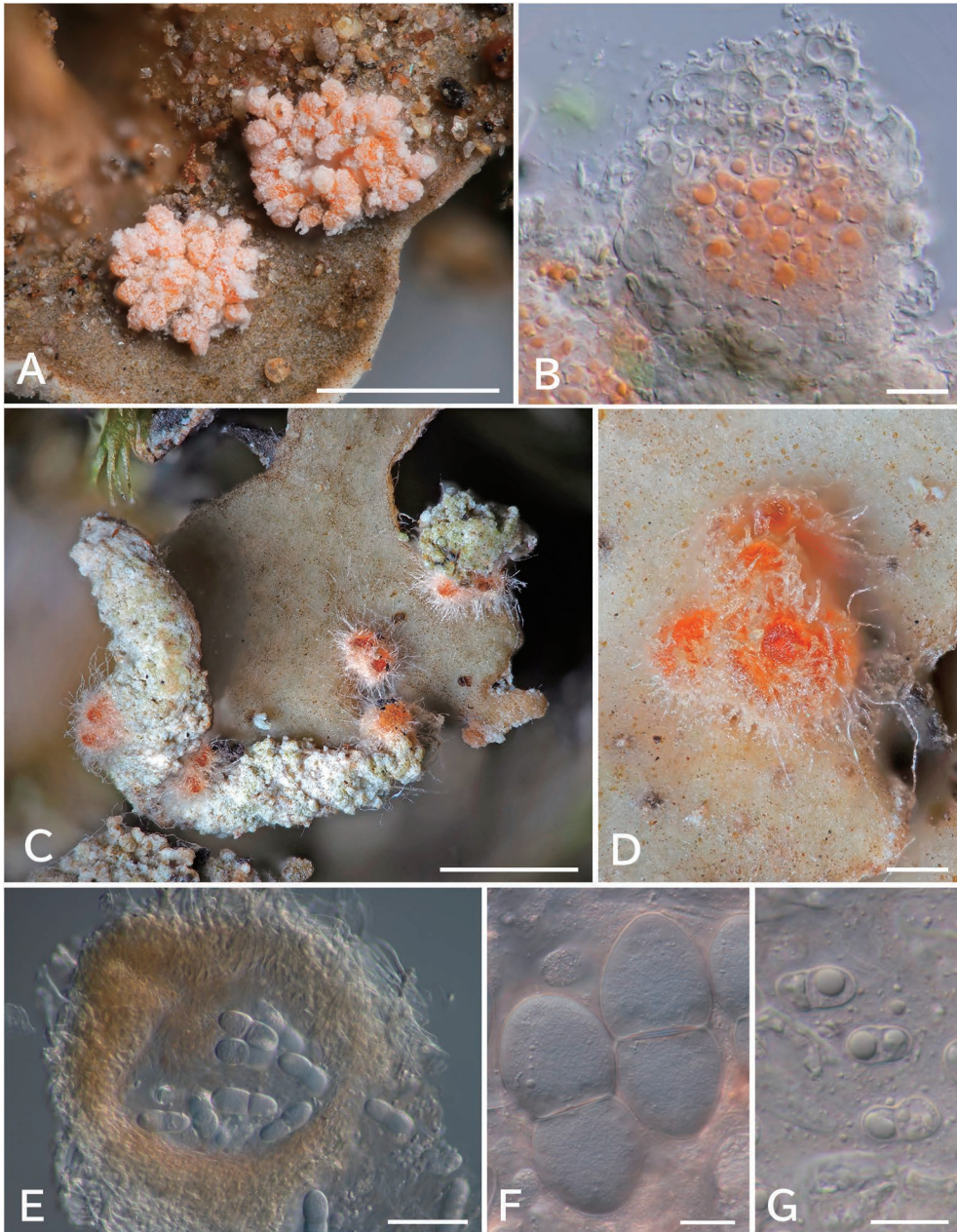


Fig. 1. *Illosporium carneum* and *Ovicuculispora parmeliae* collected in Japan. A–B. *Illosporium carneum* (K. Tadome 496, TNS). C–G. *Ovicuculispora parmeliae* (K. Tadome 613, TNS). A. Growth habit on *Peltigera didactyla*. B. Conidiomata. C. Growth habit on *Heterodermia japonica*. D. Ascomata. E. Cross section of an ascoma. F. Macrospores. G. Microspores. Scale bars: A=0.5 mm, B=20  $\mu\text{m}$ , C=1 mm, D=100  $\mu\text{m}$ , E=50  $\mu\text{m}$ , F=10  $\mu\text{m}$ , G=5  $\mu\text{m}$ .

250  $\mu\text{m}$  diam, K–, K/I–; ascomatal wall hyaline to slightly orange, 30–45  $\mu\text{m}$  thick; hymenium hyaline, 100–130  $\mu\text{m}$  tall. **Asci** clavate,

100  $\times$  30  $\mu\text{m}$ , with 1 macrospore and 3–4 microspores/ascus. **Ascospores** ellipsoid to narrowly ellipsoid, rounded at the apices, con-



Table 1. Comparisons of morphological features of *Ovicuculispora parmeliae* depending on country

Country	macrospore	microspore	Shape of macrospora	Host	Reference
Bolivia	34–60 × 12–23 μm	8–17 × 3–7 μm	1-septate	<i>Candelariella</i> sp.	Flakus <i>et al.</i> (2006)
Canada	34–50(–60) × 12–18(–20) μm	8–17 × 3.5–7 μm	1(–3)-septate	Hypogymnia physodes, <i>Parmelia sulcata</i>	Samuel (2020)
Dominica	40–45 × 20 μm	8–10 × 5 μm	Not observing	<i>Pyxine</i> sp.	Etayo and van den Boom (2013)
England	34–50(–60) × 12–18(–20) μm	8–17 × 3.5–7 μm	1–2-septate	<i>Lecanora chlorotera</i> , <i>Xanthoria parietina</i>	Hawksworth <i>et al.</i> (2010)
Japan	(30.4–)29.7–47.7(–54.4) × (11.1–)12.0–22.1(–25.5) μm	(4.9–)6.6–11.2(–12.1) × (2.3–)3.1–5.9(–6.6) μm	1-septate	<i>Heterodermia japonica</i>	This study
Russia	(18.4–)42.4–73.0(–86.0) × (6.8–)18.3–33.3(–40.0) μm	(6.8–)8.7–11.7(–16.5) × (3.3–)4.5–5.5(–7.0) μm	1-septate (very rarely 2-septate)	<i>Anaptychia</i> sp., <i>Cladonia</i> sp., <i>Heterodermia</i> cf. <i>microphylla</i> , <i>Heterodermia</i> cf. <i>obscurata</i> , <i>Myelochroa entotheciochroa</i> , <i>Parmelia</i> sp., <i>Pyxine soredata</i> , <i>Rinodina xanthophaea</i>	Zhurbenko (2014)
U.S.A. (North Carolina)	N/A	N/A	1-septate	<i>Physcia millegrana</i> , <i>Punctelia rudecta</i>	Flakus <i>et al.</i> (2006)
U.S.A. (South Carolina) (Type locality)	51 × 23 μm	9–11 × 4–6 μm	1-septate	<i>Punctelia rudecta</i>	Hawksworth (1981)

stricted at the septum, hyaline; macrospore 1-septate, (30.4–)29.7–47.7(–54.4) × (11.1–)12.0–22.1(–25.5) μm ( $n=22$ ); microspore 0–1-septate, (4.9–)6.6–11.2(–12.1) × (2.3–)3.1–5.9(–6.6) μm ( $n = 44$ ). **Anamorph** not observed.

This species is characterized by the hairy pink to reddish ascomata and extremely different sized ascospores (macrospore and microspore) within an ascus. Morphological and anatomical features of the Japanese material mentioned above agree well with the protologue and the description provided by Berkely (1874).

In the genus *Ovicuculispora*, only two species, *O. parmeliae* and *O. macrospora* Etayo, are known. *Ovicuculispora parmeliae* is reported from worldwide, while *O. macrospora* is known only from Peru. These species were originally distinguished by the macrospore size: 31–45 × 13–18 μm for *O. parmeliae* vs. 67–105 × 32–40 μm for *O. macrospora* (Etayo, 2010). However, various range of ascospore size both for macrospores and microspores were reported in *O. parmeliae* (Table 1) and the ranges of ascospores are largely overlapped with those of *O. macrospora*. Further taxonomic studies are needed for the independency of *O. macrospora* or the possibility of multiple species within *O. parmeliae*.

*Ovicuculispora parmeliae* was reported in Asia (South Korea) (Zhurbenko *et al.*, 2015),

Europe (England and Russia) (Etayo, 2010; Hawksworth *et al.*, 2010), North America (Hawksworth, 1981; Maloles *et al.*, 2018), and South America (Bolivia and Dominica) (Flakus *et al.*, 2006; Etayo and van den Boom, 2013). The distribution is now extended to Japan.

Specimen examined. JAPAN. Saitama Pref.: Mt. Myouhou, 1330 m elev., on *Heterodermia japonica* on rock, 29 July 2018, K. Tadome 613 (TNS).

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