

# New *Micarea* records from Norway and Sweden and an identification key to the *M. prasina* group in Europe

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*Micarea czarnotae* and *M. pseudomicrococca* are reported as new to Sweden, and *M. fallax* is reported as new to Norway. *Micarea laeta* and *M. melanobola* are reported from Sweden for the first time since 1927 and 1892, respectively. *Micarea fallax* is reported from three new localities in Sweden. An updated identification key for the *M. prasina* group in Central and Northern Europe is provided.

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## Introduction

The genus *Micarea* Fr. is a widespread group of crustose lichens that comprises over 100 known species worldwide (International Mycological Association 2019). Many of them are common epiphytes in boreal forests where they may cover large surfaces on bark and wood. In Australasia, Europe and the Russian Far East the taxonomy and systematics of the genus has lately received much scientific interest, resulting in over 20 new species descriptions and in a growing knowledge on species' distribution (e.g., Czarnota 2007; Czarnota & Guzew-Krzemińska 2010; Sérusiaux et al. 2010; van den Boom et al. 2017; Guzew-Krzemińska et al. 2016 & 2019; Myllys & Launis 2018; Kantvilas & Coppins 2019; Konoreva et al. 2019; Launis & Myllys 2019; Launis et al. 2019a, b; van den Boom et al. 2020). Regardless of this progress, the genus is still insufficiently known in many parts of the world.

Of the species reported here, *Micarea czarnotae*, *M. fallax*, *M. laeta* and *M. pseudomicrococca* were recently described as new to science, and *M. melanobola* was recently reinstated at the species level (Launis 2019a, b).

## Material and Methods

The specimens reported in this study were collected by several lichenologists in managed and old-growth forests in central and northern Sweden and in Norway during 1990–2018. The specimens are deposited in the Uppsala Herbarium (UPS) and Bergen Herbarium (BG).

Specimens were initially studied using a dissecting microscope. Anatomical features were examined on hand-cut apothecial sections and squash preparations mounted in water using a compound microscope. Ascospore dimensions and other anatomical measurements were made in water and in K. Chemical spot tests were performed under a compound microscope using sodium hypochlorite (C) and 10% potassium hydroxide (K) (Orange et al. 2010). Pigments were defined following Coppins (1983), Meyer & Printzen (2000) and Czarnota (2007). Some of the specimens were further studied using thin-layer chromatography (solvent C) following Culberson & Kristinsson (1970) and Orange et al. (2010). The crystalline granules were investigated by using a compound microscope with polarization lenses. Specimens were identified by Annina Kantelinen (formerly Launis) and Måns Svensson.

We extracted DNA from selected specimens using Chelex 100 (Bio-Rad, Hercules, CA, USA) following the procedure described by Ferencova et al. (2017). To amplify mrSSU, we used the primers mrSSU1 and mrSSU3R (Zoller et al. 1999). For PCR-reactions, we used Phusion Hot Start II high-Fidelity DNA polymerase following the manufacturer's protocols, with an annealing temperature of 60.3°C.

## The Species

### *Micarea czarnotae* Launis, van den Boom, Sérus. & Myllys

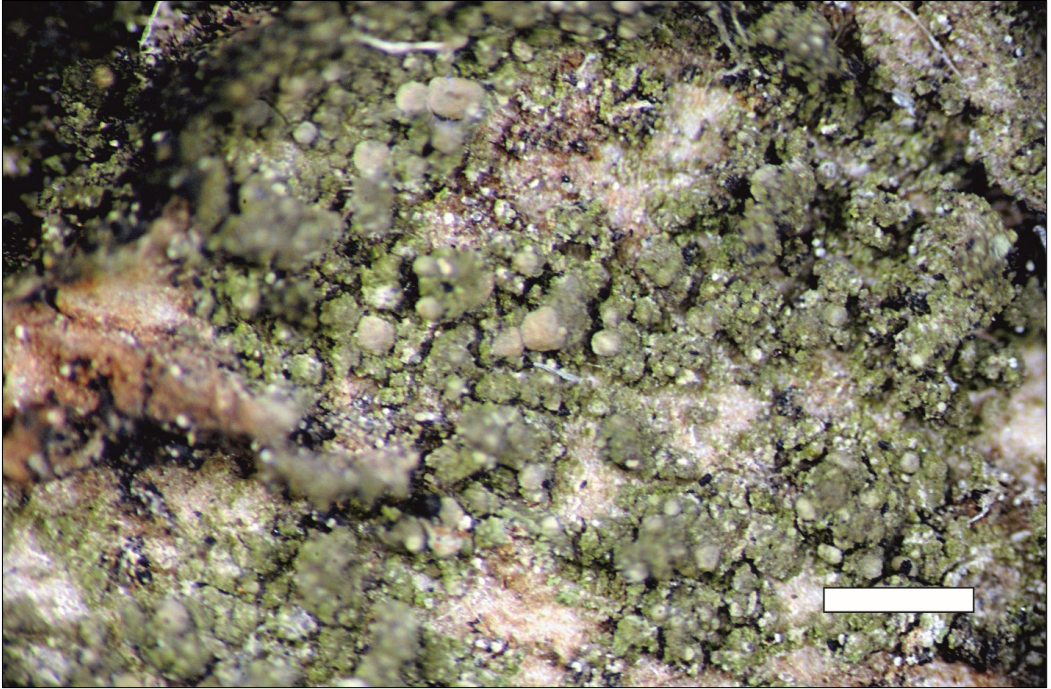
Fig. 1

*Micarea czarnotae* forms an olive-green thallus composed of goniocysts that are usually coalescing to form a dense, continuous and sometimes cracked thallus. When less developed, the thallus is warted-areolate. Apothecia are numerous, crowded, up to 0.3 mm diam., cream-white or pale brownish, often greyish tinged (K± violet, C± violet). Ascospores are oblong-ellipsoid or obovoid, 0–1 septate and 7.0–10.0 × 2.25–3.5 µm. Sessile mesopycnidia are usually present and abundant. Immersed micropycnidia are also often present but inconspicuous. The species produces methoxymicareic acid.

In phylogenetic analyses (Launis & Myllys 2019; Guzow-Krzemińska et al. 2019; van den Boom et al. 2020), *M. czarnotae* is embedded in the *M. micrococca* complex and morphologically resembles its closest relatives *M. micrococca* and *M. pseudomicrococca*. However, it differs from these two by having numerous and often greyish apothecia (Sedifolia-grey pigment), but also by forming a dense and continuous thallus that has no crystalline granules. *Micarea czarnotae* typically develops numerous sessile mesopycnidia that are less common in *M. micrococca* and *M. pseudomicrococca*.

In Sweden, *Micarea czarnotae* is currently known from four specimens. It is probably relatively common but overlooked. Searches in similar habitats to where the species is known in southern Finland, Poland, the Netherlands and Russia (Launis et al. 2019b; Stepanchikova et al. 2020) could be effective, i.e. managed and old-growth forests on bark of *Pinus sylvestris*, bark and decaying wood of *Picea abies*, bark of *Quercus* sp. and twigs of *Alnus glutinosa*. Several specimens have been collected from humid environments near a bog or a river, and from N-facing sides of standing tree trunks or from near the ground.

*Specimens examined*: **Sweden**. *Gotland*: Träkumla par., Tjängdarve (Anglarve) wooded meadow, c. 1.2 km S of Träkumla church, 57.55°N, 18.31667°E, on *Quercus robur*, 17–18 Aug 1989, A. Nordin, R. Sundin & G. Thor 91 (UPS L-161757); Rone par., Oggésänget wooded meadow, c. 500 m S of Jaksarve and c. 1.0–1.4 km W of Rone church, 57.12°N, 18.25°E, alt. 25 m, on *Betula*, 28–29 July 1990, A. Nordin, R. Sundin & G. Thor 1139 (UPS L-161768) [TLC: methoxymicareic acid]; *Värmland*: Norra Ny parish, Mjönäs, SE part, by River Klarälven, c. 8 km SE of Norra Ny, 60.34083°N, 13.34600°E, alt. 140 m, on *Sorbus aucuparia* in mixed



**Figure 1.** *Micarea czarnotae* (L-985764). Scale bar 1 mm. Photo originally published by Launis et al. 2019a, reprinted with permission of the British Lichen Society and Cambridge University Press.

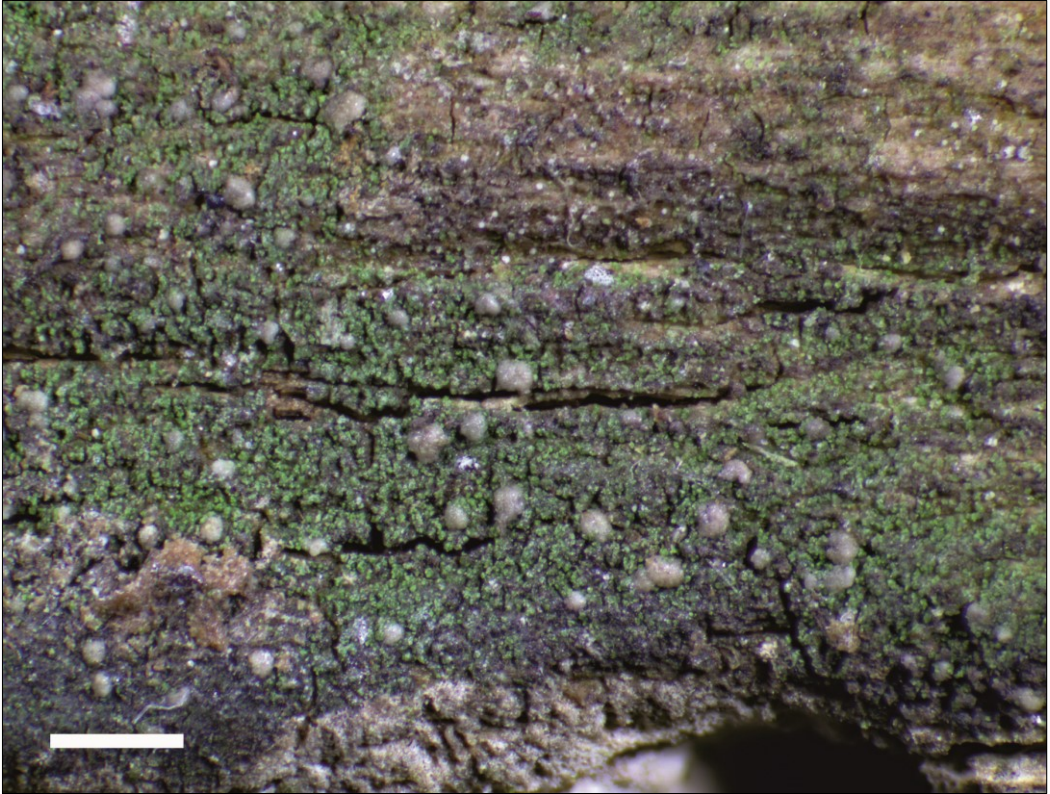
deciduous forest, 23 Oct 1993, B. Owe-Larsson, 5914a (UPS L-987189); Dalby parish. Långavängen, south part, by River Klarälven, c. 500 m SSE of Dalby, 60.64033°N, 13.00533°E, alt. 145 m, on bark of dead standing trunk of *Prunus padus* in a mixed deciduous forest, 18 Sept 1994, B. Owe-Larsson 7027b (UPS L-985764).

### *Micarea fallax* Launis & Myllys

Fig. 2

*Micarea fallax* is characterized by a vivid green or pale to dark olive-green granular thallus that is composed of goniocysts. The goniocysts are often coalescing and form larger granules or an almost continuous and cracked thallus. When less developed, the thallus is warted-granular, small-areolate, or membranous and  $\pm$  shiny. The photobiont is micareoid, with algal cells measuring 4.5–7  $\mu\text{m}$ . Apothecia are numerous, 0.2–0.4 (–0.5) mm diam., usually hemispherical or subglobose, sometimes adnate or convex and semi-immersed in the thallus, simple or tuberculate. They are cream white, pale brownish, honey brown to medium brown in colour, sometimes with a pale greyish tinge, and then K<sup>+</sup> violet and C<sup>+</sup> violet because of the *Sedifolia*-grey pigment. Ascospores are oblong-ellipsoid or obovoid, 0–1-septate and 8.0–11.0  $\times$  3.0–4.0  $\mu\text{m}$ . Meso- and micropycnidia are often present but mostly immersed between goniocysts and therefore inconspicuous, or rarely sessile. The species produces micareic acid.

*Micarea fallax* is closely related to *M. melanobola* and *M. prasina* s. str. (Launis et al. 2019b). The main distinguishing character separating *M. fallax* from *M. prasina* s. str. are the crystalline granules: *M. prasina* develops crystals in the epihymenium (sometimes also in the hymenium), whereas *M. fallax* produces granules only in the hymenium. In addition, the apothecia and ascospores of *M. fallax* are slightly smaller and the thallus usually more aggregated, i.e. the gonio-



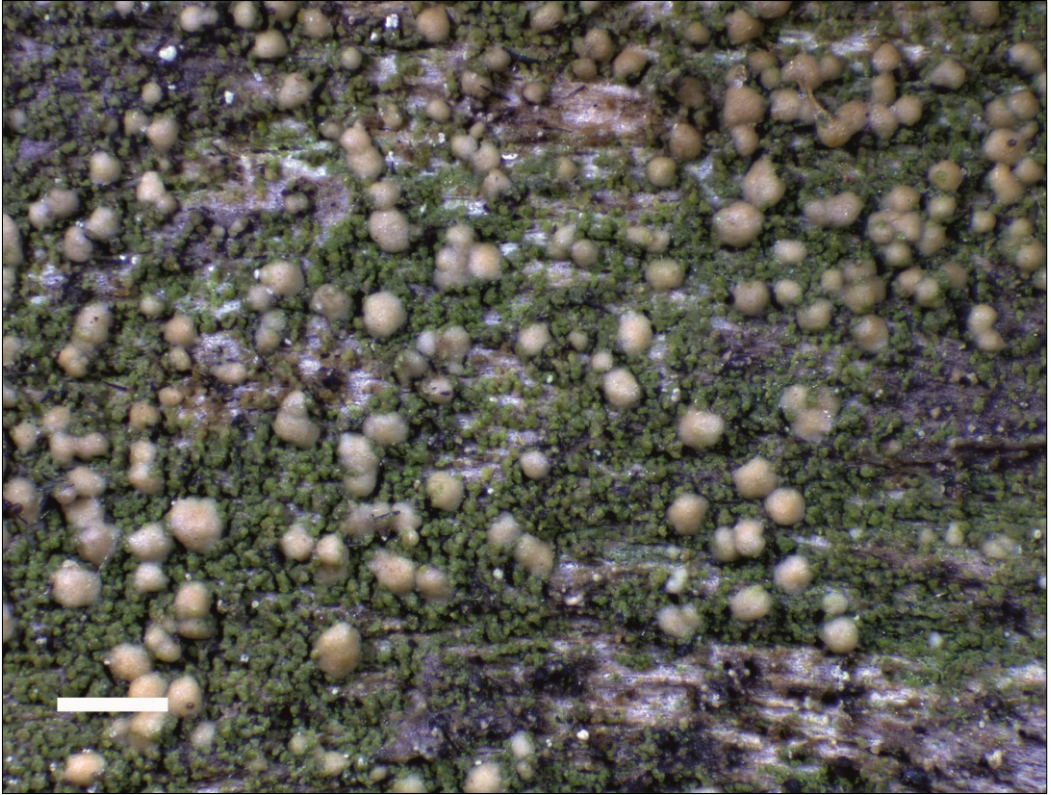
**Figure 2.** *Micarea fallax* (MS3351). Scale bar 1 mm.

cysts are clustered together and form bigger granules. *Micarea melanobola*, on the other hand, is morphologically clearly different as it has dark grey to blackish apothecia.

*Micarea fallax* can be very similar to young, poorly developed specimens of *M. laeta*. The main distinguishing character is the secondary chemistry: *M. fallax* produces micareic acid, whereas *M. laeta* produces methoxymicareic acid. Well-developed specimens also differ morphologically. The apothecia of *M. fallax* are typically smaller and hemispherical rather than adnate, and they are often brownish and/or greyish in colour rather than cream white. Also, the thallus colour of *M. fallax* is usually paler and the goniocysts are more aggregated.

*Micarea fallax* is a recently described species that is widely distributed in Europe (Launis et al. 2019b). Specimens have so far been collected in Belarus, the Czech Republic, Finland, northwest Russia, Scotland and Sweden (Launis et al. 2019b; Tarasova et al. 2020). It has been collected from bark and decaying wood of several tree species, for example *Abies alba*, *Alnus* spp., *Quercus* spp., *Picea abies* and *Pinus sylvestris*. The specimens have been collected from mature managed and old-growth forests. Here we report *M. fallax* as new to Norway and report three new collections from Sweden. The species was previously known from Sweden based on one collection (Launis et al. 2019b).

*Specimens examined:* **Norway.** Hordaland: Tysnes, Tysnesøy, the peninsula 850 m NNW of Beltestadvika, 59.99629°N, 5.45935°E, alt. 5 m, on wood of *Corylus avellana* in open deciduous forest, 9 May 2018, M.



**Figure 3.** *Micarea laeta* (MS3765). Scale bar 1 mm.

Svensson 3351 (BG, UPS L-987349; confirmed by sequencing). **Sweden.** *Hälsingland:* Trönö par., Storsjön, 61.483°N, 16.7°E, on bark of *Alnus*, 20 April 1999, Å. Ågren 545 (UPS L-131163); *Värmland:* Norra Ny parish, Mjönäs, SE part, by River Klarälven, c. 8 km SE of Norra Ny, 60.34083°N, 13.34600°E, alt. 140 m, on *Sorbus aucuparia* in mixed deciduous forest, 23 Oct 1993, B. Owe-Larsson 5914b (UPS L-987190); Dalby parish, Vingängdeltat (Strandholmarna), NW part, by River Klarälven, c. 4 km SSE Sysseleback, 60.69783°N, 12.90217°E, alt. 145 m, on *Pinus sylvestris* in mixed forest, 17 Sept 1994, B. Owe-Larsson 6946 (UPS L-987191).

### *Micarea laeta* Launis & Myllys

Fig. 3

*Micarea laeta* forms a vivid green to olive-green thallus composed of goniocysts. The thallus is a granular or almost continuous crust or, if less developed, warted-areolate. Apothecia are usually numerous, cream-white or sometimes brownish, K– (no *Sedifolia*-grey), up to 0.5 (–0.6) mm diam., adnate, convex to hemispherical or rarely subglobose and simple or tuberculate in shape. Ascospores are oblong-ellipsoid or obovoid, 0–1-septate and (8.0–) 8.5–12.0 × 3.0–4.0 μm. Micro- and mesopycnidia are usually present though hardly visible if immersed between goniocysts. The species produces methoxymicareic acid.

Based on molecular studies, *Micarea laeta* is closely related to *M. byssacea* and *M. microareolata*, which both occur in Sweden (Launis et al. 2019a). *Micarea laeta* differs from *M.*

*byssacea* by lacking the Sedifolia-grey pigment in its apothecia and by typically forming a thallus of aggregated goniocysts or a continuous crust. *M. microareolata*, in contrast, has narrower ascospores and at least partly areolate thallus.

*Micarea laeta* was recently described as a new species (Launis et al. 2019a). However, it has been previously known as a form of *M. prasina*. The reason *M. laeta* was described as a new species instead of a new combination was because the original name has been shown invalid (Coppins 1983), as the type specimen of *prasina* forma *laeta* is the same as that of *M. prasina*.

*Micarea laeta* was reported as new to Sweden in 2019 based on collections from 1890 and 1927 in Malme's and Magnusson's exsiccate where it was known as a form of *prasina* (Launis et al. 2019a). Here we report three additional specimens from 1990, 2008 and 2020. The species is probably relatively common in Sweden but overlooked. In Finland, it is known from several localities in managed and old-growth forests on bark of *Betula* spp. and decaying wood of *Picea abies*. The species has also been reported from the Russian Far-East (Konoreva et al. 2019).

*Specimens examined: Sweden. Gotland:* Lummelunda par., Ellstadaränget wooded meadow, c. 1 km NW of Burge and c. 1 km E of Lummelunda church, 57.76667°N, 18.46667°E, on base of *Quercus robur*, 1-2 Sept 1990, A. Nordin, R. Sundin & G. Thor 1299 (UPS L-161769 [TLC: methoxymicareic acid]); *Södermanland:* Stora Malm par., Nästorp, mixed forest close to forest road c. 500 m SE of the farm, c. 9.5 km S of Katrineholm, 58.908°N, 16.243°E, on trunk of *Betula*, 9 June 2008, A. Nordin 6547 (UPS L-179116); *Västerbotten:* Degerfors par., 3.5 km W of Trehörningen, along the stream between tarns Kallmossatjärnen and Nyttjärnen, 64.568405°N, 19.573551°E, alt. 300 m, on stump of *Betula* by small stream in coniferous production forest, 26 June 2020, M. Svensson 3765 (UPS L-987347; confirmed by sequencing).

*Exsiccatae:* Malme, Lichenes Suecici Exsiccati, No 23 (H) [as *Micarea prasina* Fr. f. *laeta* Th. Fr.; Sweden, Södermanland, 1890, O. Malme]; Magnusson, Lichenes Selecti Scandinavici Exsiccati, No 134 (H) [as *Catillaria prasina* (Fr.) Th. Fr. f. *laeta* Th. Fr.; Sweden, Västergötland, 1927, A. H. Magnusson].

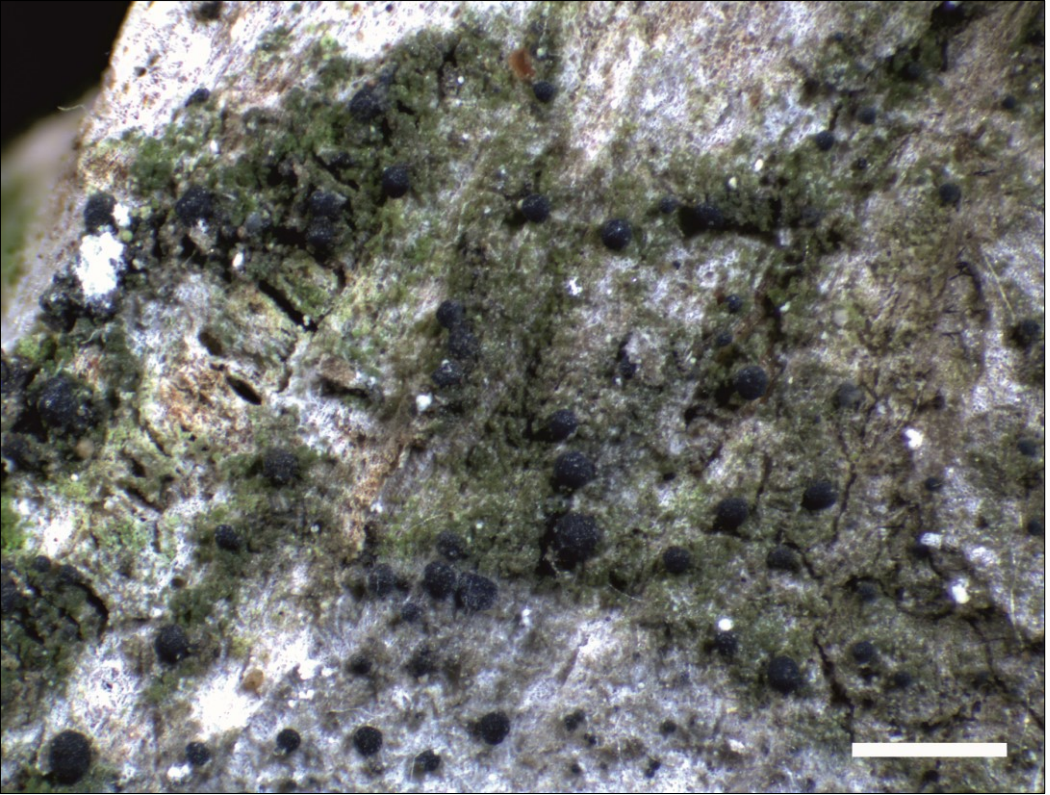
### *Micarea melanobola* (Nyl.) Coppins

Fig. 4

*Micarea melanobola* is characterized by a pale to dark vivid green thallus that is composed of goniocysts that often coalesce to form larger granules. In cases where the thallus is less developed, it is warted-areolate. Apothecia are numerous, 0.15–0.4 mm diam. and hemispherical to subglobose in shape. They are mostly dark grey to blackish, more rarely pale grey and produce the Sedifolia-grey pigment that reacts K<sup>+</sup> violet and C<sup>+</sup> violet in cross-sections. The pigment is strongly visible even in specimens collected from shaded habitats. Ascospores are oblong-ellipsoid or obovoid, 0–1 septate and 7.25–11.0 × 2.5–3.75 (–4.0) μm. Meso- and micropycnidia are usually present and numerous but mostly immersed between goniocysts and therefore inconspicuous. The species produces micareic acid.

Based on molecular studies, *Micarea melanobola* is closely related to *M. fallax* and *M. prasina* s. str. (Launis et al. 2019c). Morphologically, *M. melanobola* can be distinguished from *M. prasina* s. str. by several characters. The latter has wider and paler apothecia, its spores are slightly bigger (8–12(–14)–5) μm) and it produces crystalline granules mostly in the epihymenium, whereas *M. melanobola* produces granules in the hymenium (see photos in Launis et al. 2019b). *Micarea melanobola* differs from *M. fallax* by its dark grey to black apothecia.

*Micarea melanobola* was described by Nylander (1867, as *Lecidea melanobola*), but has since often been treated as a synonym of *M. prasina* (e.g., Hedlund 1892, Czarnota 2007). Coppins (1983) however, recognized *M. melanobola* at the species level and, likewise, did Launis et al. (2019b) after studying both morphological and molecular characters.



**Figure 4.** *Micarea melanobola* (L-872146). Scale bar 1 mm.

*Micarea melanobola* was correctly identified and reported from Sweden by Hedlund (1892, as *M. prasina* f. *melanobola*). The species was also reported as *Catillaria melanobola* (Nyl.) Vain. by Degelius (1936, p. 70) but the specimen that this report was based on is an erroneously identified specimen of *Lecidea turgidula* (UPS L-774435!). *Micarea melanobola* has been found on bark and decaying wood of *Betula* spp., *Picea abies* and *Pinus sylvestris* in boreal old-growth and managed forests, and on bark of *Quercus robur* in deciduous forests. It seems to prefer rather shaded and moist habitats, e.g., northern sides of tree trunks and/or areas near the ground. In addition to the here reported new records from central and northern Sweden, the species is known from southern and central Finland, and from one old locality in Switzerland. In addition, Czarnota (2007) mentioned one possible collection from Estonia, but no sequence is available of the specimen and it has not been seen by us. The species is likely common.

*Specimens examined:* **Sweden.** *Dalarna:* Ludvika par., Biskopsnäset, 2,6 km NO om Ludvika k:a, 60.167°N, 15.2167°E, alt. 155 m, på stambas av gammal *Picea* i sumpgranskog, 18 Jan 2000, J. Hermansson 9931 (UPS L-107292); *Medelpad:* Alnö par., Stornäset, Alnö, 4 km VNV Alnö k:a, 62.483°N, 17.483°E, *Betula* i gråalkärr, 19 Aug 1991, J. Hermansson 2748 (UPS L-125626); *Uppland:* Norrtälje par., Norrtälje, July 1887, T. Hedlund (as *Micarea prasina* f. *melanobola*, UPS L-773781); Orkesta par., about 200 m SW of Vasakullen, 59.582109°N, 18.115819°E, alt. 25 m, on bark of *Quercus robur* in broadleaved deciduous forest, 3 March 2020, M. Svensson 3701 (UPS L-987348; confirmed by sequencing); Vänge par., Fiby urskog, 59.88449°N,



**Figure 5.** *Micarea pseudomicrococca* (59151, H). Scale bar 1 mm.

17.35268°E, på granbark, 26 April 2016, M. Westberg, S. Ekman, G. von Hirschheydt 82, (UPS L-872026); Fiby urskog, 59.88821°N, 17.34580°E, på tallbark, 11 May 2016, M. Westberg, S. Ekman, G. von Hirschheydt 99 (UPS L-872044 [TLC: micareic acid]); Fiby urskog, 59.89183°N, 17.34426°E, på ek, 9 Sept 2016, M. Westberg, S. Ekman, G. von Hirschheydt 202, (UPS L-872146).

***Micarea pseudomicrococca* Launis & Myllys**

Fig. 5

*Micarea pseudomicrococca* is characterized by an olive-green, sometimes partly bright green, minutely granular thallus that is composed of goniocysts. Apothecia are few to abundant, 0.2–0.4 mm diam., plane, convex or ± hemispherical, sometimes becoming tuberculate, creamy white or often pale brownish and always K– and C– (no Sedifolia-grey pigment). Ascospores are oblong-ellipsoid or obovoid, 0–1 (–2) -septate, and 8–14 (–15) × 2.0–3.2 µm. The species develops two types of paraphyses: 1) scanty, scarcely branched, 0.8–1.0 (–1.2) µm wide and 2) thicker, 1.2–2.0 µm wide with apices usually increasing up to 3 µm. Sometimes the apices branch 1–3 times, resulting in a fork- or brush-like appearance. Meso- and micropycnidia are usually present but often immersed and therefore hardly visible. The species produces methoxymicareic acid.

Based on molecular studies, *Micarea pseudomicrococca* is closely related to *M. czarnotae* and *M. micrococca* (Launis et al. 2019a). The main distinguishing morphological characters of *M. pseudomicrococca* are the long and thin spores, and the two types of paraphyses of which the thicker one is not known from its closest relatives. Moreover, it differs from *M. micrococca* by having an olive-green instead of bright green thallus and thinner ascospores. From *M. czarnotae* it differs by lacking the Sedifolia-grey pigment in the apothecia, by developing longer ascospores and by forming a more granular thallus.



In addition to the new records from Sweden reported here, this species is known from southern and central Finland, Russia (Kaliningrad Region) and eastern Scotland (Launis et al 2019a; Konoreva et al. 2020). It has been collected from bark of *Alnus glutinosa*, *A. incana*, *Betula* sp., *Prunus padus*, *Salix caprea* and on decaying wood of fallen *Picea abies* in old-growth forests.

*Specimens examined: Sweden. Dalarna:* Nås par., Vargåsen, at the foot of the ENE slope of the ridge, 8 km SSE of Lindesnäs, 60.25°N, 14.567°E, on *Picea* log in *Picea* forest, 6 April 1997, A. Forsslund & A. Koffman 790 (UPS L-158384); *Härjedalen:* Överhogdal par., SE slope of the mountain Nördberget, 7 km NW of Överhogdal church, 62.31659°N, 14.69939°E, alt. 430 m, on *Salix caprea*, 12 Sept 2018, M. Westberg, L. Hedenäs & G. Odelvik HH084a (UPS); *Uppland:* Vänge par., Fiby urskog, 59.89183°N, 17.34426°E, på ek, 9 Sept 2016, M. Westberg, S. Ekman, G. von Hirschheydt 196 (UPS L-872140); *Västergötland:* Nödinge par., Surte, 2 km S of the church, at the stream between the two small lakes “Keillers damm” and “Kodammen”, 57.81485°N, 12.02183°E, alt 50 m, at the base of large *Alnus glutinosa* in dense mixed deciduous/coniferous forest, 22 Dec 2008, G. Thor 22919 (UPS L-200226).

**Key to species of the *Micarea prasina* group in Central and Northern Europe**

Species known only from Macaronesia or Portugal are not included in the key. A further species of the *M. prasina* group, *M. herbarum*, was omitted as it lacks secondary chemistry and is most similar to species outside of the *M. prasina* group, such as *M. denigrata* and *M. misella*.

- 1. Thallus C+ red or C+ orange ..... 2
  - Thallus C–, or rarely C+ violet ..... 3
- 2. Thallus containing xanthonenes, C+ persistent orange, with soralia/clusters of proliferating granules pale yellow-green ..... *M. xanthonica*
  - Thallus and apothecia containing gyrophoric acid, C+ red (not persistent), KC+ red, thallus ± leprose, bright green, apothecia usually absent ..... *M. viridileprosa*
- 3. With ± stalked (sometimes broadly sessile), usually tomentose pycnidia, apothecia (when present) pale to pale brown ..... 4
  - Without stalked pycnidia ..... 6
- 4. Pycnidia stalked dark grey to dark brownish with white tomentum, walls K+ violet, C+ violet (Sedifolia-grey), 0.2–0.5 (–1.0) mm tall, thallus pale olive green to bright green, contains micareic acid ..... *M. fennica*
  - Pycnidia stalked or broadly sessile, lighter in colour, thallus without secondary substances . . . 5
- 5. Pycnidia stalked, brownish, greyish or lilac with white tomentum, walls K+ violet, C+ violet (Sedifolia-grey), 0.2–0.5 mm tall, thallus dull green or olive green, containing orange-brown droplets reacting K+ violet (Intrusa-yellow) ..... *M. hedlundii*
  - Pycnidia broadly sessile to stalked, brownish, greyish or lilac with whitish tomentum at least in lower parts, walls K– or if sometimes greyish K± violet (Sedifolia-grey), up to 0.3 mm tall, thallus bright green, no orange-brown droplets in thallus ..... *M. tomentosa*
- 6. Thallus coralloid, with abundant branched “isidia” forming a ± continuous layer, apothecia rare ..... 7
  - Thallus not coralloid/isidiate ..... 8
- 7. On wood and acidic bark, contains micareic acid ..... *M. isidioprasina*
  - On bark and wood of deciduous trees, contains methoxymicareic acid ..... *M. pauli*

8. Thallus containing prasinic acid (detectable as c.  $5 \times 50 \mu\text{m}$  crystals in acetone extract), usually on soil ..... *M. subviridescens*  
 – Thallus with micareic or methoxymicareic acid ..... 9
9. Thallus with micareic acid ..... 10  
 – Thallus with methoxymicareic acid ..... 16
10. Thallus with distinct areoles, only partly granular ..... *M. meridionalis*  
 – Thallus granular or sorediate, sometimes warted if thin, but never distinctly areolate ..... 11
11. Thallus sorediate or farinose ..... 12  
 – Thallus usually granular, of goniocysts, sometimes poorly developed ..... 13
12. Thallus minutely sorediate or farinose, thick, yellowish to whitish green in thicker parts and dark olive green in thin parts, bright green when fresh, internally K<sup>-</sup> and C<sup>-</sup> .. *M. flavoleprosa*  
 – Thallus sorediate, with well-delimited soralia or in older parts scattered to confluent clusters of proliferating granules, internally K<sup>+</sup> violet, C<sup>+</sup> violet in well-lit habitats ..... *M. soralifera*
13. Apothecia always dark grey to blackish, even if growing in shade ..... 14  
 – Apothecia brownish or pale to medium grey, sometimes partly dark grey if in well-lit habitat ..... 15
14. On decaying hard wood in habitats exposed to light, ascospores  $6-8 (-8.5) \times 2-3 \mu\text{m}$ , pycnidia numerous especially when apothecia are rare, emergent to short-stalked ..... *M. nowakii*  
 – Usually on bark in shaded and moist habitats, ascospores  $7-11 \times 2.5-3.5 (-4) \mu\text{m}$ , pycnidia immersed ..... *M. melanobola*
15. Usually on decaying wood, thallus granular or vertically proliferating giving it a soft isidious appearance, crystalline granules (visible in polarized light) always in the epihymenium and sometimes also in the hymenium ..... *M. prasina s.str.*  
 – Usually on bark, thallus granular, often coalescing to form larger granules or a more or less thick, almost continuous and cracked thallus, if on decaying wood thallus thin or membranous, crystalline granules in the hymenium but not in the epihymenium ..... *M. fallax*
16. Apothecia rarely present, white or brownish, internally K<sup>-</sup>, C<sup>-</sup>, 0.2–0.3 mm in diam., thallus sorediate, soralia delimited or diffuse, green or locally bluish and then K<sup>+</sup> violet, on bark and decaying wood, mostly in microhabitats where only few other lichen species occur .....  
 ..... *M. microsorediata*  
 – Apothecia present and usually abundant, thallus minutely granular or forming a continuous dense crust, sometimes partly areolate ..... 17
17. Apothecia up to 0.6 (–0.7) mm wide, often adnate ..... 18  
 – Apothecia up to 0.4 mm wide, rarely adnate ..... 21
18. Thallus minutely granular, olive green, apothecia usually (at least in part) greyish, epihymenium often K<sup>+</sup> violet, C<sup>+</sup> violet ..... *M. byssacea*  
 – Thallus granular or at least partly areolate, vivid green – olive green – whitish green, apothecia cream white to brown, internally C<sup>-</sup>, K<sup>-</sup> or K<sup>±</sup> dulling ..... 19
19. Thallus granular and/or a continuous crust, apothecia cream white to pale brownish, ascospores  $3-4 \mu\text{m}$  wide ..... *M. laeta*  
 – Thallus at least in part areolate, apothecia cream white to brown ..... 20

20. Thallus at least partly small-areolate, consisting of goniocysts, with internal crystalline granules (visible in polarized light), apothecia cream white (no pigments), ascospores 2–3  $\mu\text{m}$  wide . . . . . *M. microareolata*  
 – Thallus areolate, consisting of flattened to convex often subsquamulose granules without internal crystalline granules, apothecia grayish brown, pale brown to dark brown (Superba-brown), ascospores 2.5–5  $\mu\text{m}$  wide . . . . . *M. pseudotsugae*
21. Apothecia very small, 0.15(–0.2) mm diam., numerous and crowded, always cream white, internally K–, C–, thallus thinly granular or membranous . . . . . *M. pusilla*  
 – Apothecia 0.2–0.4 mm wide, cream white or greyish and then epihymenium K+violet, C+ violet . . . . . 22
22. Thallus warted, cracked, forming a continuous dense crust without internal crystalline granules, olive green, apothecia often greyish, epihymenium K+ violet, C+ violet, ascospores 7–10  $\times$  2.0–3.5  $\mu\text{m}$ , paraphyses –1.5  $\mu\text{m}$  wide . . . . . *M. czarnotae*  
 – Thallus granular, bright to pale olive green with crystalline granules, apothecia cream white, internally K–, C–, ascospores up to 16  $\mu\text{m}$  long, paraphyses –1.5  $\mu\text{m}$  wide or –2–3  $\mu\text{m}$  wide . . . . . 23
23. Thallus bright green, ascospores 3–4.5  $\mu\text{m}$  wide, one type of paraphyses –1.5  $\mu\text{m}$  wide . . . . . *M. micrococca*  
 – Thallus pale olive green to bright green, ascospores 2–3  $\mu\text{m}$  wide, two types of paraphyses –1.5  $\mu\text{m}$  wide and –2  $\mu\text{m}$  wide with apices –3  $\mu\text{m}$  wide . . . . . *M. pseudomicrococca*

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