

## Unveiling a surprising diversity in the lichen genus *Micarea* (*Pilocarpaceae*) in Réunion (Mascarenes archipelago, Indian Ocean)

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**Abstract:** Detailed anatomical and chemical studies conducted on recent collections made in almost all suitable habitats on Réunion, a small remote tropical island in the Indian Ocean, yielded a surprising diversity in the widespread lichen genus *Micarea* (*Pilocarpaceae*, *Lecanorales*). Twenty-one species are recognized, including 13 described here as new to science. They are: *Micarea alectorialica*, *M. bebourensis*, *M. borbonica*, *M. boryana*, *M. cilaensis*, *M. hyalinioxanthonica*, *M. isidiosa*, *M. melano-prasina*, *M. pseudocoppinsii*, *M. pseudolignaria*, *M. sublithinella*, *M. takamakae* and *M. tenuispora*. Notes on local ecology and important biogeographical features are also given and a key to the species is provided. Isidii-form areolae are reported for the first time in the genus (*M. isidiosa* and *M. tenuispora*), as well as the production of protolichesterinic and confluent acids (*M. sublithinella* and *M. takamakae*, respectively). Two groups within the genus are species-rich on the island: the *M. peliocarpa* group with possibly 5 species, including 3 new to science, and the *M. prasina* group with 4 species, including 2 new to science. *Micarea levicula* is reported here for the first time since its description, and the status of the material that can be referred to *M. micrococca* s. lat. needs further study.

**Key words:** lichen diversity, lichenized Ascomycota, new species, Southern Hemisphere, taxonomy, tropical habitats

*Accepted for publication 16 September 2013*

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### Introduction

The species is the fundamental unit of any study on the biodiversity and ecosystems of our planet, and yet, many groups of organisms have only a small fraction of their species formally described (Gaston 2000). Fungi as a major phylum present in almost all biomes represent a remarkable example: the number of species is expected to be much higher than a million, while only 100 000 are currently described (Blackwell 2011; Hawksworth 2012). We performed detailed anatomical and chemical studies of lichen material recently collected in Réunion (a small and remote island in the Indian Ocean) in a

widespread and speciose genus (*Micarea* Fr., *Pilocarpaceae*, *Lecanorales*) to describe each species and formulate a sound taxonomic treatment of all species found in this limited, but very diverse, territory in the tropics. By showing that the genus *Micarea* is species-rich in Réunion, with many undescribed species, we provide further data for the better assessment of the total number of undescribed lichen taxa (Lücking *et al.* 2009; Bass & Richards 2011).

Although there are many species of *Micarea* in the Southern Hemisphere, the few monographic treatments of the genus, however masterful, have addressed only European species (Coppins 1983, 2009; Czarnota 2007). Molecular inferences resolved the genus into different clades and thus it is polyphyletic (Andersen & Ekman 2005; Sérusiaux *et al.* 2010; Schmall *et al.* 2011): *M. crassipes* is the type species of the distantly related genus *Helocarpon*, *M. sylvicola* and its relatives belong to the *Psoraceae*, and all other species form a supported but poorly resolved clade

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with all accessions of the *Ectolechiaceae* and the *Pilocarpaceae* s. str. nested into it. Further phylogenetic studies with several loci are therefore needed before a well-supported delimitation of the genus can be adopted.

Phylogenetic inferences from mtSSU sequences (Czarnota & Guzow-Krzemińska 2010) were used to investigate the species delimitation within the well-known, albeit notoriously difficult, *Micarea prasina* group. Three lineages were resolved within *M. micrococca*, two being formally recognized at species level [*M. byssacea* (Th. Fr.) Czarnota *et al.* and *M. micrococca* (Körb.) Gams ex Coppins s. str.]. This study assumed that a phylogenetic tree produced with data from a single locus can disentangle a difficult group of species, whereas gene trees represent 'local optima' that require additional tests and appropriate statistical methods to yield a robust species tree (Maddison 1997; Edwards 2008; Knowles & Kubatko 2010; Camargo *et al.* 2012a, b; Carstens *et al.* 2013). It nevertheless demonstrates that the variation within the *M. prasina* group is quite substantial and requires detailed investigation.

Even when excluding the species that belong elsewhere in the *Lecanorales*, the genus is very diverse and occurs on all continents, including the Antarctic, and its diversity is estimated at c. 90 species (Coppins 2009). The area best sampled and studied is certainly Europe (Czarnota 2007; Coppins 2009). Asia (from the western Himalaya to Japan) and tropical mountains in the three continents represent unexplored and highly promising biomes for studying the diversity of the genus.

Réunion is a small island of 2512 km<sup>2</sup> in the Indian Ocean, part of the Mascarene archipelago along with two other islands, Mauritius and Rodrigues. It has a volcanic origin, and one of the most active volcanoes in the world (Piton de la Fournaise) is located on its eastern side, with an elevation of 2631 m. Otherwise it is a serrated mountain range (highest point at 3069 m at the Piton des Neiges), dissected in huge 'cirques' and very deep gorges. Its position in the tropical zone makes its climate warm and seasonal, although the temperature can be quite low

at high elevations. A working list of lichen species found on the island was published recently (van den Boom *et al.* 2011), based on collections gathered over the last 15 years. A total of 463 taxa were recorded, including several rare species, large expansion of the distribution range for others, and the detection of an austral element (species whose distribution range is limited to the Southern Hemisphere). Finally, analysis of the status of species endemic to the island pointed to the urgent need for taxonomical studies in speciose and poorly known genera. *Micarea* is one of these and the taxonomy of species found on the island is the aim of this paper.

## Materials and Methods

This study is mainly based on extensive collections of *Micarea*, made by the authors on the island in 2008, and hosted in LG and the private herbaria of the first two authors (h refers to the private herbarium of the collector). Further specimens gathered in 2009 by one of us (ES), with Nicolas Magain, were also included. Anatomical data were gathered and measured in dilute KOH for conidia and paraphyses width, and on material mounted in water for all other characters. In each collection, c. 5 well-developed ascospores representing the size and shape variation detected, conidia and paraphyses were measured up to 0.1 µm accuracy using *camera lucida* drawings.

Chemical compounds were studied using several methods: medulla under UV light; melting point and microcrystallization; thin-layer chromatography (TLC) using solvent system A (toluene/1,4-dioxane/acetic acid 180:45:5) or C (toluene/acetic acid 170:30) when gyrophoric acid was expected (Huneck & Yoshimura 1996; Orange *et al.* 2010) and visualization of spots with sulphuric acid sprayed over the plates, followed by heating at 110°C for c. 5 min. Insoluble pigments are characterized following the classification of Meyer & Printzen (2000).

## Results

### Chemical compounds

Here we present data on the chemical compounds detected in our material. Details are provided only for unusual compounds or those that can be difficult to distinguish. The numeral in TLC rubric refers to the height, measured in mm, after a 45 mm run; H refers to the spot colour after charring in H<sub>2</sub>SO<sub>4</sub>; U2 refers to UV examination at 254 nm,

while U3 refers to 360 nm; and finally extract description refers to acetone extraction on a microscope slide.

Methoxymicareic acid (Elix *et al.* 1984) = prasina A (*sensu* Coppins 1983): TLC 26; U2+, U3± white (“blue-white” in Coppins 1983); H yellow-brown; U3 after charring dark brown; crystals not melting on heating (or only after prolonged boiling).

Micareic acid (Elix *et al.* 1984) = prasina B (*sensu* Coppins 1983): TLC 26; U2+, U3± white (“blue” but less than prasina A in Coppins 1983); H (orange-) yellow; U3 after charring vivid yellow; crystals melting on gentle heating.

Prasinic acid (Elix *et al.* 1984) = prasina C (*sensu* Coppins 1983): TLC 24; U2+, U3± white (“grey or pale mauve” or “colourless” in Coppins 1983, depending on solvent system used); H grey; U3 after charring dark blue-grey; extract soon milky by forming rod-shaped crystals.

Methylhiassic acid: TLC 12; U2+ grey, U3-; H grey; can only be separated from gyrophoric acid by TLC in solvent C (Orange *et al.* 2010), not in A. It was found in *Micarea borbonica* sp. nov. and *M. peliocarpa*.

Unknown 1 = unknown in *M. melanoprasina* sp. nov.: TLC 31; U2+, U3-; H pale greenish grey; U3 after charring light greenish grey; crystals melting on gentle heating, soon recrystallizing; extract clear, gummy, without crystals; a substance probably related to micareic acid.

Unknown 2 = most probably confluent acid, or a related compound, detected in *M. takamakae* sp. nov.: TLC 24; U2+, U3-; H pale yellowish with greyish rim; extract gummy, with radial wrinkles, later turning milky.

Unknown 3 = unknown in *M. pseudolignaria* sp. nov.: TLC 28; U2+, U3-; H yellow-brown (as in methoxymicareic acid); U3 after charring dark brown (as in methoxymicareic acid); extract clear, gummy, white within the ring, amorphous, not polarizing; small crystals in thallus not melting.

Besides the well-known compound argopsin and a xanthone that we tentatively refer to as

thiophanic acid, two compounds are worth mentioning: alectorialic acid, diagnostic for *M. alectorialica* sp. nov., and a fatty acid (protolichesterinic acid) reported here for the first time in the genus and diagnostic for *M. sublithinella* sp. nov. Another fatty acid, close to rangiformic acid, was also detected in *M. alectorialica* sp. nov.

Insoluble pigments have been characterized by Meyer & Printzen (2000); the following have been detected in our material (H being the reaction to HCl, and N to HNO<sub>3</sub>):

Cinereorufa-green: bright aeruginose, K+ green, H-, N+ red, found in *Micarea alectorialica* sp. nov., *M. boryana* sp. nov., *M. incrassata*, *M. isidiosa* sp. nov., *M. lignaria*, *M. melanoprasina* sp. nov., *M. pseudocoppinsii* sp. nov., *M. pseudolignaria* sp. nov., *M. takamakae* sp. nov. and *M. tenuispora* sp. nov. In *M. borbonica* sp. nov., *M. cilaensis* sp. nov., *M. cinerea*, *M. peliocarpa* and *M. pseudocoppinsii* sp. nov., the same pigment is detected but has a slightly different colour (greyish blue and not bright aeruginose as in other species) and is a surface incrustation of hyphae and not diffuse in the hymenial gelatine (as in other species). We consider it a variant of the Cinereorufa-green that requires further investigation.

Laurocerasi-brown: pale reddish brown, K+ purple-brown, H-, N-, found in *Micarea bebourensis* sp. nov.

Sedifolia-grey: greyish, K+ violet, found in *Micarea hedlundii* and *M. prasina*.

Superba-brown: pale brown, K+ dull brown, found in *Micarea incrassata*.

Unknown 4: violet-red, K+ green, H-, forming dark blue granules in N which get more greenish when further applying K, found in the hymenium of *Micarea isidiosa* sp. nov. The granules are quite similar to those found in *Lecidea hypnorum* but, in this species, they do not require application of N to be detected.

Unknown 5: this substance can be detected at the goniocysts centre of *Micarea hedlundii* as tiny oily drops, which are not soluble in acetone, and therefore cannot be analyzed with TLC.

Additional brown pigment(s) that lack characteristic reactions and have thus not been classified by Meyer & Printzen (2000) were also observed.

In several species (*Micarea bebourensis* sp. nov., *M. boryana* sp. nov., *M. levicula*, *M. melanoprasina* sp. nov. and *M. prasina*), and in some collections of others (*M. isidiosa* sp. nov., *M. lignaria* and *M. pseudolignaria* sp. nov.), the thallus hyphae are I+ light blue after soaking in KOH (hemiamyloid); the reaction is often weak and not always constant. Such a hemiamyloid reaction has also been detected in many European species of *Micarea* but, to our knowledge, has never been found in other genera of the *Lecanorales*.

### Taxonomy (Table 1)

We could detect and delimit 21 species in our material, out of which only eight can be assigned to an already described species; the other 13 are thus described as new to science in this paper. A key for their identification is presented below.

Two subgeneric entities yielded several new species and can be described as speciose groups on the island. They are the *M. peliocarpa* group and the *M. prasina* group (*sensu* Coppins 1983). The first one comprises *M. borbonica* sp. nov., *M. boryana* sp. nov., *M. cinerea*, *M. peliocarpa* and possibly *M. pseudocoppinsii* sp. nov., while the second includes *M. levicula*, *M. melanoprasina* sp. nov., *M. prasina* and possibly *M. hyalinoxanthonica* sp. nov. The latter group further includes material that contains methoxymicareic acid and belongs to *M. micrococca* s. lat. (Coppins 2009); its taxonomy needs further study and is not dealt with in this paper.

### Ecology and biogeography (Table 2)

Interestingly, no species known so far only from the Southern Hemisphere was detected in our material, although one (*M. boryana* sp. nov.) seems to be close to *Micarea mutabilis*, described and as yet known only from Tasmania (Australia). The austral element detected in the working list of lichens present on Réunion (van den Boom *et al.* 2011) cannot thus be consolidated. The other species

of *Micarea* so far restricted to the Southern Hemisphere (Coppins & Kantvilas 1990; Kantvilas & Elix 1994; Coppins 1999; Aptroot 2002; Fryday 2004; Cáceres *et al.* 2013) are: *Micarea almbornii* Coppins, *M. corallothallina* M. Cáceres *et al.*, *M. endoviolasces* Coppins, *M. intersociella* (Sirt.) Coppins, *M. magellanica* (Müll. Arg.) Fryday (= *M. austroternaria* Coppins & Kantvilas), *M. pannarica* Fryday, *M. subgranulans* (Vain.) Aptroot and *M. subternaria* (Vain.) Aptroot. *Micarea poliocheila* (Vain.) Aptroot, restricted to Brazil (Minas Gerais and Rio de Janeiro), has been transferred to *Bilimbia* by Kalb (2007).

Interestingly, habitats at the highest elevations (>2000 m), and more precisely outcrops in dry and exposed conditions above cloud level, yielded three species that are either widespread in the temperate and boreal zones of the Northern Hemisphere (*M. erratica* and *M. lignaria*) or bipolar, being also found in subantarctic islands (*M. incrasata*). Such observations demonstrate the impressive dispersion capacity of lichen species (Honegger 1993; Romeike *et al.* 2002).

*Micarea* is absent in all habitats at low elevations on the island, including the rocky shores, open and anthropogenic vegetation, recent or old lava flows, and remnants of low elevation rainforest dominated by the *Sapotaceae* (e.g. at the nature reserve of 'Mare Longue' near St-Philippe). Following the vegetation typology provided by Cadet (1977), Strasberg *et al.* (2005) and Lacoste *et al.* (2011), we recognized six vegetation types that accommodate species of *Micarea* (Fig. 1):

Montane forest with large boles of *Acacia heterophylla*, either in natural stands or in plantations, at >1500 m elevation.

Montane forest known as 'Bois de couleurs des Hauts', easily characterized by the abundance of tree species in the genera *Dombeya* (*Malvaceae*), *Monimia* and *Tambourissa* (*Monimiaceae*), and others in the *Euphorbiaceae*, *Rubiaceae*, *Rutaceae*, *Nuxia verticillata*, and locally the native bamboo *Nastus borbonicus* and tree ferns (*Cyathaea*), mainly at elevations >1300 m.

TABLE 1. Summary of the taxonomy adopted for material of *Micarea* from Réunion and substantiation of the decision taken

Species name	Substantiation of the decision taken in this study
<i>M. alectorialica</i> sp. nov.	Alectorialic acid is otherwise only present in <i>M. magellanica</i> and <i>M. submilliaria</i> which do not develop soralia
<i>M. bebourensis</i> sp. nov.	Easily recognized by its tuberculate thallus, globose and almost stipitate, light to dark brown apothecia
<i>M. borbonica</i> sp. nov.	Close to <i>M. peliocarpa</i> and differing by its 7-septate, longer and larger ascospores
<i>M. boryana</i> sp. nov.	Easily recognized by its narrowly clavate to needle-like ascospores, mainly 3-septate; a member of the <i>M. peliocarpa</i> group
<i>M. cilaensis</i> sp. nov.	Easily recognized by its <i>Lecania</i> -like apothecia, close to <i>M. denigrata</i> which differs by its smaller macroconidia
<i>M. cinerea</i> (Schaer.) Hedl.	Identical with the material from Europe available to us, except for the absence of methylhiassic acid
<i>M. erratica</i> (Körb.) Hertel et al.	Identical with the material from Europe available to us
<i>M. hedlundii</i> Coppins	Identical with the material from Europe and East Africa available to us
<i>M. hyalinioxanthonica</i> sp. nov.	Distinguished from the other two xanthone-producing species by thallus, apothecia and ascospore characters; may belong to the <i>M. prasina</i> group
<i>M. incrassata</i> Hedl.	Almost identical with the material from Europe available to us
<i>M. isidiosa</i> sp. nov.	Unique combination of isidiiform areolae and bacillar, 3–7-septate ascospores
<i>M. levicula</i> (Nyl.) Coppins	A representative of the <i>M. prasina</i> group, distinguished by production of gyrophoric acid; <i>M. viridileprosa</i> differs by thallus characters and narrower ascospores
<i>M. lignaria</i> (Ach.) Held.	Identical with the material from Europe available to us, although TLC analysis could not be performed
<i>M. melanoprasina</i> sp. nov.	A representative of the <i>M. prasina</i> group, distinguished by its conspicuous blackish prothallus and production of an unknown substance
<i>M. peliocarpa</i> (Anzi) Coppins & R. Sant.	Identical with the material from Europe available to us
<i>M. prasina</i> Fr.	Identical with the material from Europe, except for the K+ violet pigment which is present in the hypothecium and not in the epihymenium
<i>M. pseudocoppinsii</i> sp. nov.	Differs from <i>M. coppinsii</i> by shorter ascospores and absence of methylhiassic acid; probably a member of the <i>M. peliocarpa</i> group
<i>M. pseudolignaria</i> sp. nov.	Differs from <i>M. lignaria</i> by its 1-septate ascospores and different chemistry
<i>M. sublithinella</i> sp. nov.	Differs from <i>M. lithinella</i> by its 0–1-septate and larger ascospores and production of protolichesterinic acid
<i>M. takamakae</i> sp. nov.	Easily distinguished by small ascospores (8·8–10·2 × 3·1–3·8 µm) and production of confluent acid
<i>M. tenuispora</i> sp. nov.	Unique combination of isidiiform areolae with narrowly clavate to needle-like, 3–5-septate ascospores

Wet montane thickets with tall ericoid species including *Erica reunionensis*, with exuberant development of ground bryophyte cover (including species of *Sphagnum*), at c. 1700–1900 m.

Open and partially grazed forests, dominated by *Sophora denudata*, on the SW side of the Piton de la Fournaise, at c. 1800–2000 m. Dry and exposed outcrops, at high elevations (> 2000 m) with xerophytic bryophytes.



TABLE 2. Distribution of the representatives of the genus *Micarea* in the different habitats where they grow on Réunion

Species name (all in the genus <i>Micarea</i> )	Montane forest dominated by <i>Acacia</i> <i>heterophylla</i>	Montane forest (‘Bois de couleur des Hauts’)	Wet montane ericoid thickets	Montane forest dominated by <i>Sophora</i> <i>denudata</i>	Outcrops at high elevation	Disturbed habitat below 700 m elevation
<i>alectorialica</i>	—	—	X	—	—	—
<i>bebouensis</i>	—	X	—	—	—	—
<i>borbonica</i>	X	X	X	X	—	—
<i>boryana</i>	—	X	—	—	—	—
<i>cilaoensis</i>	—	X	—	—	—	—
<i>cinerea</i>	—	—	X	X	—	—
<i>erratica</i>	—	—	—	—	X	—
<i>hedlundii</i>	—	X	—	—	—	—
<i>hyalinioxanthonica</i>	—	X	—	—	—	—
<i>incrassata</i>	—	—	—	—	X	—
<i>isidiosa</i>	—	—	X	—	—	—
<i>levicula</i>	X	—	—	—	—	—
<i>lignaria</i>	—	—	—	—	X	—
<i>melanoprasina</i>	X	—	—	—	—	—
<i>pelioarpa</i>	X	X	X	—	—	—
<i>prasina</i>	X	—	—	—	—	—
<i>pseudocoppinsii</i>	X	—	—	—	—	—
<i>pseudolignaria</i>	—	—	X	—	—	—
<i>sublithinella</i>	X	X	—	—	—	—
<i>takamakae</i>	—	—	—	—	—	X
<i>tenuispora</i>	—	X	—	—	—	—

The numbers of species of *Micarea* found in each habitat are presented in Table 2. As expected, the most diverse habitat is the montane forest ‘Bois de couleurs des Hauts’ with nine species, including five new species which have only been found here (*M. bebouensis* sp. nov., *M. boryana* sp. nov., *M. cilaoensis* sp. nov., *M. hyalinioxanthonica* sp. nov. and *M. tenuispora* sp. nov.). It is immediately followed by the *Acacia heterophylla* forests, with seven species. The soft, rather acidic, quick-drying and often peeling bark of that endemic tree seems to be a very suitable habitat for many species of *Micarea*. The wet ericoid thickets shelter six species, with two species new to science (*M. alectorialica* sp. nov. and *M. isidiosa* sp. nov.) being restricted to it. Furthermore, the *Sophora* open forest has only two species, including *M. borbonica* sp. nov. which is the only species present in all types of montane forest. The most distinctive *M. takamakae* sp. nov. is only known from a non-montane forest habitat.

Like many isolated islands and archipelagos all over the world, Réunion’s original biota has been devastated by human impact and the local fauna and flora are much altered by exotic species; therefore conservation evaluation and planning require detailed studies of biodiversity processes (Lagabrielle *et al.* 2009). In Réunion, the native vascular flora is estimated at *c.* 500 species and more than 3500 have been introduced, 62 being highly invasive (Baret *et al.* 2006). The question may therefore arise regarding the status of lichen species observed on the island: are some species exotic? Although we have no clue at all to support this hypothesis, the question may be relevant for species growing on introduced tree species, such as *Cryptomeria japonica*, a species widely planted on Réunion. The case of three newly described species, *M. boryana*, *M. cilaoensis* and *M. tenuispora*, is illustrative as they have been detected only on trunks of *Cryptomeria*. However, the acidic and peeling bark of this tree makes it a suitable habitat for

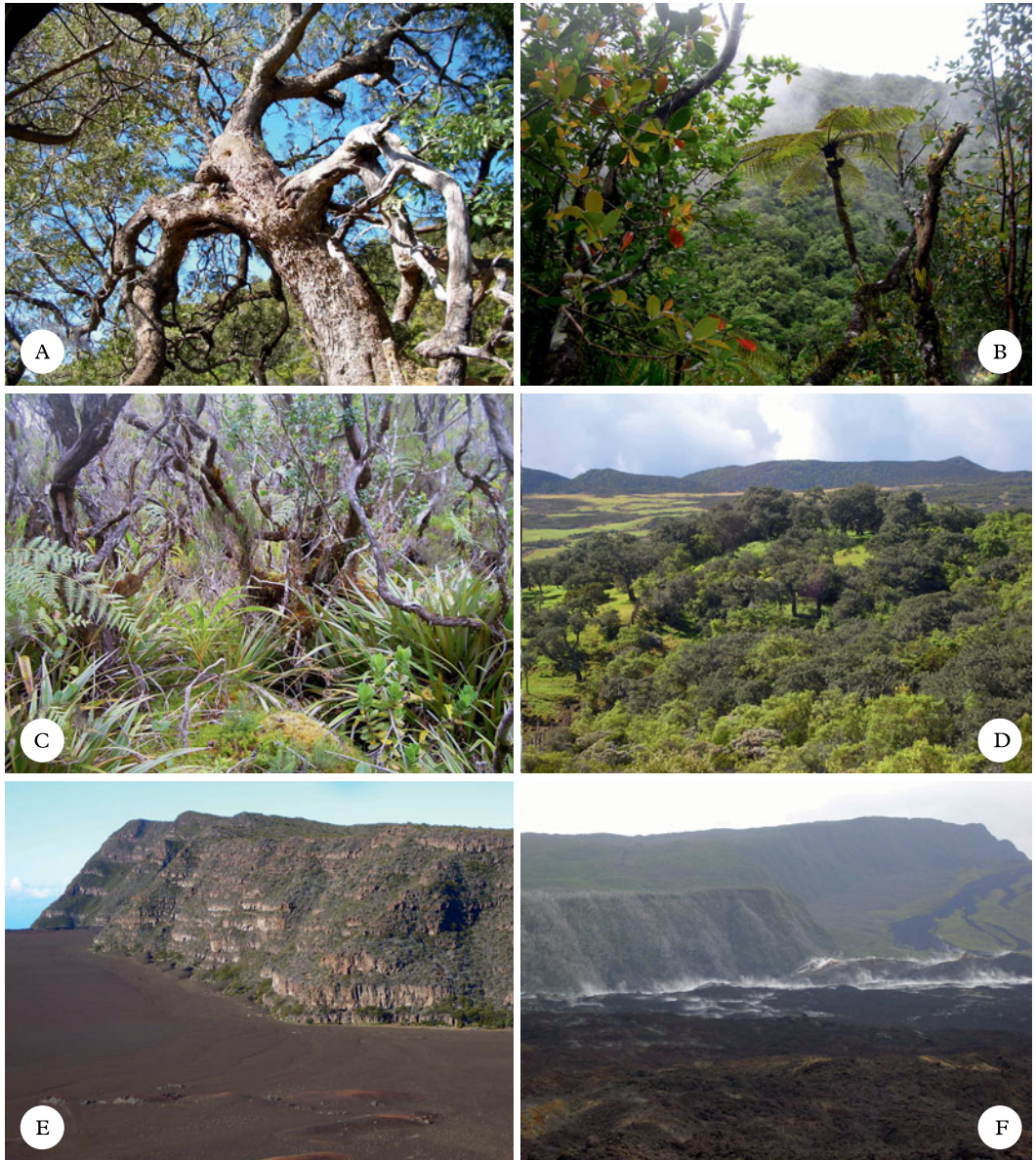


FIG. 1. Photographs of the main habitats for *Micarea* on Réunion.

A, typical peeling trunk of *Acacia heterophylla*, near Savane Cimetière (NNW of Piton de la Fournaise): seven species of *Micarea* were found in this habitat; B, typical view of understorey of the montane ‘Bois de couleurs des Hauts’ (Forêt de Bébour): the richest habitat for *Micarea* with nine species; C, wet montane ericoid thickets with *Erica reunionensis* (along the track from Bélouve to Caverne Dufour): six species occur in this spectacular habitat, including one new species with soralia and producing alectorialic acid, and one new species with isidia; D, open forest dominated by *Sophora denudata*, along road to Bourg Murat (WNW of Piton de la Fournaise): only two species were found in this habitat, including the new *M. borbonica*, the most ubiquitous species on the island; E, exposed outcrops at high elevations near the Piton de la Fournaise: three species occur in such habitats: *M. erratica*, *M. lignaria*, both widespread in the Northern Hemisphere, and *M. incrassata*, a bipolar species; F, lava flow of April 2007 within the ‘Enclos’, photographed in May 2008: no species of *Micarea* were found on old or recent lava flows at low elevation.

In colour online.

pioneer and fast-growing taxa such as *Micarea*, and is also easy to sample. We therefore postulate that these three species are native to Réunion. That *Micarea* grows easily on planted *Cryptomeria* is also observed in

the Azores, an archipelago in the North Atlantic Ocean with a high rainfall level and a much degraded vegetation, where *Cryptomeria* is also widely planted (Purvis & James 1993).

### Key to the species of *Micarea* in Réunion

- |        |  |                             |
|--------|--|-----------------------------|
| 1      | Thallus with gyrophoric acid or alectorialic acid, C+ red . . . . .  | 2                           |
|        | Thallus without gyrophoric and alectorialic acids, C- or C+ orange . . . . .   | 12                          |
| 2(1)   | Thallus with genuine convex soralia . . . . .  | 3                           |
|        | Thallus not sorediate . . . . .  | 4                           |
| 3(2)   | Thallus with alectorialic acid (K+ yellow, P+ yellow). . . . .   | <b>M. alectorialica</b>     |
|        | Thallus with gyrophoric acid (K-, P-) . . . . .  | <b>M. pseudocoppinsii</b>   |
| 4(2)   | Thallus with, or entirely made of, isidiiform areolae, ascospores long and narrow (> 20 µm long and < 3 µm wide) . . . . .                           | 5                           |
|        | Thallus without isidiiform areolae . . . . .   | 6                           |
| 5(4)   | Ascospores bacillar, straight to slightly curved; aeruginose hymenium contrasting with reddish purple hypothecium . . . . .                          | <b>M. isidiosa</b>          |
|        | Ascospores acicular; hymenium colourless and hypothecium pale brown to dark bluish . . . . .   | <b>M. tenuispora</b>        |
| 6(4)   | Ascospores 0-1(-2)-septate . . . . .   | 7                           |
|        | Ascospores 3-septate or more . . . . .   | 9                           |
| 7(6)   | Thallus formed of vivid green goniocysts; apothecia white . . . . .  | <b>M. levicula</b>          |
|        | Thallus not formed of goniocysts; apothecia white or grey to brown . . . . .   | 8                           |
| 8(7)   | Thallus thin, uneven; macroconidia 38-48 µm . . . . .  | <b>M. cilaoensis</b>        |
|        | Thallus tuberculate; macroconidia unknown . . . . .  | <b>M. bebourensis</b>       |
| 9(6)   | Ascospores fusiform, mainly or only 7-septate. . . . .   | 10                          |
|        | Ascospores mainly or only 3-septate. . . . .   | 11                          |
| 10(9)  | Ascospores 3.4-4.4 µm wide; macroconidia 57-78 × 1.2-1.5 µm . . . . .  | <b>M. cinerea</b>           |
|        | Ascospores 3.0-4.1 µm wide; macroconidia 30-40 × 1.0-1.3 µm . . . . .  | <b>M. borbonica</b>         |
| 11(9)  | Ascospores fusiform, 3.6-4.7 µm wide, less than 17 µm long . . . . .   | <b>M. peliocarpa</b>        |
|        | Ascospores narrowly clavate to needle-like, 2.0-2.5 µm wide, more than 17 µm long . . . . .  | <b>M. boryana</b>           |
| 12(1)  | Thallus with xanthonces, C+ orange-yellow . . . . .  | <b>M. hyalinoxanthonica</b> |
|        | Thallus without xanthonces, C- . . . . .   | 13                          |
| 13(12) | Thallus composed of goniocysts . . . . .   | 14                          |
|        | Thallus not composed of goniocysts. . . . .  | 18                          |
| 14(13) | Pycnidia stipitate, with tiny hairs, thallus with K+ violet pigment . . . . .  | <b>M. hedlundii</b>         |
|        | Pycnidia not stipitate, without hairs, or pycnidia absent . . . . .  | 15                          |
| 15(14) | Thallus with conspicuous black prothallus; presence of Cinereorufa-green pigment in thallus and apothecia and unknown pigment in apothecia . . . . . | <b>M. melanoprasina</b>     |
|        | Thallus without dark prothallus . . . . .  | 16                          |



- 16(15) Apothecia dark; micareic or confluent acid present. . . . . 17  
 Apothecia whitish to brownish; methoxymicareic acid present. . . . .  
 . . . . . **M. micrococca s. lat.** (not treated)
- 17(16) Apothecia with K+ violet pigment; micareic acid present. . . . . **M. prasina**  
 Apothecia without K+ violet pigment but epihymenium blue-green, K–; confluent  
 acid present. . . . . **M. takamakae**
- 18(13) Ascospores (1–)3–7-septate . . . . . **M. lignaria**  
 Ascospores 0–1-septate . . . . . 19
- 19(18) Saxicolous; no lichen substances. . . . . 20  
 Corticolous or terricolous; lichen substances present . . . . . 21
- 20(19) Apothecia marginate, up to 0.4 mm diam.; epihymenium aeruginose . . . . .  
 . . . . . **M. erratica**  
 Apothecia immarginate, up to 0.6 mm diam., epihymenium brown, locally with blue-  
 green pigment . . . . . **M. incrassata**
- 21(19) Ascospores 13–15 × 5–6 µm; protolichesterinic acid present . . . . **M. sublithinella**  
 Ascospores 8–9 × 3–4 µm; chemistry different, not a fatty acid . . . . .  
 . . . . . **M. pseudolignaria**

### The Species

#### **Micarea alectorialica Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807670

Thallus areolate, sorediate, soralia to 0.6 mm diam.; apothecia convex, up to 0.7 mm, shining black; ascospores fusiform, 17–20 × 4.5–5.6 µm, (1–)3-septate; production of alectorialic acid.

Type: Réunion, Forêt de Bébour, path from Bélouve to cabane Dufour, 21°5.10'S, 55°31.36'E, 1890 m, wet montane ericoid thickets, on *Erica*, 2 June 2008, *M. Brand* 58863 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2A)

*Thallus* c. 5 cm across, formed by dispersed areolae; areolae first globose, 0.1–0.2 mm across, pale-coloured, then bursting into a soralium; *soralia* to 0.6(–0.8) mm diam., convex, sometimes aggregated to almost stipitate, white to light greenish; *soredia* 25–35 µm. *Photobiont* micareoid, cells c. 5.0–5.5 µm. *Cortex* absent, but in young areolae upper layer with more crystals; *soredia* strongly interspersed with crystals (alectorialic acid).

*Apothecia* up to 0.7 mm diam., shining black, convex without margin, often complex, and then made of fused small apothecia. *Excipulum* bluish in outer parts, inside pale,

formed by strongly conglutinated radiating hyphae. *Hypothecium* pale or light bluish. *Hymenium* c. 55 µm high; *epihymenium* dark blue. *Paraphyses* c. 1.5 µm thick, apically branched and anastomosing. *Asci* clavate, c. 46 × 12 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, fusiform 17.0–20.0 × 4.5–5.6 µm, (1–)3-septate.

*Micropycnidia* numerous, superficial between areolae, black, c. 70 µm; *microconidia* narrow, fusiform with tapering ends, 6.6–8.3 × 0.9–1.0 µm.

*Chemistry*. Alectorialic acid (K+ yellow, P+ yellow, C+ red) in thallus and soralia; fatty acid also present (extract as rangiformic acid, but larger agglomerations). Pigment in thallus and apothecia belonging to *Cinereorufagreen*.

*Etymology*. The new species is named after the chemical compound that makes this species easy to recognize amongst the species of *Micarea* present on Réunion.

*Habitat and distribution*. On *Erica* stems at 1900–2000 m, in wet montane ericoid thickets, abundant.

*Notes*. Alectorialic acid is rare amongst species of *Micarea* as it is so far detected in

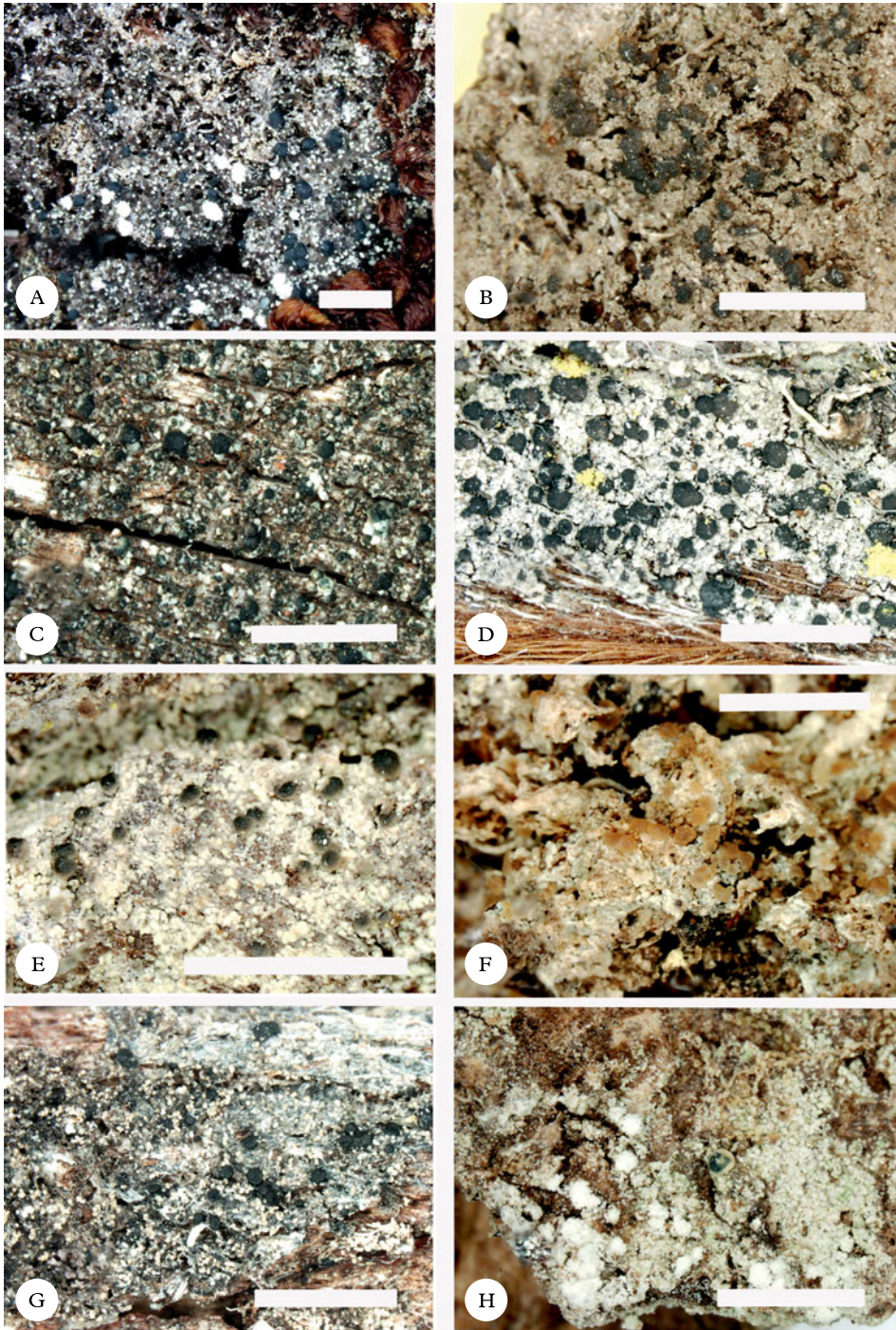


FIG. 2. Photographs of the new species described from Réunion. A, *Micarea alectorialica* sp. nov. (holotype); B, *M. bebourensis* sp. nov. (holotype); C, *M. borbonica* sp. nov. (holotype); D, *M. boryana* sp. nov. (holotype); E, *M. cilaensis* sp. nov. (holotype); F, *M. hyalinoxanthonica* sp. nov. (holotype); G, *M. isidiosa* sp. nov. (holotype); H, *M. pseudocoppinsii* sp. nov. (holotype). Scale = 1 mm. In colour online.



only two species: *M. magellanica* (Müll. Arg.) Fryday (= *M. austroternaria* Coppins & Kantvilas) restricted to the Southern Hemisphere (Coppins & Kantvilas 1990; Fryday 2004), and *M. submilliaria* (Nyl.) Coppins, a mostly Northern Hemisphere species (Coppins 2009), but both do not produce soralia, although the surface of the latter is usually eroding to form sorediate patches. Only three other species of *Micarea* produce soralia: *M. coppinsii* Tønsberg, *M. pseudocoppinsii* (here described as new) and *M. viridileprosa* Coppins & van den Boom (soralia usually not clearly delimited and forming a leproid surface); they can all be distinguished by the production of gyrophoric acid (van den Boom & Coppins 2001; Coppins 2009).

*Additional specimen examined.* **Réunion:** same locality as the type, 21°05'31"S, 55°30'41"E, 1910–2000 m, wet ericoid thickets with *E. reunionensis* and *Phyllica nitida*, on *Erica*, 9 xi 2009, N. Magain & E. Sérusiaux s. n. (LG).

### ***Micarea bebourensis* Brand, van den Boom & Sérus. sp. nov.**

Mycobank No.: MB807671

Thallus typically tuberculate when young, tubercles 0.10–0.15 mm across; apothecia up to 0.6 mm, greyish brown; ascospores ovate to shortly bacillar, 11–14 × 3.3–4.3 µm, 1(–3)-septate; production of gyrophoric acid.

Type: Réunion, Forêt de Bébour, trail to Cassé de Takamaka, 21°07'5"S, 55°34'5"E, 1340 m, wet montane rainforest, on rotting standing trunk, 1 June 2008, P. van den Boom 40344 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2B)

*Thallus* up to 2 cm diam., pale to brownish greyish or greenish, uneven, typically tuberculate when young, with tubercles 0.10–0.15 mm broad and high, eventually formed of coarse and agglomerated granules, first pale, eventually breaking up at the top of tubercles or at the margins of granules, and forming a rough blue-grey surface (resembling tiny soralia, but no genuine soredia are formed). *Cortex* absent, often with thin, clear epinecral layer. *Photobiont* micareoid. Thallus filled with crystals (gyrophoric acid).

*Apothecia* up to 0.6 mm diam, light to dark greyish brown, often unevenly coloured (partly

dark, partly pale), almost globose, with constricted base. *Excipulum* greyish brown in outer parts, pale inside. *Hypothecium* pale (reddish) brown, conglutinate. *Hymenium* c. 50–60 µm high; *epihymenium* patchily brownish. *Paraphyses* 0.7–1.1 µm thick, branched and strongly anastomosing; some paraphyses with a thickened apex (1.8 µm). *Asci* cylindrical, c. 40–53 × 10 µm, tholus of the *Psora*-type. *Ascospores* 8 per ascus, ovate to shortly bacillar, 11–14 × 3.3–4.3 µm, 1(–3)-septate.

*Micropycnidia* inconspicuous, immersed, with brownish top, c. 35 µm. *Microconidia* bacillar with rounded ends, some slightly curved, 5.9–7.1 × 0.9–1.1 µm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red), mainly in the thallus, epihymenium, excipulum and pycnidia wall. Brownish pigment belonging to Laurocerasi-brown, in epihymenium, slightly brownish, K+ purple-brown; subhymenium and hymenium in K slightly rose-coloured.

*Etymology.* This new species is named after the Bébour forest, one of the largest and best preserved montane forests on Réunion, where many interesting lichen species grow.

*Habitat and distribution.* On introduced tree species, including *Cryptomeria japonica* and decaying wood, in lower montane forest at 1200–1500 m.

*Notes.* The almost globose apothecia, sometimes almost stipitate, and the thallus tubercles (best observed in young thalli) represent the most obvious characters to distinguish this species. Its generic assignment to *Micarea* is questionable as the asci are cylindrical (not clavate as in other species of the core group of *Micarea*) and the tholus is much akin to the *Psora*-type (*sensu* Ekman *et al.* 2008). The anatomy of apothecia (globose apothecia with a constricted base and development of excipular tissue) makes it close to *Micarea lignaria* and *M. pseudolignaria* sp. nov.; *M. bebourensis* is easily differentiated from both by the absence of an aeruginose pigment and the production of gyrophoric acid.

*Additional specimens examined.* **Réunion:** same locality as the type, *P. van den Boom* 40370 (h); Bélouve, 21°3.74'S, 55°32.29'E, 1500 m, montane forest, on planted *Cryptomeria*, 2008, *M. Brand* 58215 (h); Plaines-des-Palmistes, Ravine Sèche, 21°8.63'S, 55°35.31'E, 1200 m, planted exotic trees in sheltered valley, on *Cryptomeria*, 2008, *M. Brand* 58141 (h); Forêt de Bébour, path W of Col de Bébour, 21°07.2'S, 55°33.6'E, 1490 m, *Cryptomeria* plantation, on *Cryptomeria*, 2008, *P. van den Boom* 40322 (h).

**Micarea borbonica Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807672

Thallus small, to 1.5 cm, dull white to pale greenish; apothecia up to 0.5 mm diam., whitish to pale brownish or pale to dark bluish grey; ascospores fusiform with rounded ends, 15–27 × 3.0–4.1 µm, 3–7-septate; macroconidia strongly and repeatedly curved sigmoid, 30–42 × 1.0–1.3 µm, indistinctly 3-septate; production of gyrophoric acid.

Type: Réunion, WNW of Piton de la Fournaise, along road to Bourg Murat, 21°11.9'S, 55°36.9'E, 1970 m, small forest with *Sophora denudata* trees, on *Sophora*, 4 June 2008, *P. van den Boom* 40644 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2C)

*Thallus* small, to 1.5 cm across, dull white to pale greenish, uneven, c. 50 µm high or consisting of small granules, some of them resembling small isidia. Upper part c. 15 µm without algae, of loosely interwoven hyphae. *Photobiont* micareoid, cells c. 5 µm, photobiont layer interspersed with crystals (gyrophoric acid).

*Apothecia* up to 0.2–0.5 mm diam., whitish to pale brownish or pale to dark bluish grey, often coloured only partially, with pale margin, flat or slightly convex to almost globose, adnate with constricted base. *Excipulum* pale or bluish grey in outer parts, pale inside. *Hypothecium* colourless. *Hymenium* c. 55 µm high; *epihymenium* colourless or partly blue-grey. *Paraphyses* 1.3–1.6 µm thick, branched and anastomosing. *Asci* clavate, 33–40 × 12–15 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, fusiform with rounded ends, 15–27 × 3.0–4.1 µm, (3–)7-septate, often curved.

*Macroconidia* not rare, globose, 100–140 µm, top often blue-grey; *macroconidia* strongly and repeatedly curved sigmoid (when observed under unpressed cover

slip), 30–42 × 1.0–1.3 µm (measured under pressed cover slip), faintly 3-septate. *Microconidia* inconspicuous, semi-superficial, c. 35 µm, pale. *Microconidia* narrow fusiform with tapering ends, 5–7(–10) × 0.8–1.0 µm.

*Chemistry.* Gyrophoric and methylhiasc acids (K–, P–, C+ red), mainly in thallus, hymenium, excipulum and pycnidia. Pigment in apothecia belonging to *Cinereorufa*-green.

*Etymology.* The name of this new species refers to the old name of the island, 'Ile Bourbon' in French. It is indeed characteristic of all habitats, natural or anthropogenic, in the montane forest zone of the island.

*Habitat and distribution.* On native and exotic trees (*Acacia heterophylla*, *Cryptomeria*, *Sophora denudata*, *Platanus* and on branches of *Erica*), and decorticated wood, between 800–2000 m.

*Notes.* Ascospores in this new species are typically 7-septate, although 3–6-septate ones can be found usually in immature or poorly developed apothecia. *Micarea borbonica* is closely related to *M. peliocarpa*, a species also found in Réunion; it differs in having convex to subglobose areoles, longer and narrower ascospores (13.6–17.0 × 3.6–4.7 µm in collections of *M. peliocarpa* from Réunion), and is usually 7-septate (mostly 3-septate in *M. peliocarpa*). A further related species is *M. cinerea*, also found on Réunion, that can be distinguished by larger spores (24–30 × 3.4–5.0 µm) and much longer macroconidia (57–78 × 1.2–1.5 µm). See further notes under *M. cinerea* and *M. peliocarpa*.

*Additional specimens examined.* **Réunion:** Piton de la Fournaise, 0.5 km NW of Gîte du Volcan, 21°12.07'S, 55°41.53'E, 2040 m, mixed wood on N-slope, on *Acacia heterophylla*, 2008, *M. Brand* 58361, 58376 (h); Plaine-des-Palmistes, 21°6.98'S, 55°37.13'E, 1100 m, *Platanus* branches in garden, 2008, *M. Brand* 58696 (h); *ibid.*, on decorticated wood of telegraph pole, 2008, *P. van den Boom* 40621 (h); Cilaos, Forêt du Grand Matarum, path to Cabane Dufour, 21°7.08'S, 55°29.19'E, 1770 m, wet montane ericoid thickets on steep SW slope, on thin twigs, 2008, *M. Brand* 59713 (h); WNW of Piton de la Fournaise, along road to Bourg Murat, 21°11.6'S, 55°37.5'E, 2090 m, disturbed wood with *Sophora denudata*, on *Sophora*, *P. van den Boom* 40665 (h); ESE of Le Tampon, NNE of Petite-île, 21°18.9'S, 55°35.4'E, 800 m, open place with mature



*Cryptomeria* trees, on *Cryptomeria*, 2008, P. van den Boom 40806 (h).

**Micarea boryana Brand, van den Boom & Sérus. sp. nov.**

Mycobank No.: MB807673

Thallus areolate, greenish to greyish brown, eroding when old; apothecia to 0.4(–0.6) mm, grey to bluish black; ascospores narrowly clavate to needle-like, 16–27 × 2.0–2.5 μm, (1–)3(–4)-septate; production of gyrophoric acid.

Type: Réunion, Cirque de Cilaos, N of Cilaos, Forêt du Grand Matarum, trail to Caverne Dufour, 21°07.3'S, 55°29.2'E, montane forest, 1420 m, on *Cryptomeria*, 31 May 2008, P. van den Boom 40264 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2D)

*Thallus* up to 5 cm across, greenish to greyish brown, continuous, made of small flat to convex or even subglobose areolae, with a thin endo- to epiphloeodal dark bluish black prothallus made of narrow hyphae, colourless or partly dark brownish or bluish hyphae. *Areolae* either flat (0.1–0.6 mm broad, 0.05 mm thick) or subglobose (granules *c.* 0.1 mm across), eroding at the margins in old thalli, slightly shiny. *Cortex* absent, but a thin, clear epinecral layer can be observed. *Photobiont* micareoid, cells *c.* 5–8 μm. Thallus filled with crystals of gyrophoric acid.

*Apothecia* up to 0.4(–0.6) mm diam., grey to bluish black, sometimes with a pale margin, first flat, without a distinct margin, then semiglobose. *Excipulum* with radiating hyphae, varying in colour (often in same apothecium) from pale to superficially bluish and centrally light brown. *Hypothecium* pale or brownish. *Hymenium* *c.* 30–55 μm high; *epihymenium* patchily greyish-bluish. *Paraphyses* 1.0–1.2 μm thick, branched and anastomosing. *Asci* 25–37 × 10–15 μm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, in one bundle, narrowly clavate to needle-like, 16.0–27.0 × 2.0–2.5 μm, (1–)3(–4)-septate, sometimes apically slightly enlarged and tapering towards their basal ends.

*Mesopycnidia* often present and conspicuous, sessile, *c.* 160–230 μm diam. and 200–270 μm in height, dark brownish, with white blob of conidia on top; pigment brown to greenish brown or aeruginose, K–; wall with

crystals of gyrophoric acid, mainly near the apex. *Mesoconidia* ovate, 4.0–4.5 × (1.3–)1.5–1.6 μm. *Micropycnidia* rarely present, inconspicuous, with a dark brownish wall. *Microconidia* fusiform, 4.0–4.5(–5.0) × 1.0–1.1 μm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red) detected in thallus, but also in pale parts of apothecia and in mesopycnidia. Pigment in thallus and apothecia belonging to *Cinereorufa*-green. Brown pigment in hypothecium K+ reddish to purple-brown.

*Etymology.* This new species is named after the French officer and first lichen collector on the island, J. B. G. M. Bory de Saint-Vincent (1778–1846) who described several spectacular and now well-known species, such as *Cladonia candelabrum*, *C. giganteum*, *Lobaria retigera*, *Stereocaulon vulcani* and *Sticta ambavillaria*.

*Habitat and distribution.* Found at several localities on the island, between 1200–1500 m, always epiphytic on the exotic *Cryptomeria japonica*.

*Notes.* We first assigned these collections to *Micarea mutabilis* Coppins & Kantvilas, described from Tasmania (Coppins & Kantvilas 1990). According to the original description, the latter, however, clearly differs by several important characters: absence of prothallus, larger asci (40–50 × 9–10 μm), ascospores longer and more septate [21–41 × 2.2–3.0 μm; (1–)5–7(–8)-septate], absence of conspicuous pycnidia producing mesoconidia (the mesoconidia described for that species are actually microconidia). We believe such discrepancies are worth species recognition. Other species with needle-shaped or acicular ascospores are (Coppins 2009): *Micarea globulosella* (Nyl.) Coppins, distinguished by its black and subglobose apothecia and smaller ascospores [(10–)12–19(–24) × 2.0–2.5(–3.0) μm]; *M. synotheoides* (Nyl.) Coppins distinguished by the absence of chemical compounds and variable ascospores [needle-like, fusiform to rod-shaped, (0–)1–3-septate, 14–35(–43) × 1.8–2.5(–3.0) μm]; *M. pycnidiphora* Coppins & P. James, together with *M. stipitata* Coppins & P.

James, both being easily recognized by their numerous, stipitate pycnidia; and finally *M. tenuispora* sp. nov., described here as new from Réunion, which is easily recognized by its isidiiform thallus areolae.

*Additional specimens examined.* **Réunion:** same locality as the type, 2008, *P. van den Boom* 41041 (h); Plaines-des-Palmistes, Ravine Sèche, 21°8.63'S, 55°35.31'E, 1200 m, planted exotic trees in wood in sheltered valley, on *Cryptomeria*, 2008, *M. Brand* 58141, 58146 (h), *P. van den Boom* 39776 (h); Bélouve, 21°3.74'S, 55°32.29'E, 1500 m, disturbed montane forest, on *Cryptomeria*, 2008, *M. Brand* 58206 (h).

**Micarea cilaensis Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807675

Thallus thin, uneven, consisting of slightly convex granules, green; apothecia to 0.4 mm, adnate, with constricted base; ascospores ovoid to ellipsoid, 11–12 × 4.0–4.4 µm, 0–1-septate; production of gyrophoric acid.

Type: Réunion, Cirque de Cilaos, Forêt du Grand Matarum, trail to Caverne Dufour, 21°07.3'S, 55°29.2'E, 1420 m, montane forest, on *Cryptomeria*, 31 May 2008, *P. van den Boom* 40230 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2E)

*Thallus* rather extensive (3 cm across), green, thin (65–90 µm), uneven, made of slightly convex granules. *Cortex* absent. *Photobiont* micareoid, cells c. 5–9 µm. Photobiont layer interspersed with crystals of gyrophoric acid.

*Apothecia* up to 0.4 mm diam., whitish to greyish with pale margin, flat or slightly convex, adnate with constricted base. *Excipulum* well developed, made of thin reticulate hyphae, filled with crystals, colourless. *Hypothecium* colourless. *Hymenium* c. 35–42 µm high; *epihymenium* colourless or faintly greenish grey, in K unchanged or locally brownish. *Paraphyses* 1.3 µm thick, branched and anastomosing. *Asci* clavate, c. 28 × 12 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ovoid to ellipsoid, 11–12 × 4.0–4.4 µm, 0–1-septate.

*Pycnidia* not rare, superficial or semi-immersed, white, ampulliform, c. 150 µm diam., top with crystals; *macroconidia* straight or more or less curved, 38–48 × 0.9–1.1 µm, non-septate, cylindrical with rounded ends; in same pycnidia, *microconidia* can be

found: *microconidia* bacilliform, 5.2–7.1 × 0.9–1.1 µm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red) detected in thallus, hymenium, excipulum, pycnidia. Pigment in apothecia belonging to *Cinereorufa*-green.

*Etymology.* The name chosen for this new species refers to the most spectacular cirque on the island, the Cirque de Cilaos, where this rare species has been discovered.

*Habitat and distribution.* Known from a single locality, on the exotic *Cryptomeria japonica* at the margin of disturbed natural forest, at 1420 m elevation.

*Notes.* *Micarea cilaensis* could be confused with a species of *Lecania* because of its apothecia with a brownish disc and whitish margin, and its well-developed excipulum. However, examination of the hamathecium and ascus-type immediately point to the genus *Micarea*. Also remarkable are the large ampulliform pycnidia producing macro- and microconidia together. *Micarea cilaensis* is close to *M. denigrata* (Fr.) Hedl., a widespread species in the Northern Hemisphere which also produces large ampulliform pycnidia; the latter differs by its narrower ascospores [(7–)9–16(–18) × 2.0–3.3(–3.5) µm] and much smaller macroconidia (12–24 × c. 1 µm; Coppins 2009).

*Additional specimen examined.* **Réunion:** same locality as the type, *P. van den Boom* 40229 (h, hb Brand 62255).

**Micarea cinerea (Schaer.) Hedl.**

*Thallus* up to c. 1 cm across, made of small granules (c. 0.1–0.2 mm diam.), some of them resembling small isidia, white to pale grey.

*Apothecia* to 0.3 mm diam., whitish, beige, pale yellowish brown or dark bluish grey, often unevenly coloured, with a slightly pale margin, flat or convex to almost globose, adnate with constricted base. *Hymenium* c. 50 µm; *epithecium* yellowish or more rarely bluish, K–. *Hypothecium* hyaline. *Asci* 37–45 × 15–20 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, fusiform, 24–30 × 3.4–5.0 µm, (3–)7-septate, straight to often curved.

*Pycnidia* large, *c.* 200 µm diam., partly immersed in areoles. *Macroconidia* long and slightly flexuose, 7–10-septate, 57–78 × 1.2–1.5 µm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red), mainly in thallus, hymenium, excipulum and pycnidia wall; methylhiassic acid absent. Pigment in apothecia belonging to *Cinereorufa*-green.

*Habitat and distribution.* On *Erica* in wet montane ericoid thickets at 2000 m, and on trunk of *Sophora* at similar elevation.

*Notes.* In European collections of this species, methylhiassic acid is detected as well as gyrophoric acid; this acid has not been detected in the material from Réunion. See further data under *M. borbonica*. *Micarea cinerea* is a widespread species as it occurs in Europe, North and Central America, Asia and Australia (Tasmania), according to Coppins (2009).

*Specimens examined.* **Réunion:** Forêt de Bébour, trail from Gîte de Bélouze, 3.5 km to the south-west, to Caverne Mussard, 21°05.3'S, 55°31.3'E, 1980 m, wet montane ericoid thickets, 1980 m, on *Erica*, 2008, *P. van den Boom* 40526, 40555 (h, hb Brand 61471); WNW of Piton de la Fournaise, along road to Bourg Murat, 21°11.9'S, 55°36.9'E, small open forest with *Sophora denudata*, on *Sophora*, 1970 m, 2008, *P. van den Boom* 40644A (h).

### ***Micarea erratica* (Körb.) Hertel et al.**

*Thallus* of scattered whitish areoles; areolae up to 0.5 mm diam., with a *c.* 15 µm thick epinecral layer. *Photobiont* not micareoid, cells to 15 µm.

*Apothecia* up to 0.4 mm broad, black, flat, with a distinct margin. *Excipulum* of conglutinated radiate hyphae, outer part aeruginose, inner part hyaline. *Hypothecium* dark brown. *Hymenium* *c.* 25 µm; *epihymenium* aeruginose. *Paraphyses* simple, *c.* 1.8 µm thick. *Asci* *c.* 25 × 10 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, narrowly ellipsoid, *c.* 7 × 3 µm.

*Mesopycnidia* numerous, *c.* 70–100 µm, immersed, upper side dark bluish, lower side unpigmented. *Mesoconidia* *c.* 3.2–4.5 × 1.1–1.9 µm.

*Chemistry.* No lichen substances detected.

*Habitat and distribution.* On volcanic rocks in meadow, at *c.* 2000 m elevation.

*Notes.* This single collection falls within the variation of European specimens of that species, including the size and height of apothecia, and we have no doubt it belongs to the widespread *M. erratica*. The species has been recognized as the sole representative of the new genus *Leimonis* (Harris 2009), an option not retained so far (Coppins 2009).

*Specimen examined.* **Réunion:** track Bourg Murat to Piton de la Fournaise, 21°12.63'S, 55°36.57'E, 1970 m, volcanic rock outcrops in meadow on NW slope, on stones, 2008, *M. Brand* 59027 (h).

### ***Micarea hedlundii* Coppins**

*Thallus* less than 1 cm across, made of abundant and aggregated goniocysts, forming coralloid masses, dark greenish to greyish. *Goniocysts* 17–32 µm diam., locally with coarse crystals. *Hyphae* partly with brown-grey pigment (K+ violet). *Photobiont* micareoid, *c.* 5 µm.

*Apothecia* absent.

*Pycnidia* stipitate; stipe 0.24–0.40 mm high, 100–160 µm thick, surface with loose, curly, grey tomentum, made of *c.* 1.7 µm thick hyphae; pycnidia *c.* 140 µm, 1–3(–5) on a stipe. *Mesoconidia* elliptic, *c.* 4.2–5.2 × 1.6–2.1 µm.

*Chemistry.* Unknown 5 at the centre of goniocysts, and *Sedifolia*-grey.

*Habitat and distribution.* On soft rotting wood of standing trunks in montane forest, at 1400–1900 m elevation.

*Notes.* Apothecia are absent in our material from Réunion, but otherwise we could not detect any differences with available collections from Western Europe, from the Albertine Rift in Africa and most recent descriptions (Czarnota 2007; Coppins 2009). The recently described *M. tomentosa* Czarnota & Coppins (Czarnota 2007), known from central and northern Europe (Suija et al. 2008), also has stalked pycnidia but differs by the complete absence of pigment H in the goniocysts.

*Specimens examined.* **Réunion:** Cilaos, Forêt du Grand Matarum, along path to Cabane Dufour, 21°6.29'S, 55°29.58'E, 1870 m, low forest on steep SW slope, on *Dombeya* tree, 2008, *M. Brand* 59739 (h); Forêt de Bébour, trail to Takamaka, 21°05.9'S, 55°34.3'E, 1370 m, wet rainforest, on rotting standing trunk, 2008, *P. van den Boom* 40883 (h).—**Rwanda:** Virunga volcanoes, southern flank of the Karisimbi, c. 3400 m, open forest with *Hagenia abyssinica* and *Hypericum revolutum*, on big bole of *Hagenia*, 1974, *J. Lambinon* 74/1524 (LG; confirmed by B. J. Coppins, 1992); *ibid.*, 01°29'12.56"S, 029°28'37.38"E, c. 3200 m, on *Hagenia*, x 2010, *E. Sérusiaux* s. n. (LG).

**Micarea hyalinioxanthonica Brand,  
van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807676

Thallus thin, pale greenish, made of goniocysts; apothecia up to 0.6 mm, adnate pale beige, translucent when wet; ascospores bacillar, 13.2–17.0 × 3.2–3.6 µm, 3-septate; production of xanthone (thallus and apothecia C+ orange).

Type: Réunion, Forêt de Bébour, Sentier de Takamaka, 21°06.48'S, 55°34.02'E, 1380 m, low trees in montane forest, on *Dombeya*, 7 June 2008, *M. Brand* 59293 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2F)

*Thallus* c. 3 cm diam., pale greenish, thin, overgrowing decaying bryophytes, soft, felty, made of small (20–30 µm diam.) goniocysts. *Photobiont* micareoid, 5–8 µm, individually surrounded with a mantle of furcate hyphae, partly aggregated in goniocysts; thallus also with striae, thick-walled hyphae (c. 2 µm) and sometimes including crystals.

*Apothecia* abundant, 0.1–0.5(–0.6) mm diam., adnate with constricted base, pale beige, translucent when wet, rarely greyish, first flat, with hardly distinct margin, then convex. *Excipulum* thin, chondroid, with thin, branching hyphae, outer parts sometimes with protruding hyphae, giving a hairy appearance. *Hypothecium* pale or patchily light brownish. *Hymenium* c. 50 µm high, strongly conglutinated, colourless. *Paraphyses* c. 1.3 µm thick, branched and anastomosing. *Asci* clavate, c. 45–50 × 12 µm; tholus of *Micarea*-type. *Ascospores* 8 per ascus, bacillar, 13.2–17.0 × 3.2–3.6 µm, 3-septate, distinctly constricted at septa, with more or less globose cells.

*Pycnidia* absent.

*Chemistry.* Xanthone (thiophanic acid?) in thallus and apothecia (K+ yellow; P–, C+ and KC+ orange). Crystals in thallus and apothecia, in streaks in hymenium and excipulum.

*Etymology.* The name chosen combines the chemical compound produced by this new species and a diagnostic character of its apothecia, being translucent when wet.

*Habitat and distribution.* Only known from the type locality. It grows on decaying liverworts on bole of a *Dombeya* in rainforest (c. 1400 m).

*Notes.* Young globose apothecia of no more than 100 µm diam. contain already ripe asci. TLC gives the same result as with *Micarea xanthonica* Coppins & Tønsberg, which contains thiophanic acid (Coppins & Tønsberg 2001). This species can be distinguished by its thallus entirely made of dense goniocysts, very similar to that of *M. prasina*, apothecia rare or even absent, and ascospores (0–)1(–3)-septate. A further species containing xanthone is *Micarea isabellina* Coppins & Kantvilas, so far only known from Tasmania, growing on rocks or terricolous (Coppins & Kantvilas 1990). It can be distinguished by its areolate to irregularly warty thallus, black apothecia and larger ascospores (19–26 × 3.5–4.0 µm). Furthermore, *M. hyalinioxanthonica* can be distinguished by its ascospores that are distinctly constricted at septae, with more or less globose cells.

**Micarea incrassata Hedl.**

*Thallus* c. 2 cm across, composed of dispersed to adjacent areolae on rock, overgrowing mats of cyanophyta (*Stigonema*); *areolae* beige greenish, globose to convex, 0.1–0.2 mm. *Photobiont* micareoid, cells c. 5 µm. *Cortex* absent, thallus without crystals. Genuine cephalodia absent, but thallus clearly associated with *Stigonema*, the cells of which are clearly intermingled with hyphae within the areolae.

*Apothecia* up to 0.6 mm diam., black, convex without margin. *Excipulum* hardly distinct from hymenium. *Hypothecium* dark brown.



*Hymenium* c. 40 µm high; *epihymenium* brown, locally with blue-green pigment. *Paraphyses* c. 1.8 µm thick, mostly simple, occasionally branched. *Asci* clavate, c. 27–30 × 8–10 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ellipsoid, 8.6–10.0 × 4.2–5.0 µm, non-septate, wall c. 0.3 µm thick.

*Microspycnidia* scarce, between areolae, wall dark brown, c. 60 µm; *microconidia* bacillar, 5.7–6.8 × 1.0–1.1 µm.

*Chemistry.* No lichen substance. Pigment in thallus and apothecia belonging to Cinerorufa-green, pigment in hypothecium belonging to Superba-brown.

*Habitat and distribution.* Only known from a single collection, on recently exposed volcanic rock at high elevation.

*Notes.* Our single collection is very close to the European material of *Micarea incrassata* that we could examine. It differs, however, by its constantly 0-septate ascospores (vs. 0–2-septate in European material), smaller asci and thus lower hymenium, and absence of a chemical compound (European material has thallus crystals, not dissolving in K or HCl, but slowly in acetone). Pending further studies, we don't consider these variations to be worth taxonomic recognition.

*Micarea incrassata* is a further example of a species widespread in the Northern Hemisphere and also detected in Australia (New South Wales) and subantarctic islands, and that occurs patchily on summits in tropical areas. A similar example is *Fuscopannaria praetermissa*, present on high mountains in East Africa and in Réunion (van den Boom et al. 2011).

*Specimen examined.* **Réunion:** Piton de la Fournaise, S slope of Pas de Bellecombe, 21°12.6'S, 55°41.8'E, 2250 m, recent volcanic rock on steep S-slope, 2008, *M. Brand* 58333 (h).

### **Micarea isidiosa Brand, van den Boom & Sérus. sp. nov.**

Mycobank No.: MB807677

Thallus formed of isidioid granules growing on partly dark prothallus, greenish to brownish; apothecia up to 0.4 mm in diam, black; hypothecium purplish or reddish; ascospores bacillar, straight to slightly curved, 22.5–

29.8 × 2.8–2.9 µm, 3–7-septate; production of gyrophoric acid.

Type: Réunion, Forêt de Bébou, path from Bélouve to cabane Dufour, 21°05.10'S, 55°31.36'E, 1890 m, wet montane ericoid thickets, on *Erica*, 2 June 2008, *M. Brand* 58862 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 2G)

*Thallus* up to 3 cm diam., greenish to brownish, discontinuous, made of small globose or isidia-like areolae on thin endo- to epiphloeodal prothallus with narrow colourless or partly brownish or bluish hyphae. *Areolae* first granular (0.1 mm across) eventually becoming isidiiform (0.30 × 0.05 mm), unbranched or forked. *Cortex* absent. *Photobiont* micareoid. Thallus filled with crystals (gyrophoric acid).

*Apothecia* up to 0.4 mm diam., black, first flat, without distinct margin, then semiglobose. *Excipulum* with radiating hyphae, purplish, with few crystals. *Hypothecium* reddish or bluish. *Hymenium* c. 40 µm high; *epihymenium* and hymenium intense blue-green. *Paraphyses* c. 1.4 µm thick, branched. *Asci* c. 30–34 × 10 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, bacillar, straight to slightly curved, 22.5–29.8 × 2.8–2.9 µm, 3–7-septate.

*Microspycnidia* inconspicuous, immersed, with dark bluish wall. *Microconidia* fusiform, 3.7–4.1 × 0.9–1.0 µm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red), mainly in thallus, but also detected in apothecia. Blue pigment in thallus and apothecia K+ intense green, N+ red and H+ darker, most probably belonging to Cinerorufa-green; red pigment mainly present in hymenium (unknown 4) K+ green, N producing a precipitate of dark blue granules, H–.

*Etymology.* The name refers to the isidioid areolae forming the thallus.

*Habitat and distribution.* On *Erica* stems in wet ericoid thickets at elevations between 1900–2000 m.

*Notes.* The thallus of this species seems to be isidiate; however, the 'isidia' are not

outgrowths on a thallus or areolae as they grow directly on the prothallus; they thus represent isidiiform areolae. The thallus and apothecia of this species are much akin to those of *M. tenuispora*, also described as new in this paper; the bacillar ascospores, more vivid colours in apothecium section, with an aeruginose tinge in the epihymenium contrasting with a reddish purple hypothecium, and the unique precipitate of dark blue granules in N in the hymenium are the diagnostic characters.

*Additional specimens examined.* **Réunion:** Forêt de Bébour, path from Bélouve to cabane Dufour, 3 km from Gîte Bélouve, 21°05'10"S, 55°31'36"E, 1890 m, tall ericoid thickets in montane forest, on *Erica*, 2008, *M. Brand* 58865 (h); *ibid.*, 21°05'3"S, 55°31'3"E, 1980 m, on *Erica*, 2008, *P. van den Boom* 40529 (h).

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

*Thallus* diffuse, vivid green, made of delicately and finely coralloid goniocysts; *goniocysts* 25–53 µm diam. or cylindrical (*c.* 50 × 18 µm), round to ovate, often more or less angular, fused to form branched coralloid structures up to 150 µm high, made of conglutinated hyphae and micareoid photobiont (cells *c.* 6 µm), interspersed with crystals (gyrophoric acid), locally some hyphae protrude to form low papillae on the surface.

*Apothecia* up to 0.5 mm diam., white, adnate, slightly constricted at base, without any visible margin, convex. *Excipulum* narrow (<10 µm thick), formed by radiating, conglutinate hyphae; surface of excipulum sometimes rough because of protruding hyphae. *Hypothecium* colourless. *Hymenium* 50–55 µm high. *Paraphyses* 1.3–1.6 µm thick, branched and anastomosing. *Asci* *c.* 39–55 × 8–12 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ellipsoid, 10.3–10.8 × 3.7–4.1 µm, 0–1-septate.

*Micropycnidia* occasionally present, small, white; *microcomidia* 9.8 × 0.8 µm, narrow fusiform. *Mesoconidia* occasionally present, 5.5 × 1.3 µm.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red), crystals present only at the centre of the goniocysts.

*Habitat and distribution.* On natural stands of *Acacia heterophylla*; so far only found near the Piton de la Fournaise, where it grows with the related *M. prasina*.

*Notes.* *Micarea levicula* has been recognized as a member of the *M. prasina* group by van den Boom & Coppins (2001), on the basis of its type and only available collection from Cuba (H-Nyl. 20762). The short description provided matches the material collected in Réunion. *Micarea viridileprosa* Coppins & van den Boom, also a member of the *prasina* group with gyrophoric acid, differs by the loose, non-coralloid and smaller, more soredia-like goniocysts, the localization of the gyrophoric acid crystals on the outer parts of the hyphae surrounding the goniocysts, and finally by the narrower spores (*c.* 11–14 × 3.0–3.4 µm). *Micarea viridileprosa* is so far known from western Europe, where it can be quite common, and Tasmania (van den Boom & Coppins 2001; Coppins 2009). The recently described *M. corallothallina* (Cáceres *et al.* 2013) from NE Brazil has a thallus made of “irregularly densely branched isidioid granules of *c.* 50 µm thick” but can be distinguished by the absence of any chemical compounds.

*Specimens examined.* **Réunion:** NNW of Piton de la Fournaise, trail along Ravine Savane Cimetière, 21°11'6"S, 55°37'5"E, 2050 m, mixed forest with mature *Acacia heterophylla*, on *Acacia*, 2008, *E. Sérusiaux* s. n. (LG), *P. van den Boom* 39979, 40001 (h); Piton de la Fournaise, 0.5 km NW of Gîte du Volcan, 21°12'82"S, 55°41'18"E, 2040 m, *Acacia heterophylla* wood on N-slope, 2008, *M. Brand* 58353 (h).

### *Micarea lignaria* (Ach.) Hedl.

*Thallus* consisting of small (100 µm across), convex, light grey granules over an algal layer growing on saxicolous mosses. *Photobiont* micareoid, cells round, *c.* 6.5–8.0 µm.

*Apothecia* *c.* 0.25 mm broad, convex, black, immarginate. *Hymenium* *c.* 60 µm, epihymenium blue. *Ascospores* 8 per ascus, fusiform, *c.* 20.0 × 5.2 µm, 5–7-septate.

*Chemistry.* Pigment in apothecia belonging to Cinereorufa-green.

*Habitat and distribution.* On steep rock face at 2450 m.

*Notes.* This collection is very small, but all characters match those of European collections. The thallus is P+ red, but is too small for chemical analysis; the shape of crystals in the thallus is identical to that of argopsin, the lichen substance diagnostic of *M. lignaria*. The ascospores are rather small but fall within the range of European material. The species is widespread as, according to Coppins (2009), it occurs in Europe, North and South America, and Asia (Siberia).

*Specimen examined.* **Réunion:** Cilaos, path Le Bloc to cabane Dufour, Côteau de Kervéguen, 21°6.72'S, 55°29.70'E, 2450 m, basalt of W-exposed rock face, 2008, *M. Brand* 59904 (h).

### **Micarea melanoprasina Brand, van den Boom & Sérus. sp. nov.**

Mycobank No.: MB807678

Thallus to 5 cm, pale green on black prothallus; apothecia 0.2–0.5 mm, dark grey to black; ascospores oval-oblong to slightly clavate, 8.5–10.5 × 2.8–4.0 µm, 0–1-septate; production of unknown compound.

Type: Réunion, 'Réserve naturelle de la Roche Ecrite', track to the summit, 20°58'6"S, 55°26'26"E, c. 1500 m, montane forest, on *Acacia heterophylla*, 4 November 2009, *N. Magain & E. Sérusiaux* s. n. (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 3A & B)

*Thallus* to 5 cm across, pale green, made of coralloid goniocysts growing on bluish black prothallus; thallus surrounded by bluish black prothallus, consisting of c. 2 µm thick blue-black, irregularly intricately hyphae; *goniocysts* 14–30 µm, round to ovate, fused to form branched coralloid structures to 200 µm high, composed of conglutinated hyphae in a gelatinized matrix and micareoid photobiont (cells c. 4–5 µm), interspersed with small crystals (melting in boiling water forming oily drops, recrystallizing after cooling).

*Apothecia* 0.2–0.5 mm diam., grey to black, adnate, without visible margin, convex. *Excipulum* colourless or dark blue, formed by radiating hyphae. *Hypothecium* pale or more or less blue-aeruginose, and brownish (K+ purplish brown) in lower part. *Hymenium* 33–37 µm high, more or less aeruginose near base;

*epihymenium* colourless to aeruginose. *Paraphyses* 1.1–1.5 µm thick, branched and anastomosing. *Asci* c. 32–35 × 12–13 µm; tholus of the *Micarea*-type. *Ascospores* 8 per ascus, oval-oblong to slightly clavate, 8.5–10.5 × 2.8–4.0 µm, 0–1-septate, septum not in middle of the spore but somewhat to the wider end (old spores occasionally 3-septate).

*Microperycnidia* occasionally present, small (15–30 µm), immersed, colourless; *microconidia* shortly bacilliform, 4.0–4.5 × 1.0 µm.

*Chemistry.* Unknown 1 in thallus (K–, P–, C–). Pigment in thallus and apothecia belonging to Cinereorufa-green.

*Etymology.* The name of this new species refers to the bluish black prothallus that makes it very characteristic amongst species of the *M. prasina* group, to which it belongs.

*Habitat and distribution.* On trunks of trees, including *Acacia heterophylla*, and on branches of shrubs (*Gaertnera vaginata*, *Chassalia coralloides*, *Dombeya* sp.) in montane rainforest (1400–1900 m).

*Notes.* A distinctive species, easily recognized because of its dark prothallus and finely coralloid-goniocystose thallus, very much akin to that of *M. prasina*. *Micarea melanoprasina* is indeed related to the *M. prasina* group and can be distinguished by the presence of Cinereorufa-green in the thallus and apothecia, as well as the unnamed brown pigment in the apothecia. *Micarea subviridescens* (Nyl.) Hedl. has a dark bluish green thallus, made of dense aggregated goniocysts, dark apothecia, larger ascospores (10–18 × 4–6 µm) and contains prasinic acid (Coppins 2009).

*Additional specimens examined.* **Réunion:** Bélouve forest, 21°03.93'S, 55°32.93'E, 1600 m, pristine montane forest, on tree, 27 v 2008, *E. Sérusiaux* s. n. (LG); Bois de sans Souci, 21°1.23'S, 55°22.10'E, 1350 m, montane forest, on *Gaertnera vaginata*, 2008, *M. Brand* 59994 (h); 21°01.22'S, 55°22.23'E, 1380 m, open shrub woodland, degraded montane forest, on *Chassalia coralloides*, 2008, *M. Brand* 60103 (h); E of Le Tampon, Forêt de Notre-Dame de la Paix, 21°15.1'S, 55°36.5'E, 1720 m, montane forest, on *Dombeya*, 2008, *P. van den Boom* 40775 (h); Cirque de Cilaos, Forêt du Grand Matarum, along path to Cabane Dufour, 21°07.04'S, 55°29.23'E, 1870 m, montane forest, on *Dombeya*, 2008, *M. Brand* 59740 (h).



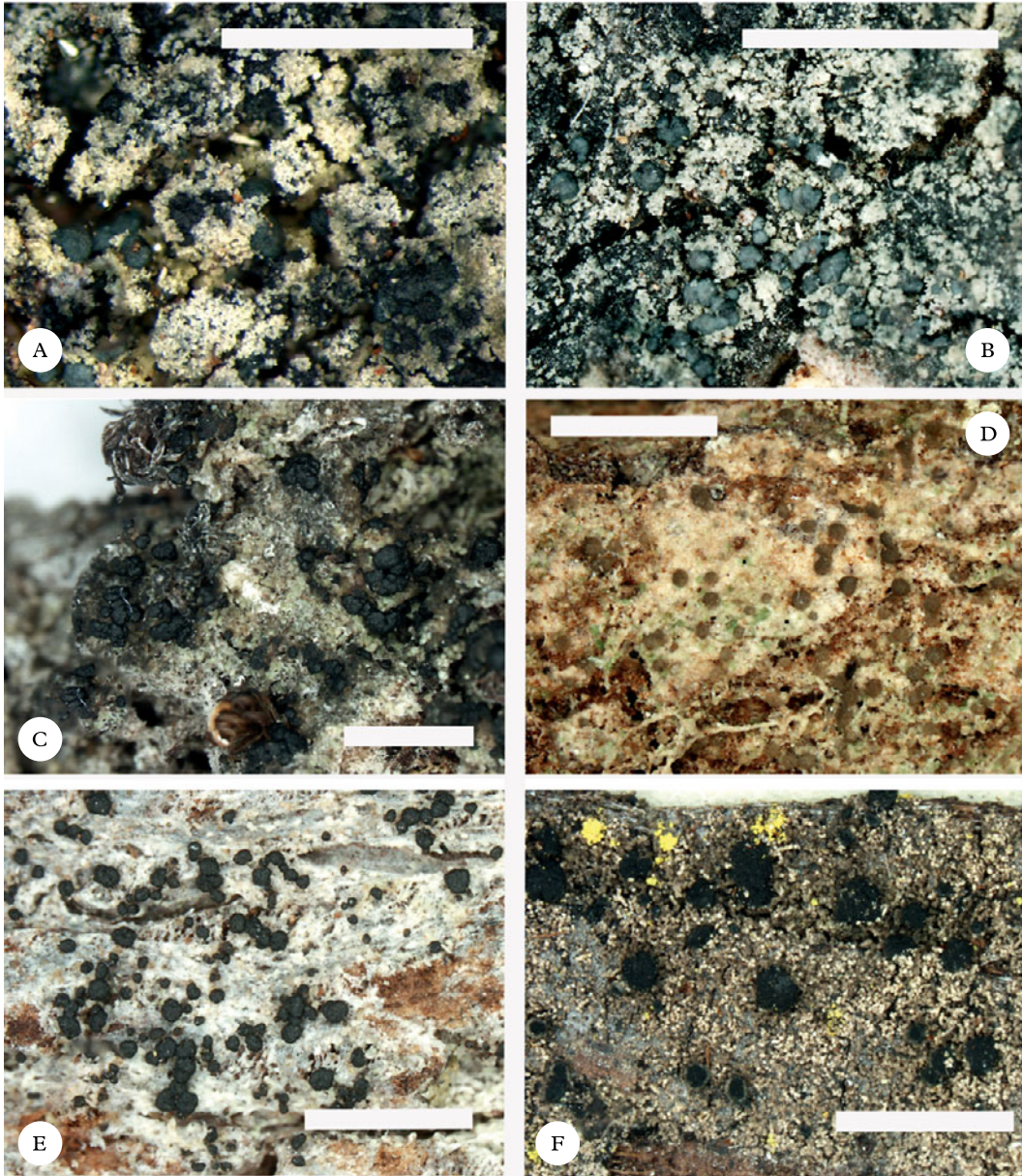


FIG. 3. Photographs of the new species of *Micarea* described from Réunion. A & B, *M. melanoprasina* sp. nov. (holotype); C, *M. pseudolignaria* sp. nov. (holotype); D, *M. sublithinella* sp. nov. (holotype); E, *M. takamakae* sp. nov. (holotype); F, *M. tenuispora* sp. nov. (holotype). Scale = 1 mm. In colour online.

***Micarea peliocarpa* (Anzi) Coppins & R. Sant.**

*Thallus* rather small, up to 1.5 cm across, pale greenish, uneven, *c.* 50  $\mu$ m high. Upper

part *c.* 15  $\mu$ m without algae, of loosely interwoven hyphae. *Photobiont* micareoid, photobiont layer interspersed with crystals (gyrophoric acid).



*Apothecia* up to 0.6 mm diam., whitish or dark bluish grey, often patchily coloured, with pale margin, flat or low convex, almost globose, adnate with constricted base. Outer parts of excipulum pale or bluish grey, pale inside. *Hypothecium* colourless. *Hymenium* c. 40–60 µm high; *epihymenium* colourless or patchily blue-grey, if pigmented then pigment also descending in hymenium. *Paraphyses* 1.1–1.4 µm thick, branched and anastomosing. *Asci* clavate, c. 35–55 × 12–15 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, fusiform with rounded ends, 3-septate, 13.6–17.0 × 3.6–4.7 µm.

*Macroconidia* not rare, globose, c. 120–150 µm, top blue-grey or not; *macroconidia* curved (but not spirally), 45–58 × 1.1–1.3 µm, indistinctly 3-septate. *Microconidia* rare, inconspicuous, semi-superficial, c. 45 µm, pale. *Microconidia* narrowly fusiform with tapering ends, 6.3–8.1 × 0.7–0.9 µm.

*Chemistry.* Gyrophoric and methylhiascic acids (K–, P–, C+ red), mainly in thallus, hymenium, excipulum and pycnidia. Pigment in thallus and apothecia belonging to *Cinereorufa*-green.

*Habitat and distribution.* Mostly on soft bark of shaded *Acacia heterophylla* trees, at 1500–2000 m; also found on *Erica*, and sometimes overgrowing mosses.

*Notes.* Within the speciose *Micarea peliocarpa* group in Réunion, we recognize *M. borbonica* sp. nov. with 7-septate fusiform ascospores, and thus close to *M. cinerea* (see further comments under *M. borbonica*), *M. boryana* sp. nov. with 3-septate narrowly clavate ascospores (see under that species) and also *M. peliocarpa* s. str. which encompasses collections with consistently 3-septate, fusiform ascospores. The size of ascospores falls in the range of European populations as provided by Coppins [2009: (11–)15–23(–24) × 3–5(–6) µm]. However, in the Réunion populations the ascospores are on average wider than in Europe: 13.6–17.0 × 4.1–4.7 µm in Réunion vs. 12.2–22.5 × 3.5–4.2 µm in Europe (unpublished results, based on studies of 35 collections).

*Specimens examined. Réunion:* St-Paul, road to Piton Maïdo, 21°03.24'S, 55°21.39'E, 1500 m, edge of open woodland, on large *Acacia heterophylla*, 2008, *M. Brand* 59488 (h); Cilaos, Plateau du Petit Matarum, path from Le Bloc to Cabane Dufour, 21°06.96'S, 55°29.22'E, 1900 m, montane forest, on *Acacia heterophylla*, 2008, *M. Brand* 59756 (h); *ibid.*, 21°07.3'S, 55°29.2'E, 1420 m, montane forest, on tree, 2008, *P. van den Boom* 40282 (h); Piton de la Fournaise, 0.5 km NW of Gîte du Volcan, 21°12.8'S, 55°41.18'E, 2040 m, on *Acacia heterophylla* in wood on N-slope, 2008, *M. Brand* 58356a, 58356b (h); Forêt de Bébou, path Bélouve to cabane Dufour, 3 km from Gîte Bélouve, 21°05.10'S, 55°31.36'E, 2040 m, wet high ericoid thickets, on *Erica*, 2008, *M. Brand* 58864 (h).

### *Micarea prasina* Fr.

*Thallus* diffuse, c. 1 cm across, green, thin (50 µm), granular, made of goniocysts 30–40 µm diam., round, dark greyish green; *goniocysts* composed of thin hyphae interspersed with small crystals (melting in boiling water). *Photobiont* micareoid, cells c. 4–6 µm.

*Apothecia* up to 0.3 mm diam., dark grey to dull black, convex, adnate with narrow base, without any visible margin. *Excipulum* in lower part of apothecia c. 40 µm wide, formed of radiating hyphae. *Hypothecium* dark grey-brown (K+ violet). *Hymenium* to 50 µm high. *Paraphyses* c. 1.2–1.3 µm thick, branched and anastomosing. *Asci* c. 40–42 × 9–12 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ovoid-ellipsoid, 9.3–12.8 × 3.8–4.3 µm, (0–)1-septate.

*Microconidia* sparse, white or grey; *microconidia* 6.3–7.1 × 0.9–1.1 µm, narrow fusiform, straight or slightly curved.

*Chemistry.* Micareic acid. With Sedifolia-grey pigment in inner excipulum, hypothecium and in diffuse streaks in hymenium.

*Habitat and distribution.* On bark of *Acacia heterophylla*, intermixed with the related *M. levicula*, and so far only found in natural stands of *Acacia heterophylla* near the Piton de la Fournaise.

*Notes.* Our material differs from *Micarea prasina*, as it is now circumscribed in Europe (Coppins 2009), by the location of the K+ violet pigment in the hypothecium instead of the epihymenium. Otherwise the thallus

made of finely dissected and coralloid gonio-cysts, and the production of micareic acid, are diagnostic for *M. prasina*. We refrain from describing a new species on that sole basis. A K+ violet hypothecium is otherwise only known from *M. endoviolascens* Coppins from South Africa (Coppins 1999), easily distinguished by its corticated squamules, and *M. hypoviolascens* Czarnota & Coppins from a single locality in W Scotland (Czarnota & Coppins 2005), distinguished by its areolate thallus and production of an unknown substance.

*Specimens examined.* **Réunion:** NNW of Piton de la Fournaise, trail along Ravine Savane Cimetièrre, 21°11.6'S, 55°37.5'E, 2050 m, mixed forest with mature *Acacia heterophylla*, on *Acacia*, 2008, *P. van den Boom* 39976 (h); Piton de la Fournaise, c. 0.5 km NW of Gîte du Volcan, 21°12.82'S, 55°41.18'E, 2040 m, on *Acacia heterophylla* in wood on N-slope, 2008, *M. Brand* 58355 (h).

***Micarea pseudocoppinsii* Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807679

Thallus diffuse, small, pale greenish, with convex soralia; apothecia to 0.4 mm, white, pale orange or partly bluish grey, convex; ascospores bacillar-ellipsoid, 11.5–13.0 × 4.2–5.7 µm, (0–)3-septate; production of gyrophoric acid.

Type: Réunion, NNW of Piton de la Fournaise, trail along Ravine Savane Cimetièrre, 21°12.06'S, 55°41.46'E, 2050 m, mixed forest with mature *Acacia heterophylla*, on *Acacia*, 28 May 2008, *P. van den Boom* 39991 (LG—holotype; hb. v.d. Boom, hb. Brand 61466—isotype).

(Fig. 2H)

*Thallus* diffuse, small (1.5 cm across) pale greenish, made of small granules or gonio-cysts, locally with soralia; *goniocysts* 18–48 µm diam., round to ovoid, partly coalescing but not coralloid. *Photobiont* micareoid, c. 5–8 µm. *Soralia* sometimes numerous, round, convex, 0.3–0.6 mm broad; soredia light green, very fine, 11–32 µm diam.

*Apothecia* up to 0.4 mm diam., white, pale orange or partly bluish grey, convex, adnate with constricted base, without any visible margin. *Excipulum* formed by radiating, conglomerate hyphae, outer parts pale or bluish

grey, pale inside, partly incrustated with gyrophoric acid crystals. *Hypothecium* colourless. *Hymenium* c. 50–55 µm high; *epihymenium* colourless or blue-grey in patches. *Paraphyses* 1.7–1.9 µm thick, simple or branched, strongly conglutinate. *Asci* clavate, for example 32–47 × 11–16 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, bacillar-ellipsoid, 11.5–14.7 × 4.2–5.7 µm, (0–)3-septate, straight to curved.

*Pycnidia* not found.

*Chemistry.* Gyrophoric acid (K–, P–, C+ red), mainly in thallus and soredia, sometimes in excipulum. Pigment in apothecia belonging to *Cinereorufa*-green.

*Etymology.* The name refers to another species of *Micarea*, *M. coppinsii*, which was dedicated to our talented colleague and friend, Dr Brian J. Coppins.

*Habitat and distribution.* On soft bark of *Acacia heterophylla* or overgrowing mosses, between 1500–2050 m elevation.

*Notes.* Genuine soralia are rare in *Micarea*. Beside *M. pseudocoppinsii*, they are only known in two other species: *M. alectorialica*, here described as new and easily identified by its black apothecia and production of alectorialic acid, and *M. coppinsii* Tønsberg, also producing gyrophoric acid. The latter species differs in producing methylhiassic acid together with gyrophoric acid, and has fusiform, sometimes slightly clavate, longer ascospores (20–28 × 4–5 µm) (Coppins 2009). *Micarea viridileprosa* Coppins & van den Boom has a bright, green, leproid thallus without clearly delimited soralia and has smaller ascospores [8–12(–14) × 2.5–4.0 µm]. *Micarea pseudocoppinsii* is most likely related to the group of *M. peliocarpa* as it has the same type of apothecia, and to *M. peliocarpa* which differs by its less-developed thallus and lack of soralia.

*Additional specimen examined.* **Réunion:** Forêt de Bébour, near Gîte de Bélouve, 21°03.74'S, 55°32.31'E, 1520 m, old plantations of *Acacia heterophylla* trees, on *Acacia*, 2008, *P. van den Boom* 39861 (h).

**Micarea pseudolignaria Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807680

Thallus muscicolous, areolate, greyish green; apothecia to 0.6 mm, shining black, convex; ascospores ellipsoid,  $8.0\text{--}9.2 \times 3.0\text{--}3.3 \mu\text{m}$ , (0–)1-septate; production of unknown substance.

Type: Réunion, Forêt de Bébour, path Bélouve to cabane Dufour,  $21^{\circ}04.77'S$ ,  $55^{\circ}31.64'E$ , 1740 m, soil in ericoid thickets, 2 June 2008, *M. Brand* 58846 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 3C)

*Thallus* c. 2 cm across, overgrowing decaying bryophytes, uneven, made of coalescent, 0.2–0.3 mm diam., slightly convex, greyish greenish areolae. *Photobiont* micareoid, cells c. 5  $\mu\text{m}$ . *Cortex* absent but areolae partly covered by a hyaline epinecral layer. Thallus without crystals, except for lower part of photobiont layer more or less opaque due to oily drops and tiny crystals.

*Apothecia* up to 0.6 mm diam., shining black, convex without any distinct margin, often coalescing to form compound apothecia. *Excipulum* with radiating conglutinated hyphae, outer parts brownish to bluish, colourless inside. *Hypothecium* colourless. *Hymenium* c. 40  $\mu\text{m}$  high, lower part more or less inspersed; *epihymenium* blue. *Paraphyses* 1.5  $\mu\text{m}$  thick, strongly branched and anastomosing. *Asci* clavate, c.  $35 \times 9 \mu\text{m}$ , tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ellipsoid,  $8.0\text{--}9.2 \times 3.0\text{--}3.3 \mu\text{m}$ , (0–)1-septate, wall c. 0.3  $\mu\text{m}$  thick.

*Micropycnidia* superficial (i.e. on thin thallus overgrowing leafy liverworts), c. 75  $\mu\text{m}$  diam., wall dark from bluish pigment. *Microconidia* bacillar,  $4.6\text{--}5.8 \times 0.9\text{--}1.0 \mu\text{m}$ .

*Chemistry*. Unknown 3 in thallus (K–, P–, C–), most probably present as tiny oil droplets or crystals. Pigment in apothecia belonging to Cinereorufa-green.

*Etymology*. The name refers to the widespread *M. lignaria*, which could be easily confused with this new species.

*Habitat and distribution*. Only known from the type locality. On soil, among rich stands of *Cladonia*, in montane ericoid shrubs.

*Notes*. This new species looks very much like *M. lignaria* (Ach.) Hedl., also found in a single locality in Réunion, but has smaller 1-septate ascospores and a different chemistry. In *M. lignaria*, ascospores are 3–7-septate,  $16\text{--}28(-38) \times 4.3\text{--}5.7(-7.0) \mu\text{m}$ , and the thallus produces argopsin (var. *lignaria*) or unidentified xanthonenes (var. *endoleuca*). Furthermore, *M. lignaria* has a greenish hue in the lower part of the hymenium, which is never inspersed. The rare *M. temaria* (Nyl.) Vězda, known only from the Northern Hemisphere, has a similar thallus and apothecia but differs by the lack of lichen substances and (1–)3-septate,  $13\text{--}22 \times 3.5\text{--}5.0 \mu\text{m}$  ascospores (Coppins 2009).

**Micarea sublithinella Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807681

Thallus thin, with flattened rounded areoles, green; apothecia up to 0.4 mm diam.; ascospores obovoid,  $12.5\text{--}15.0 \times 5.0\text{--}5.8 \mu\text{m}$ , 0–1-septate; production of protolichesterinic acid.

Type: Réunion, NNW of Piton de la Fournaise, trail along Ravine Savane Cimetière,  $21^{\circ}12.06'S$ ,  $55^{\circ}41.46'E$ , 2050 m, mixed forest with mature *Acacia heterophylla*, on *Acacia*, 28 May 2008, *P. van den Boom* 39980 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 3D)

*Thallus* c. 2 cm across, thin (25–50  $\mu\text{m}$ ), green, continuous or consisting of flat rounded areoles growing over a thin, slightly shiny film over the substratum. *Photobiont* micareoid, cells c. 5–6  $\mu\text{m}$ , thallus with a few crystals.

*Apothecia* numerous and small, up to 0.4 mm diam. (deformed apothecia up to 0.5 mm), dull, light brownish, broadly adnate, immarginate, convex to semiglobose. *Excipulum* thin (less than 10  $\mu\text{m}$ ). *Hypothecium* pale. *Hymenium* c. 55–75  $\mu\text{m}$  high; *epihymenium* colourless or faintly brownish, with crystals in vertical streaks. *Paraphyses* 1.0  $\mu\text{m}$  thick, branched. *Asci* c.  $50\text{--}70 \times 15\text{--}16 \mu\text{m}$ , tholus of the *Micarea*-type. *Ascospores* 8 per ascus, obovoid (apical part slightly broader),  $12.5\text{--}15.0 \times 5.0\text{--}5.8 \mu\text{m}$ , 0–1-septate, wall thin (c. 0.2  $\mu\text{m}$ ).



*Pycnidia* not found.

**Chemistry.** Protolichesterinic acid (K–, P–, C–), with crystals mainly detected in epihymenium, but also present in thallus.

**Etymology.** The name refers to *M. lithinella*, a widespread species that could be easily confused with this new species.

**Habitat and distribution.** On wood of rotting trunks, or on trees, including *Acacia heterophylla*, in montane forests.

**Notes.** Most characters of *Micarea sublithinella* fit the the traditional concept of the genus *Micarea* (*sensu* Coppins 1983), but the larger asci and production of fatty acid set it apart. In the field it can easily be confused with *M. lithinella* (Nyl.) Hedl., a widespread species in the Northern Hemisphere, but this species is a pioneer saxicolous species in disturbed habitats, has smaller asci (35–50 × 8–13 µm), smaller and simple ascospores (6.5–9.5 × 2.5–4.0 µm) and no compounds detected (Coppins 2009). Species related to *M. lithinella*, such as *M. farinosa* Coppins & Aptroot, also lack compounds.

**Additional specimens examined. Réunion:** same locality as the type, *E. Sérusiaux* s. n. (LG); Forêt de Bébou, trail to Takamaka, 21°05.9'S, 55°34.3'E, 1370 m, wet montane forest, on trees, 2008, *P. van den Boom* 40872 (h); E of Le Tampon, Forêt de Notre-Dame de la Paix, 21°15.1'S, 55°36.5'E, 1720 m, montane forest, on tree, 2008, *P. van den Boom* 40745 (h).

***Micarea takamakae* Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807682

Thallus semi-endoxylic, made of goniocysts, whitish; apothecia up to 0.2 mm diam., adnate; ascospores ellipsoid, 8.8–10.2 × 3.1–3.8 µm, 0–1-septate; production of unknown substance.

Type: La Réunion, WSW of St-Benoît, along the road to Takamaka, c. 3 km SW of Abondance les Hauts, 21°03.5'S, 55°38.5'E, 620 m, disturbed area with planted trees, on decaying tree, 11 June 2008, *P. van den Boom* 41009 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 3E)

**Thallus** inconspicuous, diffuse, partly endoxylic on soft, decaying wood, whitish, made of dispersed, round goniocysts, c. 30–75 µm diam., either in empty dead cells of

the bark or, when superficial, goniocysts covered by clear necrotic tissue. *Photobiont* micareoid, cells c. 5–7 µm. Crystals detected in goniocysts.

**Apothecia** very numerous and small (up to 0.2 mm diam.), black, adnate with constricted base to nearly stipitate, first flat without any distinct margin, then convex, often forming clusters. *Excipulum* well developed in under part, made of chondroid tissue; outer part hyaline, inner part locally brown. *Hypothecium* pale, opaque because of numerous small crystals. *Subhymenium* reddish brown. *Hymenium* c. 35 µm high; *epihymenium* dull blue-green and brownish, with small dark granules in K. *Paraphyses* 1.4 µm thick, branched. *Asci* c. 27–30 × 11–13 µm, tholus of the *Micarea*-type. *Ascospores* 8 per ascus, ellipsoid, 8.8–10.2 × 3.1–3.8 µm, 0–1-septate, wall c. 0.3 µm thick.

*Pycnidia* not found.

**Chemistry.** Unknown 2, assumed to be confluent acid or a related compound (K–, P–, C–). Pigment in epihymenium belonging to *Cinereorufa*-green.

**Etymology.** The name refers to a spot on the northern flank of the island, 'Le Cassé de Takamaka', a landscape of dramatic beauty.

**Habitat and distribution.** Only known from the type locality, at rather low elevation (620 m) in a high rainfall area, on decaying wood of standing trunk.

**Notes.** *Micarea takamakae* has an excipulum and hymenium very much akin to those of *M. erratica*, but all other characters are quite different and set it apart from that species. Confluent acid has never been reported in the genus but all chemical features point to that substance. Small ascospores are a further interesting feature of this new species, amongst the species found on Réunion and not belonging to the *M. micrococca-prasina* aggregate.

***Micarea tenuispora* Brand, van den Boom & Sérus. sp. nov.**

MycoBank No.: MB807683

Thallus very thin to endophloeodal, isidiate or made of isidiiform areolae, isidia small cylindrical to coralloid, up to 0.3 mm high; apothecia to 0.9 mm, dark grey to black, ascospores acicular, narrowly clavate,  $31\text{--}35 \times 2.2\text{--}2.5 \mu\text{m}$ , 3–5-septate; production of gyrophoric acid.

Type: Réunion, Cirque de Cilaos, Forêt du Grand Matarum, trail to Caverne Dufour,  $21^{\circ}07.3'S$ ,  $55^{\circ}29.2'E$ , 1420 m, montane forest, on *Cryptomeria*, 31 May 2008, P. van den Boom 40231 (LG—holotype; hb. v.d. Boom, hb. Brand—isotype).

(Fig. 3F)

*Thallus* to 5 cm across, pale greenish to brownish, discontinuous, thin (c.  $50 \mu\text{m}$  thick), consisting of scattered areolae, soon forming isidia or becoming isidiiform, on thin endo- to epiphloeodal dark bluish hypothallus with narrow, colourless or locally dark brownish or bluish hyphae; mature thallus always with isidiiform areolae (c.  $0.2 \text{ mm}$  high,  $0.05\text{--}0.07 \text{ mm}$  thick). *Cortex* absent, often with thin epinecral layer. *Photobiont* micareoid. Thallus filled with crystals of gyrophoric acid.

*Apothecia* up to 0.8 mm diam., sessile to substipitate, black, usually with a pale margin when young, first flat, without distinct rim, then usually but not always semiglobose. *Excipulum* with radiating hyphae, varying in colour (often in the same apothecium) from pale (then with crystals) to superficially bluish and centrally light brown. *Hypothecium* pale brown to dark bluish. *Hymenium* c.  $55 \mu\text{m}$  high; *epihymenium* greyish bluish in patches. *Paraphyses* c.  $1.3 \mu\text{m}$  thick, branched and anastomosing. *Asci* c.  $44 \times 11 \mu\text{m}$ , tholus of the *Micarea*-type. *Ascospores* 8 per ascus, in one bundle, sometimes twisted, acicular, apically inflated and tapering towards the base,  $31\text{--}35 \times 2.2\text{--}2.5 \mu\text{m}$ , 3–5-septate.

*Micropycnidia* scarce, inconspicuous, sessile, c.  $110 \mu\text{m}$ , with blue-green top, brownish wall. *Microconidia* narrow fusiform, average  $3.8\text{--}4.1 \times 1.1\text{--}1.2 \mu\text{m}$ .

*Chemistry*. Gyrophoric acid (K–, P–, C+ red), mainly in thallus, but also in pale parts of apothecia and in pycnidia. Pigment in thallus and apothecia belonging to *Cinereorufagreen*. Brown pigment in hypothecium K+ reddish to purple.

*Etymology*. The name was chosen to emphasize the thin ascospores of this species.

*Habitat and distribution*. On bark of the exotic *Cryptomeria japonica*, between 1200–1500 m elevation, at edges of disturbed natural forests.

*Notes*. *Micarea tenuispora* is easily distinguished by its 'isidiate' thallus and 3–5-septate ascospores. Isidia or isidiiform thallus areolae are reported in only two species of *Micarea*, both described here as new. For differences to *M. isidiosa* sp. nov., see under that species.

*Additional specimen examined*. **Réunion**: Cilaos, Forêt du Grand Matarum,  $21^{\circ}07.17'S$ ,  $55^{\circ}29.10'E$ , 1450 m, disturbed margin of montane forest, on *Cryptomeria*, 2008, M. Brand 58685 (h).

We are greatly honoured to publish our paper in this special issue of *The Lichenologist* for the 65th birthday of our most distinguished colleague and friend, and the world expert on *Micarea* taxonomy, Dr Brian J. Coppins.

Field studies in Réunion were made possible with the help and advice from the Parc National de La Réunion, especially through the courtesy of Mr B. Lequette and Mr J. M. Pausé. Dr Cl. Ah-Peng and Prof. D. Strasberg of the University of La Réunion in Saint-Denis were also very helpful. We thank them all most sincerely. We further thank the Senior Editor of *The Lichenologist*, Prof. P. D. Crittenden, and the three Editors of this special volume (Dr Alan Fryday, Dr Gintaras Kantvilas and Dr Chris Ellis). Both referees contributed to the final version of this manuscript as their notes and suggestions were very helpful: we thank them warmly.

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