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POLYCOCCUM HAWKSWORTHIANUM (POLYCOCCACEAE, TRYPETHELIALES), A NEW LICHENICOLOUS FUNGUS ON *LEPRA* AND *VARICELLARIA* FROM INDIA

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The study revealed a new species of *Polycoccum* colonising thallus of lichen genus *Lepra* and *Varicellaria* in tropical and temperate regions of India. The genus belonging to the family Polycoccaceae is represented by 7 species in India. Though the genus is host-specific, there are 12 genera of lichens which are home for more than one species of this fungus. It is the second known species of *Polycoccum* on members of *Lepra* and *Varicellaria*, and differs from the previously known ones – 1) *Polycoccum ochvarianum* by being gall forming and having smaller perithecia [(88–)104–*128*–152(–170) × (81–)95–*114*–133(–145) μm] and 2) *Polycoccum* sp. in having smaller perithecia [op. cit. vs. 250–300 μm], hymenial gelatine I–, and smaller asci [(50–)55–60–65(–75) × (10–)13–15–17(–18) vs. 90 × 14 μm].

Key words: Ascomycota, lichens, new species, taxonomy

INTRODUCTION

The genus *Polycoccum* Saut. ex Körb. (Körber 1865) belonging to family Polycoccaceae Ertz, Hafellner et Diederich is characterised by dark perithecioid ascomata, pseudoparenchymatous exciple, fissitunicate asci with brown 1-septate ascospores, a centrum usually I– and K/I– (but in a few species K/I+ blue or violet), and a hamathecium of persistent, branched and anastomosing interascal filaments. The genus is represented by 60 species (Diederich *et al.* 2018) across the world and forms a commensalistic symbiosis with its host, often producing gall-like structures on the host thallus.

Polycoccum species are confined either to a single host lichen or a group of related species, except 7 which colonise more than one host genus (Table 1). In the present paper the author describes a new species of *Polycoccum* colonising thallus of bark/wood inhabiting *Lepra* and *Varicellaria* species, thus raising the number of species to 61 across the world and 8 in India (Table 2). It is the second known species of *Polycoccum* on a member of *Varicellaria*, and it differs from the previously described one – *Polycoccum ochvarianum* – in being gall inducing and having smaller perithecia [(88–)104–*128*–152(–170) × (81–)95–*114*–133(–145) μm]. Similarly, it is also the second known species of *Polycoccum* on

members of *Lepra*, and differs from the previously described one – *Polycoccum* sp. – in having smaller perithecia [op. cit. vs. 250–300 μm], hymenial gelatine I–, and smaller asci [(50–)55–60–65(–75) × (10–)13–15–17(–18) vs. 90 × 14 μm].

MATERIALS AND METHODS

The lichen specimens of *Lepra* and *Varicellaria* deposited in the herbaria of CSIR-National Botanical Research Institute (LWG) including the personal herbarium of D. D. Awasthi (AWAS) and Lucknow University (LWU) were carefully examined under stereozoom dissecting microscope (Olympus SZ61) for the presence of lichenicolous fungi. Thin hand-cut sections were made for studying the anatomy of fruiting bodies and examined under a compound microscope (Olympus BX53) equipped with Olympus differential interference contrast optics. Microscopical examination was done in water, 10% KOH (K), lactophenol cotton blue (LCB), Lugol's iodine, directly (I) or after a KOH pre-treatment (K/I). Ascospore measurements are presented as: arithmetic mean – standard deviation, arithmetic mean, and arithmetic mean + standard deviation, flanked by the minimal and maximal measurements in parentheses, followed by the number of measurements (n). Values in italics (e.g., *–128–*) are arithmetic means.

RESULTS AND DISCUSSION

Polycoccum hawksworthianum Y. Joshi, *spec. nova*
(Figs 1–2)

MycoBank No.: MB 835610

Similar to Polycoccum islandicum, *but differs in having smaller perithecia [(88–)104–*128*–152(–170) × (81–)95–*114*–133(–145) μm], bigger spores [(17–)20–*21*–22(–23) × (5–)6–7–8(–9) μm] and* Lepra *and* Varicellaria *as hosts.*

Type: India. West Bengal, Darjeeling district, between Renluck and Sandakpoo, on thallus of *Lepra variolosa* colonising dead wood log, June 1948, D. D. Awasthi 237 (holotype: LWG-AWAS 14371; isotype: RUBL).

Ascomata growing in tuberculiform galls on the thallus of *Lepra* and *Varicellaria* species, galls (0.5–)0.7–1.5(–1.8) mm diam., never peltate, concolorous with the thallus, with numerous ascomata (up to 20). Perithecia completely immersed in the galls with only the black ostioles visible, subglobose to ovoid, (88–)104–*128*–152(–170) × (81–)95–*114*–133(–145) μm, flattened at the apex, ostiole *ca* 25–50 μm diam. Ascomatal wall pale brown to dark brown, 10–30 μm, composed of 4–10 layers of radially compressed cells, forming a textura angu-

laris. Hamathecium consisting of branched and anastomosing septate pseudoparaphyses, 1–1.5 μm thick, not markedly swollen at the apices; hymenial gelatine I– (Lugol's), after pre-treatment with K. Asci arising from the lower part of the ascomatal cavity, cylindrical to clavate, shortly stalked, bitunicate, the apex thickened, (6–)8-spored, (50–)55–*60*–65(–75) × (10–)13–*15*–17(–18) μm (n = 30); wall I–. Ascospores oblique monostichously to irregularly distichously arranged, ellipsoid to soleiform, 1-septate, constricted at the septum, the cells ± equal in size, some tending to taper towards the rounded ends or rounded at the apices, first hyaline to pale olivaceous to olivaceous brown, then dark red-brown, pigmentation particularly deep around the septum, K+ intense, [(17–)20–*21*–22(–23) × (5–)6–*7*–8(–9) μm (n = 30), smooth, not ornamented, Q = (2.1–)2.6–2.8–3; perispore 0.5 μm. Conidiomata not seen.

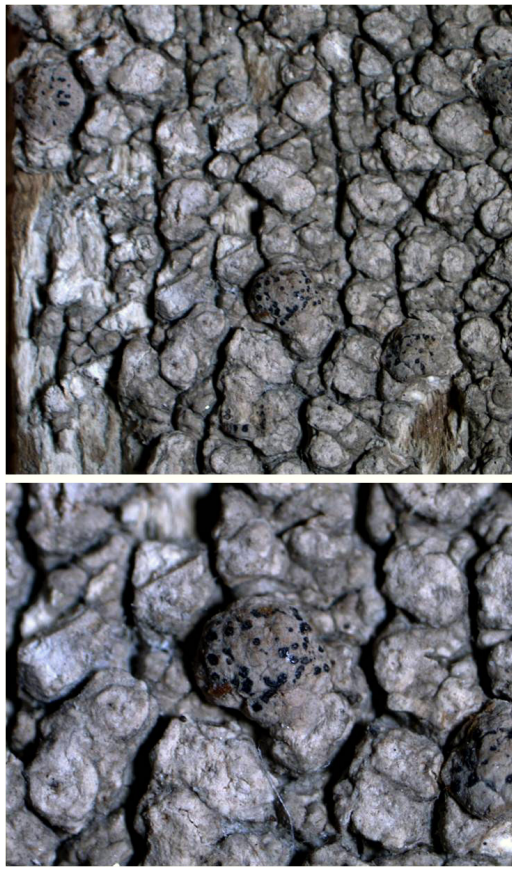

Fig. 1. Polycoccum hawksworthianum (holotype): A) Thallus of *Lepra variolosa* infected by *Polycoccum* (scale bar = 1 mm). B) Magnified view of infected part (scale bar = 1 mm)

Host: The fungus induces the formation of conspicuous tuberculate gall-like swellings in the host thallus, hence it seems to be a parasite on *Lepra* and *Varicellaria*.

Etymology: The epithet is given after Prof. David L. Hawksworth, for his immense contribution in the field of investigation of lichenicolous fungi.

Ecology and distribution: The new taxon is reported from tropical and temperate regions of India colonising corticolous/lignicolous species of *Lepra variolosa* (Kremp.) I. Schmitt, A. W. Archer et Lumbsch and *Varicellaria velata* (Turner) I. Schmitt et Lumbsch.

Taxonomic and ecological remarks: The genus *Polycoccum* in India is represented by 8 species (including the new taxon) colonising various corticolous, saxicolous, and more rarely terricolous lichens. Of these 8 species, 3 are strictly corticolous, 2 saxicolous, 1 terricolous, while 2 species share various substrates

(corticolous/saxicolous and corticolous/lignicolous, respectively) (Table 2). As far as their distribution in India is considered, 5 species are reported from Uttarakhand, 2–2 from Himachal Pradesh and Jammu & Kashmir, and 1–1 from Bihar, Himachal Pradesh, Kerala, Ladakh, Madhya Pradesh, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal (Table 2).

As it is well known that except for 7 species (*op. cit.*) the rest of the members of this genus are host-specific and are confined to a particular host (Table 1). *Polycoccum microsticticum* (Leight.) Arnold used to colonise 5 lichen genera, followed by *P. marmoratum* (Kremp.) D. Hawksw. (4 genera), *P. ochvarianum* Y. Joshi (3 genera), *P. arnoldii* (Hepp ex Körb.) D. Hawksw., *P. hawksworthianum* Y. Joshi, *P. rugulosarium* (Linds.) D. Hawksw. and *P. tinantii* Diederich (2 genera each). Furthermore, there are 12 genera of lichens, which are being infected by more than one *Polycoccum* species (Table 3). The members of *Buellia* and *Placopsis* are infected by 4 species each, followed by *Cladonia* and *Rhizocarpon* (3 each), *Acarospora*, *Aspicilia*, *Lecanora*, *Lepra*, *Physcia*, *Pseudocyphellaria*, *Rinodina* and *Varicellaria* (2 each).

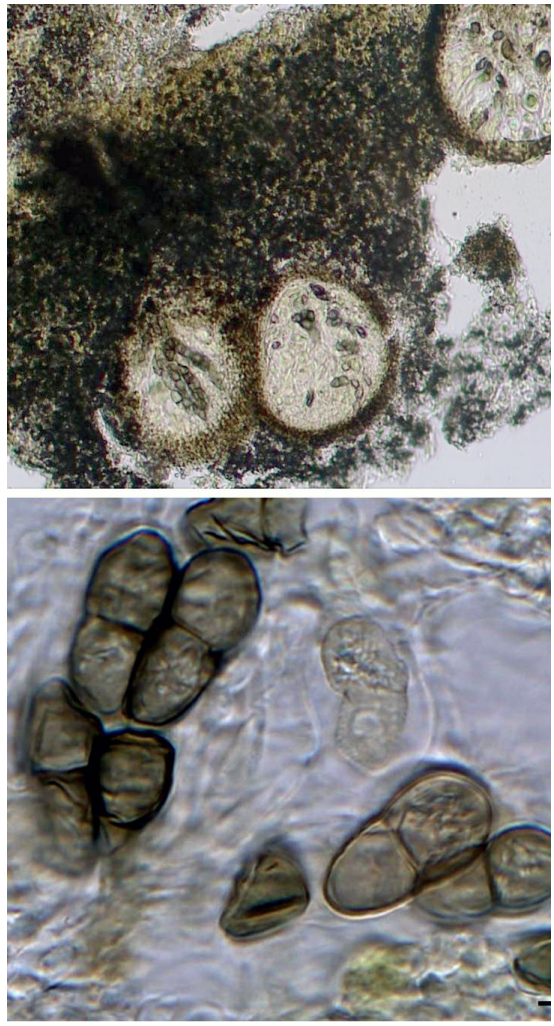

Fig. 2. Polycoccum hawksworthianum (holotype): Top = vertical section through galls with perithecia (scale bar = 50 μm). Bottom = ascospores (scale bar = 10 μm)

Polycoccum ochvarianum, the other known species of this genus colonising members of Ochrolechiaceae (*Ochrolechia* and *Varicellaria*) and Pertusariaceae (*Pertusaria*) (Table 2), differs from the new taxon in being commensalistic (i.e. never induces wart-like galls on the thallus) and has sessile, larger perithecia of 275–310 × 205–250 μm. Similar *Polycoccum*

Table 1

Polycoccum species colonising more than one lichen genera

Species	Host genera	Reference(s)
Polycoccum arnoldii (Hepp) D. Hawksw.	*Diploschistes, Rhizocarpon*	Hawksworth and Diederich (1988)
Polycoccum hawksworthianum Y. Joshi	*Lepra, Varicellaria*	Present paper
Polycoccum marmoratum (Kremp.) D. Hawksw.	*Clauzadea, Polyblastia, Thelidium, Verrucaria*	Atienza *et al.* (2003), Hawksworth and Diederich (1988), Santesson (1993), Sérusiaux *et al.* (1999)
Polycoccum microsticticum (Leight.) Arnold	*Acarospora, Buellia, Ionaspis, Placopsis, Rhizocarpon*	Hawksworth and Diederich (1988), Lamb (1947), Leighton (1873)
Polycoccum ochoarianum Y. Joshi	*Ochrolechia, Pertusaria, Varicellaria*	Joshi *et al.* (2017)
Polycoccum rugulosarium (Linds.) D. Hawksw.	*Austroplaca, Gondwania*	Hawksworth and Diederich (1988), Hawksworth and Iturriaga (2006), Pegler *et al.* (1980)
Polycoccum tinantii Diederich	*Blastenia, Gyalolechia*	Diederich (1990), Joshi *et al.* (2018)

species, with ascomata diam. < 150 μm and 8-spored asci are *P. decolorans* Calatayud et Triebel, *P. microsticticum* (Leight.) Arnold and *P. rubellianae* Calatayud et V. Atienza. These species have differently sized ascospores: 18–22 × 6–8 μm, 14–18 × 7–8 μm and 11–14 × 6–7 μm, respectively, and used to colonise different host genera, *Immersaria*, *Acarospora* and *Caloplaca*, respectively. In its external appearance the species comes closer to *P. deformans* R. Sant. et Brackel, *P. perrugosae* Brackel and *P. islandicum* Brackel et F. Berger, which differs not only in host selection [all inhabiting the thallus of saxicolous lichen (*Placopsis*) and inducing the formation of peltate galls] and hymenial gel reaction (I+ faint violet), but in other characters too. *P. deformans* has bigger perithecia 135–200 × 125–175 μm and ellipsoid spores; similarly *P. perrugosae* has bigger perithecia (175–210 × 100–175 μm) and bigger and narrower spores [(19–)22.4–27.4(–30) × (5–)5.3–6.1(–6.5) μm], however, *P. islandicum* has bigger perithecia (150–235 × 130–200 μm) and smaller spores [(13–)13.5–15.8(–17.5) × (6–)6.6–7.5(–8) μm].

Polycoccum sp. inhabiting thallus of *Lepra amara* (Ach.) Hafellner (syn. *Pertusaria am-*

Table 2
Distribution of the lichenicolous genus *Polycoccum* in India

Species	Hosts	Lichen habitat	Distribution in India	Reference
P. clauzadei Nav.-Ros. et Cl. Roux	*Rusavskia elegans* (Link) S. Y. Kondr. et Kärnefelt (thallus and apothecial disc)	saxicolous	Ladakh, Uttarakhand	Zhurbenko (2013)
P. hawksworthianum Y. Joshi	*Lepra variolosa* (Kremp.) I. Schmitt, A. W. Archer et Lumbsch, *Varicellaria velata* (Turner) I. Schmitt et Lumbsch (thallus)	corticolous, lignicolous	Himachal Pradesh, West Bengal	Present manuscript
P. ibericum Etayo et van den Boom	*Rinodina* sp. (thallus)	corticolous	Jammu & Kashmir	Joshi (2018)
P. microsticticum (Leight.) Arnold	*Acarospora fuscata* (Ach.) Arnold (thallus)	saxicolous	Himachal Pradesh	Joshi *et al.* (2016)
P. ochvarianum Y. Joshi	*Ochrolechia androgyna* (Hoffm.) Arnold, *Pertusaria acuta* Müll. Arg., *P. amarkantakana* Preeti Srivast. et D. D. Awasthi, *P. coccodes* (Ach.) Nyl., *P. coronata* (Ach.) Th. Fr., *P. granulata* (Eschw.) Müll. Arg., *P. himalayensis* D. D. Awasthi et Preeti Srivast., *P. melastomella* Nyl., *P. neilgherrensis* (Müll. Arg.) D. D. Awasthi et P. Srivast., *P. pertusa* (L.) Tuck., *P. quassiae* (Fée) Nyl., *P. rigida* Müll. Arg., *P. splendens* D. D. Awasthi et Preeti Srivast., *P. subdepressa* Müll. Arg., *P. subochracea* Stirt., *P. tuberculifera* Nyl., *Varicellaria velata* (Turner) I. Schmitt et Lumbsch (thallus)	corticolous	Bihar, Himachal Pradesh, Kerala, Madhya Pradesh, Odisha, Tamil Nadu, Uttarakhand, Uttar Pradesh	Joshi *et al.* (2017)
P. peltigerae (Fuckel) Vězda	*Peltigera canina* (L.) Willd. (thallus)	terricolous	Uttarakhand	Joshi *et al.* (2016)
P. pulvinatum (Eitner) R. Sant.	*Physcia* sp., *P. dubia* (Hoffm.) Lettau, *P. stellaris* (L.) Nyl. (thallus and/or apothecial disc)	corticolous, saxicolous	Jammu & Kashmir, Uttarakhand	Zhurbenko (2013)
P. tinantii Diederich	*Gyalolechia flavorubescens* (Huds.) Søchting, Frödén et Arup (thallus)	corticolous	Uttarakhand	Joshi *et al.* (2018)

Table 3
Genera of lichens inhabited by more than one *Polycoccum* species

Host lichen genus	Lichenicolous *Polycoccum* species
Acarospora	*P. acarosporicola* Halıcı et D. Hawksw., *P. microsticticum* (Leight.) Arnold
Aspicilia	*P. aksoyi* Halıcı et V. Atienza, *P. thallicola* Arnold
Buellia	*P. epizoharyi* Calat. et V. Atienza, *P. microsticticum* (Leight.) Arnold, *P. nigrosporum* Etayo, *P. stellulatae* (Vouaux) Hafellner
Cladonia	*P. cladoniae* Diederich et D. Hawksw., *P. laursenii* Zhurb., *P. microcarpum* Diederich et Etayo
Lecidea	*P. follmannii* (C. W. Dodge) Alstrup, *P. kerneri* J. Steiner
Lepra	*P. hawksworthianum* Y. Joshi, *P.* sp. Brackel
Physcia	*P. atrostriatae* van den Boom, *P. pulvinatum* (Eitner) R. Sant.
Placopsis	*P. deformans* R. Sant. et Brackel, *P. islandicum* Brackel et F. Berger, *P. perrugosae* Brackel, *P. squamarioides* (Mudd) Arnold
Pseudocyphellaria	*P. longisporum* Etayo, *P. stictaria* (Linds.) D. J. Galloway
Rhizocarpon	*P. arnoldii* (Hepp) D. Hawksw., *P. microsticticum* (Leight.) Arnold, *P. versisporum* (Bagl. et Carestia) D. Hawksw.
Rinodina	*P. ibericum* Etayo et van den Boom, *P. rinodinae* van den Boom
Varicellaria	*P. ochvarianum* Y. Joshi, *P. hawksworthianum* Y. Joshi

ara (Ach.) Nyl.) growing on bark of *Quercus suber* from Central Italy (Brackel 2015) is very much close to the new taxon, but differs in having bigger perithecia (250–300 μm), hymenial gelatine I+ faintly bluish and bigger asci (90 × 14 μm). Since the author has not seen the type specimen of above-mentioned species, it would be too early to say that *P. hawksworthianum* and *Polycoccum* sp. are similar species.

Additional specimen examined: India. Himachal Pradesh, Parbati River Valley, on the way to Bhandag Thaj from Pulga, alt. 3,150 m, on thallus of *Varicellaria velata* colonising tree trunk of *Pinus sylvestris*, 25 June 1975, D. D. Awasthi and K. Dange 75408 (LWG-LWU 04523).

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