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NOTE

The lichenicolous genus *Polycoccum* Saut. ex Körb. from India

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ABSTRACT: *Polycoccum rinodinae* var. *galligenum*, the third taxon associated with the lichen genus *Rinodina* is described as a new variety to science from alpine regions of Uttarakhand, India. The new variety is primarily characterised by small, gall-like deformations on the thallus of its host, 8-spored asci, with 1-septate, hyaline to brown, uniseriately or irregularly arranged verruculose ascospores. Additionally, three other *Polycoccum* species are reported for the first time in India, expanding their known geographical distributions. These are: *Polycoccum nigrosporum* colonizing thallus of *Buellia aethalea*, *P. rubellianae* colonising thallus of *Neobrownliella cinnabarina* and *P. rinodinae* var. *rinodinae* colonising thallus of saxicolous species of *Rinodina*.

KEY WORDS: galls, Himalaya, new record, perithecioid ascomycetes, *Polycoccum rinodinae* var. *galligenum*, *Rinodina*.

INTRODUCTION

The lichenicolous genus *Polycoccum* Saut. ex Körb., which belongs to the family Polycoccaceae Ertz, Hafellner et Diederich, is characterised by its dark perithecioid ascomata, pseudoparenchymatous exciple, fissitunicate asci containing brown, mostly 1-septate ascospores, a centrum that is typically I– and K/I– (though a few species exhibit K/I+ blue or violet), and a hamathecium composed of persistent, branched and anastomosing hamathecial filaments (Calatayud 2004).

The genus currently has 61 taxa worldwide (Robert *et al*., 2005; Diederich *et al.* 2018; Brackel and Berger 2019; Joshi 2020, 2022; van den Boom 2020, Zimmermann and Berger 2021), the majority of which forms commensalistic relations with their host lichens and frequently produces galls on the host thallus. With the exception of eight species [*viz*. *P. arnoldii* (Hepp) D. Hawksw., *P. hawksworthianum* Y. Joshi, *P. marmoratum* (Kremp.) D. Hawksw., *P. microsticticum* (Leight.) Arnold, *P. ochvarianum* Y. Joshi, *P. rugulosarium* (Linds.) D. Hawksw., *P. tinantii* Diederich and *P. versisporum* (Bagl. & Carestia) D. Hawksw.], which are capable of infesting several host genera, the rest of the species of the genus are specific to a single host lichen species or a closely related group of species (Atienza *et al*., 2003; Lawrey and Diederich, 2016; Diederich *et al*., 2018).

In the present manuscript we are reporting four taxa of *Polycoccum* from subalpine to alpine regions of Indian Himalaya, of which one is new to science i.e. *Polycoccum rinodinae* var. *galligenum* (on thallus of saxicolous *Rinodina* sp.) while the other three *viz. Polycoccum nigrosporum* Etayo (on thallus of *Buellia aethalea* (Ach.) Th. Fr.), *P. rinodinae* var. *rinodinae* van den Boom (on thallus of saxicolous *Rinodina* sp.) and *P. rubellianae* Calat. & V. Atienza (on thallus of *Neobrownliella cinnabarina* (Ach.) S.Y. Kondr., Upreti & A. Thell) are new records for India. These additions bring the total number of *Polycoccum* species to 15 in India of which six induces galls while nine are not gall forming (Table 1).

MATERIAL AND METHODS

The specimens are deposited in the herbarium of University of Rajasthan, Jaipur (RUBL). Macroscopical examinations were carried out using a dissecting microscope (Olympus SZX10), while thin, hand-cut sections of the ascomata were analysed under a compound microscope (Olympus BX53) equipped with differential interference contrast optics. Sections were examined in water and 10% KOH [K]. Amyloid reactions were tested using Lugol's iodine solution [I], with and without pre-treatment with KOH [K/I]. Ascospore measurements were made in water and are indicated as (min–) ($\bar{x}$ – SD) – $\bar{x}$ – ($\bar{x}$ + SD) (–max), followed by the number of samples measured (n), where 'min' and 'max' are the extreme values observed, $\bar{x}$ the arithmetic mean and SD the corresponding standard deviation.

TAXONOMIC TREATMENT

Polycoccum rinodinae var. ***galligenum*** Y. Joshi & S. Bisht, ***var. nov.*** **Fig. 1**

MycoBank No.: MB 858770

Type**: INDIA,** Uttarakhand, Chamoli district, Gamsali village, in route to Gamsali Bugyal, on saxicolous *Rinodina* sp., 30°45'27"N, 79°49'19"E, 3787 m, 13 October 2023, *S. Bisht* 00193 (RUBL 21754).

Diagnosis**:** Similar to *Polycoccum rinodinae* s. str., but differing in shorter ascospores [(11–)12.8–*14.3*–15.8(–17) vs 16–20 µm] and in inducing galls.

Table 1. Comparative analysis of ***Polycoccum*** species in India.

Taxa	Gall formation	Perithecia (µm)	Asci (µm)	Ascospore arrangement within ascus	spores No.	Ascospores (µm)	Pycnidia	Conidia (µm)	Host(s)	Host's habitat	Distribution	In India	Reference
P. aksoyi	No	160–210	35–40 × 13–17	Irregularly uni- to biseriate	8	12–15 × 6.5–7	Absent	Absent	*Aspicilia grisea, Aspicilia sp.*	S	Asia – India, Japan, Turkey; Europe – Netherlands, Ukraine	UK	17; 51; 7; 45; 27
P. clauzadei	Yes	(120–)140–190 × (110–)120–180	(45–)50–75(–80) × 13–15	Irregularly uni- or biseriate	4–6	15–18.5(–19.5) × (6.5–)7–9(–9.5)	Absent	Absent	*Rusavskia elegans*	S	Asia –India, Russia; Europe – Austria, France, Norway, Sweden; N. America – Canada	LA, UK	34; 40; 1; 50; 12; 23; 35; 4
P. evae	No	100–200	65–90 × 17–22	Irregularly uni- to biseriate	6–8	(17–)18–23(–25) × (6–)7–10(–11)	Absent	Absent	*Dimelaena oreina*	S	Asia – India, Russia; Europe – Austria, Romania, France, Spain and Switzerland; N. America	UK	6; 16; 46; 42; 35; 4; 27
P. hawks-worthianum	Yes	(88–)104–152(–170) × (81–)95–133(–145)	(50–)55–65(–75) × (10–)13–17(–18)	Uniseriate to irregularly biseriate	6–8	(17–)20–22(–23) × (5–)6–8(–9)	Absent	Absent	*Lepra variolosa, Varicellaria velata*	C, L	Asia – India	HP, WB	21
P. ibericum	Yes	50–90	38–50 × 10–12	Biseriate to irregularly arranged	8	9.5–12.5 × 4–5(–5.5)	Absent	Absent	*Rinodina sp.*	C	Asia – India; Europe – western Spain and eastern Portugal	JK	44; 20
P. kerneri	No	170–250	85 × 22	Uniseriate	8	(12–)14–15(–17.5) × (7–)8–10(–10.5)	Absent	Absent	*Lecidea fuscoatra, Lecidea sp.*	S	Asia – India; Europe –Canary Islands, France, Germany, Greece, and the British Isles. N. America	UK	18; 14; 16, 5; 35; 36; 27
P. lecanorum	No	100–200	(50–) 57–81 (–85) × (11–)12–17(–19)	Irregularly biseriate	(6–)8	)13–16(–19) × (5–)5–7(–9)	Absent	Absent	*Lecanora frustulosa*	S	Asia – India	HP	22
P. microsticticum	Yes	(50–)100–150	65–90 × 10–12	Irregularly uni- to biseriate	4–8	14–18 × 7–8.5	Absent	Absent	*Acarospora sp., A. subgen. Xanthothallia, Buellia stellulata, Ionaspis sp., Rhizocarpon sp, Sporastatia sp.*	S	Asia – India; Europe –Austria, British isles, France, Germany, Ireland, Italy, Luxembourge, Norway, Sweden; N. America – Greenland, U.S.A.	HP	19; 2; 37; 30; 23; 35;
P. nigrosporum	No	110–120 × 90–100	55–63 × 14–17	Biseriate	8	13.5–16 × 8–9.5	Absent	Absent	*Buellia aethalea*	S	Asia – India; Europe – Spain; South America – Ecuador	UK	9; 48; 52
P. ochvarianum	No	275–310 × 205–250	75–100 × 10–15	Uni- to biseriate	6(–8)	(17.5–)20–22(–25) × (7–)7.5–10(–11)	Absent	Absent	*Ochrolechia androgyna, Pertusaria acuta, P. amarkantakana, P. coccodes, P. coronata, P. granulata, P. himalayensis, P. neilgherrensis, P. pertusa, P. quassiae, P. rigida, P. splendens, P. subdepressa, P. subochracea, P. tuberculifera, Varicellaria velata*	C, S	Asia – India	BR, HP, KL, MP, OD, TN, UK, UP	24
P. pulvinatum	Yes	160–200 × 145–200	(60–)65–75(–80) × 15–18	Uniseriate	(4–)8	16–20 × 5–6.5(–7)	Present	4.5 × 1.5	*Physcia adscendens, P. aipolia, P. albinea, P. caesia, P. dubia, P. dimidiata, P. leptalea, P. stellaris, P. tenella, P. tribacia, P. wainioi*	S	Widely distributed; across Europe; Asia – India, Malaysia, Russia; N. America – U.S.A., Greenland; S. America – Chile; New Zealand	JK, UK	39; 47; 34; 29; 38; 10; 49; 33; 28; 26; 35
P. rinodinae var. *rinodinae*	No	c. 125	50–80 × 12–17	Biseriate	8	16–20 × 5–6.5(–7)	Present	4–5 × 0.8–1	*Rinodina beccariana* var. *beccariana, R. beccariana* var. *lavicola, R. etayoi*	S	Asia – India, Russia; Europe – France, Spain	UK	9, 13, 32, 35, 41, 43, 52
P.rinodinae var. *galligenum*	Yes	90–150	(40–)51–74 (–85) × (10–)11–15 (–16)	Uniseriate to irregularly arranged	8	(11–)12–15(–17) × 4–6(–7)	Absent	Absent	*Rinodina sp.*	S	Asia – India	UK	52
P. rubellianae	No	90–100	43–55 × 10–12	Uni- to biseriate	8	(10–)11–14(–15) × (5–)6–7	Occasionally present	3–4·5 × 1–1·5	*Caloplaca rubelliana, Caloplaca sp., Neobrownliella cinnabarina*	S	Asia – India, Europe – Spain; S. America – Bolivia	UK	3; 11; 15; 31; 52
P. tinantii	No	170–280	n.a.	Irregularly uniseriate to biseriate	8	16–23(–25) × 6–9.5(–12)	Absent	Absent	*Blastenia ferruginea, Gyalolechia flavorubescens*	C	Asia – India; Europe – Luxembourg	UK	8; 25

1. Alstrup, 2004; **2.** Alstrup & Hawksworth, 1990; **3.** Atienza *et al.*, 2003; **4.** Berger & Zimmerman, 2021; **5.** Calatayud, 2004; **6.** Calatayud & Rico, 1995; **7.** Darmostuk & Golovenko, 2016; **8.** Diederich, 1990; **9.** Etayo, 2010; **10.** Etayo & Sancho, 2008; **11.** Flakus & Kukwa, 2012; **12.** Freebury, 2014; **13.** Gonnet *et al.*, 2017; **14.** Hafellner, 1996; **15.** Hafellner, 2015; **16.** Hafellner *et al.*, 2002; **17.** Halici *et al.*, 2007; **18.** Hawksworth, 1994; **19.** Hawksworth & Diederich, 1988; **20.** Joshi, 2018; **21.** Joshi, 2020; **22.** Joshi, 2022; **23.** Joshi *et al.*, 2016; **24.** Joshi *et al.*, 2017; **25.** Joshi *et al.*, 2018; **26.** Joshi *et al.*, 2020; **27.** Joshi *et al.*, 2024; **28.** Knudsen & Kocourková, 2012; **29.** Kocourková, 1999; **30.** Kocourkova, 2000; **31.** Kondratyuk *et al.*, 2016; **32.** Llop 2013; **33.** Motiejūnaitė *et al.*, 2011; **34.** Navarro-Rosinés & Roux, 1998; **35.** Roux *et al.*, 2020; **36.** Schiefelbein *et al.*, 2024; **37.** Serusiaux *et al.*, 1999; **38.** Svane & Alstrup, 2004; **39.** Triebel *et al.*, 1991; **40.** Urbanavichene & Urbanavichus, 2009; **41.** Urbanavichus & Urbanavichene, 2015; **42.** Urbanavichus & Urbanavichene, 2019; **43.** van den Boom, 2010; **44.** van den Boom & Etayo, 2014; **45.** van der Kolk *et al.*, 2024; **46.** Vondrák & Šoun, 2008; **47.** Wedin, 1994; **48.** Yánez-Ayabaca *et al.*, 2023; **49.** Zhurbenko, 2009; **50.** Zhurbenko, 2013; **51.** Zhurbenko *et al.*, 2015; **52.** Present study. **Abbreviations:** C = Corticolous, L = Lignicolous, S = Saxicolous; Bihar = BR, Himachal Pradesh = HP, Jammu & Kashmir = JK, Kerala = KL, Ladakh = LA, Madhya Pradesh = MP, Odisha = OD, Tamil Nadu = TN, Uttar Pradesh = UP, Uttarakhand = UK, West Bengal = WB, n.a. = not available

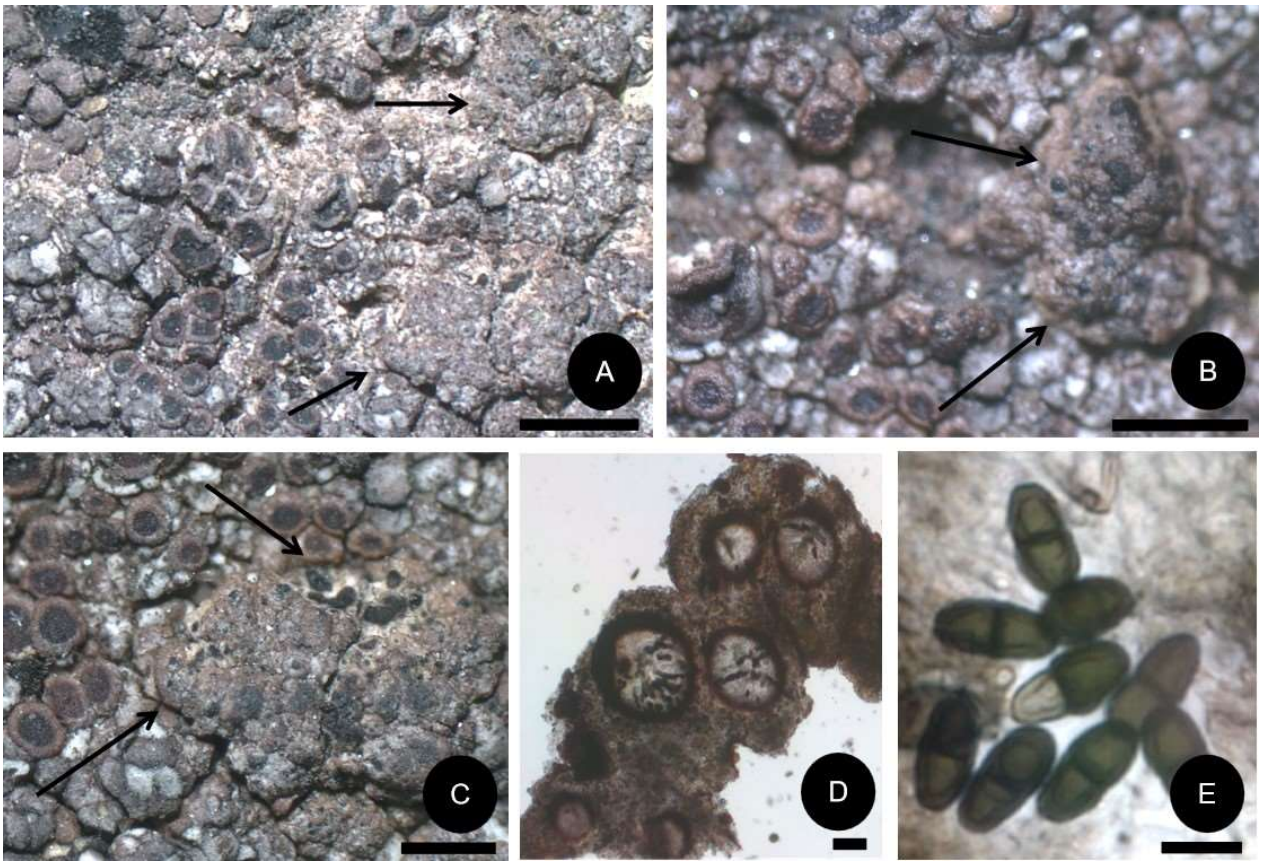

Fig. 1. ***Polycoccum rinodinae* var. *galligenum*.** Arrows indicating galls. **A.** Habit, dry; **B.** Habit, wet; **C.** Magnified view of a gall; **D.** Section through a gall showing perithecia with ascospores; **E.** Mature ascospores after treatment with K. Scale bars: **A–C** = 1 mm; **D** = 50 µm; **E** = 10 µm.

Description*: *Ascomata perithecioid, arising in groups on the thallus of the host, immersed in galls and with ostiole visible, black, subglobose, (90–)110–130(–150) µm diam., galls with 5–10 ascomata, 150–320 µm. ***Exciple*** hyaline to reddish brown, ca. 5–10 µm thick, composed of 3–5 layers of elongate cells forming a paraplectenchymatic structure. ***Hymenial gel*** I–. ***Hamathecial filaments*** abundant, septate, simple to branched and anastomosing, c. 1–1.5 µm wide. ***Asci*** cylindrical to subcylindrical, bitunicate, short stalked, wall apically thickened, 8-spored, (40–)51.4–*63.2*–74.9(–85) × (10–)11.6–*13.5*–15.3(–16) µm (n = 25), K/I–, I– in all parts. ***Ascospores*** uniseriately or irregularly arranged, oblong to ellipsoid, apices obtuse, 1-septate, not or slightly constricted at the septum, both cells ±equal in size, with a thick and irregular gelatinous sheath when young, hyaline to dark brown, delicately to coarsely verrucose when mature, (11–)12.8–*14.3*–15.8(–17) × (4–)4.6–*5.4*–6.3(–7) µm (n =80), K+ olive brown. ***Conidiomata*** not observed.

***Host*:** On the thallus of an unidentified saxicolous *Rinodina*. The new variety induces distinct galls but does not visibly damage the host, therefore it is considered a commensalist.

***Ecology and distribution*:** The new taxon is known only from the type locality i.e. Central Himalaya, Uttarakhand, India, where it is thriving on a saxicolous *Rinodina* in alpine ecosystem at an elevation of 3787 m along with *Polycoccum rinodinae* var. *rinodinae* van den Boom.

***Etymology*:** The epithet refers to the induction of galls.

***Note*:** *Polycoccum ibericum* Etayo & van den Boom and *P. rinodinae* var. *rinodinae* are two other taxa of *Polycoccum* that have previously been reported on various species of *Rinodina* [*Rinodina* sp., *R. beccariana* Bagl. var. *beccariana*, *R. beccariana* var. *lavicola* (M. Steiner) Matzer & H. Mayrhofer and *R. etayoi* Giralt & van den Boom]. However, they both differ from the new taxon in several characters: *P. rinodinae* var. *rinodinae* does not induce galls and has larger ascospores [16–20 × 5–6.5(–7) µm], while *P. ibericum* colonises corticolous species of *Rinodina* and has smaller asci and ascospores [38–50 × 10–12 µm and 9.5–12.5 × 4–5(–5.5) µm, respectively].

There are three other species of *Polycoccum* colonising members of lichen family Physciaceae apart from *Rinodina*. These are: *Polycoccum atrostriatae* van den Boom, *P. heterodermiae* Calat. and *P. pulvinatum*

(Eitner) R. Sant., which differ from the new taxon in several characters. First and foremost all of these colonise foliose members of Physciaceae, such as *Physcia* and *Leucodermia.* Likewise, the new variety, *P. heterodermiae* and *P. pulvinatum* induce gall formation on the host thallus, but differ not only in host preference but in several more characters (see key). In contrast, *P. atrostriatae* which colonises *Physcia*, has somewhat smaller ascospores [8.5–12 × 4.5–5.5(–6) µm] and does not induce galls on the host.

Key to all *Polycoccum* on Physciaceae Zahlbr.

1a. On foliose lichens ……... 2
1b. On crustose lichens ……..…….…... 4
2a. On *Leucodermia erinacea*; gall inducing, perithecia 130–200 × 120–200 µm; ascospores dark brown, strongly verruculose, with a distinct gelatinous sheath, 11–13 × 6–8 µm ..... ***Polycoccum heterodermiae***
2b. On *Physcia* spp.; perithecia 40–120 µm .....…….. 3
3a. Not gall inducing; perithecia 40–70 µm; ascospores small [8.5–12 × 4.5–5.5(–6) µm]; on corticolous *Physcia atrostriata* ….. ***P. atrostriatae***
3b. Gall inducing; perithecia 110–120 × 90–100 µm; ascospores large [(14–)18–21(–23) × (6–)7.5–8.5(–9) µm], on saxicolous inhabitants of *Physcia*, *viz. P. aipolia*, *P. caesia*, *P. dubia*, *P. stellaris* ... ***P. pulvinatum***
4a. Gall inducing ……..…….. 5
4b. Not gall inducing, ascospores 16–20 × 5–6.5(–7) µm, pale brown to dark brown, asci 8-spored; on saxicolous *Rinodina* …….. …… ***P. rinodinae*** var. ***rinodinae***
5a. Perithecia 50–90 µm wide; asci 38–50 × 10–12 µm; ascospores 9.5–12.5 × 4–5(–5.5) µm, brown, on corticolous *Rinodina* sp. ... ***P. ibericum***
5b. Perithecia 90–150 µm wide; asci 40–85 × 10–16 µm; ascospores (11–)12.8–*14.30*–15.8(–17) × (4–)4.56–*5.44*–6.32(–7) µm; hyaline to dark brown, on saxicolous *Rinodina* sp. ….. ***P. rinodinae*** var. ***galligenum***

New records in India

Polycoccum nigrosporum Etayo

Description*: *Ascomata lichenicolous, perithecioid, subglobose, immersed, 100–130 µm wide. ***Hamathecial filaments*** abundantly branched and anastomosed, 1 µm thick. Hymenial gel I–. ***Asci*** narrowly clavate, 8-spored, 60–64 × 10–11 µm, I– in all parts. ***Ascospores*** uni- or biseriately arranged in the asci, ellipsoid, with rounded ends, olive-brown to black, 13.5–16 × 8–9.5 µm. ***Conidiomata*** not seen.

***Host*:** On thallus of *Buellia aethalea.*

***World distribution*:** Ecuador (Yánez-Ayabaca *et al*., 2023), India (present manuscript), Spain (Etayo, 2010).

***Specimens examined*: INDIA,** Uttarakhand, Chamoli district, Malari village, 30°40'45"N, 79°54'08"E, 3350 m, on thallus of *Buellia aethalea* colonising rock, 24 May 2023, *S. Bisht* 00074/A (RUBL 21752); on way to Sumna, near four point, 2909 m, on thallus of *Buellia aethalea* colonising rocks, 21 May 2023, *S. Bisht* 00054 (RUBL 21753).

Polycoccum rinodinae van den Boom

Description*: *Ascomata lichenicolous, perithecioid, subglobose, immersed, 100–115 µm wide. ***Hamathecial filaments*** abundantly branched and anastomosed, 1.5–2 µm thick. Hymenial gel I–. ***Asci*** cylindrical, 8-spored, 55–70 × 13–15 µm, I– in all parts. ***Ascospores*** biseriately arranged in the asci, ellipsoid, 1-septate, hyaline to pale brown with a perispore when young, dark brown and coarsely verrucose when mature, 17–19 × 5–6 µm. ***Conidiomata*** not seen.

***Host*:** On thallus of saxicolous *Rinodina* sp.

***World distribution*:** Canary Islands (van den Boom, 2010), Cavallo Islands (Gonnet *et al.*, 2017), France (Roux *et al.*, 2020), India (present manuscript), Russia (Urbanavichus and Urbanavichene, 2015), Spain (Etayo, 2010; Llop, 2013).

***Specimens examined*: INDIA,** Uttarakhand, Chamoli district, Badrinath, Mana Valley, near mata murti temple, 30°46'12"N, 79°29'27"E, 3228 m, on *Rinodina* sp., 03 October 2023, *S. Bisht* 00142 (RUBL 21757); Mana Valley, on way to Vasudhara falls, 30°47'12"N, 79°27'20"E, 3735 m, on thallus of *Rinodina* sp. 19 June 2023, *S. Bisht* 00149 (RUBL 21760); ibid 30°47'13"N, 79°27'31"E, 3769 m, *S. Bisht* 00143 (RUBL 21756).

Polycoccum rubellianae Calat. & V. Atienza

Description*: *Ascomata lichenicolous, perithecioid, subglobose, immersed, 90–100 µm wide. ***Hamathecial filaments*** septate, branched and anastomosed, 1.5–2 µm thick. Hymenial gel I–. ***Asci*** subcylindrical, short-stalked, 8-spored, 43–55 × 10–12 µm, I– in all parts. ***Ascospores*** uni- or biseriately arranged in the asci, ellipsoid, 1-septate, dark brown, with a thick gelatinous sheath when young, almost disappearing in mature ascospores, coarsely verrucose when mature, (10–)11–13(–14) × 6–7 µm. ***Conidiomata*** absent.

***Host*:** On thallus of *Neobrownliella cinnabarina.*

***World distribution*:** Bolivia (Flakus and Kukwa, 2012), India (present manuscript), Italy (Hafellner, 2015), Korea (Kondratyuk *et al.*, 2016), Spain (Atienza *et al*., 2003).

***Specimen examined*: INDIA,** Uttarakhand, Pithoragarh district, Dharchula, near Narayan ashram, 30°12'09"N, 80°50'13"E, 2633 m, on thallus of *Neobrownliella cinnabarina* colonising rocks, 31 May 2024, *S. Bisht* 00192 (RUBL 21758).

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