

Documentation of lichenicolous fungi from India - Some additional Reports

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ABSTRACT

This manuscript records twelve lichenicolous fungi, namely *Arthonia coronata* Etayo (on *Flavoparmelia caperata*), *Dactylospora deminuta* (Th. Fr.) Triebel (on *Parmotrema kamatii*), *Didymocyrtis bryonthae* (Arnold) Hafellner (on *Lecanora* sp.), *Muellerella triseptata* Diederich (on *Physcia*), *Phoma peltigerae* (P. Karst.) D. Hawksw. (on *Peltigera didactyla*), *Polycoccum ibericum* Etayo & van den Boom (on *Rinodina* sp.), *Tremella cladoniae* Diederich & M.S. Christ. (on *Cladonia* spp.), *T. phaeophysciae* Diederich & M.S. Christ. (on *Phaeophyscia* sp.), *Zwackhiomyces physciicola* Alstrup (on *Physcia gomukhensis*) and *Z. sphinctriniformis* Grube & Hafellner (on *Romularia* sp.) along with two new species viz. *Endococcus physciae* sp. nov. growing on *Physcia* and *Opegrapha gyalolechia* sp. nov. growing on *Gyalolechia flavorubescens* from India.

Key words: *Caloplaca*, fungi, *Gyalolechia*, lichen, *Opegrapha*, *Physcia*, *Teloschistaceae*.

INTRODUCTION

Lichenicolous fungi represent a highly specialized and successful group of organisms that live exclusively on lichens, most commonly as host-specific parasites, but also as broad-spectrum pathogens, saprotrophs and commensals (Diederich *et al.*, 2018). These fungi are assumed to represent an important repository of new taxa belonging to many groups of fungi (Hawksworth and Rossman, 1997), but their overall diversity remains uncharted territory. To date 167 species of lichenicolous fungi have been reported from India (Joshi *et al.*, 2018), which is very few in comparison to other countries. The present study, which is in continuation with my earlier contributions on this group of fungi (Joshi *et al.*, 2015, 2016 a,b,c,d; 2017a,b; 2018; Singh *et al.*, 2017), hereby describe two undescribed species and document ten other noteworthy species which are new records for India, thus raising the tally of lichenicolous fungi to 179 from India.

MATERIALS AND METHODS

The present study is based on lichen specimens lodged at the herbaria of CSIR-National Botanical Research Institute (LWG) and Kerala Forest Research Institute (KFRI) along with some fresh collections from Uttarakhand. Voucher specimens are deposited in the lichenological herbaria of CSIR-National Botanical Research Institute (LWG) and Kerala Forest Research Institute (KFRI). Macroscopical examination was carried out using a stereo-zoom dissecting microscope (Olympus SZ61), and microscopical studies of sections were made using Olympus BX53 microscope. Microscopical examinations and measurements were made on hand-cut sections mounted in distilled water and lactophenol cotton blue (LCB). The measurements are given as (min.-) (X-SD)-X-(X+SD)(-max.), where X = mean value and SD = standard deviation, followed by total numbers of measurements (*n*) given in parentheses. Macro- and micro-photographs were taken with a digital camera mounted on Olympus SZ61 Stereo-zoom dissecting microscope and Olympus BX 53 fitted with a differential interference contrast. Asci and ascospore measurements were recorded after mounting in water.

TAXONOMY

1. *Arthonia coronata* Etayo, *Bulletin de la Société Linnéenne de Provence* **47**: 95 (1996)

Materials Examined: INDIA. Arunachal Pradesh, Tawang district, around Monastery, 27°35'6.5" N, 91°51'27.7" E, alt. 2966 m, 16 June 2015, on *Flavoparmelia caperata* colonizing bark, R. Bajpai, 15-026572 (LWG-33025). Himachal Pradesh, Kinnaur district, Recong Pass, on way from Chini to Pangi village, alt. 2900 m, 03 November 2003, on *Flavoparmelia caperata* colonizing bark, Upreti, Srivastava & Prakash, 03-002667 (LWG-13107); Kullu district, Kothi Forest near guest house, alt. 2500 m, 31 May 1994, on *Flavoparmelia caperata* colonizing rocks, D.K. Upreti, 213570 (LWG-12935); Shimla district, Rampur, Sarahan, 2 Km towards Gaura, alt. 2000 m, 16 May 2002, on *Flavoparmelia caperata* colonizing rocks, S. Nayaka & R. Srivastava, 02-76630 (LWG-12966). Uttarakhand, Chamoli district, Lata, alt. 2700 m, 09 October 2006, on *Flavoparmelia caperata* colonizing rocks, Shobha & Jitendra, 06-011111 (LWG-13130).

2. *Dactylospora deminuta* (Th. Fr.) Triebel, *Bibliotheca Lichenologica* **35**: 209 (1989)

Material Examined: INDIA. Kerala, Palakkad district, Silent Valley National Park, Anginda, alt. 2200 m, s.d., on *Parmotrema kamatii* colonizing bark, Stephen, 23634 (KFRI).

3. *Didymocyrtis bryonthae* (Arnold) Hafellner, *Fungal Diversity* **74**: 66 (2015)

Material Examined: INDIA. Uttarakhand, Nainital district, on way to Naina Peak, alt. 2500 m, 26 December 2009, on *Lecanora* sp. colonizing bark, H. Kholia, 09-014444 (LWG-35600).

4. *Endococcus physciae* Y. Joshi sp. nov.

Fig. 1. a-e

Mycobank no.: MB 829214

Diagnosis: Similar to *Endococcus exerrans* Nyl. in having somewhat similar ascospore size (11-14 µm long) but differs

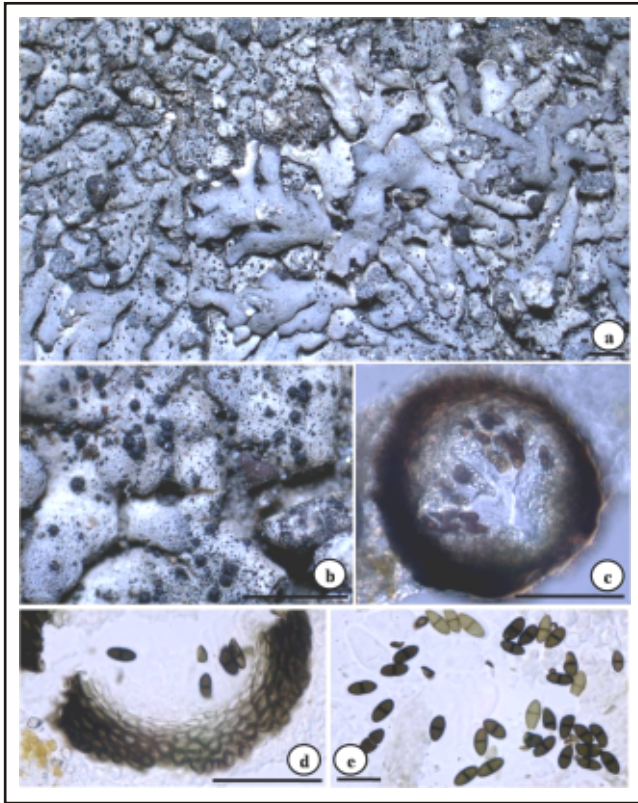


Fig. 1. (a): *Endococcus physciae* infecting the thallus of *Physcia gomukhensis* (Scale = 2 mm), (b): enlarged view of *E. physciae* (Scale = 1 mm), (c): a perithecium (Scale = 10 μ m), (d): walls of the perithecium (Scale = 10 μ m), (e): mature ascospores (Scale = 10 μ m).

in having wider ascospores ((4-)4.67-5.42-6.18(-7) vs 3-4 μ m) and different host (*Physcia* (Schreb.) Michx. vs *Rhizocarpon* Ramond ex DC.).

Holotype: INDIA. Uttarakhand, Chamoli district, Valley of Flowers, alt. 3450 m, on *Physcia gomukhensis* D.D. Awasthi & S.R. Singh colonizing rock, 20 October 1964, A. Singh, 85420 (holotype LWG-35601).

Etymology: The epithet refers to the host lichen genus *Physcia* on which the fungus is colonizing.

Description: Lichenicolous fungus growing on the thallus of *Physcia*, apparently parasymbiotic (Fig. 1a). *Ascomata* perithecioid, arising singly, erumpent subglobose, ostiolate, upper part around ostiole black, lower part dark brown to reddish brown, 80-200 μ m tall, 80-200 μ m wide (Fig. 1b&c). *Ascomata* wall mostly 7-layered, brown, in basal part 8-25 μ m and in ostiolar region 7-10 μ m (Fig. 1d); central region K-, I- & K/I-. Hamathecium of periphyses lining the ostiole cavity and spreading to upper wall of ascomatal cavity, simple, hyaline, ca. 1-3 μ m wide. Hymenial gel I-, K/I-. *Asci* arising from bottom and sides of ascomatal cavity, clavate, sessile, fissitunicate, with a typical *Endococcus* apical beak, cylindrical to subclavate, (22-)27.42-35-42.57(-45) \times (5-) 6.74-11.57-16.39(-17) μ m (n=25); with an apparently thin external K/I+ blue cap around the ascus. *Ascospores* uniseriately or biseriately arranged in the ascus, hyaline and

non-septate when young, sooner becoming dark brown and ornamented, 1-septate, narrowly constricted at the septa, perispore present, 0.5 μ m wide (Fig. 1e). *Ascospore* cells usually equal, with pointed apices, with or without oil drops, septum ca. 0.5 μ m wide, wall dark brown, ornamented ca. 1 μ m thick (thicker than the septum), distinctly verruculose, (12-)12.19-13.14-14.09(-15) \times (4-)4.67-5.42-6.18(-7) μ m (n=25). Conidiomata not observed.

Hosts: The new taxon is found growing on *Physcia adscendens* (Fr.) H. Olivier, *P. gomukhensis* and *P. sinuosa* Moberg colonizing soil and rock.

Distribution: So far the species is reported from sub-tropical to alpine regions of India ranging from 980 to 3450 m.

Remarks: The new taxon is characterized by its small, erumpent ascomata and ascospores with pointed ends and *Physcia* as a host. The genus itself is represented by 44 species across the world colonizing various lichens, but none has been reported on lichen genus *Physcia* so far (Diederich *et al.*, 2018). The new species resembles *Endococcus perpusicus* Nyl. in having ascospores with attenuated ends, but differs in having smaller and narrower ascospores [(12-)12.19-13.14-14.09(-15) \times (4-)4.67-5.42-6.18(-7) μ m vs (12-)15-25(-30) \times (4-)5-6(-9) μ m] and host preference (*Physcia* vs *Schaereria* Körb. and some crustose lichens such as *Protoblastenia rupestris* (Scop.) J. Steiner, *Porpidia tuberculosa* (Sm.) Hertel & Knoph and *Lecidella carpathica* Körb.). *E. exerrans* Nyl. having somewhat similar ascospore size (11-14 μ m long) differs from the new taxon in having narrower ascospores (3-4 vs (4-)4.67-5.42-6.18(-7) μ m) and different host (*Rhizocarpon* vs *Physcia*). *Endococcus apiciicola* (J. Steiner) R. Sant. (on *Usnea* Dill. ex Adans.), *E. incrassatus* Etayo & Breuss (on *Placidopsis* Beltr.), *E. oreinae* Hafellner (on *Dimelaena oreina* (Ach.) Norman), *E. perpusicus* Nyl. (on *Schaereria*, also reported from other saxicolous lichens), *E. propinquus* (Körb.) D. Hawksw. (on *Porpidia* Körb.) and *E. rugulosus* (Leight.) Nyl. (on *Verrucaria* Schrad., but in India it is reported from *Aspicilia* A. Massal. and *Rhizocarpon*) are some other known species of *Endococcus* from India, which differs from the new taxon in host selection.

Materials Examined: INDIA. Jammu & Kashmir, Kishtwar district, Kishtwar High Altitude National Park, Sondar, alt. 2019 m, on *Physcia* sp. colonizing rock, August 2017, Vishal Kumar, s.n. (LWG-YJ-35602). Karnataka, Bangalore, Bannerghatta Hazam Kalu, alt. 980 m, 30 April 1979, on *Physcia sinuosa* colonizing rock, D.D. Awasthi, D.K. Upreti & U.C. Misra, 79-257 (LWG-35603). Uttarakhand, Chamoli district, Valley of Flowers, alt. 3450 m, 20 October 1964, on *Physcia gomukhensis* colonizing rock, A. Singh, 85406 (LWG-35604); Uttarkashi district, Gomukh area, right bank, 5th moraine, alt. 3840 m, on *Physcia adscendens* colonizing soil, D.D. Awasthi & S.R. Singh, 8506 (LWG-35605).

5. *Muellerella triseptata* Diederich, *Lejeunia* 119: 10 (1986)

Material Examined: INDIA. Jammu & Kashmir, Pahalgam, at Baisaran, alt. 2440 m, 27 June 1977, on *Physcia* sp. colonizing dead wood, K. Dange, 77-141 (LWG-08403).

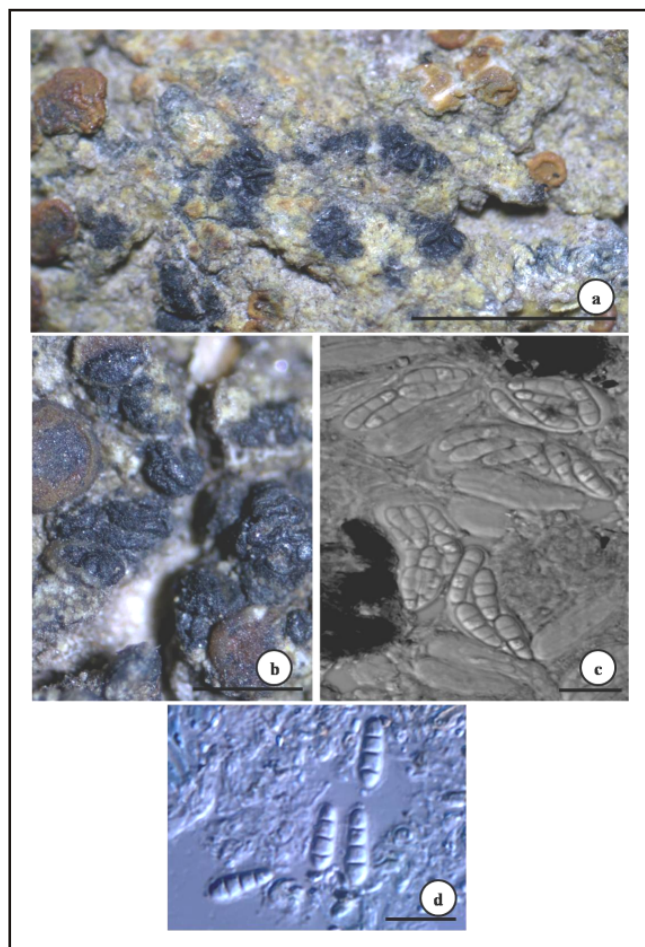


Fig. 2. (a): *Opegrapha gyalolechiai* infecting the thallus of *Gyalolechia flavorubescens* (Scale = 2 mm), (b): enlarged view of *O. gyalolechiai* (Scale = 1 mm), (c): ascus with ascospores (Scale = 10 µm), and (d): mature ascospores (Scale = 10 µm).

6. *Opegrapha gyalolechiai* Y. Joshi sp. nov.

Fig. 2. a-d

Mycobank no.: MB 828946

Diagnosis: Similar to *Phacothecium varium* in having lirellate apothecia and 3-septate hyaline ascospores, but differs in having a different host (*Gyalolechia* vs *Xanthoria*) and narrower ascospores (3-5 vs 6-7 (-8) µm).

Holotype: INDIA. Himachal Pradesh, Sirmaur district, Renuka, Arate Reserve Forest, alt. 2010 m, on *Gyalolechia flavorubescens* colonizing bark of *Quercus*, 02 July 2000, Chatterjee, Dubey & Nayaka, 20-66765 (Holotype - LWG 008328).

Etymology: The epithet refers to the host lichen genus *Gyalolechia* A. Massal. on which the fungus is colonizing.

Description: Ascomata lichenicolous, developing over large surfaces of the host thallus and rarely on apothecia, lirellate with a narrow slit,

neither branched nor exposed, sessile, densely clustered and contiguous, individual ascomata black, epruinose, 0.1-0.4 × 0.1-0.2 mm, in section ascomata unilocular (**Fig. 1a&b**). True exciple black, laterally 16-20 µm in thick upper part, K-, continuous under the hypothecium, 12-14 µm thick below ($n=10$). Hypothecium hyaline to pale brown, K-. Hymenium hyaline, 39-71 µm ($n=10$), K-, I+ slightly blue, K/I+ blue. Epihymenium brownish, K-. Hamathecium of septate, branched to anastomosed paraphyoids, 1-2 µm thick, apically nondistinctly swollen. Asci broadly ellipsoid, 4-(6-8)-spored, wall apically thickened, (28-)28.45-35.2-41.94(-48) × (9-)10.44-12.2-13.95(-15) µm ($n=25$). Ascospores hyaline, not becoming brown and coarsely verrucose at maturity, elongate ellipsoid, (1-)2-3-septate, slightly constricted at the septa, (8-)11.69-13.92-16.16(-17) × (3-)3.46-4.28-5.11(-5) µm ($n=25$) (**Fig. 1c & d**), with a thin gelatinous perispore of c. <1 µm. Conidiomata not observed.

Host: The species was documented growing over the thallus and apothecial disc of *Gyalolechia flavorubescens* (Huds.) Søchting, Frödén & Arup and is not causing any apparent damage to the host and hence can be considered commensalist (**Fig. 1a**).

Distribution: The new species is so far known from two sites in Himalaya and is confined on the thallus and apothecial disc of *Gyalolechia flavorubescens*, common corticolous lichen occurring throughout India. Since, no lichenicolous *Opegrapha* Ach. species have been reported on this widely distributed host, *O. gyalolechiai* may be a rare species currently known only from the temperate and sub-temperate regions of Central Himalaya.

Remarks: The new taxon is characterized by its very invasive, small, lirellate to rounded ascomata colonizing the host thallus and apothecial disc, and smaller ascospores. *Opegrapha insidens* (J. Steiner) S.Y. Kondr., *O. hellespontica* Vondrák & Kocourk., *O. aff. rupestris* 1 Vondrák & Kocourk., *O. aff. rupestris* 2 Vondrák & Kocourk. (Vondrák and Kocourková, 2008) and *O. vulpina* Vondrák, Kocourk. & Tretiach are some other species of *Opegrapha* which used to colonize members of *Teloschistaceae*, especially species of *Caloplaca* Th. Fr. and *Xanthoria* (Fr.) Th. Fr., but differs from the new taxon in several characters (**Table 1**). Macroscopically and microscopically, it also shows

Table 1. Comparative analysis of lichenicolous *Opegrapha* growing on members of lichen family *Teloschistaceae*.

Characters	<i>O. insidens</i>	<i>O. hellespontica</i>	<i>O. aff. rupestris</i> 1	<i>O. aff. rupestris</i> 2	<i>O. vulpina</i>	<i>O. gyalolechiai</i>
Ascospore size (µm)	18-26 × 6-10	(14-)16-75±1.25 (-19) × (5 -)6-5±0.75 (-7-5)	(15-)17±1.3 (-19) × (5 -)6-5±0.7 (-7)	(15-)16-25±1 (-18) × (5.5 -)6-25 ±0.5(-7)	(11-5-)14-5±1.4 (-18) × (5 -)6-0±0.7(-8)	(8-)11.69-13.92-16.16(-17) × (3 -)3.46-4.28-5.11(-5)
Host	<i>Athalia pyraea</i> (Ach.) Arup, Frödén & Søchting and <i>Caloplaca variabilis</i> (Pers.) Müll. Arg.	<i>Variospora aurantia</i> (Pers.) Arup, Frödén & Søchting	<i>Leprolacla citrochroa</i> (Ach.) Arup, Frödén & Søchting	<i>Caloplaca variabilis</i> (Pers.) Müll. Arg.	<i>Pyrenodesmia erodens</i> (Tretiach, Pinna & Grube) Søchting, Arup & Frödén and <i>Caloplaca albopruinos a</i> (Arnold) H. Olivier	<i>Gyalolechia flavorubescens</i> (Huds.) Søchting, Frödén & Arup
Habitat of the host	Saxicolous	Saxicolous	Saxicolous	Saxicolous	Saxicolous	Corticolous
Distribution	Southern Iran	Turkey	Czech Republic, Greece, Italy, Malta	Czech Republic, Slovakia	Czech Republic, Italy, Romania	India

similarity to *Phacographa zwackhii* (Zwackh.) Hafellner and *P. glaucomarina* (Nyl.) Hafellner, but differs in having smaller ascospore size [(8-)11.69-13.92-16.16(-17) × (3-)3.46-4.28-5.11(-5) μm vs 20-26 × 3-4 μm vs 21-24 × 7-8 μm], septation of ascospores [(1-)2 to 3-septate vs 3 to 4-septate vs 3-septate] and host lichen genus (*Caloplaca* vs *Phlyctis* (Wallr.) Flot. vs *Lecanora* Ach.). In its external appearance, the new taxon also resembles *Phacothecium varium* (Tul.) Trevis., which however, differs in having different host i.e. *Xanthoria* and wider ascospores (6-7(-8) μm).

Material Examined: INDIA. Uttarakhand, Bageshwar district, en route to Pindari Glacier, from Khati to Dwali, alt. 2210-2734 m, on *Gyalolechia flavorubescens* colonizing bark, 12 May 2007, Y. Joshi & S. Joshi, 07-010089 (LWG 11372).

7. *Opegrapha melanospila* Müll. Arg., *Flora* (Regensburg) **60** (30): 474 (1877)

Material Examined: INDIA. Uttarakhand, Pithoragarh district, Gangolihat, Futsil Sacred forest, on *Parmotrema reticulatum* colonising *Quercus leucotrichophora*, 03 May 2015, Shashi Upadhyay, Kapil Bisht and Pooja Joshi, LF-06/2015 (LWG-35606).

8. *Phacothecium varium* (Tul.) Trevis. *Linnaea* **28**: 298 (1857)

Material Examined: INDIA. Jammu & Kashmir, Srinagar district, Harwan, Dachigam National Park, alt. 1740 m, on *Xanthoria parietina* colonizing fallen twigs, 03 August 2005, M.A. Sheikh, s.n. (LWG-35607).

9. *Phoma peltigerae* (P. Karst.) D. Hawksw., *Transactions of the British Mycological Society* **74** (2): 381 (1980)

Material Examined: INDIA. Uttarakhand, Chamoli district, on way to Neeti, 10 Km before Gamsali, alt. 3300 m, 20 August 2007, on *Peltigera didactyla* colonizing bark, D.K. Upreti & S. Nayaka, 07-010247 (LWG-19022).

10. *Polycoccum ibericum* Etayo & van den Boom, *Opuscula Philolichenum* **13**: 60 (2014)

Material Examined: INDIA. Jammu & Kashmir, Srinagar district, Harwan, Dachigam National Park, alt. 1800 m, 03 August 2005, on *Rinodina* sp. colonizing bark, M.A. Sheikh, 05-006605 (LWG-14290).

11. *Tremella cladoniae* Diederich & M.S. Christ., *Bibliotheca Lichenologica* **61**: 65 (1996)

Materials Examined: INDIA. Himachal Pradesh, Kullu district, Great Himalayan National Park, Gumtaro to Patal, alt. 2500-3000 m, 07 September 1999, on *Cladonia pyxidata* colonizing rocks, D.K. Upreti, 99-53646 (LWG-006588). Uttarakhand, Uttarkashi district, Gangotri, en route to Gomukh, Chirwasa, near river, 30°58'40.2" N, 79°01'33.7" E, alt. 3555 m, 05 May 2017, on *Cladonia aubradiana* colonizing bark, R. Bajpai, 17-031252 (LWG-36608).

12. *Tremella phaeophysciae* Diederich & M.S. Christ., *Bibliotheca Lichenologica* **61**: 142 (1996)

Material Examined: INDIA. Uttarakhand, Pauri district,

29°50'40.8" N, 78°40'45.1" E, alt. 1740 m, 14 April 2015, on *Phaeophyscia* sp. colonizing bark, V. Shukla & R. Bajpai, s.n. (LWG-35609).

13. *Zwackhiomyces physciicola* Alstrup, *Graphis Scripta* **5** (2): 102 (1993)

Materials Examined: INDIA. Uttarakhand, Uttarkashi district, Gangotri, en route to Gomukh, Chirwasa, near river, 30°58'41.06" N, 79°01'35.16" E, alt. 3562 m, 04 May 2017, on *Physcia gomukhensis* colonizing rock, R. Bajpai, 17-026962 (LWG-35610), 05 May 2017, on *Physcia gomukhensis* colonizing rock, R. Bajpai, 17-026979 (LWG-35611).

14. *Z. sphinctriniformis* Grube & Hafellner, *Nova Hedwigia* **51** (3-4): 325 (1990)

Material Examined: INDIA. Himachal Pradesh, Parbati River Valley, just below Kheer Ganga along stream, alt. 3150 m, 23 June 1975, on *Romjularia* sp. colonizing rock, D.D. Awasthi & K. Dange, 75340 (LWG-13457).

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