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RESEARCH ARTICLE

Taxonomic studies on the lichenized fungi inhabiting bamboos and rattans of KFRI Peechi campus

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Abstract: A total of 17 lichen taxa inhabiting the bamboos and rattans of the Kerala Forest Research Institute, Peechi campus were enumerated. Out of these, sterile specimens of *Cryptothecia*, *Pyxine*, *Tricharia*, and some species of *Porina* and *Strigula* were identified up to generic level based on thallus morphology, anatomical and chemical characters. The study added eight species viz., *Diorygma soozanum* (Zahlbr.) M. Nakan. & Kashiw., *Fellhanera bouteillei* (Desm.) Vězda, *Graphis pyrrhocheiloides* Zahlbr., *Gyalectidium* cf. *filicinum* Müll. Arg., *Herpothallon cinereum* G. Thor, *Porina tetramera* (Malme) R. Sant., *Puiggariella nemathora* (Mont.) S.H. Jiang, Lücking & J.C. Wei, and *Tricharia* sp. as new distributional records to Kerala. The genera *Fellhanera*, *Gyalectidium*, *Puiggariella*, and *Tricharia* are reported for the first time in Kerala. Brief descriptions of the species new to Kerala are provided.

Keywords: bambusicolous lichens, biodiversity, Kerala, new records, taxonomy

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Introduction

The Kerala Forest Research Institute (KFRI) Peechi campus is in Thrissur district of Kerala. The campus is about 20 km east of Thrissur city between 10°31′ 47.5″ N latitude and 76°22′7.5″ E longitude, extends over an area of 28 ha as part of reserve forest adjacent to Peechi-Vazhani Wildlife Sanctuary, a part of the Western Ghats Biodiversity hotspot (Fig. 1). The campus is divided lengthwise by Thrissur-Peechi Road, and the left bank irrigation canal of the Peechi dam reservoir cuts across it almost through the middle and has an orchidarium, cane, palmetum, bambusetum, arboretum, medicinal plant garden, etc. The campus is permeated with many bamboos and rattans, which exhibit luxuriant growth of lichens.

Lichens that grow on the culms and leaves of bamboos are generally known as bambusicolous lichens. However, the lichens inhabiting bamboos and rattans were poorly documented in India and globally as well. Generally, the bambusicolous lichens were treated under the foliicolous category and as corticolous when growing on culms by many lichenologists worldwide, and in many cases, the substratum was not specified. Accurately determining the number of lichens associated with bamboo is therefore challenging. Based on a preliminary literature survey, about 30 species of lichens were reported to be bambusicolous globally (Lucking, 2008; Aptroot, 2003), of which three species are known from India (Singh and Sinha, 2010; Singh and Pinokiyo, 2014).

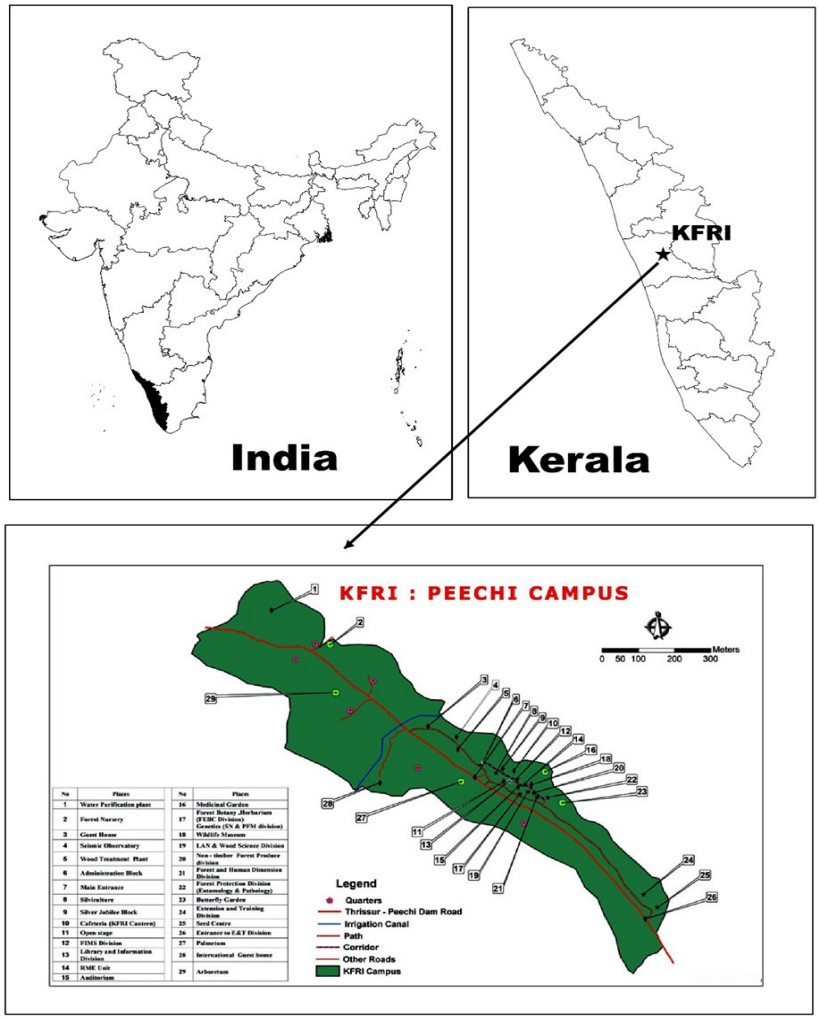

Fig 1. Map showing the study site.

Materials and methods

About 80 lichen samples were collected from bamboos and rattans growing in the KFRI Peechi campus during February 2023 to April 2023 and were deposited at the KFRI herbarium (Kerala Forest Research Institute, Kerala). The lichens were collected from ten species of bamboos and five species of rattans (Table 1). Morphological and anatomical characters were studied using stereo zoom (Olympus SZ61 and LEICA S9i) and LEICA DM2000 compound microscopes attached to the camera and the image analysis software. The amyloid reactions were tested in Lugol's iodine solution (I) with and without pre-treatment of KOH

All measurements were made on material mounted in distilled water. Chemical analysis was performed on species with regular spot tests and thin layer chromatography following Orange *et al*. (2001). The literature of Awasthi (2007), Singh and Pinokiyo (2014), Lücking (2008), and Jagadeesh Ram and Sinha (2016) were followed for the identification of various lichen taxa. The recent classification compiled by Wijayawardene *et al*. (2022) was followed for segregating species into families. Recent nomenclatures are updated following Index Fungorum. The species of bamboo and rattans were identified by following Renuka *et al.* (2010) and Seethalakshmi and Kumar (1998).

Table 1. List of species of bamboos and rattans from which lichens were collected

Sl. No.		Species	Lichens collected
1	**Bamboos**	*Bambusa balcooa* Roxb.	Culms
2		*Bambusa bambos* (L.) Voss	Culms, Leaves
3		*Bambusa tulda* Roxb.	Culms
4		*Bambusa vulgaris* Nees	Culms
5		*Bambusa wamin* E.G.Camus	Culms
6		*Bambusa multiplex* Raeusch.	Culms
7		*Dendrocalamus giganteus* Munro	Culms
8		*Dendrocalamus membranaceus* Munro	Culms
9		*Dendrocalamus strictus* (Roxb.) Nees.	Culms
10		*Ochlandra travancorica* Gamble	Culms, Leaves
1	**Rattans**	*Calamus baratangensis* Renuka & Vijayak.	Leaves
2		*Calamus longisetus* Griff.	Leaves
3		*Calamus metzianus* Schltdl.	Leaves
4		*Calamus tenuis* Roxb.	Leaves
5		*Korthalsia rogersii* Becc.	Leaves

Results and Discussion

A total of 80 lichen samples were collected which consisting of 17 species under 13 genera and 8 families (Table 2). Out of these, sterile specimens of *Cryptothecia*, *Gyalectidium*, *Pyxine, Tricharia*, and some species of *Porina* and *Strigula* were identified up to generic level based on thallus morphology, anatomical and chemical characters. Some specimens could not be identified due to immature thallus and absence of ascospores. Comparing the growth of lichens on bamboo and rattan showed that 13 species inhabit on bamboos, 5 sp. on rattans, and 2 sp. viz., *Fellhanera bouteillei* and *Gyalectidium* sp. grow on both bamboo and rattans. In bamboo, most lichen species grow on *Dendrocalamus membranaceus* (4 sp.). Two species of lichens grow on *Bambusa bambos*, *Bambusa vulgaris* and *Thyrsostachys oliveri*. *Bambusa balcooa*, *Bambusa wamin*, *Dendrocalamus giganteus*, *Bambusa tulda*, *Bambusa multiplex*, *Ochlandra travancorica* possess only one species each. In rattans, 3 species of lichens were found to grow on *Calamus baratangensis* and one species on *Calamus longisetus* and *Calamus metzianus*.

The crustose lichens were more dominant (16 sp.) and we could find only one foliose lichen, i.e., *Pyxine* sp. Among the lichen families, Pilocarpaceae, Strigulaceae, and Graphidaceae were the dominant families with 3 species each, followed by Arthoniaceae, Trichotheliaceae, and Gomphillaceae with 2 species respectively, and Caliciaceae and Coenogoniaceae were represented by one species each.

The lichen biota of the state of Kerala was represented by 689 species (Sinha, 2021). The present study has added eight new records for Kerala [marked by the asterisk (*) in Table 2].

Table 2. List of lichens inhabiting on bamboos and rattans of KFRI Peechi campus (* = new to Kerala)

Sl. No	Species	Family	Habitat	Host species	Voucher number
1	*Calopadia fusca* (Müll. Arg.) Vězda	Pilocarpaceae	on leaves	*Calamus metzianus* Schltdl.	23-40488, 23-40485C 23-40470
2	*Calopadia* sp.	Pilocarpaceae	on culms	*Dendrocalamus membranaceus* Munro	23-40431C, 23-40432B
3	*Cryptothecia* sp.	Arthoniaceae	on culms	*Dendrocalamus membranaceus* Munro	23-40431B
4	*Coenogonium dilucidum* (Kremp.) Kalb & Lücking	Coenogonia-ceae	on culms	*Bambusa balcooa* Roxb.	23-40412
5	**Diorygma soozanum* (Zahlbr.) M. Nakan. & Kashiw.	Graphidaceae	on culms	*Dendrocalamus membranaceus* Munro, *Dendrocalamus gigan-teus* Munro, *Bambusa vulgaris* Nees	23-40408, m23-40420 23-40421, 23-40429A 23-40432A, 23-40438 23-40440, 23-40453 23-40475, 23-40476 23-40477, 23-40478
6	**Fellhanera bouteillei* (Desm.) Vězda	Pilocarpaceae	on leaves	*Bambusa bambos* (L.) Voss	23-40404, 23-40447 23-40489
7	*Graphis lineola* Ach.	Graphidaceae	on culms	*Bambusa tulda* Roxb.	23- 40415
8	**Graphis pyr-rhocheiloides* Zahlbr.	Graphidaceae	on culms	*Bambusa vulgaris* Nees	23-40409
9	**Gyalectidium* cf. *filicinum* Müll. Arg.	Gomphillaceae	on leaves	*Thyrsostachys oliveri* Gamble, *Calamus baratangensis* Renuka & Vijayak.	23-40485A, 23-40437
10	**Herpothallon cinereum* G. Thor	Arthoniaceae	on culms	*Dendrocalamus membranaceus* Munro	23-40421A, 23-40429B 23-40431A
11	**Porina tetramera* (Malme) R. Sant.	Trichotheliace-ae	on culms	*Bambusa multiplex* Raeusch., *Ochlandra travancorica* Gamble	23-40481 23-40462
12	*Porina* sp.	Trichotheliace-ae	on culms	*Bambusa wamin* E.G. Camus	23-40448
13	*Pyxine* sp.	Caliciaceae	on culms	*Thyrsostachys oliveri* Gamble	23- 40419
14	**Puiggariella nemathora* (Mont.) S.H. Jiang, Lücking & J.C. Wei	Strigulaceae	on leaves	*Calamus baratangensis* Renuka & Vijayak.	23-40486
15	*Strigula nitidula* Mont.	Strigulaceae	on leaves	*Calamus longisetus* Griff.	23-40487
16	*Strigula* sp.	Strigulaceae	on leaves	*Bambusa bambos* (L.) Voss	23- 40410
17	**Tricharia* sp.	Gomphillaceae	on leaves	*Calamus baratangensis* Renuka & Vijayak.	23-40485B

New records to Kerala

Diorygma soozanum (Zahlbr.) M. Nakan. & Kashiw., Bull. Natl. Mus. Nat. Sci., Tokyo, B. 29(2): 86, 2003. *Graphina soozana* Zahlbr., Feddes Repert. Spec. Nov. Regni Veg. 31: 215, 1933. (Graphidaceae). Fig. 2A.

Thallus creamy white, smooth with cracks especially along the lirellae; lirellae ±flexuous and branched; disc covered by thick white pruina; exciple uncarbonized, poorly developed; hymenium clear, I+ weakly bluish violet; asci 1(–2)-spored, ascospores hyaline, muriform, I+ violet, 90–150 × 30–50 µm. Thallus K+ yellow turning red, norstictic and connorstictic acids detected in the TLC.

Remarks: Previously the species were reported from Arunachal Pradesh, Assam, Nagaland and Tripura (Sinha *et al*., 2018), Meghalaya (Behera and Nayaka, 2020) and Mizoram (Thangjam *et al*., 2022). In the present study, it was found growing abundantly on the culms of different bamboo species.

Specimens examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10°32′2″N 76°20′31″ E, elev. 58 m, on culms, 14 March 2023, *S Senha* 23-40421, 23-40429A, 23-40432A (KFRI); *ibid*., 10°53′42″N 76°34′18″ E, elev. 87 m, 27 March 2023, *S Senha* 23-40475, 23-40476, 23-40477, 23-40478 (KFRI); 10°31′51″N 76° 20′34″ E, elev. 87 m, 13 March 2023, *S Senha* 23-40408 (KFRI); 10°31′38″N 76°21′0″ E, elev. 10 m, 22 March 2023, *S Senha* 23-40438, 23-40440 (KFRI); 10° 53′33″ N 76°34′34″ E, elev. 70 m, 20 March 2023, *S Senha* 23-40453 (KFRI).

Fellhanera bouteillei (Desm.) Vězda, Folia Geobot. Phytotax. 21: 214, 1986. *Parmelia bouteillei* Desm., Ann. Sci. Nat. Bot., ser. 3(8): 191, 1847. (Pilocarpaceae). Fig. 2B.

Thallus continuous, in circular patches, whitish with bluish tinge, farinose to fine granular, sometimes appear as sorediate; apothecia rounded to irregular, margin pale to whitish; disc pale yellowish; excipulum colourless; asci 8-spored, ascospores hyaline, 1-septate, 9–13 × 2.5–5 µm.

Remarks: Earlier reported from Arunachal Pradesh, Assam, Goa, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, West Bengal (Randive *et al*., 2017), and Karnataka (Krishnamurthy and Subramanya, 2017).

Specimens examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10°52′94″N 76°34′69″ E, elev. 59 m, on leaves, 17 April 2023, *S Senha* 23-40489 (KFRI); *ibid*., 10°31’51”N 76°20’31” E, elev. 66 m, 13 March 2023, *S Senha* 23-40404 (KFRI); 10°53′25″N 76° 34′41″E, elev. 88 m, 20 March 2023, *S Senha* 23-40447 (KFRI).

Graphis pyrrhocheiloides Zahlbr., Cat. Lich. Univ. 2: 321, 1923. (Graphidaceae). Fig. 2C.

Thallus greenish white, with numerous calcium oxalate crystals; lirellae unbranched, scripta-morph, labia entire; exciple laterally carbonized; hymenium clear; asci 8-spored, ascospores hyaline, 6–9-septate, I+ blue, 11–30 × 6–8 µm. Thallus K+ yellow turning red, P+ golden yellow (near lirellae), norstictic and salazinic acids detected in TLC.

Remarks: Earlier, the species was reported as corticolous in Arunachal Pradesh, Assam, Karnataka, Maharashtra, Manipur, Orissa, Tamil Nadu, Uttarakhand, Uttar-Pradesh, and West Bengal, and foliicolous habitat in Goa (Nayaka *et al*., 2021; Randive *et al*., 2017). In this report, the species was found growing on the culms of *Bambusa vulgaris*.

Specimen examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10° 31′51″N 76°20′34″ E, elev. 66 m, on culms, 13 March 2023, *S Senha* 23-40409 (KFRI).

Gyalectidium cf. ***filicinum*** Müll. Arg., Flora 64: 101, 1881. (Gomphillaceae). Fig. 2D.

Thallus crustose, whitish to greenish-grey, in small patches, finely verruculose with calcium oxalate crystals, sometimes with hyphophores; ascomata apothecia, circular in outline; disc greenish white, epruinose; excipulum indistinct; hymenium hyaline, clear; asci and ascospores not seen.

Remarks: Previously the species was reported from Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, West Bengal (Singh and Sinha, 2010) and Karnataka (Kumar and Krishnamurthy, 2016). At present, we are treating it here as *Gyalectidium* cf. *filicinum* because the studied specimens have the ascomata without ascospores. It was found growing on the leaves of bamboos and rattans.

Specimens examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10°52′88″N 76°34′79″ E, elev. 69 m, on leaves, 17 April 2023, *S Senha* 23-40485A (KFRI); *ibid.*, 10°31′39″N 76°21′0″E, elev.

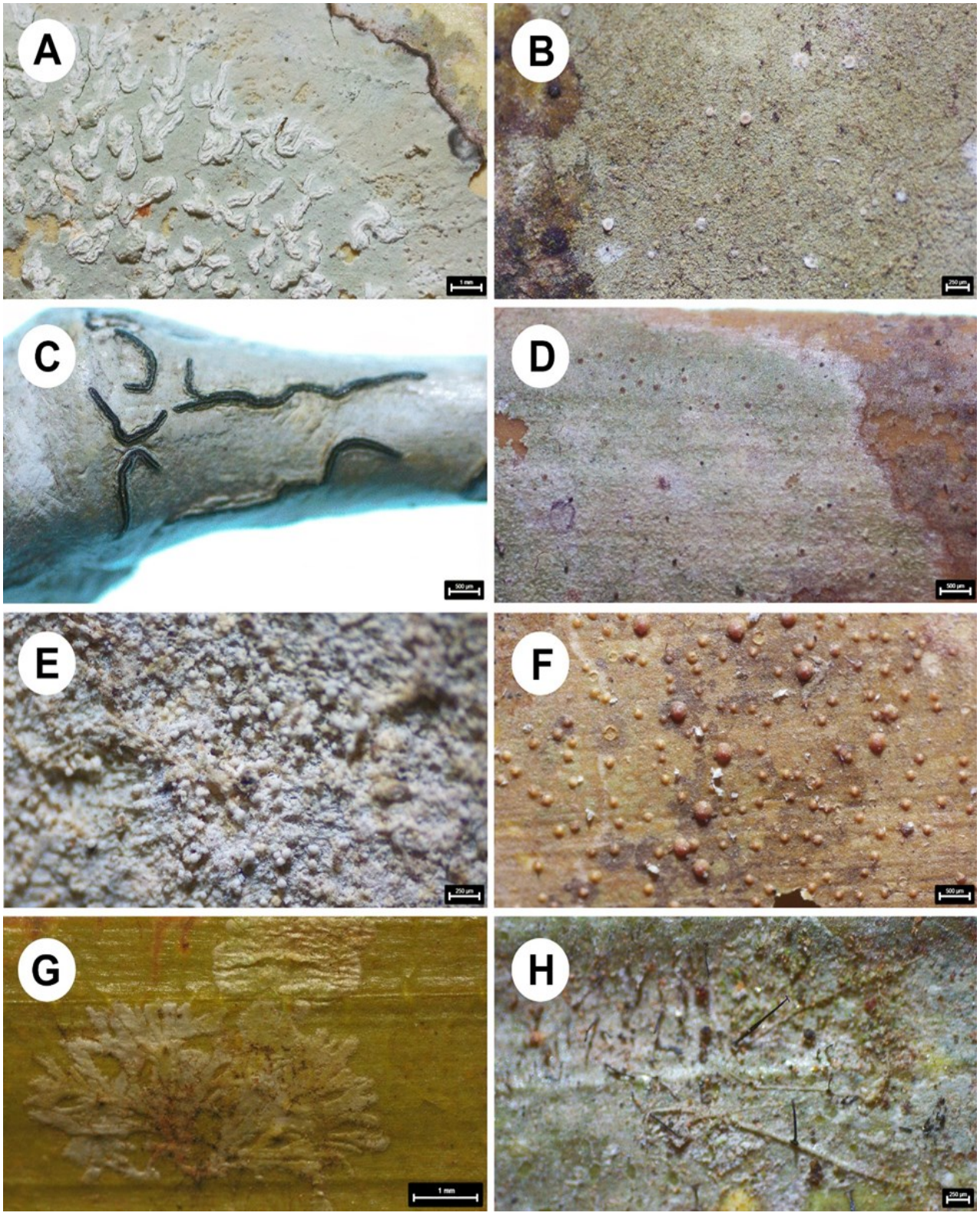

Fig 2. Habits (A) *Diorygma soozanum*; (B) *Fellhanera bouteillei*; (C) *Graphis pyrrhocheiloides*; (D) *Gyalectidium* cf. *filicinum*; (E) *Herpothallon cinereum*; (F) *Porina tetramera*; (G) *Puiggariella nemathora*; (H) *Tricharia* sp. Scale bars: A & G = 1 mm; B, E & H = 250 µm; C, D & F = 500 µm.

83 m, 22 March 2023, *S Senha* 23-40437 (KFRI).

Herpothallon cinereum G. Thor, Biblioth. Lichenol. 99: 34, 2009. (Arthoniaceae). Fig. 2E.

Thallus crustose, loosely appressed to the substrate, dull, greenish-grey to grey, with many calcium oxalate crystals; prothallus byssoid, whitish; pseudoisidia numerous, cylindrical, rarely branched, byssoid-felty with many projecting hyphae; ascomata not seen. Confluentic acid detected in TLC.

Remarks: Previously reported from Arunachal Pradesh, Sikkim, and West Bengal (Singh *et al*., 2018).

Specimens examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10°32′2″N 76°20′31″ E, elev. 58 m, on culms, 14 March 2023, *S Senha* 23-40421A, 23-40429B, 23-40431A (KFRI).

Porina tetramera (Malme) R. Sant., J. Ecol. 40: 129, 1952. *Phylloporina tetramera* Malme, Ark. Bot. 23A: 31, 1929. (Trichotheliaceae). Fig. 2F.

Thallus crustose, usually in small ±rounded patches, grey to greyish-green; prothallus lacking; perithecia orange red-brown, globose, constricted at base; involucrellum dark reddish-brown, K+ brownish red; paraphyses simple; asci obclavate, 8-spored, ascospores hyaline, 3-septate, fusiform, usually one end obtuse, the other acute, 16–25 × 3–5 µm.

Remarks: The species is considered as rare and reported from Arunachal Pradesh as foliicolous habitat (Singh and Pinokiyo, 2014). In the current study, it was found growing on the culms of different bamboo species.

Specimens examined: Kerala, Thrissur district, Peechi, KFRI Campus, 10°53′25″N 76°34′41″ E, elev. 88 m, on culms, 20 March 2023, *S Senha* 23-40481 (KFRI); *ibid*., 10°53′10″N 76°34′61″ E, elev. 78 m, 24 March 2023, *S Senha* 23-40462 (KFRI).

Puiggariella nemathora (Mont.) S.H. Jiang, Lücking & J.C. Wei, Fungal Diversity 102: 282, 2020. *Strigula nemathora* Mont., Hist. Phys: Cuba Bot. Pl. Cell 9: 96, 1845. (Strigulaceae). Fig. 2G.

Thallus subcuticular, lobulate, with elongate to laciniate, greenish-grey, lobe margins with numerous minute, white papillae; perithecia erumpent to prominent, covered by a thick thallus layer up to ostiole; excipulum hyaline; involucrellum confluent with excipulum, hyaline to pale brown; paraphyses unbranched; asci oblong, 8-spored, ascospores hyaline, fusiform, 1-septate, constricted at septa, 15 –25 × 3.5–6 µm.

Remarks: Earlier reported from Andaman Islands, Arunachal Pradesh (Singh and Pinokiyo, 2014), Assam (Gupta and Sinha, 2018), and Karnataka (Subramanya and Krishnamurthy, 2015). Previously this species was known as *Strigula nemathora* Mont., but recently Jiang *et al*. (2020) reinstated the genus *Puiggariella* Speg. (Type species: *Puiggariella apiahyna* Speg. (Puiggariella nemathora (Mont..) S.H. Jiang, Lücking & J.C. Wei]) to accommodate the species of *Strigula* Fr. with quite characteristic thallus morphology (often laciniate and with white papillae) and the uncarbonized perithecia which often feature ridges or fissures. According to Jiang *et al*. (2020), the distribution of *Strigula nemathora* (≡*Puiggariella nemathora*) is difficult to ascertain, but it may deal with a neotropical taxon, as this morphotype is mostly known from that region.

Conclusion

The study conducted at the KFRI Peechi campus in Kerala has provided a comprehensive enumeration of lichen taxa inhabiting bamboos and rattans. A total of 17 species from 13 genera and eight families were identified. The research has significantly contributed to understanding lichen diversity in Kerala by adding eight species as new distributional records for the region. The scarcity of documentation on lichens associated with bamboos and rattans globally and in India is highlighted, setting the stage for the importance of this study. The findings highlight the need for more in-depth studies on lichen diversity, especially on less-explored substrates such as bamboo and rattan. In conclusion, this research expands the knowledge of lichen biota in Kerala and underscores the importance of documenting and comprehending the distribution and diversity of these organisms in various ecological niches.

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