An overview of *Poronia* in India and the extended distribution of *P. nagaraholensis* on elephant dung from the Western Ghats of India

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Abstract

Poronia is an important genus of Sordariomycetes, and has been identified in the feces of many animals in addition to its specific association with elephant dung. This article presents an overview of *Poronia* species reported worldwide with a focus on India; the occurrence, molecular phylogeny and extended distribution of *P. nagaraholensis*; and a note on use of social media platforms in research investigations. Based on the literature review, only nine out of the 24 species that have been recognized worldwide were found to occur in India. A curated list of *Poronia* species is provided along with additional collections of *Poronia* from Kerala and Karnataka. This is the first comprehensive compilation of *Poronia* in India.

Keywords: Checklist, Coprophilous Fungi, Distribution, Diversity, Taxonomy

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1. Introduction

The taxonomy of *Xylaria* and its related genera in Xylariaceae has been extensively investigated by mycologists over many years. However, significant debate persists regarding the classification of ascocarps with stipitate stromata that terminate in capitate, hemispherical, or irregular, fertile, sculptured heads. These are typically classified within a few closely related genera (e.g., *Kretzschmaria*, *Podosordaria*, *Xylaria* and *Poronia*) under Xylariaceae (Ahmad 1946, Dennis 1957a, b, Martin 1967, Rogers 1979). The micromorphological features, such as the nature of the spores and germ slits, are not sufficient to differentiate these genera from one another.

Precise studies have delineated these genera based on their habit and macromorphology (Ahmad 1946, Dennis 1957a, b, Martin 1967, Rogers 1979, Pande 2008). For instance, as noted by Martin (1967), *Kretzschmaria* can be distinguished from *Poronia* by its caespitose growth habit and wood-based habitat. Likewise, *Poronia* can be differentiated from both *Xylaria* and *Podosordaria* by the presence of stalked stroma, which forms a capitate to flattened disc with embedded perithecia, unlike the clavate to filiform or subglobose stroma with erumpent ascocarps found in the latter genera (Krug and Cain 1974, Martin 1967). *Podosordaria* and *Poronia* are closely connected genera that are sometimes considered *Xylaria* but are differentiated from the latter owing to the presence of capitate stromata and coprophilous habitats. *Poronia* has a flattened, nailhead-like fertile region, but *Podosordaria* possesses a subglobose head (Dennis 1957a, b). Rogers et al. (1998) assigned *Podosordaria* to *Geniculosporium*, whereas *Poronia* has *Lindquistia* anamorphs. The morphology, cultural growth and formation of conidium have been studied in *P. pileiformis* by Paden (1978).

Poronia Willd. (1787) was established with *P. gleditschii* Willd. as the type to include species characterized by "black carbonous perithecia embedded in a white fleshy hemi-spherical or discoid stroma borne on a long or short stipe" (Ahmed 1946). The term *Poronia* is generated from the Latin noun *porus* (meaning, pores - a reference to the holes), which represents the perithecia structures on the top of the cap, as these fungi do not have a bolete-like structure underneath. Subsequently, Dennis (1957b) expanded the genus to include some Eastern hemispherical terrestrial taxa resembling *Xylaria*, which possess white flat-headed structures with rooting bases, likely originating from buried wood. The sexual morph of the genus possesses stalked stromata as a flattened disc (Krug and Cain 1974). *Poronia* is now accepted in Xylariaceae (Ascomycota) based on morphology and multigene phylogeny (Daranagama et al. 2018, Wendt et al. 2018).

Poronia is known for its small, disk-like fruiting bodies that grow on dung, particularly of herbivores like horses and cattle. The genus is notable for its ecological role and potential pharmaceutical applications (Anderson et al. 1984, Poyser et al. 1986, Anderson et al. 1988, Becker and Stadler 2021). The diversity of *Poronia* is relatively limited compared to other genera of Xylariaceae, but the species within this genus have adapted to specific ecological niches, often dictated by the type of dung they colonize. *Poronia* species play an important role in the decomposition of dung and nutrient cycling in ecosystems by breaking down organic matter, helping to return nutrients to the soil, supporting plant growth and maintaining soil health. Their presence indicates a healthy ecosystem where nutrient recycling is active (Whalley 1985).

Poronia has upright stipitate fruit bodies, with a fertile part forming a capitate to flat disc on a stalked stroma. The stromata may be simple or have branches. The perithecia are embedded with elevations, either present or absent. The asci are stipitate, cylindrical, and feature a well-developed apical ring, which typically turns blue with Melzer's reagent. The ascospores are light- to dark-brown, asymmetrical, one-celled, or unequal two-celled due to the presence of a hyaline cellular appendage with a short to long visible or invisible germ slit (Lloyd 1920, Dennis 1957b, Martin 1967, Dennis 1978).

Among all discovered *Poronia* species, *P. punctata* (nail fungus) alone is considered vulnerable under the rare and threatened species category by the IUCN (https://www.iucnredlist.org/, Persiani and Ainsworth 2019). The cause of its decline is scientifically unknown. Some researchers speculate that changes in the nutrition of horses, donkeys, and cows, the use of fertilizers, and the disappearance of individual horse and donkey populations may be the contributing factors. Across much of Europe, herbicides, plant pesticides and other synthetic chemicals are used in the 'worming' of horses, which has been considered to decrease *P. punctata*. This species was discovered in Croatia only after fungi received legal protection under the Preliminary List of Rare and Endangered Species. Several authors mentioned that the diversity of *Poronia* is least explored in India (Ahmad 1946, Deepna and Manimohan 2012, Hembrom et al. 2013, Crous et al. 2023).

Poronia species are typically found in grasslands, pastures, and areas where herbivores graze, as they depend on dung for their growth and reproduction. The specific ecology of each species can vary, with some preferring certain types of dung over others. By contributing to the decomposition of dung, *Poronia* species help improve soil fertility and structure, which makes them important in sustainable agriculture and pasture management. The ability of *Poronia* species to break down organic material suggests potential in bioremediation, where they could be used to decompose waste materials and pollutants in the environment (Hyde et al. 2020). Some species, like *P. punctata*, characteristically produce cellulase (Robertson and Koehn 1978). *Poronia* species, like other fungi, produce a variety of metabolites. Metabolites, Poronitins A and B, 4-pyrone and 4-pyridone derivatives were isolated from *P. gigantea* growing on elephant dung and may be useful as chemotaxonomic markers (Isaka et al. 2012, Hyde et al. 2020). These compounds could have pharmaceutical or industrial applications, making them interesting subjects for biotechnological research (Stadler 2011, Becker and Stadler 2021).

The present study reviews the occurrence of *Poronia* species recorded in India. Additionally, the occurrence of *P. nagaraholensis* is discussed in detail to identify the collections made by several members and community participants. The identity of *P. nagaraholensis* was established based on microscopic and macromorphological studies. The anamorphic state of *P. nagaraholensis* is illustrated in the present investigation. A special note on their habitat, ecology and MycoAsia Fungi-ID online platform, which enabled us to connect with mycophiles, is provided.

2. Materials and methods

Data compilation: Data on *Poronia* species described across the globe are retrieved from the online resources, which include MycoBank, Index Fungorum, Species Fungorum and IMI herbarium. Published literature is consulted and compiled. As taxonomic opinions for species tend to change, the current status is provided to avoid confusion with synonymy and to highlight taxonomic changes.

Sample collection: Sampling was done during field survey (mushroom foray) conducted in Karnataka and Kerala from 2017 to 2024. Though it was not intended for *Poronia* alone, we recorded the occurrence of *Poronia* sp. in elephant inhabited forest areas of Karnataka and

Kerala. Further, community participation was received through online platforms, i.e., MycoAsia Fungi-ID and MycoIndia, which enabled us to connect with enthusiastic mycophiles. This led to the collections and documentation of extended distribution. The GPS data, substrate-associated data and season data are collected and used to present the extended distribution of *Poronia* after the identification process. All the specimens collected during forays were preserved in fungaria at the University of Mysore and the Kerala Forest Research Institute (KFRI).

Morphological characterization: Morphological features of fruiting structures (stromata) were recorded. Attempts were made to record the perithecia and their associated structures. The powdery mass of spores (possibly asexual structures that need to be validated) present in the young fruiting bodies of *Poronia* sp. were subjected to microscopic examination. The spores were mounted in a lactophenol and aniline-blue mixture. Microscopic observations of rehydrated tissue (5% aqueous KOH) were carried out in bright field microscopy (Leica DM2000 LED compound microscope). Measurements were taken for 20 spores.

DNA extraction, PCR amplification and sequencing: Genomic DNA was extracted from the stromata by the CTAB method (Zhang et al. 1998). PCR was performed with a thermocycler (Eppendorf, Germany) by using ITS1-ITS4 primer-pair (White et al. 1990) for amplification of the internally transcribed spacer region of rRNA gene. The PCR amplification was executed in a 25 µl reaction mixture [1 µl of template DNA, 12.5 µl of Taq DNA polymerase Master Mix RED (Amplicon, Denmark), 20 pM of each forward and reverse primer (1.0 µl) (Sigma, Bangalore, India)] and the final volume of 25 µl with 9.5 µl of nuclease-free water. The PCR specifications include initial denaturation at 95 ºC for 5 min, followed by 35 cycles of denaturation at 95 ºC for 1 min, annealing at 57.6 ºC for 1 min, and extension at 72 ºC for 1 min. The PCR products obtained were assessed using a gel documentation system on a 1.2% agarose gel (Bio-Rad, model number 1708270) with electrophoresis (20 min at 90V) using an electrophoresis unit (Cleaver Scientific, England). Subsequently, the amplified PCR products were sequenced using a DNA sequence analyzer (ABI3730I DNA analyzer, Applied Biosystems) at AgriGenome Labs Pvt. Ltd., Kochi, Kerala, India. A nucleotide-BLAST (nBLAST) search was performed for each DNA sequence. The nearest match was considered and comprised in phylogenetic tree building with reference sequences obtained from the nucleotide database of NCBI GenBank (Table 1).

Phylogenetic analysis: Sequences were assembled using DNASTAR Lasergene SeqMan Pro v. 8.1.3. Phylogenetic trees were constructed based on the initial blast results obtained from the NCBI blast tool. Sequence alignments of the ITS region were prepared using CLUSTALW in MEGA v. X (Kumar et al. 2018) and manually amended when necessary. Initially, a phylogenetic tree was generated based on individual loci using Maximum Likelihood (ML) (Saitou and Nei 1987) to verify the topology of the newly generated sequence. Bootstrap analyses were performed to assess the robustness of the phylogenetic groupings, ensuring statistical reliability of the observed relationships. The percent of replicate trees in which the associated taxa grouped together in the bootstrap test (1000 replicates) are shown next to the diversions (Felsenstein 1985) in Fig. 3. The evolutionary distances (ED) were calculated using the Kimura 2-parameter technique (Kimura 1980) in units of the number of base substitutions per site. This analysis consists of 18 nucleotide sequences. All positions with gaps and missing data were removed (complete deletion option). A total of 418 positions were found in the final dataset. The phylogenetic position of *P. nagaraholensis* is indicated in bold (Fig. 3).

3. Results and discussion

There are 38 records of *Poronia* species in MycoBank (https://www.mycobank.org) and Index Fungorum (https://www.indexfungorum.org). There are 23 entries of *Poronia* species in Species Fungorum (https://www.speciesfungorum.org). A critical analysis of all the entries from MycoBank, Index Fungorum, Species Fungorum and IMI Herbarium, Kew was performed and the results are presented in Table 1. The data analysis showed a total of 24 entries (accepted species) are listed under *Poronia* in Index Fungorum and only 10 species are listed in Species Fungorum as validly accepted species (Table 1). It may be attributed to the difficulties in data curation, as some species entries lack geographical data, type species, and others. Therefore, critical observations of all the specimens are listed in Table 1.

Several *Poronia* species described previously have been shifted to various other genera: *Biscogniauxia, Hypocrea, Hypoxylon, Podosordaria, Sphaeria, Xylaria* and *Xylosphaera*. Further, observations on geographical distribution revealed that *Poronia* is present or reported from 14 countries across the globe and India is represented by nine species among them, six are exclusively found to occur in India (*P. arenaria*, *P. gigantea*, *P. indica*, *P. nagaraholensis*, *P. polyporoides* and *P. radicata*) followed by two species each from Brazil (*P. fornicata* and *P. hemisphaerica*); Germany (*P. erici* and *P. gleditschii*) and the Philippines (*P. hypoxyloides* and *P. pileiformis*). The remaining 10 countries are represented by a *Poronia* species as presented in Table 1.

Table 1. List of *Poronia* species recorded and their distribution (Taxon in boldface, validly accepted *Poronia* species).

Taxon	Current name	Locality	Substrate	Publication year	MB number
Poronia arenaria Syd., P. Syd. & E.J. Butler	***Poronia arenaria*** Syd., P. Syd. & E.J. Butler	India	On sandy soil associated with *Casuarina*	1911	197201
Poronia australiensis (Læssøe, C.A. Pearce & K.D. Hyde) J.D. Rogers, Y.M. Ju & F. San Martín	***Poronia australiensis*** (Læssøe, C.A. Pearce & K.D. Hyde) J.D. Rogers, Y.M. Ju & F. San Martín	Queensland (Australia)	On wallaby dung	1998	443673
Poronia caelata Pat.	***Poronia caelata*** Pat.	Society Is.	On rotten wood	1906	196890
Poronia chardoniana Toro (1926)	*Xylaria chardoniana* (Toro) J.H. Mill. 1934	-		1926	260428
Poronia claviformis Welw. & Curr.	***Poronia claviformis*** Welw. & Curr.	Angola	On rotten wood	1868	636121
Poronia cupularis (Fr.) Rabenh.	*Hypocrea cupularis* (Rabenh.) Fr. 1849	-		1844	202178

Poronia doumetii Pat.	*Podosordaria doumetii* (Pat.) P.M.D. Martin	Tunisia	On sandy soil	1893	202399
Poronia ehrenbergii Henn.	*Xylosphaera ehrenbergii* (Henn.) Dennis	Arabia		1893	202106
Poronia erici Lohmeyer & Benkert	***Poronia erici*** Lohmeyer & Benkert	Germany	On the dung of *Oryctolagus cuniculus* or *ovisaries*	1988	133680
Poronia fimetaria Pers.	***Poronia fimetaria*** Pers.	France	-	1818	NA
Poronia fornicata Möller	***Poronia fornicata*** Möller	Santa Catarina (Brazil)	On charred wood	1901	202312
Poronia gigantea Sacc.	***Poronia gigantea*** Sacc.	India (Kerala)	On the dung of *Elephas maximus indicus*	1914	202168
Poronia gleditschii Willd.	***Poronia gleditschii*** Willd.	Germany	On the dung of *Bos taurus*	1787	431941
Poronia heliscus (Mont.) Mont.	*Hypoxylon heliscus* Mont.	French Guiana (France)	On dead trunks	1855	202326
Poronia hemisphaerica Starbäck	***Poronia hemisphaerica*** Starbäck	Mato Grosso (Brazil)	On the dung of *Equus callabus*	1901	202031
Poronia hircina F.L. Tai & C.T. Wei	*Podosordaria hircina* (F.L. Tai & C.T. Wei) J.C. Krug & Cain	China	On the dung of *Capra*	1933	202230
Poronia hypoxyloides Rehm	***Poronia hypoxyloides*** Rehm	Philippines	On soil, associated with Poaceae	1914	202215
Poronia indica S. Ahmad	***Poronia indica*** S. Ahmad	India	On dead wood and dead roots of Poaceae	1946	289927
Poronia ingii (J.D. Rogers & Læssøe) J.D. Rogers, Y.M. Ju & F. San Martín	***Poronia ingii*** (J.D. Rogers & Læssøe) J.D. Rogers, Y.M. Ju & F. San Martín	Canary Island	On the rotten frond of a *Phoenix dactylifera*	1998	443674
Poronia johorensis (Morgan-Jones & Lim) Morgan-Jones	***Poronia johorensis*** Morgan-Jones & Lim	Malaysia	In sand	1973	120709
Poronia jugoyasan Hara	*Podosordaria jugoyasan* (Hara) Furuya & Udagawa	Japan	On the dung of *Lepus brachyurus*	1960	337530
Poronia leporina Ellis & Everh.	*Podosordaria leporina* (Ellis & Everh.) Dennis	Missouri (USA)	On the dung of Oryctolagus	1890	198450

Poronia macrorhiza Speg.	***Poronia macrorhiza*** Speg. 1880	Argentina	On the dung of *Equus callabus*	1880	198136
Poronia macrospora Peck	***Poronia macrospora*** Peck.	Connecticut (USA)	On sandy soil	1906	198331
Poronia minuta Petch	***Poronia minuta*** Petch	Sri Lanka	On the dung of *Lepus*	1917	198293
Poronia nagaraholensis Mahadevak., P.V.S.R.N. Sarma, Chalasani, Podile & Chandran.	***Poronia nagaraholensis*** Mahadevak., P.V.S.R.N. Sarma, Chalasani, Podile & Chandran.	Karnataka, India	On elephant dung	2023	844003
Poronia oedipus (Mont.) Mont.	***Poronia oedipus*** (Mont.) Mont.	India	-	1856	198511
Poronia pileiformis (Berk.) Fr.	***Poronia pileiformis*** (Berk.) Fr.	Philippines, India	On 'sclerotoid tuber'	1851	198377
Poronia polyporoides Henn.	***Poronia polyporoides*** Henn.	India	On dead wood and on soil	1902	198215
Poronia punctata (L.) Fr.	***Poronia punctata*** (L.) Fr.	Sweden and India	On the dung of *Equus caballus*	1849	198420
Poronia radicata Hembrom, A. Parihar & K. Das	***Poronia radicata*** Hembrom, A. Parihar & K. Das	India	On ground, under *Putranjiva roxburghii*	2013	805422
Poronia repanda (Fr.) Fr.	*Biscogniauxia repanda* (Fr.) Kuntze	Sweden	On trunks of Sorbus	1818	634255
Poronia scutellata Fr.	***Poronia scutellata*** Fr.	-	-	1849	198106
Poronia truncata Fr.	***Poronia punctata*** (L.) Fr.	-	-	1818	496309
Poronia turbinata Ellis & Everh.	*Penzigia turbinata*	Nicaragua	On bark	1893	232900
Poronia ustorum Pat.	*Podosordaria ustorum*	New Caledonia	On burnt stumps of Poaceae	1887	232627

***Poronia* species recorded from India:** In India, a total of nine species of *Poronia* are recorded, among them, six *Poronia* species are reported to occur only in India. *Poronia arenaria* (associated with Casuarina on sandy soil from Tamil Nadu), *P. indica* (associated with the root and stem of Poaceae), *P. polyporoides* (on dead wood and on soil), and *P. radicata* (on ground, under *Putranjiva roxburghii*) are not associated with dung. A *P. punctata* specimen, IMI 162551 (associated with *Artocarpus integrifolia*), is deposited at the IMI Herbarium, Royal Botanic Garden, Kew, with an unknown submitter. *Poronia oedipus* has no substrate details from India. However, *P. gigantea*, *P. pileiformis*, *P. punctata*, and *P. nagaraholensis* have been reported from the Western Ghats (Karnataka and Kerala) and all of them are associated with elephant dung. The taxonomic details of all nine species recorded or described from India are presented below.

Poronia arenaria Syd., P. Syd. & E.J. Butler, Annales Mycologici 9: 420 (1911)
MycoBank: MB 197201
Type: Butler 1127, HCIO, New Delhi
This species was associated with Casuarina plants on sandy soil (Tamil Nadu).

Poronia gigantea Sacc., Annales Mycologici 12 (3): 302 (1914)
Myco**Bank:** MB 202168
Type: NA
This taxon is reported from Kerala on the dung of *Elephas maximus indicus*. No details of the type specimen or associated information are available for this taxon.

Poronia indica S. Ahmad. Lloydia 9: 142 (1946)
MycoBank: MB 289927
On dead wood and dead roots of Poaceae: India. Further, there is no information available on the type species, herbarium location or associated details for this fungus.

Poronia nagaraholensis Mahadevak., Sarma, Danteswari, Podile, Chandran. 2022/23 Persoonia
MycoBank: MB 844003
Holotype: AMH 10454

Recent Observations: Virajpet (2019), Peechi-Vazhani Wildlife Sanctuary (2022), Biligiriranga Tiger Reserve and Wild Life Sanctuary (2023), Sultan Batheri (2023), Munnar (2023/24), Pookode (2024), Ranipuram Peak (2024).

Poronia oedipus (Mont.) Mont., Syll. gen. sp. crypt. (Paris): 209 (1856)
MycoBank: MB198511
Holotype: NA
Poronia oedipus is reported to occur in Uttar Pradesh (IMI 116129, collection by S.T. Tilak, July 1965), Delhi (IMI 15222, collection by E.J. Butler, June 1906) and Kerala (IMI 253725, collection by S. Gacharich, November 1980). Except for the collection by Butler, which provided the substrate information, the remaining two collections lack the details of the substratum.

Poronia pileiformis (Berk.) Fr. Nova Acta Regiae Societatis Scientiarum Upsaliensis Ser. 3, 1: 129 (1851)
MycoBank: MB 198377
Holotype: NA
Recent Observation: Deepna and Manimohan (2012) reported the occurrence of *P. pileiformis* from Kerala, Rawla and Nurula (1983) from Meghalaya, followed by Patel et al. (2018), who reported from the Western Ghats regions of Karnataka.

Poronia polyporoides Henn., Hedwigia 40: 340 (1902)
MycoBank: MB 198215
Type: Gollan 25; Gollan 151
It is reported to be associated with deadwood and soil from Uttar Pradesh. No further information is available on this taxon.

Poronia punctata (L.) Fr., Summa vegetabilium Scandinaviae 2: 382 (1849)
MycoBank: MB 198420
Holotype: NA
The original description was provided by Linnaeus (1753).
Remarks: Reported only in herbarium depositions at Kew, IMI Herbarium. No associated information is available from an Indian perspective. It is known to occur on the dung of Wallaby (Victoria), *Vombatus ursinus* (Australia), *Equus caballus* (Great Britain), and *Bos taurus* (Czechoslovakia), except for two records of its association with plants from India (*Artocarpus integrifolia*) and Sweden (*Qaisera carinata*).

Poronia radicata Hembrom, A. Parihar & K. Das, CREAM 3 (2): 183 (2013)
MycoBank: MB 805422
Holotype: CAL 1140
Recent Observation: After the description of a new species, it was reported to occur in the state of Maharashtra (Rajendra and Prakash 2016).

Distribution of *Poronia nagaraholensis*:
A recent field survey revealed the occurrence of this genus in different elephant-inhabited forest areas in Karnataka and Kerala. That includes Biligiriranga Tiger Reserve and Wildlife Sanctuary (2023 and 2024), Peechi-Vazhani Wildlife Sanctuary (2022), Madikeri (2018, 2019, 2021), Virajpet (2021), Wayanad (2023), Sulthan Bathery (2023) and Munnar (2023). The GPS coordinates are marked and a GPS map is generated to show the extended distribution of *P. nagaraholensis* in Western Ghats areas (Fig. 4).

Specimen examined: Karnataka - Virajpet, Nagarahole life sanctuary, on elephant dung, 18.09.2019, S. Mahadevakumar, P.V.S.R.N. Sharma and Danteswari (UOM2021-27); Karnataka - Chamarajanagar, Biligiriranga Tiger Reserve and Wild Life Sanctuary, on elephant dung, 23.07.2023, M. Mahesh BRMM10 (UOM2023-18); Kerala - Thrissur, Peechi-Vazhani Wildlife Sanctuary, on elephant dung, 29.05.2022, S. Mahadevakumar, Shambhu Kumar and K.T. Mufeeda (KFRIMH1516); Kerala - Wayand forest areas, on elephant dung, JM1 (Elias Rowther); Kerala Moonnar (private coffee and cardamom plantation), on elephant dung, JM2 Jinu Muraleedharan; Kasaragod, Ranipuram Hills, on elephant dung, 05.06.2024, Jinu Muraleedharan JM3 (UOM2024-10).

The general characteristics of *P. nagaraholensis* specimens collected from Peechi-Vazhani Wildlife sanctuary as well as Munnar forest areas were recorded. Young stromata at different developmental stages were collected. Specimens collected from BR Tiger Reserve and wildlife Sanctuary showed well-developed stromata with anamorphic growth on the fertile part of the stromata (Fig. 1A, B). Stromata appeared in groups and were sometimes solitary, rarely branched (up to 3 stromata from a rhizome) (Fig. 1C – G), rhizomorph was swollen and shorter than the stromata. Stroma is generally smooth and becomes hard at maturity. Stromata long, solitary, unbranched, 8–23 cm × 1.5–7.4 mm; stromata attached to a rhizomorph; the rhizomorph, 3.5–14.9 × 1.5–2.9 cm; fertile part consisting of 0.8–1.3 cm broad head on the top of the stalk; dark brown at the base and whitish at the top with black papillate ostioles, stroma smooth, becomes hard on maturity. Stroma is solid, filled with a cream-coloured matrix. Matured perithecial structures were not observed. Asci and ascospores were not observed. Spores and mature perithecia were not found. Many *Poronia* species lack anamorphic descriptions.

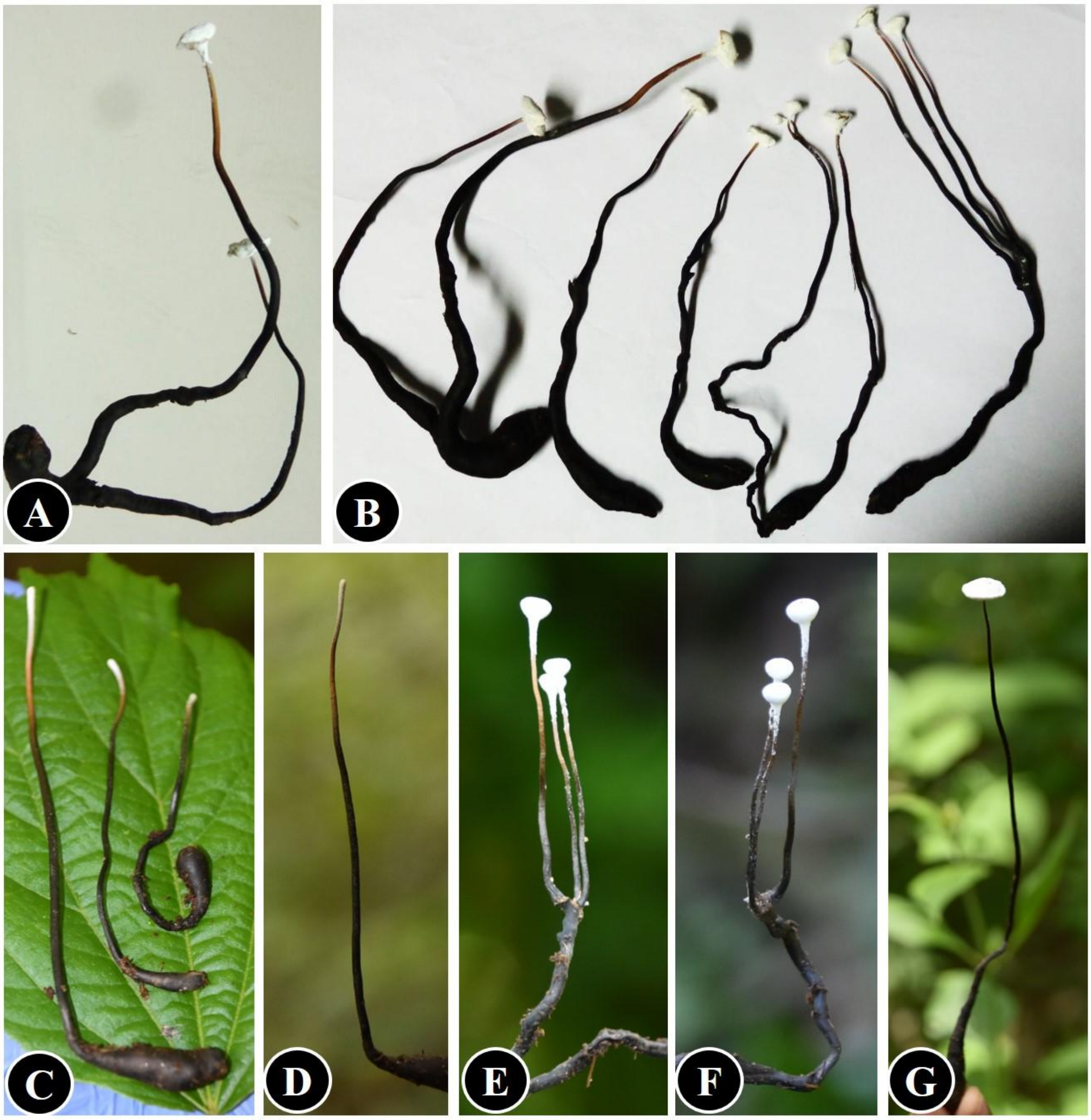

Figure 1. A–B, *Poronia nagaraholensis* collected from BRT reserve and wildlife sanctuary (BRMM10) shows stromata with anamorphic growth; **C–G,** *P. nagaraholensis* collected from Peechi-Vazhani wild life sanctuary shows stromata at varied developmental stages and their branching pattern.

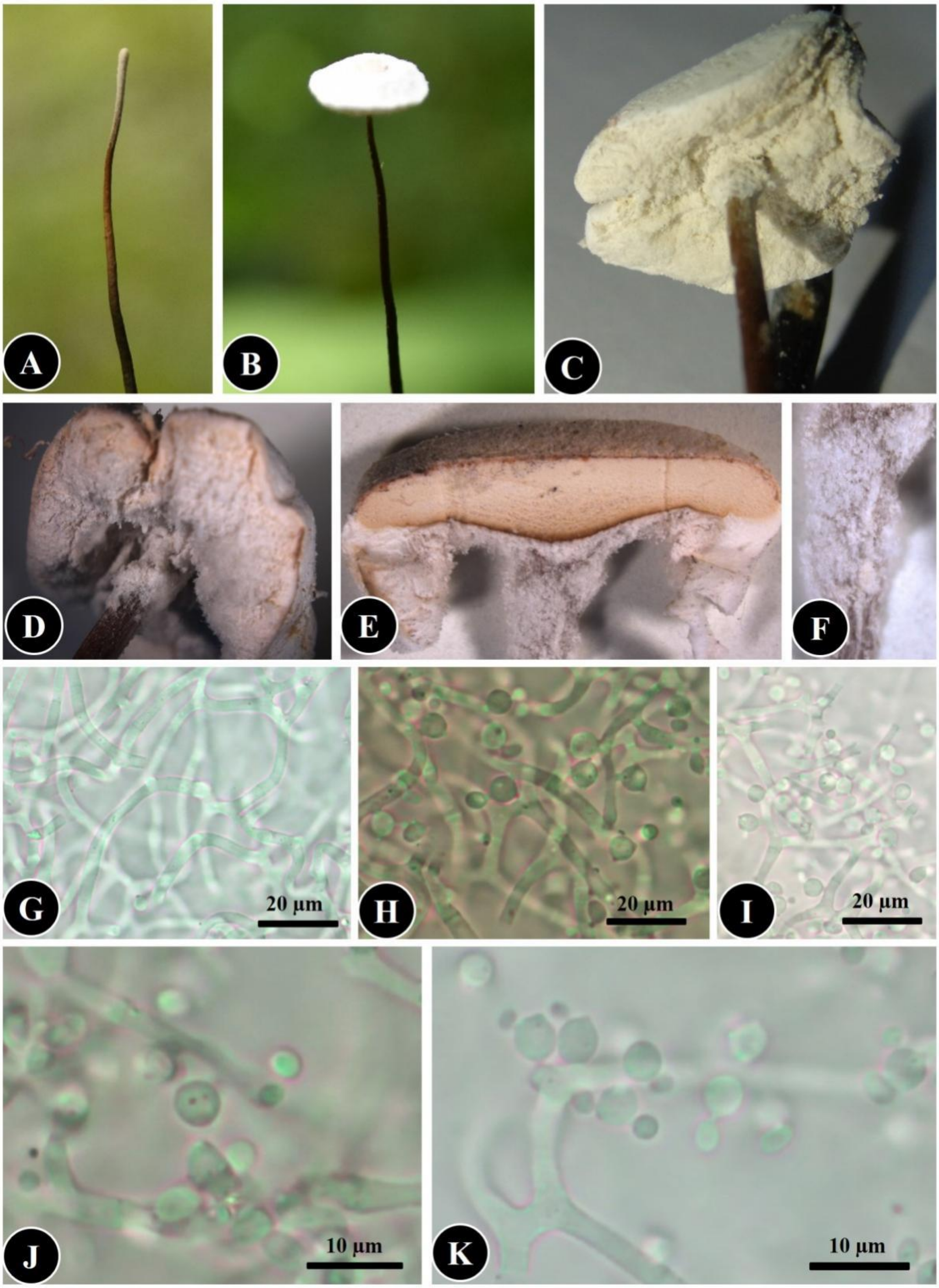

Figure 2. *Poronia nagaraholensis* anamorphic stages: **A** – immature stromata without any fertile cap development; **B** – young stromata with an anamorphic structure covering the fertile cap; **C** – close view of the anamorphic powdery mass developed all over the fertile cap; **D – F,** cross section of the fertile cap showing no sign of perithecial development; **G** – hyphal structures of anamorphic state; **H – K,** conidia of *P. nagaraholensis* observed under a compound microscope.

P. nagaraholensis was described in 2023 and no anamorphic details were provided. The present study provides a detailed account of the asexual morph associated with the stromata of *P. nagaraholensis*. Detailed micro-morphological examinations of anamorphic structures developed from immature stromata showed that immature stromata bear conidia in a whitish, light-pinkish layer and the powdery white mass developed on top of the sexual fruiting body, which later shred off as the stroma matured (Fig. 2A-C). As the perithecial stromata developed, the conidial layer shreds off, leaving the cap-like teleomorphic stroma consisting of perithecia. The conidia were globular, ellipsoidal and measured 4.3–7.5 µm and developed on hyphal structures (Fig. 2G–K). There is no differentiation in the hyphal structures observed. Depending on the age and condition, the stromata of a single species might be more or less white or black with a white or black and white shredding outer layer.

ITS data analysis by nBLAST showed that the voucher specimen KFRIMH 1516 (OR224624) shared 99.47% (GB Accession: ON427756; 561/564 bp, 0% gap), followed by the type species of *P. pileiformis* WSP 88113001 (GB Accession: GU324760 (NR_158882.1); 569/630 bp, 41 (6%) gaps) shared 90.32%; *P. australiensis* voucher MEL:2382965 (GB Accession: KP012826; 418/450 bp, 8 (1%) gaps), shared 92.89%; *Aerolospora bosensis* shared 93.56% (GB Accession: LR812704; 421/450 bp, 9 (2%) gaps); and *A. bosensis* CBS 572.63 shared 93.56% (GB Accession: MH858360; 421/450 bp, 9 (2%) gaps) sequence similarity. Further, nrITS sequence data for the voucher specimen BRMM10 (UOM2023-18) (Acc. No. PQ100674, 587 bp) were found to be similar to that of KFRIMH1516 obtained in nBLAST analysis.

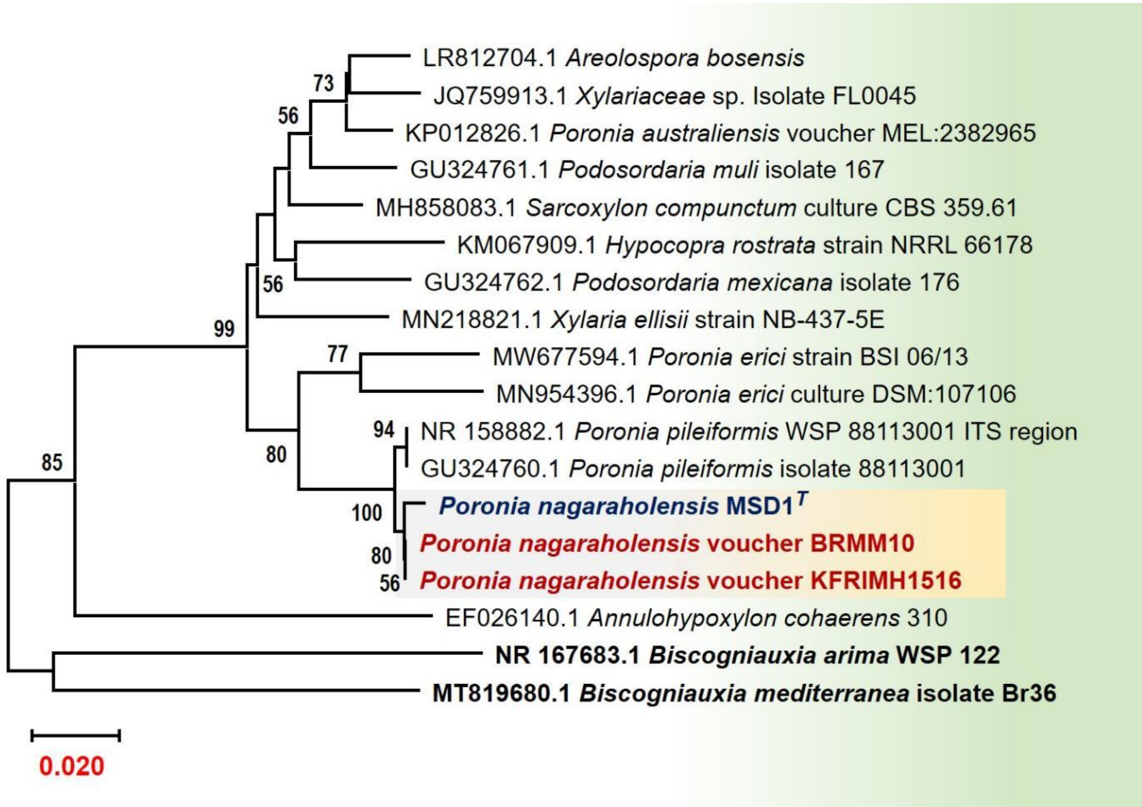

Figure 3. Phylogenetic tree constructed based on ITS sequences of *Poronia* species and *P. nagaraholensis* vouchers from the present study. The tree is rooted with *Biscogniauxia mediterranea* Br36 and *B. arima* WSP 122.

Further, the phylogenetic tree constructed by the ML method along with the reference sequences from NCBI-GenBank database revealed that the sequences shared a common clade with the reference sequences from the type specimens (Fig. 3), indicating that the collections from the present investigations were identical based on morphology and molecular sequence analysis.

Impact of social media in distribution: Mycophiles and passionate mushroom hunters who frequently visited elephant-inhabited areas in Kerala and Karnataka spotted the occurrence of *Poronia* species. They shared the details on the social media platforms, viz., MycoAsia Fungi-ID and MycoIndia. The details of these collections, including the occurrence, location, GPS data, and specimen to investigate, were received. This indicates the impact of social media on biodiversity assessment. While compiling the extended distribution of *P. nagaraholensis*, the MycoAsia Fungi-ID forum helped in recording additional localities and the details are presented in the map (Fig. 4).

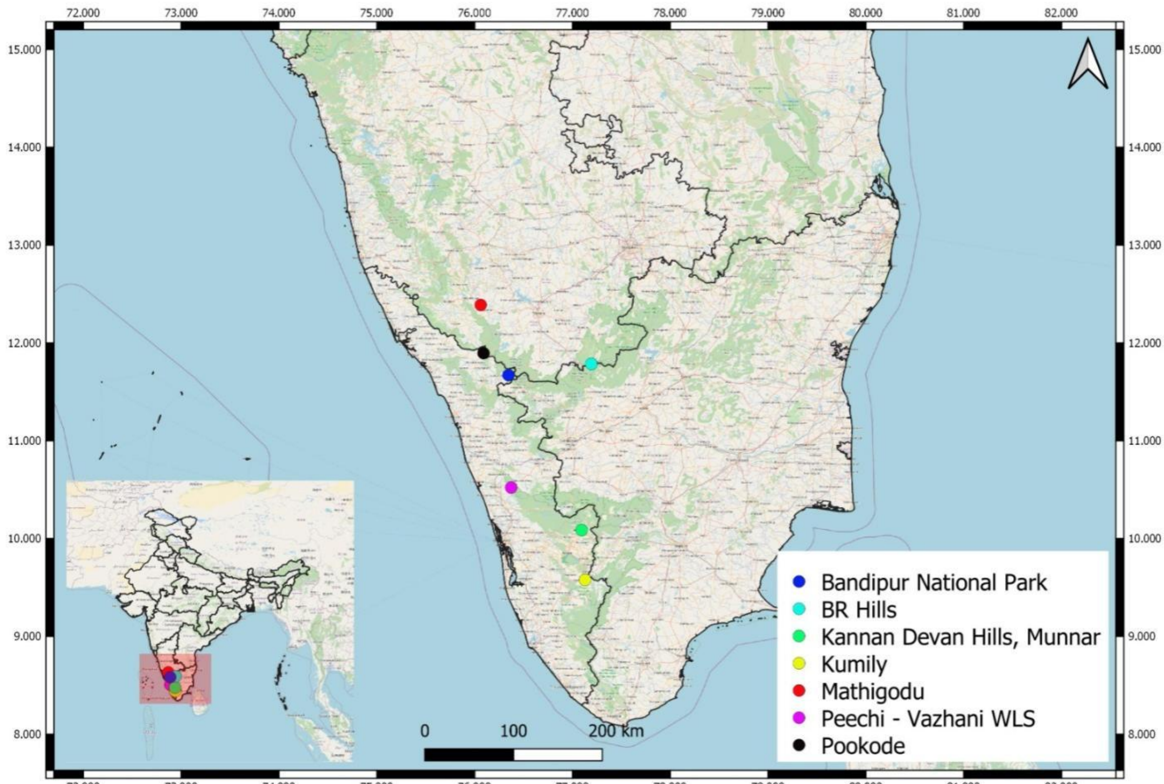

Figure 4. GPS locations showing the extended distribution of *Poronia nagaraholensis* from the Western Ghats of India.

The identities of the specimens received from the MycoAsia Fungi-ID connected mycophiles were confirmed by morphology as well as molecular sequence analysis. Field images shared by community participants from Kerala and Karnataka are presented in **Fig. 5.** In recent times, public and community participation in assessing biodiversity has gained significance. The involvement of the public can do wonders for assessing the biodiversity around us. As we can see, the enthusiastic mycophiles during their survey shared the information on the occurrence of *Poronia* species, which helped us provide a detailed extended distribution. This type of community participation offers additional information to the scientific fold, which helps in better understanding and utilization.

Habitat and ecology: *P. nagaraholensis* is coprophilous, found typically on the older dung of elephants (Crous et al. 2023). It develops fruiting bodies during the rainy season and post-rainy season. There are multiple-factor interactions associated with the development of fruiting bodies that are yet to be investigated (time of fruiting body development, temperature, humidity and decay condition of dung). The spores produced as an extra peridial layer around the central immature structures are recorded. It is common to observe asexual fruiting structures, and so far, sexual spores have not been observed. Mature fruiting bodies are yet to be collected for further enriching the illustration and characterizing the fungus. Further efforts to obtain pure culture media (PDA) were unsuccessful.

Figure 5. Community participation in the assessment of the extended distribution of *Poronia nagaraholensis* in the Western Ghats (Karnataka and Kerala): **A–D,** observation by Jinu Muraleedharan from Moonnar (private coffee and cardamom plantation), Kerala; **E–H,** by Elias Rowther, Sultan Bathery, Wayanad, Kerala; **I–K,** by Jinu Muraleedharan from Ranipuram Hills (Kerala); **L–P,** collection by Mahesh M from BR Tiger Reserve and Wild Life Sanctuary (Karnataka) (Photo Credit: A, B, C, D, I, J, & K – Jinu Muraleedharan; E, F & G – Elias Rowther; & L, M, N, O, & P – Mahesh M).

4. Conclusions and future perspectives

Macrofungi are known to occur on a wide range of substrates and among these, the dung of various animals also harbour several groups of fungi. Numerous fungi have been shown to grow on elephant dung, suggesting that it could serve as an ideal substrate (Pegler 1977, Thomas et al. 2001, Manimohan et al. 2007, Kaur et al. 2014, Karun and Sridhar 2015). In the Brahmagiri Wildlife Sanctuary, Western Ghats of Karnataka, Karun and Sridhar (2015) identified six macrofungal species on elephant dung (*Conocybe pubescens*, *Coprinus patouillardii*, *Panaeolus fimicola*, *Podosordaria elephanti*, *Psilocybe coprophila*, and *P. fimetaria*). Karun and Sridhar (2015) reported the occurrence of macrofungi (31 genera in 8 families) on a variety of dungs and substrates. According to several studies (Natarajan and Raman 1983, Vrinda et al. 1999, Thomas et al. 2001, Manimonan et al. 2007, Noordeloos et al. 2007, Mohanan 2011, Deepna and Manimohan 2012), Kerala state is represented by 27 species, followed by six species from Karnataka and one from Tamil Nadu (Karun and Sridhar 2015).

This work provides an overview of *Poronia* species reported across the globe in general and from India in particular, including their occurrence and distribution. A curated list of *Poronia* species is presented, with additional collections of *P. nagaraholensis* from Kerala and Karnataka characterized using morphological and molecular analysis. Notably, *P. nagaraholensis*, a recently described species from the Western Ghats, was also found in other forest areas, indicating an extended distribution. This compilation is the first comprehensive account of *Poronia* in India. Among these, *P. punctata* is considered rare and threatened by the IUCN. In India, the diversity of *Poronia* is underexplored. Overall, based on this study and other research works, *Poronia* was found to be an understudied genus, largely confined to elephant dung. The challenges inherent to morphological identification necessitate the integration of molecular data to support taxonomic investigation and nomenclature to explore *Poronia* diversity.

India's extensive elephant habitats offer a promising opportunity for discovering new *Poronia* species. Like many other members of Sordariomycetes, *Poronia* might be a potential source of secondary metabolites with pharmaceutical significance. Therefore, it is essential to conduct thorough investigations of fungi associated with elephant dung across the country. Further efforts are needed to establish pure cultures and harness their bioprospecting potential.

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