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## Journal of Threatened Taxa

The international journal of conservation and taxonomy

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

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#### THREE INTERESTING WOOD ROTTING MACRO-FUNGI FROM JHARKHAND, INDIA

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26 February 2016 | Vol. 8 | No. 2 | Pp. 8518–8525  
10.11609/jott.2133.8.2.8518-8525



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ISSN 0974-7907 (Online)  
ISSN 0974-7893 (Print)

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**Abstract:** Routine surveys of mycologically unexplored forest areas of Jharkhand, followed by a thorough examination of macro-fungal collections reveal two hitherto unrecorded poroid species (Basidiomycete) for Indian mycobiota namely, *Ganoderma elegantum* and *Perenniporia bambusicola*, and a less known hydroid wood-rotting species *Beenakia fuliginosa*. Detailed taxonomic descriptions coupled with illustrations are provided for all three taxa and compared with allied taxa.

**Keywords:** India, Jharkhand, Wood-rotting macrofungi.

Jharkhand is one of the richest states of India in terms of forest and mineral resources. Forests are mainly dominated by many economically important plants including sal (*Shorea robusta*) and bamboos, which are major sources of forest products for the native tribal people as well as being a rich host of wood rotting macrofungi. Rajmahal Hills and Koderma Wildlife Sanctuary are parts of this state and remain neglected from the mycological point of view except for a few sporadic reports (Currey 1874; Bodding 1925–1940; Panigrahi 1966; Anonymous 2013; Parihar et al. 2013). A critical examination of the specimens and a study of the relevant literature (Sorbhoy et al. 1981; Bilgrami et al. 1991; Jamaluddin et al. 2004; Ranadive et al. 2011; Sharma 2012; Tiwari et al. 2013) revealed two new records and one less known to Indian

## THREE INTERESTING WOOD ROTTING MACRO-FUNGI FROM JHARKHAND, INDIA

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mycobiota and are presented here with descriptions and illustrations of macro- and micro-morphological details.

### MATERIALS AND METHODS

Macro-fungal surveys of tropical deciduous (50–450 m) forest areas have been undertaken during the monsoon (August–September) season from 2008 to 2014. Macro-morphological characterization was made with the fresh basidiomata in the field or in the base camp (Fig. 1). Field photographs of these fresh macro-fungi and their habitats were captured with the aid of a Nikon D200s and Olympus C-5060. Colour codes and terms (mostly) are based on the Methuen Handbook of Colour (Kornerup & Wanscher 1978). After the Macromorphological characterization basidiomata were dried with the help of a wooden drier.

Micromorphological characterization was undertaken with the help of a light microscope: Olympus CX 41 from the free hand sections of the dry basidiomata mounted in a mixture of 5% KOH, phloxin, Congo red, and separately with Melzer's reagent or lacto-phenol and cotton blue. Measurements of spores were noted from 20 randomly chosen basidiospores. Spore-measurement and quotient indicating length-width ratio ( $Q = L/W$ ) are presented here as minimum-mean-maximum. Herbarium name follows

**DOI:** <http://dx.doi.org/10.11609/jott.2133.8.2.8518-8525>

**Editor:** R.K. Verma, Tropical Forest Research Institute, Jabalpur, India.

**Date of publication:** 26 February 2016 (online & print)

**Manuscript details:** Ms # 2133 | Received 30 June 2015 | Final received 23 August 2015 | Finally accepted 02 February 2016

**Citation:** Hembrom, M.E., A. Parihar & K. Das (2016). Three interesting wood rotting macro-fungi from Jharkhand, India. *Journal of Threatened Taxa* 8(2): 8518–8525; <http://dx.doi.org/10.11609/jott.2133.8.2.8518-8525>

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**Funding:** Botanical Survey of India, Ministry of Environment, Forest and Climate change, Govt. of India.

**Conflict of Interest:** The authors declare no competing interests.

**Acknowledgments:** The authors are grateful to the Director, Botanical Survey of India (BSI), Kolkata and the entire forest department of Jharkhand for providing all kinds of facilities during the present study. Help rendered by Dr. Md. N. Aziz (BSI, Cryptogamic Unit) and Dr. P. Lakshminarasimhan (BSI, Central National Herbarium) are also duly acknowledged.

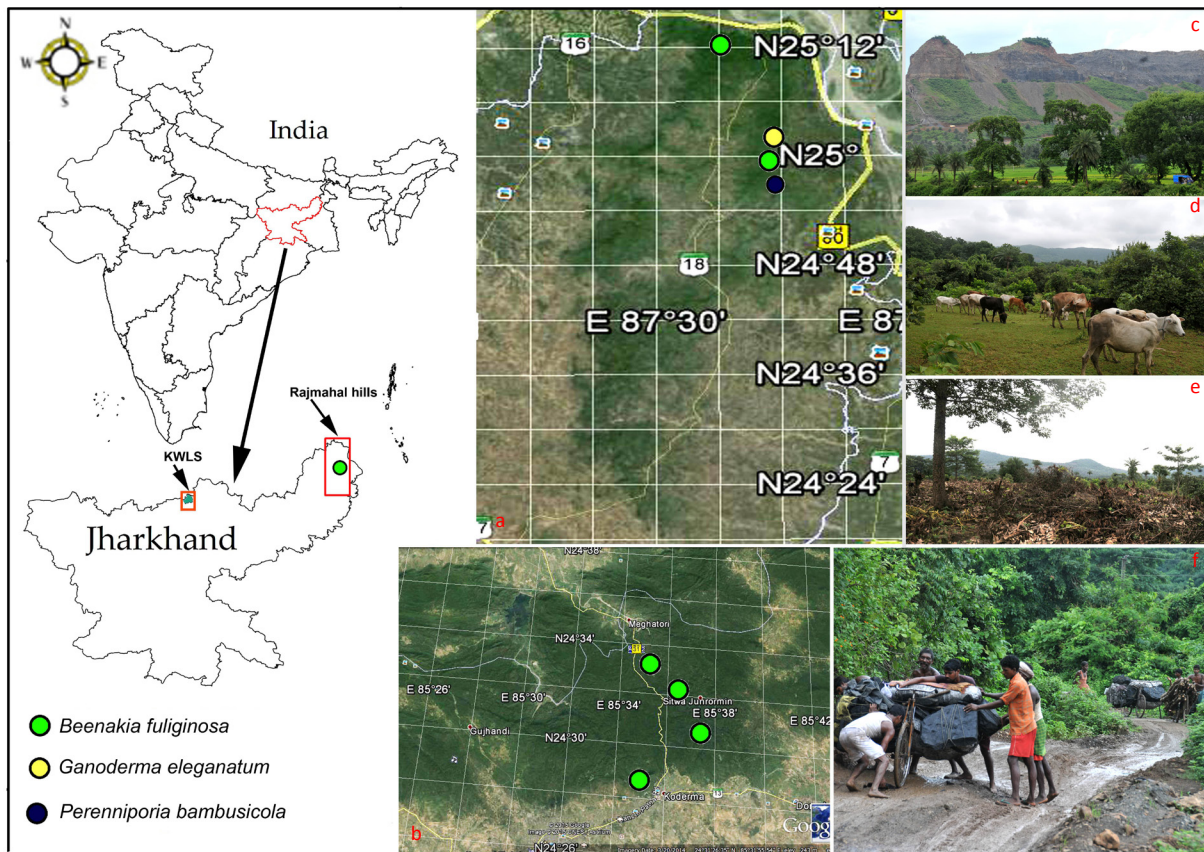


Figure 1. a - Google image of Rajmahal hills showing distribution of *Beenakia fuliginosa*, *Ganoderma elegnatum* and *Perenniporia bambusicola*; b - Google image of Koderma Wildlife Sanctuary showing distribution of *Beenakia fuliginosa*; c-f - Anthropogenic activities in the Rajmahal Hills causing habitat loss

Holmgren et al. (1990).

### Taxonomic enumeration

#### Clavariadelphaceae

*Beenakia fuliginosa* (Mass Geest.) Parmasto & Ryvar den, *Windahlia* 18: 39, 1990. (Image 1 & Fig. 2)

Basidiomata annual, 80–160 × 65–210 mm, substipitate to dimidiate, fused at base giving imbricate appearance. Pilear surface hispid to scrobiculate, small hairs agglutinated to form pyramidal shape, glabrous and smooth when dried, weakly zonate to azonate, concentrically sulcate, grayish-yellow (4B5–4B6). Margin sterile, obtuse, chalky white (A1) to pale red (10A3) or dull red (10B3) to mostly separated zones of dark green (28F8). Stipe very short, tapered at base to 50 mm long and 5–15 mm wide, covered with spines, chalky white when fresh, dark ochraceous when dried. Hymenophore hydroid, crowded with spines, chalky white to pale orange (5A3) to greyish orange (5B3) when fresh; spines 1–2 per mm, 2–10 mm long cylindrical, acute at tip; white mycelial mat spread throughout. Context 3–10 mm thick at base and gradually thinning towards the margin, soft

and spongy, dark fuscous zone, chalky white when fresh, pale ochraceous when dried.

Hyphal system monomitic. Generative hyphae thin-to thick-walled, branched, septate and clamped, a few flattened hyaline. Contextual hyphae 4–9 μm wide, thin-walled, smooth, highly interwoven. Subicular hyphae 2.5–6 μm wide, thick-walled, heavily granulate. Basidioles 15.5–23 × 5–6 μm, clavate, clamped at base, partially granulate. Basidia 14–26 × 5–7 μm, cylindrical to clavate, clamped at base, 4-sterigmate (sterigmata 2.5–6.3 μm). Basidiospores 5–6.55–8 × 4–4.52–5 μm, with Q = 1.2–1.45–2, pip shaped, verruculose, obliquely apiculate, adaxially flattened, one to three guttulate, hyaline to weakly cyanophilous and inamyloid.

**Specimens examined:** MEH-13-53 (CAL), 22.viii.2013, India, Jharkhand, Rajmahal Hills, Sahibganj District, Mandro block, Bheranda, 25°12'04.3"N & 87°36'49.4"E, 184m elevation, on living *Morus alba* trunk near base, coll. M.E. Hembrom; MEH-13-148 (CAL), 31.viii.2013, Taljhari block, Dhogada, 24°58'18.4"N & 87°40'24.1"E, 318m, on living cut stump of *Shorea robusta*, coll. M.E. Hembrom; 44905 (CAL), 03.ix.2010, Koderma Wildlife Sanctuary,

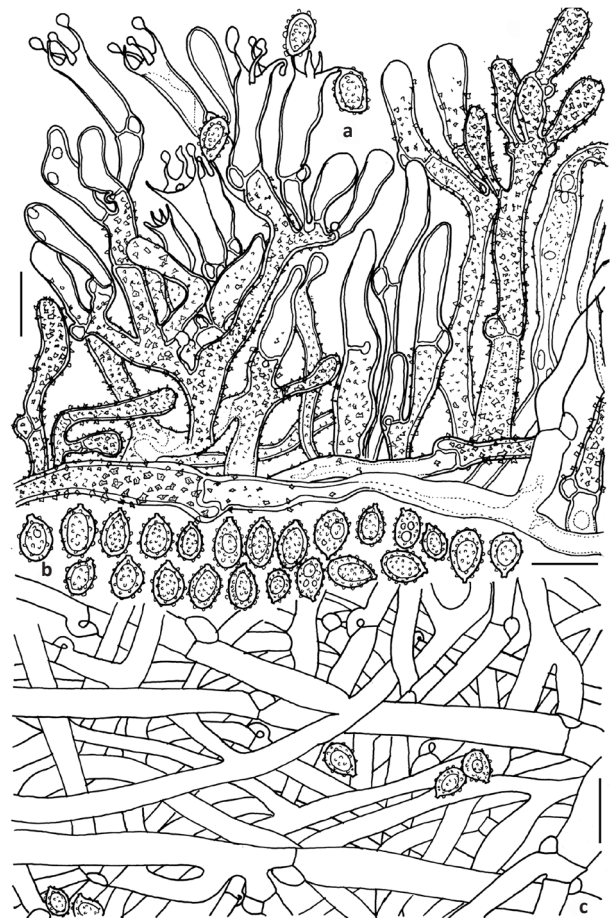
Mughalamaran, 24°30'59.70"N & 85°34'29.40"E, 392m, on living angiosperm shrub, coll. Arvind Parihar; 44930 (CAL), 06.ix.2010, Basraun, 24°33'48.90"N & 85°37'44.80"E, 372m, on living angiosperm shrub, Arvind Parihar; 44989 (CAL), 16.ix.2010, Koderma enclosure, 24°29'18.70"N & 85°35'50.10"E, 388m, on the base of a living angiosperm tree, coll. Arvind Parihar; 45027 (CAL), 45028 (CAL), 13.x.2011, Koderma NRF, 24°29'06.60"N & 85°35'49.80"E, 394m, on the base of a living angiosperm tree, coll. Arvind Parihar; 45099 (CAL), 19.x.2011, Chatarbar, 379m, 24°28'01.90"N & 85°32'13.10"E, on the base of a living angiosperm shrub, Arvind Parihar; 6646 (CAL), 6648 (CAL), 20.ix.2013, Chatarbar, 24°29'35.40"N & 85°36'13.50"E, 388m, on the base of a living angiosperm shrub, coll. Arvind Parihar; 6668 (CAL), 24.ix.2013, Khalakhtambhi, 24°28'24.10"N & 85°32'28.50"E, 378m, on the base of a living angiosperm shrub, coll. Arvind Parihar.

**Distribution:** Zambia; India, Tamil Nadu and Jharkhand (Rajmahal Hills & Koderma Wildlife Sanctuary).

**Notes:** Genus *Beenakia* includes those hydroid macro-fungi which bear macromorphological features like pileate, stipitate basidiomata with rounded, spinose hymenophore and micro-morphological features like septate clamped smooth to warted generative hyphae; clamped basidia and ellipsoid to pip-shaped or almost navicular ornamented, hyaline to yellowish, inamyloid basidiospores (Reid 1955; Cunningham 1958; Mass Geesteranus 1971; Parmasto & Ryvarden 1990; Nunez & Ryvarden 1994). In the family *Clavariadelphaceae* this genus presently holds seven valid species including *Beenakia fuliginosa* worldwide (www.index fungorum.org). The present species was erected by Mass-Geesteranus (1977) as *Psathyrodon fuliginosus* on the basis of basidiomata and spore colour, but after a critical study of type materials including Indian collections as well as re-collected materials from type locality on same substrate, it appears that these features are insufficient to raise *B. fuliginosa* as under new status by placing as *P. fuliginosus*. Hence *P. fuliginosus* becomes a synonym of *B. fuliginosa* (Parmasto & Ryvarden 1990).

This is an undocumented species in the regional and national mycoflora of India and so far only collected once from Tamil Nadu by Parmasto in 1979 (Parmasto & Ryvarden 1990). Its habitat is also interesting because it grows on the base of living stumps of *Shorea robusta* (as observed from present study); however, a few specimens were also found to grow on *Morus alba* L. and other trees and shrubs from the study areas.

Macro- and micro-morphologically, the present specimens are fairly within the circumscriptions provided



**Figure 2.** *Beenakia fuliginosa*. a - section through the hymenium showing basidia; basidioles, basidiospores and incrustation on subicular hyphae; b - basidiospores; c - interwoven hyphae in context; Scale bars: a-c = 10µm

by Parmasto & Ryvarden (1990) and Nunez & Ryvarden (1994) supported by the illustration of Mass-Geesteranus (1977); except the color of basidiomata (Pink), which may be due to geographical variation. Significant taxonomic features like monomitic clamped generative hyphae, which are thick-walled and granular in subiculum and pip shaped, verruculose, obliquely apiculate, adaxially flattened basidiospores associated with present specimens strongly recommends placing them as *B. fuliginosa*. Moreover, supplementary features of basidiospores as revealed from scanning electron microscopic (SEM) studies also agreed with that of Julich & Star (1983), and Parmasto & Ryvarden (1990).

#### Ganodermataceae

**Ganoderma elegantum** Ryvarden, *Syn. Fung.* (Oslo) 19: 81 (2004). (Image 2 & Fig. 3)

Basidiomata 40–58 mm high, annual, humicolous (perhaps attached to buried roots of bamboos), laterally



Image 1. *Beenakia fuliginosa*. a - habitat; b - stipitate habit of basidiomata; c- basidiomata showing pilear surface with scale.; d - basidiomata showing pilear surface and pore surface; e - hydroid hymenophore; f - teeth with scale; g - basidioles and basidiospores; h - basidia; i - basidiospores; j - SEM image of basidiospores; k - hyphal ends from teeth; scale bars: e = 5mm; g-i& k = 10µm; j = 5µm. © Arvind Parihar

stipitate, light weight. Pileus 15–20 × 12–17 mm and 8–10 mm thick near the stipe; surface indistinctly zonate in the middle while more distinct and sulcate towards the margin, glabrous, laccate, dark brown (7F6–7F7). Margin up to 0.5 mm wide, obtuse, distinct to indistinct from hymenial surface, sterile, concolourous with hymenophore. Pore surface pale yellow (4A3) to pale orange (5A3); pores 5–7 per mm, angular to rounded, white when fresh and ochraceous white at maturity. Stipe 40–45 mm long and 4–5 mm in diameter, cylindrical, bottleneck like near base, ring like zones in the stipe, laccate, glabrous, sulcate, and concolourous with pilear surface. Pilear context 1–5 mm thick, distinctly duplex, two black dense bands originating at the bottom of the stipe extended up to the pileus, upper part brown (6E5) and lower part dark brown (6F5); stipe context distinctly zonate, outer layer light brown, 1–2 mm thick and inner layer 2–3 mm thick, dark brown. Tubes 1–3 mm long, straight, paler than context.

Cuticle layer 20–50 µm thick, yellowish brown; cuticular cells 17–42 × 8–12 µm, thick-walled to solid, apically widened with a narrow lower part, smooth, apically amyloid. Hyphal system dimitic; generative hyphae 2.5–5 µm wide, thin-walled, clamped, branched, rare, smooth, hyaline. Skeletal hyphae 2.5–9 µm wide, thick-walled, wall 1–3 µm thick, abundant, arboriform, smooth, hyaline to yellowish-brown. Basidia and basidioles not found. Basidiospores 8–9.7–12 × 5.5–6.3–7.5 µm,  $Q=1.33-1.51-1.8$ , oblong ellipsoid, truncate or rounded at the apex, acyanophilic, inamyloid; exospores smooth and hyaline; endospore ornamented, brown.

**Specimens examined:** MEH-13-087 (CAL), 26.viii.2013, India, Jharkhand, Rajmahal Hills, Sahibganj District, Borio-block, Dalabari Village, 25°02'34.8"N & 87°39'55.3"E, 106m, on soil probably attached to buried bamboos root, near dead bamboo thickets, coll. M.E. Hembrom.

**Distribution:** Ecuador; India (Jharkhand, Rajmahal hills).

**Notes:** So far this species has been reported only from its type locality (Amazonas jungle in Ecuador confined to the neo-tropical belt) as mentioned by Ryvar den (2004) and this is the second collection from the paleo-tropical belt indicating its rare but wide range of distribution. Though the present description is based on two basidiomata collected from the Rajmahal Hills, Jharkhand, it holds enough macro- and micro-morphological features like long slender stipe, black melanoid bands in the pale brown context and oblong spores (Ryvar den 2004) to recognize the present collection as *Ganoderma elegantum*. The present specimens slightly differ as compared to type, in having apically rounded as well as truncate basidiospores ('apically rounded' in the protologue). The stipe is shorter



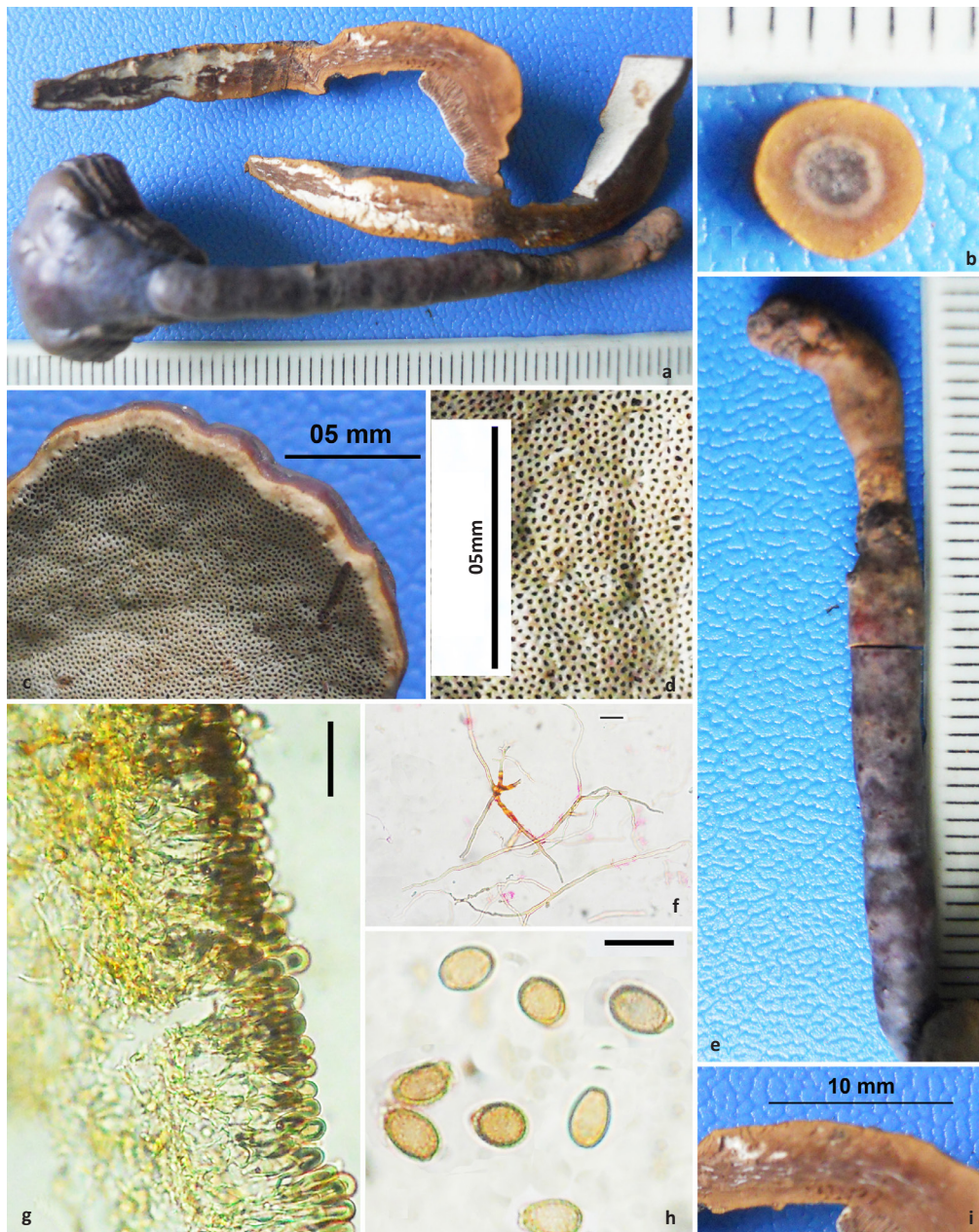
**Figure 3.** *Ganoderma elegantum*. a - cuticular cells; b - cuticular cells showing clamp at base; c - basidiospores; d - skeletal hyphae; e - clamped generative hyphae; Scale bars: a–e = 10µm

as compared to the type material (stipe is up to 150 mm long). Another taxon *G. stipitatum* Murill appeared to be allied due to a combination of characters like amyloid cuticular cells, duplex context separated by melanoid band (as Ryvar den 2004) but its short to almost negligible stipe, more club like and evenly widened cuticular cells and small basidiospores as compared to the present taxon (8–12 × 5.5–7.5 µm) separate it from the previous one. Tiwari et al. (2013) reported 17 species of *Ganoderma* from central India, but it excludes the present species.

#### Polyporaceae

*Perenniporia bambusicola* Choeyklin, T. Hatt. & E.B.G. Jones, *Fungal Diversity* 36: 122 (2009) (Image 3 & Fig. 4)

Basidiomata 3–55 × 2–25 mm and up to 0.5–1 mm thick, annual, resupinate, effused, corky when dried. Hymenophoreporoid to decurrent; pores 4–7 per mm, angular to round, deep orange (5A7) to light orange (5A5–5A4) when fresh and light orange (5A4) when

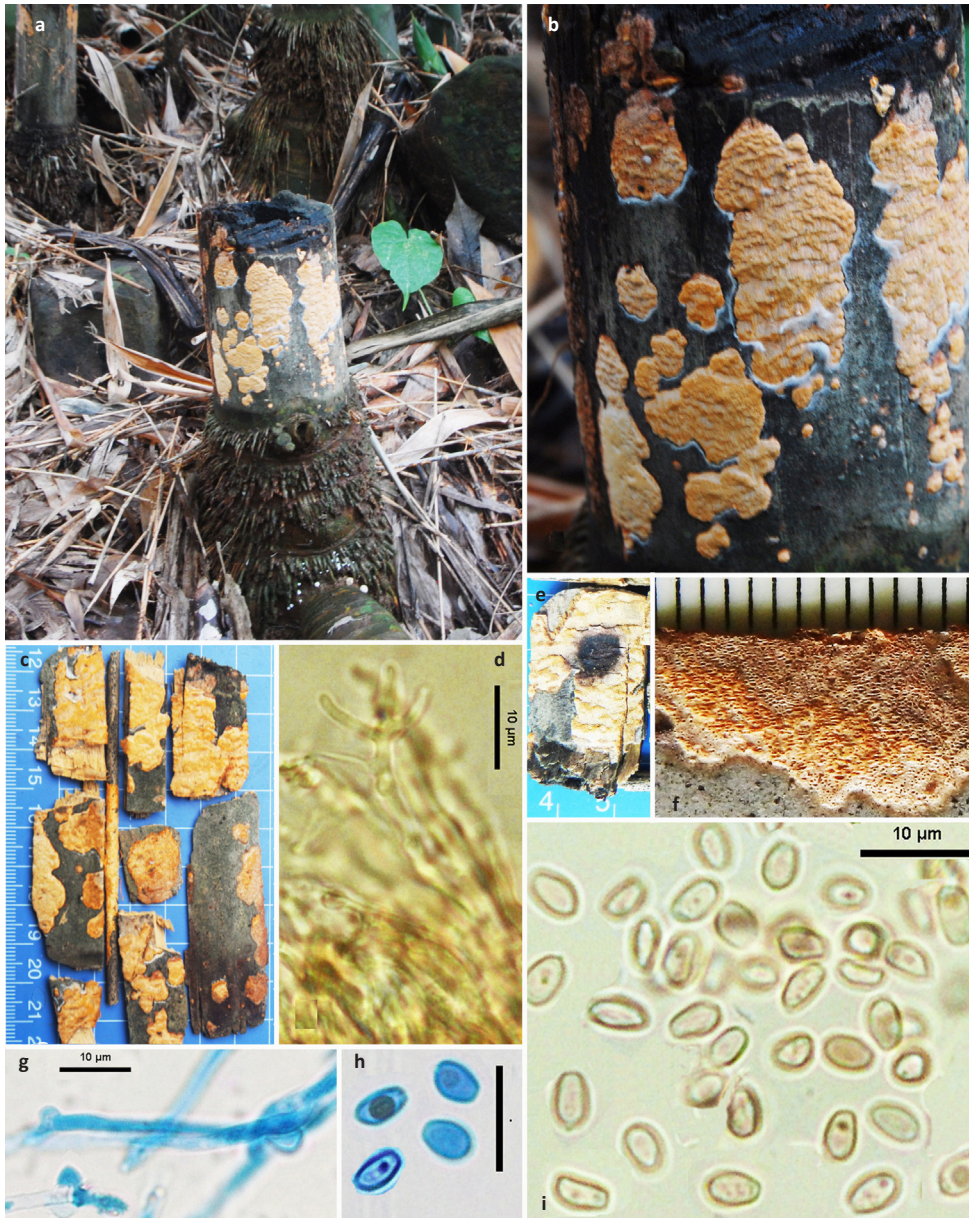


**Image 2.** *Ganoderma elgantum*. a - stipitate basidiomata with scale; b - section of stipe showing duplex context; c - basidiomata showing pore surface; d - pores with scale; e - stipe; f - arboriform skeletal hyphae; g - section showing cuticular cells; h - basidiospores; i - context. Scale bars: d = 5mm; f = 50µm; g&h = 10µm; i = 10mm. © M.E. Hembrom

dried; dissepiments thin and entire; violet to black with KOH. Margin indistinct, white mycelium present near periphery but disappear when dried. Subiculum very thin ochraceous to pale orange. Tubes tough-fibrous to leathery, decurrent, concolorous with hymenophore.

Hyphal system dimitic. Generative hyphae 1.5–3.5 µm wide, thin-walled, smooth, clamped, occasionally branched, infrequent in subiculum and tubes, hyaline. Skeletal hyphae 2.5–5 µm wide, thick-walled, wall up to 1µm thick, arboriform with stalk and side branches,

dominating in subiculum and tubes, interwoven but more or less parallel near substrate, crystalline particles present changing into violet colour with 10% KOH, hyaline to more or less dextrinoid when agglutinated. Fusoid cystidioles 16–27 × 3.5–5 µm, thin-walled, smooth, hyaline. Basidioles 12–13 × 5.5–7.5 µm, clamped at base, smooth, hyaline. Basidia 12–16 × 5–7 µm, 4-sterigmate, sterigmata 3–5 µm long, clamped at base, smooth, hyaline. Basidiospores 3.5–4.87–6 × 2.5–3.28–4 µm, Q = 1.21–1.49–2, oblong ellipsoid, truncate, thick-walled,



**Image 3.** *Perenniporia bambusicola*. a - habitat; b - resupinate habit of basidiomata; c - basidiomata with scale; d - skeletal hyphae from the hymenium; e - basidiomata turning black with KOH; f - poroid hymenophore; g - clamped generative hyphae; h - basidiospores showing cyanophilic reaction; i - weakly dextrinoid basidiospores; Scale bars: d = 10µm; g-i = 10µm. © M.E. Hembrom

smooth, hyaline, cyanophilic, weakly dextrinoid.

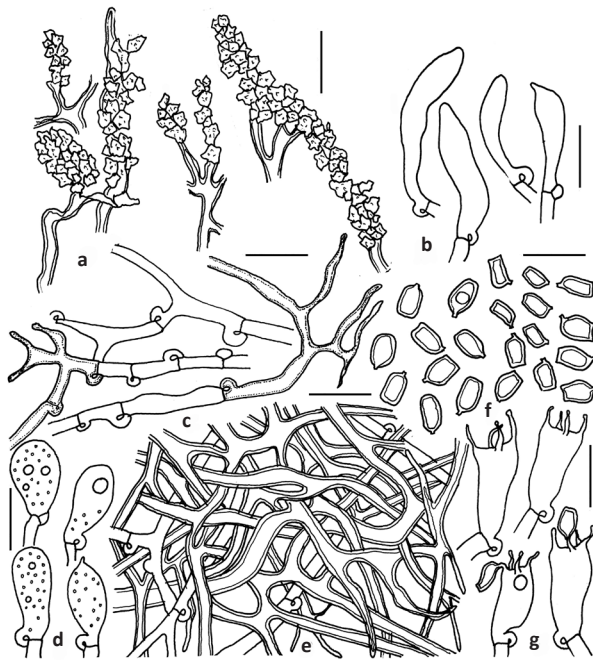
**Specimens examined:** MEH-66240 (CAL), 26.viii.2014, India, Jharkhand, Rajmahal Hills, Sahibganj District, Taljhari block, Paderkola Village Dhamdhamia, 60m, 24°55'57.0"N & 87°45'09.1"E, on dead bamboo-roots and fallen leaf litter of bamboos, coll. M.E. Hembrom.

**Distribution:** Thailand, China and India (Jharkhand, Rajmahal Hills).

**Notes:** Whereas the species' epithet itself indicates the present taxon's habitat (confined to bamboos exclusively), the habit shows (resupinate orange hymenophore which

turns into violet black with KOH) very characteristic and separating features from its close allies *Perenniporia corticola* (Corner) Decock and *P. xantha* Decock & Ryvarden. *Perenniporia xantha* can be demarked with the help of bright yellow hymenophore, arboriform skeletal hyphae and host asangiospermic wood (Decock & Ryvarden 1999; Zhao & Cui 2012) (never on bamboos). Its macro and microscopic characters are fairly within the range of type (Choeyklin et al. 2009) supported by the circumscription of Zhao & Cui (2012) except, its basidiospores, which are slightly larger than that of Zhao





**Figure 4.** *Perenniporia bambusicola*. a - skeletal hyphae with crystalline particles; b - fusoid cystidioles; c - clamped generative hyphae; d - basidioles; e - interwoven hyphae in the trama; f - basidiospores; g - basidia. Scale bars: a-g = 10 μm

& Cui (2012; 4–5.3 × 2.5–4 μm) but well agreeable with protologue (3.5–5.8 × 2.2–3.9 μm as Choeyklin et al. 2009) to determine it as *P. bambusicola*.

## DISCUSSION

Along with a large number of other fleshy fungi, the wood-rotting macrofungi face a serious threat from the high anthropogenic pressure causing habitat loss day by day due to mining, road construction, overgrazing, jhoom-cultivation and forest fires (Fig. 1). Species by species approach (for conservation) is not the realistic way in a poor country like India. Therefore, it is an exigency of conserving the habitats as such in a sustainable manner because livelihoods of the Santhal and Paharia tribes depend upon the forest (Rajmahal Hills) resources of these areas (Fig. 1). This approach will not only protect the species in discussion but also the large mycobiota of these areas will be conserved. So far no assessments have been done for wood-rotting mycobiota of these regions as per the recent IUCN categories of their occurrences, and hence more extensive surveys and ecological studies are needed to conserve the wood rotting fungi in the near future.

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ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

February 2016 | Vol. 8 | No. 2 | Pages: 8421–8540

Date of Publication: 26 February 2016 (Online & Print)

DOI: 10.11609/jott.2016.8.2.8421–8540

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#### Article

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-- Savita Sanjaykumar Rahangdale & Sanjaykumar Ramlal Rahangdale, Pp. 8421–8433

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-- Sateesh Suthari, Ramesh Kandagatla, Sarede Geetha, Ajmeera Ragan & Vatsavaya S. Raju, Pp. 8538–8540