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A new species of *Bondarzewia* from India

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Abstract: *Bondarzewia zonata*, collected from North Sikkim, is proposed here as new to science. It is characterized by basidiomata with strong zonate pilei, thin context turning persistent dark red with guaiacol, comparatively small spores with narrow ornamented ridges, and an absence of cystidioles. A detailed description coupled with macro- and micromorphological illustrations of this species is provided. Its relation to the allied species is discussed and a provisional key to the species of *Bondarzewia* is given.

Key words: Macrofungi, *Bondarzewia*, Russulales, new species, taxonomy, Sikkim

1. Introduction

The genus *Bondarzewia* was first described by Singer (1940). Presently, it accommodates subtropical (Dai et al., 2010) to temperate and wood-inhabiting parasitic (causing white rot) poroid macrofungi. Therefore, the genus *Bondarzewia* can be characterized as pileate stipitate to substipitate basidiocarps, with a dimitic hyphal system with ornamented and amyloid basidiospores (Donk, 1964, 1971; Stalpers, 1979; Ryvarden, 1991; Sharma, 2012). Redhead and Norvell (1993) added the presence of lactiferous hyphae in the circumscription of this genus and demonstrated its position near Russulaceae. Presently with 7 other genera (*Amylaria*, *Amylosporus*, *Gloiodon*, *Heterobasidion*, *Spiniger* (anamorphic *Heterobasidion*), *Stecchericium*, and *Wrightoporia*) it belongs to Bondarzewiaceae (Russulales) (Krik et al., 2010; www.indexfungorum.org). Microscopic characters that separate *Bondarzewia* and *Heterobasidion* from other genera are a dimitic hyphal system with simple septate generative hyphae, whereas dextrinoid skeletal hyphae separate *Heterobasidion* from *Bondarzewia*. Currently, *Bondarzewia* includes 4 species worldwide (www.indexfungroum.org), out of which 2 are reported from the Himalaya in India (Sharma, 2012). During a mycological survey of the underexplored northern district of Sikkim, recently being explored like other parts of the Himalaya in India (Das and Zhao, 2013; Das et al., 2013a, 2013b; Kumari and Atri, 2013; Kumari et al., 2013a, 2013b; Atri et al., 2014), 2 of the authors (KD and AP) collected an interesting species of *Bondarzewia* from a standing cut stump of *Picea*. After thorough macro- and micromorphological studies followed by a survey of the literature, it proved to be new to science. It is proposed as *Bondarzewia zonata* and described here in detail with illustrations. Its relation with closely related taxa is also discussed.

2. Materials and methods

A macrofungal survey in subalpine (2700–5000 m) forested areas was undertaken during monsoon season (July and August) in 2013. Macromorphological characterization was made with fresh basidiomata in the field or base camp. Field photographs of these fresh basidiomata and their habitats were taken with Nikon D300s and Olympus C-5060 cameras. Color codes and terms mostly follow the *Methuen Handbook of Colour* (Kornerup and Wanscher, 1978). After macromorphological characterization, the basidiomata were dried. Micromorphological characterization was done with the help of a light microscope (Olympus CX 41), using the free-hand sections of the dry basidiomata either mounted in lactophenol cotton blue and Melzer's reagent separately or treated in a mixture of 5% KOH, phloxine, and Congo red and then mounted in 30% glycerol. Spore measurements were made 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 Holmgren et al. (1990). Field emission scanning electron microscope (FESEM) illustrations of basidiospores were obtained from dry spores (spore print) that were directly mounted on a double-sided adhesive tape pasted on

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a metallic specimen stub and then scanned with gold coating at different magnifications in high vacuum mode to observe patterns of spore ornamentation. This work was carried out with an FEI Quanta FEG 250 model installed at the S.N. Bose National Centre for Basic Sciences in Kolkata, India.

3. Results

Bondarzewia zonata K. Das, A. Parihar & Hembrom **sp. nov**. (Figures 1 and 2)

MycoBank: MB 808064.

Etymology: Referring the strong zonate surface of the pileus.

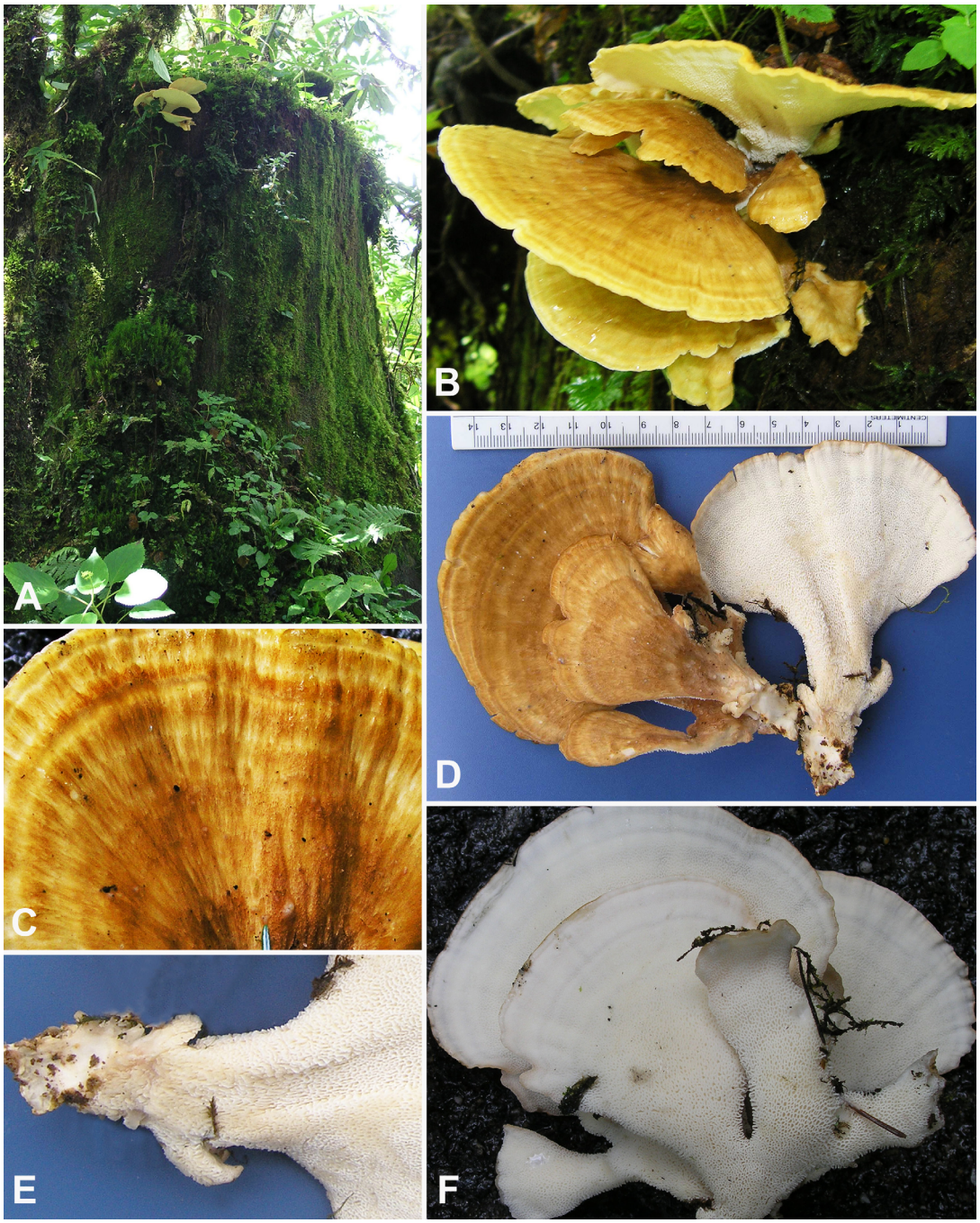

Figure 1. *Bondarzewia zonata* (from KD 13-011): A) Habitat showing cut stump of *Picea spinulosa*; B) basidiomata showing imbricate habit; C) zonations on pilear surface; D) dorsal and ventral surface of basidiomata; E) rudimentary stipe-like base; F) basidiomata showing many pilei arising from a common base.

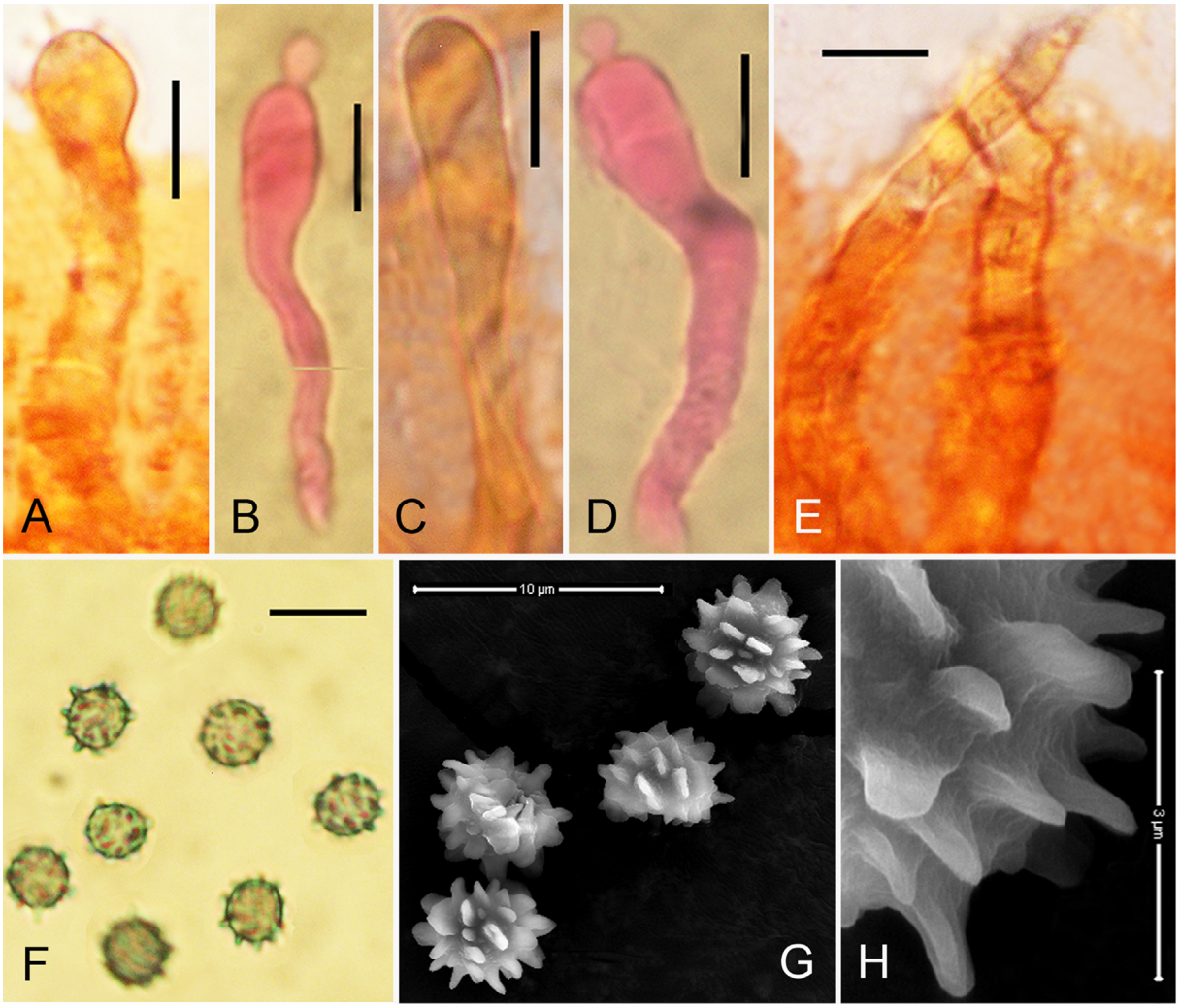

Figure 2. *Bondarzewia zonata* (from KD 13-011): A) Basidia; B–D) basidioles; E) lactiferous hyphae; F) basidiospores under light microscope; G) SEM micrographs of basidiospores showing ridges; H) SEM micrographs of basidiospores showing striations on ridges. Scale bars: A–G = 10 µm; H = 3 µm.

Holotype: India, North Sikkim, Dombang, altitude 2889 m, 27°43′42.1″N, 88°44′58.8″E, 23 July 2013, K. Das & A. Parihar, KD 13-011 (CAL 1152).

Basidiomata 32–110 × 18–95 mm in size, annual, pileate, imbricate with rudimentary stipe-like base, zonate, fan-shaped, narrow towards base; upper surface dry, glabrous, rough at the base, distinctly zonate, zones 5–10 mm in size, grayish-orange to golden yellow to brownish-orange (5B6–5B7, 5C5) at the base. Pore surface with round large to irregular pores becoming lamellate at the base, pores 2–3 per millimeter, yellowish-white, unchanging when bruised, turning pale yellow with $FeSO_4$ and salmon pink (8A4) and purplish-red (12E7–12D7) with gum guaiacol after some time. Pseudostipe 25–40 × 5–15 mm. Margin entire, sterile, concolorous with the pore surface. Context 4–5 mm thick, whitish cream, turning initially pale red (11A3) with guaiacol and later becoming dark red (10D8–10E8) persistently. Spore print yellowish-white (1A2).

Hyphal system dimitic; generative hyphae simple septate, thin-walled, hyaline, unbranched, to 4 µm wide in tramal region while branched, septate, thick-walled (wall up to 1 µm thick), hyaline with continuous to discontinuous lumen and up to 7 µm wide in context region. Skeletal hyphae thin- to thick-walled (wall up to 1.5 µm thick), hyaline, dominated in tramal region while thin- to thick-walled (wall 0.5–2.5 µm thick), solid or with a narrow continuous to discontinuous lumen up to 8 µm wide in context region. Cystidia or cystidioles absent; lactiferous hyphae present, lactiferous hyphae cylindrical, clavate, aseptate, cyanophilic, up to 6.5 µm wide. Basidia 19–32 × 5–9 µm, clavate to subclavate, 4-spored, septate at

Table. Comparative chart of *Bondarzewia zonata* sp. nov. and its allied species.

	B. berkeleyi	*B. mesenterica*	*B. podocarpi* (after Dai et al., 2010)	*B. zonata* sp. nov.
Habitat	Base of angiosperm tree belonging to Fagaceae	Base of *Pinus* tree; host-specific	On *Podocarpus*	On the cut stump of *Picea* (but not at base)
Stipe and pileus	Stipitate, stipe branched and lateral 40–100 × 30–50 mm, up to 80 mm thick; developing from underground sclerotium (Sharma, 2012)	Laterally stipitate, stipe branched; developing from underground sclerotium (Sharma, 2012)	Rudimentary stipe-like base; single pileate broadly attached; sclerotium absent	Many pilei arise from a single rudimentary base; sclerotium absent
Size of the pileus	200 × 150 × 30 mm (Sharma, 2012)	110 × 110 × 10 mm (Sharma, 2012)	70 × 90 × 20 mm (Dai et al., 2010)	32–110 × 18–95 × 4–5 mm
Pilear surface	Obscurely zonate with shades of brown	Azonate	Azonate	Distinctly zonate
Margin	Concolorous with pileus	Concolorous with pileus	White when fresh, becoming yellowish-brown when dry	Concolorous with pileus
Hymenophore	Pores circular to angular, 1–2 per millimeter, tan-colored (Sharma, 2012)	Pores angular, 1–3 per millimeter, cream-colored (Sharma, 2012)	Pores round to angular, 1–3 per millimeter, mostly 2 per millimeter, cream when fresh, yellowish-brown when dry	Pore round to irregular, becoming lamellate at the base, 2–3 per millimeter, yellowish-white, becoming pale yellow with $FeSO_4$ and salmon pink and purplish red after some time with guaiacol
Context	Up to 30 mm thick (Sharma, 2012)	Up to 10 mm thick (Sharma, 2012)	Up to 10 mm thick, pale buff and woody hard when dry	4–5 mm thick, whitish cream, becoming pale red to dark red with guaiacol
Tubes	1–2 mm deep (Sharma, 2012)	Up to 2 mm thick (Sharma, 2012)	Up to 2 mm long	Less than 2 mm, resinaceous
Cystidioles	Absent	Absent	Present, subulate, 20–23 × 6–6.5 µm	Absent
Basidia	Clavate, 40–50 × 8–14 µm (Sharma, 2012)	Broadly clavate, 40–50 × 8–14 µm (Sharma, 2012)	Clavate, 20–30 × 7.2–9 µm	Subclavate to clavate, 19–32 × 5–9 µm
Basidiospores	Globose to subglobose, 7–9 × 6–8 µm (Sharma, 2012)	Globose to subglobose, 6–8 × 5.5–7 µm (Sharma, 2012)	Subglobose to broadly ellipsoid, (5.3–)5.6–7.5(–8) µm	Globose to subglobose, 5– (5.8)–6.5 × 4.5– (5.25)–6 µm
Distribution (after Dai et al., 2010)	North temperate	North temperate	Tropical (China)	Subalpine (India)

the base, mostly embedded in hymenium. Basidiospores 5–(5.8)–6.5 × 4.5–(5.25)–6 µm, Q = 1–(1.1)–1.2, globose to subglobose, hyaline, ornamentation amyloid, composed of isolated narrow subconical to subspinoid or somewhat winged ridges of 1.2 µm high; under FESEM, each ridge further ornamented with subparallel to parallel striations.

Ecology: Rare in occurrence; grew on the cut stump (not on base) of *Picea spinulosa* (Griff.) A.Henry in the subalpine coniferous to mixed forests.

4. Discussion

Bondarzewia zonata is characterized by basidiomata with a few pilei that are fused to a rudimentary base, a strongly zonate pilear surface, context that turns persistent red with the application of guaiacol, the absence of cystidioles, small basidiospores with narrow ornamented ridges, and appearance on the cut stump of *Picea* (but not on the base of the tree) in subalpine forested areas. It resembles *B. podocarpi* Y.C.Dai & B. K. Cui (reported from tropical China, another Asian country) in the size of basidia and basidiospores, but the latter one differs macroscopically by showing basidiomata with a single pileus and an azonate pilear surface, and microscopically by the presence of cystidioles and strongly echinulate basidiospores. Moreover, *B. podocarpi* is a species of the tropical region of China living on *Podocarpus imbricatus* Blume (Podocarpaceae) (Dai et al., 2010). *Bondarzewia berkeleyi* (Fr.) Bondartsev & Singer (also known from India) differs from *B. zonata* by the large stipitate and clustered basidiomata with an underground sclerotium, growing mostly on the base of *Quercus* spp. (Sharma, 2012), and larger basidia (40–50 × 8–14 µm) and basidiospores (7–9 × 6–8 µm), as stated by Bessette et al. (1997). Other species known from India include *Bondarzewia mesenterica* (Shaeff.) Kreisel, which can be distinguished from the present species by purplish pilear surface, stipitate basidiocarps (Dai et al., 2010; Sharma, 2012), and larger basidia (40–50 × 8–14 µm) and basidiospores (6–8 × 5.5–7 µm) (Sharma, 2012). A detailed comparison of *Bondarzewia zonata* with its allied species is given in the Table. Considering the present species, the genus *Bondarzewia* has 5 species distributed in different parts of the world. Based on their striking macro- and micromorphological features, a key is given below to separate these species from each other.

4.1. A provisional key to the known species of *Bondarzewia*

1. Basidiomata with stipe; basidia always greater than 40 µm long 2

1a. Basidiomata without stipe (attached with rudimentary stipe-like base), basidia always less than 40 µm long 4

2. Basidiomata with larger pores (up to 1 per millimeter), on *Nothophagus* ..... *B. guaitecasensis*

2a. Basidiomata with smaller pores (2–3 per millimeter), at the base of coniferous trees or angiosperm trees belonging to the family Fagaceae 3

3. Basidiomata with large imbricate clusters, pilear surface ochraceous brown, at the base of hardwoods especially, on *Quercus* spp. ..... *B. berkeleyi*

3a. Basidiomata mostly single or few pilei from a common stipe, pilear surface purplish brown, at the base of conifer tree ..... *B. mesenterica*

4. Basidiomata single or imbricate, pilear surface azonate, context comparatively thick (up to 10 mm), cystidioles present, basidiospores strongly echinulate, tropical species ..... *B. podocarpi*

4a. Basidiomata always imbricate, never single, many pilei arise from a common base, pilear surface strongly zonate, context comparatively thin (4–5 mm), cystidioles absent, basidiospores never echinulate, subalpine species ..... *B. zonata*

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