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Polyporoid Fungi from Himachal Pradesh - Five New Additions

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ABSTRACT

Five polyporoid species i.e., *Fomes dahlii* Henn., *Ganoderma ahmadii* Steyaert, *G. orbiforme* (Fr.) Ryvarden, *G. sinense* J.D. Zhao, L.W. Hsu and X.Q. Zhang, and *G. tsugae* Murrill are described as new to Himachal Pradesh (India). It is pertinent to mention that *G. tsugae* is also a new record for India.

Keywords: *Polyporaceae*, Root parasite, *Ganodermataceae*, Mushroom, White rot

INTRODUCTION

Polyporoid fungi are a large group of fungi belonging to the class *Agaricomycetes* of phylum *Basidiomycota*. These are characterized by macroscopic basidiocarps with poroid hymenophore. The basidiocarps range from resupinate or effused reflexed to distinctly pileate. The pileate forms differ from gilled mushrooms in terms of their texture, which can range from corky and leathery to tough or even woody. Traditional mycologists classified majority of the polypores into a common family *Polyporaceae* and placed it under order *Aphyllophorales* (Hawksworth *et al*., 1983). However, with recent advancements in the field of DNA sequence-based phylogenetic studies, this assemblage has been rejected and polypores have been distributed in several orders and families within *Agaricomycetes* (Kirk *et al*., 2008). The taxonomic position of polypore species keeps on changing on the basis of DNA sequence-based molecular phylogenetic studies made from different parts of the world. In the present studies, the taxonomic status of the described species has been followed as per Mycobank (2023). These fungi have been associated with different kinds of rot of tree species (Floudas *et al*., 2012) which makes them a distinct group of research especially in the fields of forest ecology and conservation. The mycelium and basidiocarps of polypores have also been reported to possess various therapeutic properties such as anti-inflammatory (Park *et al*., 2004; Kim *et al*., 2019), anticancer (Kim *et al*., 2015; Ravikumar *et al*., 2021) and immunostimulant (Ramberg, 2010; Zhang *et al*., 2022). The basidiocarps of different species of the genus *Ganoderma* have been used in the traditional medicinal system practised in many Asian countries (Bishop *et al*., 2015). The presence of different bioactive compounds, such as polysaccharides, terpenoids, steroids, phenolic compounds, etc., in the basidiocarps of *Ganoderma* species is responsible for various pharmacological properties (Paterson, 2006). The studies on diversity of the polyporoid fungi will enrich the research work on evaluation of these medicinally important fungi for novel bioactive compounds.

Himachal Pradesh, the state of snow-laden mountains, is bestowed with varied altitude range, forest types and climate. The vegetation of Himachal Pradesh is quite diverse and includes tropical, sub-tropical, temperate, sub-alpine and alpine species. The polyporoid fungi have the ability to grow in association with both coniferous and broad-leaved tree species. The variation in altitude, climate and vegetation type provides an ideally suitable set of conditions for the growth of polypores all over the state. Hence, Himachal Pradesh was selected as the area of present investigations. During the years 2021-22, comprehensive field trips were conducted in various parts of study area for the collection of polypore specimens. These were studied for their morphological details and were identified as *Fomes dahlii* Henn., *Ganoderma ahmadii* Steyaert, *G. orbiforme* **(**Fr.) Ryvarden, *G. sinense* J.D. Zhao, L.W. Hsu and X.Q. Zhang, and *G. tsugae* Murrill. It is worth mentioning that all five of the described species are new to Himachal Pradesh, with *G. tsugae* also being new to India.

MATERIAL AND METHODS

The basidiocarp specimens of polyporoid fungi were collected from different localities of Himachal Pradesh during the field surveys conducted in the rainy months of years 2021-2022. Macroscopic characters such as nature and texture of the basidiocarp, nature and colour of abhymenial/hymenial surface and margin were noted in the field. The colour standards have been cited as per Kornerup and Wanscher (1978). Photographs of the basidiocarps were clicked in the field with special focus on the pilear surface, hymenophore and margins. Spore prints of the collected specimens were taken by placing a piece

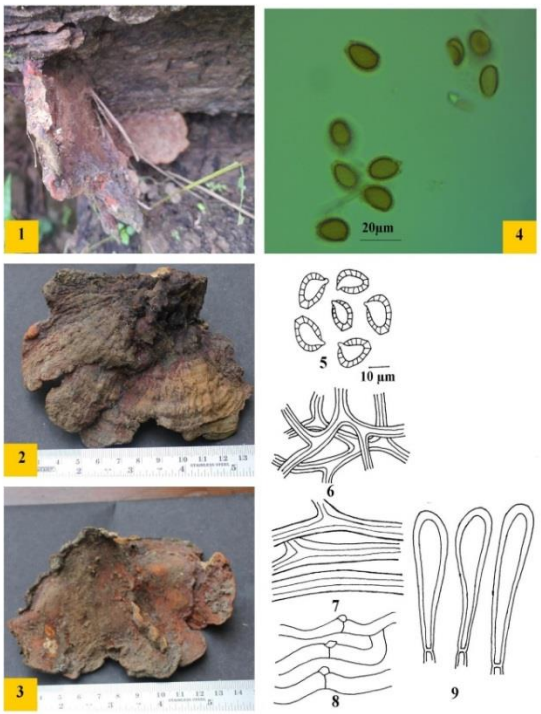
of basidiocarp with well-developed hymenophore on a glass slide kept on a black chart paper. The specimens were dried either in sun or using a portable electric drier. The microscopic features of the collected specimens were studied by making crush mount/free hand cut section preparations in water, 3%/5%/10% KOH solution, 1% Congo red in water, 1% Cotton blue in lactophenol and Melzer's reagent (0.5 gm Iodine + 1.5 gm KI + 20 gm Chloral hydrate + 20 ml distilled water). Microscopic characters such as the types of hyphae, sterile structures, basidia and basidiospores were studied using a compound microscope under different magnifications (100X, 400X, and 1000X). The outline of microscopic details was drawn with the help of camera lucida mounted on the compound microscope. The identified specimens were deposited in the Herbarium, Department of Botany, Punjabi University, Patiala (PUN).

TAXONOMIC DESCRIPTIONS

Fomes dahlii Henn., *Botanische Jahrbücher für Systematik Pflanzengeschichte und Pflanzengeographie*, **25**: 499 (1898). **Figures 1-9**

Basidiocarp annual, pileate, sessile, corky to woody, solitary; pileus flabelliform, up to 9×7×1 cm; abhymenial surface laccate, concentrically zonate and radially rugose, chestnut brown to blackish brown when fresh, no significant change after drying; hymenial surface poroid, sordid brown to brown when fresh, no significant change after drying; pores suborbicular, 5-7 per mm; dissepiments thin, entire; pore tubes up to 6 mm long, light brown; context up to 4 mm thick, reddish brown, homogeneous; margin acute, lobate, irregular, concolorous on both abhymenial and hymenial surface and sterile up to 1.5 mm on hymenial surface. **Pilear crust** irregular hymenioderm; cuticular elements 40-46.8 × 9.3-10.9 µm, subclavate to clavate, thick-walled, yellowish brown to brown. **Hyphal system** trimitic; generative hyphae up to 4.7 µm wide, hyaline, thin-walled, septate, clamped, branched; skeleto-binding hyphae up to 6 µm wide, thick-walled to almost solid, branched, aseptate, brownish to brown; binding hyphae up to 4 µm wide, subhyaline, thick-walled, irregularly branched. **Basidia** not observed. **Basidiospores** 9-11 × 6.2-7.8 µm, ovoid to broadly ovoid, truncate at apex, bitunicate; exospore thin, hyaline, smooth; endospore thick, brown, echinulate with long and thick markings; inamyloid, acyanophilous.

Collection examined: Himachal Pradesh, Kangra, Baijnath, on angiospermous logs, Hardesh 12038 **(PUN)**, 30 October, 2021.



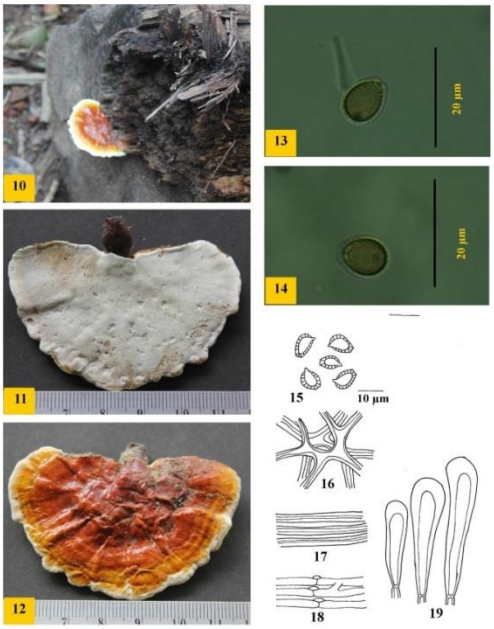
Figures 1-9: *Fomes dahlii* 1, Basidiocarp attached with the substrate; 2, Basidiocarp showing abhymenial surface; 3, Basidiocarp showing hymenial surface; 4. Photomicrograph showing basidiospores; 5, Basidiospores; 6, Binding hyphae; 7, Skeleto-binding hyphae; 8, Generative hyphae; 9, Cuticular elements.

Remarks: This species is characteristic in having laccate pilear surface that is usually chestnut brown to blackish brown, concentrically zonate and radially rugose. Earlier it was described by Kaur *et al*. (2023) from Union Territory of Chandigarh. It is a new record for Himachal Pradesh.

Ganoderma ahmadii Steyaert, *Persoonia*, **7(1)**:91 (1972). **Figures 10-19**

Basidiocarps annual, pileate, stipitate, corky when fresh, woody on drying; pileus suborbicular or subflabelliform, up to 5.5×3.5×0.3 cm; abhymenial surface weakly laccate, zonate towards the margins, slightly concave or somewhat subinfundibuliiform in the centre, rugulose, pale orange to greyish orange to brownish red to violet brown when fresh, orange white to brownish orange to reddish brown to violet brown after drying; hymenial surface poroid, greyish brown to brown when fresh, brown to dark brown on drying; pores suborbicular, 5-6 per mm; dissepiments thin, entire; pore tubes short, not more than 1mm long, greyish brown; context up to 2 mm thick, fibrous, soft, homogenous, dark brown; margin acute, somewhat wavy to irregular, concolorous on the abhymenial side; violet brown, and sterile up to 5 mm on the hymenial side; stipe subcentral to lateral, subcylindric to subcomplanate, 1.5 cm long, 0.5 cm thick, strongly

laccate. **Pilear crust** hymenioderm; cuticular elements 35.3-57.7 × 8.7-13.6 µm, thick-walled, irregular, brown, clavate. **Hyphal system** trimitic; generative hyphae up to 3.4 µm wide, subhyaline, thin-walled, branched, septate, clamped; skeletal hyphae up to 4.0 µm wide, aseptate, thick-walled to solid, faintly brown to brownish; binding hyphae up to 3.7 µm wide, much branched, aseptate, thick-walled, subhyaline; **Basidia** not observed, **Basidiospores** 7.5-10 × 5.3-7.1 µm, ellipsoid to ovoid, bitunicate; exospore thin, hyaline, smooth; endospore thick, brown, distinctly echinulate with long and thick markings; inamyloid, acyanophilous.



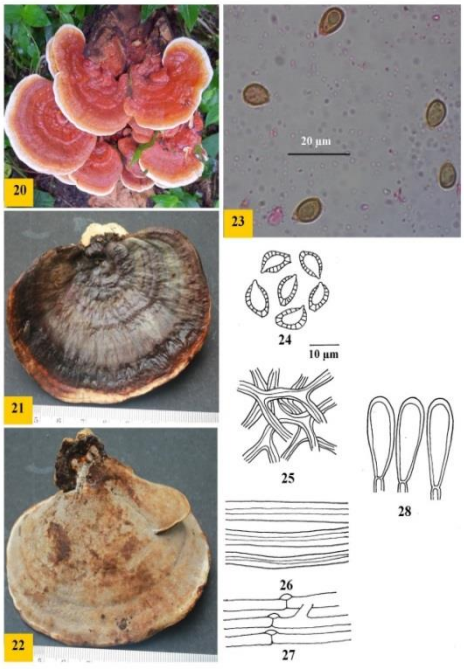
Figures 10-19: *Ganoderma ahmadii*. 10, Basidiocarp attached with the substrate; 11, Basidiocarp showing abhymenial surface; 12, Basidiocarp showing hymenial surface; 13-14, Photomicrograph showing basidiospores; 15, Basidiospores; 16, Binding hyphae; 17, Skeletal hyphae; 18, Generative hyphae; 19, Cuticular elements.

Collection examined: Himachal Pradesh, Hamirpur, Kangoo, Nara, on the logs of *Mangifera indica*, Hardesh 12037 **(PUN)**, 11 September 2022.

Remarks: This species is characterised by subflabelliform, weakly laccate pileus that is slightly concave in the centre. In India, it has been earlier recorded from Maharashtra (Ranadive, 2013) and Uttarakhand (Sharma, 2012; Singh, 2016; Manoharachary *et al*., 2022) and West Bengal (Manoharachary *et al*., 2022).

Ganoderma orbiforme **(**Fr.) Ryvarden, *Mycologia*, **92(1)**:187 (2000). **Figures 20-28**

Basidiocarps perennial with narrow stipe like base, corky to woody; pileus suborbicular, subflabelliform to choncate, up to 8×6×1 cm; abhymenial surface laccate, distinctly concentrically zonate, radially rugose, greyish orange to brownish red to reddish brown when fresh, greyish brown to blackish brown on drying; hymenial surface poroid, yellowish white to pale yellow when fresh, greyish yellow when dry; pores suborbicular, 4-6 per mm; dissepiments thin, entire; pore tubes up to 7 mm long, indistinctly stratified, brown; context up to 3 mm thick; brown, homogenous; margin obtuse, incurved, entire to somewhat wavy to irregular, yellowish brown on the abhymenial side; greyish white and sterile up to 4 mm on the hymenial side. **Pilear crust** hymenioderm; cuticular elements 25.4-28 × 8.7-9.3 µm, thick-walled, yellowish brown, clavate. **Hyphal system** trimitic; generative hyphae up to 4.3 µm wide, subhyaline, thin-walled, septate, clamped; skeletal hyphae up to 6.2 µm wide, thick-walled to solid, aseptate, light-brown to brown; binding hyphae 3.4 µm wide, much branched, thick-walled, subhyaline. **Basidia** not observed. **Basidiospores** 9-11 × 5.5-7.5 µm, ovoid, bitunicate; exospore thin, hyaline, smooth; endospore thick, nearly colourless to brownish, echinulate**,** with long and thick markings; inamyloid, acyanophilous.



Figures 20-28. *Ganoderma orbiforme*. 20, Basidiocarp attached with the substrate; 21, Basidiocarp showing abhymenial surface; 22, Basidiocarp showing hymenial surface; 23, Photomicrograph showing basidiospores; 24, Basidiospores; 25, Binding hyphae; 26, Skeletal hyphae; 27, Generative hyphae; 28, Cuticular elements.

Collection examined: Himachal Pradesh, Kangra, Dharamshala, Tea Garden, on the log of some gymnosperm, Hardesh 12039 **(PUN)**, 24 July 2022.

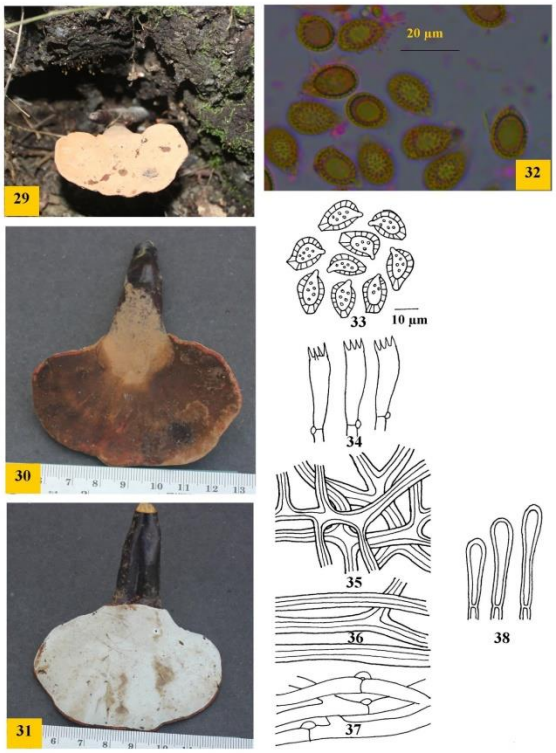
Remarks: *Ganoderma orbiforme* is characterised by shortly stipitate, laccate, brown to blackish brown or black pilei. Foroutan and Vaidya (2007) described it first from India from Maharashtra and was subsequently listed/described by Bhosle *et al*., (2010), Ranadive *et al*., (2011), Ranadive (2013) from Maharashtra and Singh (2016) from Uttarakhand.

Ganoderma sinense J.D. Zhao, L.W. Hsu and X.Q. Zhang, *Acta Mycologica Sinica*, **19**:272 (1979). **Figures 29-38**

Basidiocarps annual, pileate, stipitate, corky to woody; pileus dimidiate, suborbicular to subcochleariform, 6.5×4.5×0.8 cm; abhymenial surface laccate, somewhat concentrically sulcate and radially rugose, purplish black to blackish, or purplish brown when fresh, no significant change when dry; hymenial surface poroid, yellowish white to greyish brown when fresh, greyish orange to greyish brown on drying; pores round to angular, 5-6 per mm; dissepiments thin, entire; pore tubes up to 4 mm long, greyish brown; context up to 4 mm thick, fibrous, soft, uniformly brown, homogenous; margin obtuse, slightly revolute, irregular, thick, concolorous on both abhymenial and hymenial surfaces, sterile up to 1.5 mm on hymenial surface; stipe dorsolateral, cylindrical, up to 20×1.5 cm , deeply laccate. **Pilear crust** hymenioderm; cuticular elements 18.5-28.5 × 4.5-6 µm, thick-walled, apex inflated, smooth, yellowish brown, clavate. **Hyphal system** trimitic; generative hyphae up to 4.6 µm wide, branched, septate, clamped, thin-walled, subhyaline; skeleto-binding hyphae light brown to brown, thick-walled to solid, up to 5.3 µm wide; binding hyphae up to 5 µm wide, much branched, aseptate, thick-walled, subhyaline. **Basidia** clavate, 19.5-21.5 × 4.5-5.6 µm, tetrasterigmate, with basal clamp; sterigmata up to 3.7 µm in length. **Basidiospores** 9.5-12 × 5.5-7.5 µm, ovoid, slightly truncate at apex, bitunicate; exospore thin, hyaline, smooth; endospore thick, brownish, echinulate, with long and thick markings; inamyloid, acyanophilous.

Collection examined: Himachal Pradesh, Mandi, Gohar, Sayoj, on root of stump of *Quercus leucotrichophora,* Hardesh 12040 **(PUN)**, 03 October 2021.

Remarks: This species is characterised by purplish black to purplish brown pileus; uniformly brown context and dorsolateral, comparatively long stipe. Earlier this has been reported by Singh (2016) from Uttarakhand.

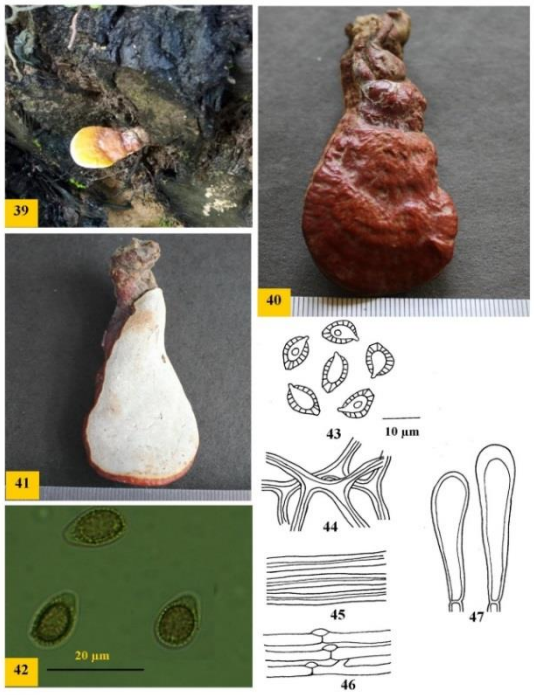


Figures 29-38: *Ganoderma sinense*. 29, Basidiocarp attached with the substrate; 30, Basidiocarp showing abhymenial surface; 31, Basidiocarp showing hymenial surface; 32, Photomicrograph showing basidiospores; 33, Basidiospores; 34, Basidia; 35, Binding hyphae; 36, Skeleto-binding hyphae; 37, Generative hyphae; 38, Cuticular elements.

Ganoderma tsugae Murrill, *Bulletin of the Torrey Botanical Club*, **29**:601 (1902). **Figures 39-47**

Basidiocarps annual, pileate, stipitate, corky to woody; pileus subflabelliform, up to 3.5×4×1 cm; abhymenial surface laccate, indistinctly zonate, pale orange to purplish brown when fresh, reddish brown on drying; hymenial surface poroid, greyish white when fresh, greyish brown on drying; pores round to angular, 4-5 per mm; dissepiments thin, entire; pore tubes up to 5 mm long, greyish brown; context up to 5 mm thick, homogenous, brown; margin obtuse, entire, concolorous on the abhymenial side; reddish brown, sterile up to 3 mm on the hymenial surface; stipe thick and short, lateral, up to 3.5 × 1.5 cm, purplish black, strongly laccate. **Pilear crust** hymenioderm; cuticular elements 36.5-44 × 6.2-10.2 µm, clavate. **Hyphal system** trimitic; generative hyphae up to 3.4 µm wide, branched, septate, clamped, thin-walled, subhyaline; skeletal hyphae up to 4.0 µm wide, aseptate, thick-walled to solid, light brown to brown; binding hyphae up to 3.1 µm wide, thick-walled, branched, subhyaline. **Basidia** not observed. **Basidiospores** 9.3-10.8 × 6.2-7.5 µm, ovoid, truncate at the apex, bitunicate; exospore thin, hyaline, smooth; endospore thick, brownish,

echinulate, with long and thick markings; inamyloid, acyanophilous.



Figures 39-47: *Ganoderma tsugae*: 39, Basidiocarp attached with the substrate; 40, Basidiocarp showing abhymenial surface; 41, Basidiocarp showing hymenial surface; 42, Photomicrograph showing basidiospores; 43, Basidiospores; 44, Binding hyphae; 45, Skeletal hyphae; 46, Generative hyphae; 47, Cuticular elements.

Collection examined: Himachal Pradesh, Kangra, Bir, on the stump of *Quercus leucotrichophora,* Hardesh 12041 **(PUN)**, 28 September 2022.

Remarks: *Ganoderma tsugae* is characterised by laccate pilear surface, homogenous context and strongly laccate stipe. It is distributed in Canada, North America, China and Japan (Gilbertson and Ryvarden, 1986; ji-Ding, 1989; Mycobank, 2023). It is being described for the first time from India.

CONCLUSIONS

Genus *Ganoderma* and *Fomes* have been earlier reported from Himachal Pradesh, with their 22 species and 2 species respectively (Manoharachary *et al*., 2022 and Kaur *et al*., 2023). During the course of present studies, *Ganoderma tsugae* is described as new to India. In addition to this, four polyporoid species i.e. *Fomes dahlii, Ganoderma ahmadii*, *G. orbiforme* and *G. sinense* are described as new to Himachal Pradesh.

The introduction of new records to the diversity of genus *Ganoderma* and *Fomes* will further enhance the understanding of distributional pattern and host diversity of polyporoid fungi from Himachal Pradesh. In context with the medicinal activities of polyporoid fungi, most of the previous studies were centred on *Ganoderma lucidum*. The newly described records of genus *Ganoderma* and *Fomes* could be further be explored for their medicinal properties and novel bioactive compounds.

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