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SOME ADDITIONS TO THE DIVERSITY OF GENUS *PHELLINUS* QUÉL. FROM WOOD ROTTING FUNGAL FLORA OF DISTRICT DEHRADUN (UTTARAKHAND), INDIA.

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ABSTRACT: Dehradun is an important district of Uttarakhand with large forest cover and has a vast diversity of wood rotting fungi. This paper highlights 4 new records of genus *Phellinus* Quél. (*P. merrillii*, *P. nigricans*, *P. pini* and *P. pullus*) based on 25 collections made from district Dehradun, Uttarakhand, India which spread over 5 different species. Of these 5 species, *P. pullus* is a new addition to Indian mycota. *P. nigricans* and *P. pullus* are valuable additions to the total count of *Phellinus* diversity of Uttarakhand. Photographs, drawings, detailed descriptions and information about locality of the taxa are given.

KEYWORDS: *Basidiomycota*; India; *Phellinus*; Sporophores; Uttarakhand.

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1. INTRODUCTION

The genus *Phellinus* Quél. (*Hymenochaetaceae*, *Hymenochaetales*, *Agaricomycetes*, *Agaricomycotina* and *Basidiomycota*) is cosmopolitan in its distribution. There are 180 species of *Phellinus* worldwide according to "The Dictionary of Fungi" [1] and this number has reached to 306 [2]. The earlier workers reported 107 species of this genus from India including 42 records from Uttarakhand and 19 from district Dehradun. The species of this genus are characterized by resupinate to effused to reflexed to pileate, sessile, annual to perennial and solitary to imbricate sporophores. Pilear surface is light brown to dark brown to black, tomentose or velutinate or scrupose or rimose, concentrically zonate to azonate and crustose with age. Hymenial surface is poroid, light brown to dark brown to

reddish brown and with round to angular to daedaloid pores. Context is homogeneous to duplex. Tube layers usually stratified. Hyphal system is dimitic. Generative hyphae are subhyaline to pale yellow, simple septate, thin- to thick-walled and branched. Skeletal hyphae are golden yellow to golden brown, aseptate, thick-walled and occasionally branched. Setal hyphae/setae present or absent. Setae if present are dark brown to rusty brown, ventricose to subventricose to subulate, acuminate and darkening in KOH solution. Setal hyphae when present are extremely long and vary in width. Basidia are subhyaline to pale yellow, clavate and four sterigmate. Basidiospores are subhyaline to golden yellow to golden brown, ellipsoid to broadly ellipsoid to subglobose to globose, smooth, thin-to thick-walled, inamyloid, acyanophilous to weakly cyanophilous to cyanophilous. The present work was taken keeping in view the large forest cover and need of more exploration of *Phellinus* diversity from district Dehradun. An identification key, detailed descriptions (Figures1–2), distribution pattern (Map-I) and host diversity (Figures 6–9) of 5 species of *Phellinus* is being provided in the present context.

2. MATERIALS AND METHODS

Phellinus species occur as parasites or saprophytes on a wide range of dead and living angiosperms and gymnosperms wood and are lignicolous. The field characters of collections belonging to this genus are brown, woody hard sporophores giving positive xanthochroic reaction (turning permanently black on KOH application).

2.1. MACROSCOPY

Morphological details regarding dimensions, color, consistency of pilear and hymenial surface and margins were observed. The dimensions, color characteristics, type of context and tube layers were also observed. For color standards Methuen's Handbook of colors was used [3]. Spore prints of the collected specimen were also taken. The sporophores were either dried in the sun or with electric drier at 40– 45°C.

2.2. MICROSCOPY

Microscopic details of the collections pertaining to type, color, dimensions of hyphae, basidia, basidiospores, setae and setal hyphae were observed by making crush mounts and cutting free hand sections in water as well as 3%, /5% and 10% KOH solutions followed by their staining in 1% Phloxine and 1% Congo red. The color reactions (amyloid/dextrinoid and cyanophilous) of various structures were observed using Melzer's reagent (0.5 g Iodine, 1.5 g Potassium iodide, 20 g chloral hydrate and 20 mL distilled water) and 1% cotton blue in lactophenol respectively. Details of microscopic structures were drawn under compound light microscope at different magnifications 10x × 10x, 10x × 40x, 10x × 100x (oil immersion lens) and camera lucida. A detailed description pertaining to macroscopy and microscopy of each specimen was made followed by comparison of these details with published literature/physical comparison with the type material. The collections were then kept in cellophane packets/zip lock polythene with 1, 3-Dichlorobenzene crystals and after

assigning herbarium numbers with the abbreviation PUN these were submitted at the herbarium of Department of Botany, Punjabi University, Patiala.

3. RESULTS AND DISCUSSION

The present investigation provides valuable information regarding 4 first reports of *Phellinus*(*P. merrillii*, *P. nigricans*, *P. pini* and *P. pullus*)based on 25 collections belonging to 5 species from district Dehradun, Uttarakhand, India. Of these 4 species, *P. pullus* is a first report for India and *P. pullus* and *P. nigricans* are new records for Uttarakhand.

Key to *Phellinus* species

1. Setae present.....2
1. Setae absent.....3
2. In association with species of *Pinus*, pores 1–3 per mm…….....….*P. pini*
2. In association with species of *Betula*, pores 8–9 per mm…….....***P. nigricans***
3. Context duplex…….....***P. pullus****
3. Context homogeneous…….....4
4. Sporophore imbricate, margins acute, pores 5–7 per mm pore tubes ≤58 mm deep.....*P. allardii*
4. Sporophore solitary, margins obtuse, pores 7–8 per mm, pore tubes ≤5.5 mm deep.....*P. merrillii*

* = New to India; Highlighted in bold = New to Uttarakhand

1. *Phellinus allardii* (Bres.) S. Ahmad, *Basidiomycetes* of West Pakistan: 57, 1972.

Macroscopy of sporophores (Figure 1; A–B)

Perennial, resupinate, effused, reflexed to pileate, woody hard, heavy, broadly attached, triquetrous in section, imbricate, pileus ≤8 × 5.8 × 6 cm (L × W × T)* Pilear surface: Reddish brown to dark brown to almost black, glabrous, rimose, concentrically sulcate, crustose, crust ≤500 µm thick. Hymenial surface: Light brown to greyish brown, glancing; pores round to angular, 5−7 per mm; dissepiments ≤90 µm thick. Context: Very thin (≤1 mm) at the base, dark brown. Pore tubes: ≤58 mm deep, greyish brown to brown, stratified; individual pore tubes ≤ 3 mm thick, with ≤500 µm thick context between the tubes. Margins: Acute, regular to somewhat wavy, concolourous on the pilear surface, sterile ≤1 mm, paler concolourous on the hymenial surface.

Microscopy of sporophores (Figure 2: Plate I)

Hyphal system: Dimitic. Generative hyphae ≤2 µm wide; skeletal hyphae ≤4 µm wide, yellowish brown to brown.Hymenial setae**:** Absent**.** Tramal setae and setal hyphae**:** Absent.Basidia: 10.4−13 × 4.5−5.2 µm, clavate; sterigmata ≤2.6 µm long. Basidiospores: 4.5−6.5 × 3.2−5.2 µm, ellipsoid to broadly ellipsoid, yellowish brown to golden brown, thick-walled, usually uniguttulate, acyanophilous to weakly cyanophilous to cyanophilous.

Collections examined: Thano forest range, on trunk of *Shorearobusta*, Uzma Azeem 8764 (PUN),

October 12, 2011; Laxman Sidh Mandir, on angiospermous stump, Uzma Azeem 8765 (PUN), October 14, 2011; Lachhiwala, on trunk of *S. robusta*, Uzma Azeem 8766 (PUN), October 14, 2011; Chakrata, at the base trunk of *Quercus leucotrichophora*, Dhingra and Uzma Azeem 8767 (PUN), September 16, 2012; Deoban, on trunk of *Cedrus deodara*, Dhingra and Uzma Azeem 8768 (PUN), September 18, 2012; Mussoorie, Landour, on trunk of *Rhododendron arboreum*, Dhingra and Uzma Azeem 8769 (PUN), September 20, 2012; Rajaji tiger reserve (Motichur range), on trunk of *S. robusta*, Uzma Azeem 8770 (PUN), October 6, 2012; Mussoorie, Landour, on trunk of *C. deodara*, Uzma Azeem 8771 (PUN), October 7, 2012; Kalsi, Sahiya, on trunk of *S. robusta*, Uzma Azeem 8772 (PUN), September 5, 2013; Sahastradhara, on trunk of *Dalbergia sissoo*, Uzma Azeem 8773 (PUN), September 6, 2013; Sahastradhara, at the base of trunk of *Acacia catechu*, Uzma Azeem 8774 (PUN), September 7, 2013; Timli forest range, on trunk of *S. robusta*, Uzma Azeem 8775 (PUN), September 8, 2013; Mussoorie-Chakrata, on trunk of *C. deodara*, Dhingra and Uzma Azeem 8776 (PUN), April 29, 2014; Mussoorie, Landour, on trunk of *Q. leucotrichophora*, Dhingra and Uzma Azeem 8777 (PUN), April 30, 2014; Mussoorie Mall road, on trunk of *Q. leucotrichophora*, Dhingra and Uzma Azeem 8778 (PUN), May 1, 2014; Mussoorie, Lal tibba, on trunk of *Q. leucotrichophora*, Dhingra and Uzma Azeem 8779 (PUN), August 22, 2014; Mussoorie, Barlowganj, on the dead decaying angiospermous stump, Dhingra and Uzma Azeem 8780 (PUN), August 23, 2014; Lachhiwala, on trunk of *Syzygium cumini*, Uzma Azeem 8781 (PUN), August 24, 2014; Dehradun to Mohand road, on trunk of *A*. catechu, Uzma Azeem 8782 (PUN), August 27, 2015; Dhoolkot, on the trunk of *S. robusta*, Uzma Azeem 8783 (PUN), August 30, 2015.

Remarks: This is the most commonly encountered species in the present work and is characterized by heavy sporophores, rimose, concentrically sulcate pilear surface and lack of setae.

2. *Phellinus merrillii* (Murrill) Ryvarden, Norwegian Journal of Botany 19: 234, 1972.

Macroscopy of sporophore (Figure 1; C–D)

Perennial, pileate, solitary, boadly attached, semicircular, dimidiate, pileus ≤ 2.5 × 3.5 × 2 cm. Pilear surface:Brown to reddish brown, tomentose to glabrous, irregularly to concentrically sulcate, crustose, crust ≤480 µm. Hymenial surface: Light brown to dark brown, glancing; pores round to angular, 7−8 per mm; dissepiments ≤60 µm thick. Context: Homogeneous, ≤13 mm thick, yellowish brown to dark brown, lustrous, limited on the pilear surface by a distinct black line. Pore tubes: ≤5.5 mm deep, conclorous with the pore surface, stratified. Margin: Obtuse, regular, brownish orange on the upper surface, yellowish brown, sterile ≤5 mm on the lower surface.

Microscopy of sporophore (Figure 2 Plate II)

Hyphal system: Dimitic. Generative hyphae ≤4 µm wide, subhyaline to pale yellow; skeletal hyphae ≤4.5 µm wide, golden brown. Hymenial setae: Absent. Tramal setae and setal hyphae:Absent. Basidia: 5.8−13 × 4.5−6.5 µm, clavate; sterigmata ≤2 µm long. Basidiospores: 5.2−6.5 × 3.8−5.2 µm, broadly ellipsoid to subglobose to globose, golden yellow, thick-walled, usually uniguttulate,

acyanophilous.

Collection examined: Forest Research Institute (FRI), on trunk of *Azadirachta indica*, Uzma Azeem 8799 (PUN), August 26, 2014.

Remarks: This species is peculiar in having tomentose to glabrous, concentrically sulcate pilear surface and absence of setal elements.

3. *Phellinus nigricans* (Fr.) P. Karst., Finlands Basidsvampar (11): 134, 1899.

Macroscopy of sporophores (Figure 1; E–F)

Perennial, pileate, solitary, broadly attached, pileus ≤11.2 × 7 × 5 cm.Pilear surface: Greyish brown to greyish black to almost black, glabrous, rimose, sulcate, crustose, crust ≤500 µm thick.Hymenial surface: Light brown to brown; pores round to angular, 8−9 per mm; dissepiments ≤53 µm thick. Context: Homogenous, ≤3 mm thick, below the crust, rusty brown to reddish brown, ≤500 µm thick between the tubes. Pore tubes: ≤46 mm deep, stratified.Margins: Acute, irregularly wavy, concolourous on the pilear surface, paler concolourous, sterile ≤1 mm on the hymenial surface.

Microscopy of sporophores (Figure 2; Plate III)

Hyphal system: Dimitic. Generative hyphae ≤2.9 µm wide; skeletal hyphae ≤4.5 µm wide and golden brown. Hymenial setae: 37−40 × 10.3−16.2 µm, ventricose, acuminate, straight, dark brown to rusty brown, thick-walled; projecting ≤14 µm out of the hymenium. Tramal setae and setal hyphae: Absent. Basidia: Not found. Basidiospores: 4.5−6.5 × 2.6−5.2 µm, broadly ellipsoid to subglobose, golden brown, thick-walled, usually uniguttulate, acyanophilous.

Collections examined: Kalsi, Sahiya, on trunk of *Betula* sp., Uzma Azeem 8800 (PUN), October 7, 2012; Kalsi, Sahiya, on trunk of *Betula* sp., Uzma Azeem 8801 (PUN), September 2, 2015.

Remarks:It is characterized by solitary, rimose, crustose pilear surface and broadly ellipsoid to subglobose, golden brown and acyanophilous spores.

4. *Phellinus pini* (Brot.) A. Ames, Annales Mycologici 11 (3): 246, 1913.

Macroscopy of sporophore (Figure 1; G–H)

Perennial, pileate, imbricate, broadly attached, ungulate to applanate, pileus ≤8.5 × 5 × 2 cm. Pilear surface: Reddish brown to dark brown, tomentose, glabrous with maturity and on drying, rimose, concentrically sulcate, crustose, crust ≤500 µm thick.Hymenial surface: Yellowish brown to brown; pores round to angular to daedaloid, 1−3 per mm; dissepiments angular to daedaloid, ≤56 µm thick. Pore tubes: ≤7 mm deep, stratified, conclorous with the pore surface. Context: Homogeneous, ≤10 mm thick, reddish brown to dark brown, ≤480 µm thick between the tubes. Margins: Acute, regular to lobed, concolourous on the upper surface, yellowish brown, sterile ≤1 mm on the hymenial surface.

Microscopy of sporophore (Figure 2; Plate IV)

Hyphal system: Dimitic. Generative hyphae ≤3 µm wide; skeletal hyphae ≤5.2 µm wide, yellowish brown, occasionally branched. Hymenial setae: 35−72 × 11.6−20.1 µm, subulate, acuminate, straight, reddish brown to dark brown, thick-walled; projecting ≤36 µm out of the hymenium. Tramal setae

and setal hyphae: Absent. Basidia: 8.4−13 × 5.8−7.2 µm, clavate to broadly clavate; sterigmata ≤4 µm long. Basidiospores**:** 6.5−10.3 × 4.5−6.5 µm, broadly ellipsoid to subglobose, subhyaline to pale yellow, thin- to thick-walled, usually uniguttulate, weakly cyanophilous.

Collection examined: Chakrata, on trunk of *Pinus wallichiana*, Dhingra and Uzma Azeem, 8803 (PUN), September 17, 2012.

Remarks: It is found in association with species of genus *Pinus*. It is peculiar in having 1–3/mm, round to angular to daedaloid pores, cyanophilous basidiospores and subulate setae.

5. *Phellinus pullus* (Mont. & Berk.) Ryvarden (1972)

Macroscopy of sporophores (Figure 1; I–J)

Perennial, pileate, imbricate, usually narrowly attached, pendent, dimidiate, pileus ≤2.3× 2.6 × 1 cm.Pilear surface: Greyish brown to reddish brown, glabrous to tomentose, rimose, concentrically sulcate, crustose, crust ≤500 µm thick.Hymenial surface: Yellowish brown to dark brown; pores round to angular, 8−9 per mm; dissepiments ≤58 µm thick.Pore tubes: ≤3 mm deep, concolourous with the pore surface.Context: ≤7 mm thick, delimited from tomentum by the black crust, duplex, lower part ≤2 mm thick, yellowish brown, hard, shiny, upper part ≤5 mm thick, light brown to dark brown, fibrous.Margins: Acute, irregularly wavy, inturned on maturity, concolourous on both the pilear and hymenial sides of the sporophore, sterile ≤1 mm on the lower side.

Microscopy of sporophores (Figure 2; Plate V)

yphal system: Dimitic. Generative hyphae ≤3.2 µm wide;skeletal hyphae ≤4.5 µm wide and golden yellow to golden brown.Hymenial setae: Absent.Tramal setae and setal hyphae: Absent.Basidia: 7.7−11.6 × 3.8−5.8 µm, clavate; sterigmata ≤3.2 µm long.Basidiospores: 3.2−4.5 × 3.2−3.8 µm, broadly ellipsoid to ovoid to subglobose, golden yellow, thin- to thick-walled, usually uniguttulate, acyanophilous.

Collections examined: Kalsi, Sahiya, on angiospermous stump, Uzma Azeem 8804 (PUN), September 4, 2015. Remarks:This species is peculiar in having smaller, pendent sporophores, duplex context and lacking setae. * (L=Length, W=Width and T=Thickness).

Taxonomy

Taxonomy of 5 species of *Phellinus* collected during fungal surveys (July–November) to different localities of district Dehradun in the years 2010–2015 (Map–I) was done. It is worth mentioning here that *Phellinus pullus* is a new addition to the diversity of genus *Phellinus* for India, *P. nigricans* and *P. pullus* are new records for Uttarakhand and*P. merrillii, P. nigricans, P. pini* and *P. pullus* are first records for district Dehradun. The current status and earlier reports of new records is as per Table 1.

Host diversity

Out of the 25 collections, 21 (84%) have been found in association with angiospermous hosts and 4 (16%) with gymnospermous hosts (Figure 3). Amongst the angiospermous hosts, a maximum of 6 (24%) collections have been found associated with *Shorea robusta*, followed by 4 (16%) with

Quercus leucotrichophora, 3 (12%) with unidentified angiospermous hosts, 2 each (8%) with *Acacia catechu* and *Betula* sp., 1 each (4%) with *Azadirachta indica*, *Dalbergia sisso*, *Rhododendron arboreum*, and *Syzygium cumini*. Of the 4 (16%) collections associated with gymnospermous hosts, 3 (12%) are found associated with *Cedrus deodara*and 1 (4%) with *Pinus wallichiana*.

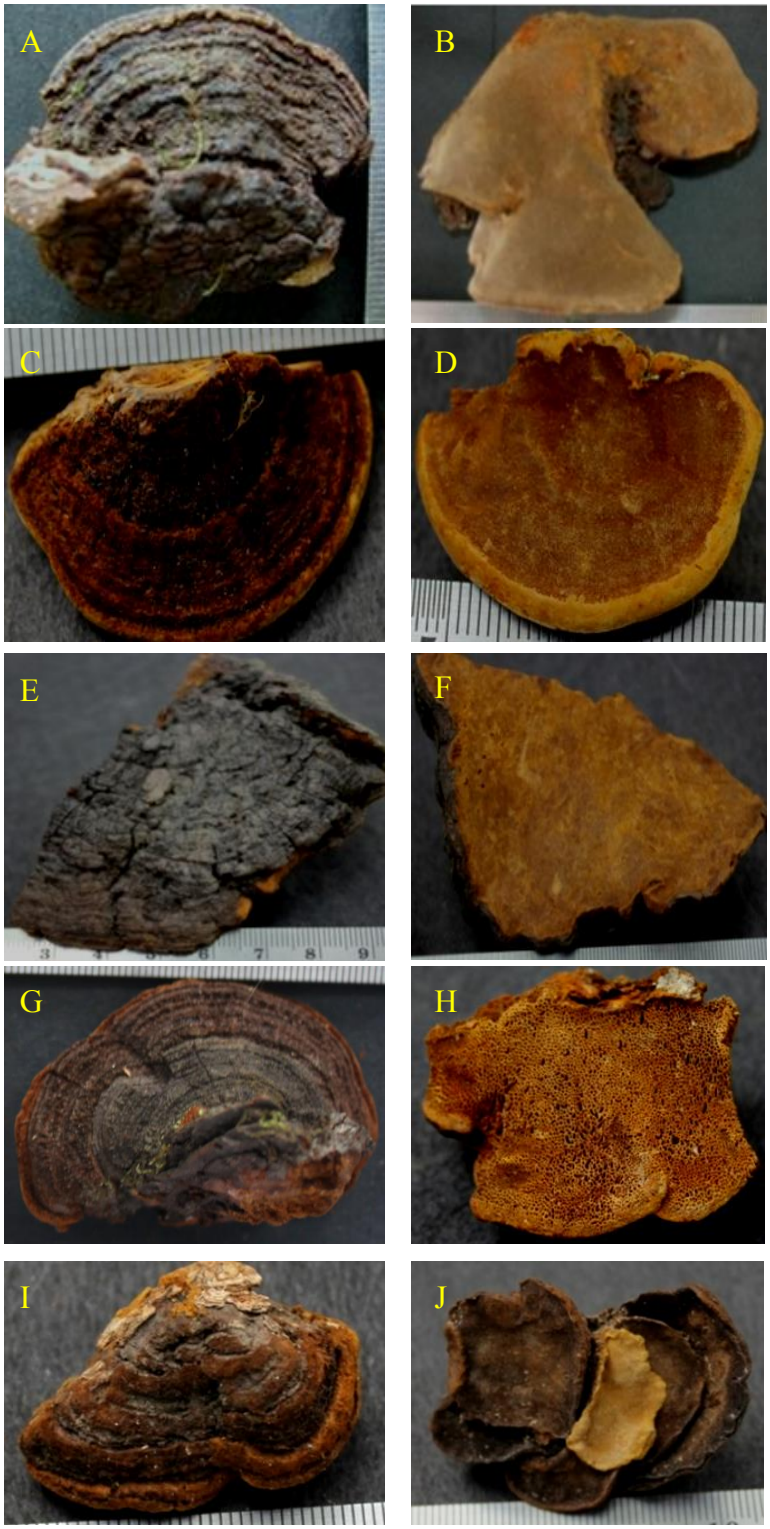

Fig. 1 *Phellinus allardii*: A (Pilear surface), B (Hymenial surface), *P. merrillii*: C (Pilear surface), D (Hymenial surface), *P. nigricans*: E (Pilear surface), F (Hymenial surface), *P. pini*: G (Pilear surface), H (Hymenial surface) and *P. pullus*:I (Pilear surface), J (Hymenial surface).

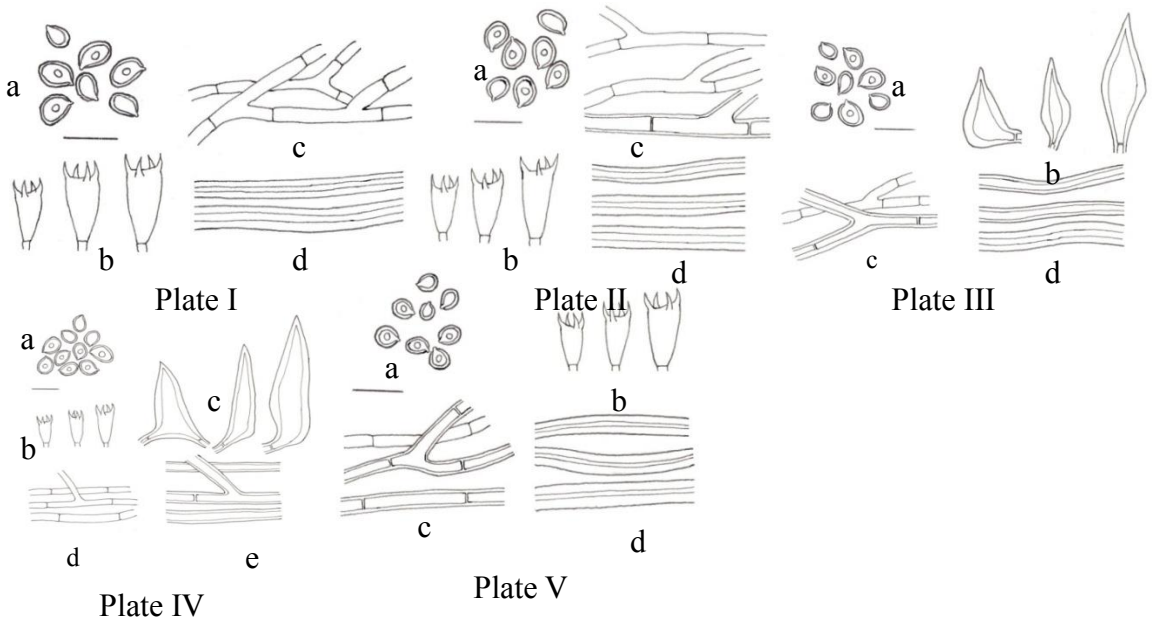

Fig. 2 *Phellinus allardii* - Plate I: (a-spores, b-basidia, c-generative hyphae, d-skeletal hyphae), *P. merrillii* - Plate II: (a-spores, b-basidia, c-generative hyphae, d-skeletal hyphae), *P. nigricans* - Plate III: (a-spores, b-setae, c-generative hyphae, d-skeletal hyphae), *P. pini* - Plate IV: (a-spores, b-basidia, c- setae, d-generative hyphae, e-skeletal hyphae) and *P. pullus* - Plate V: (spores, b-basidia, c-generative hyphae, d-skeletal hyphae). Scale bar = 10 µm.

Map I. Distribution pattern of 5 species of *Phellinus* across district Dehradun

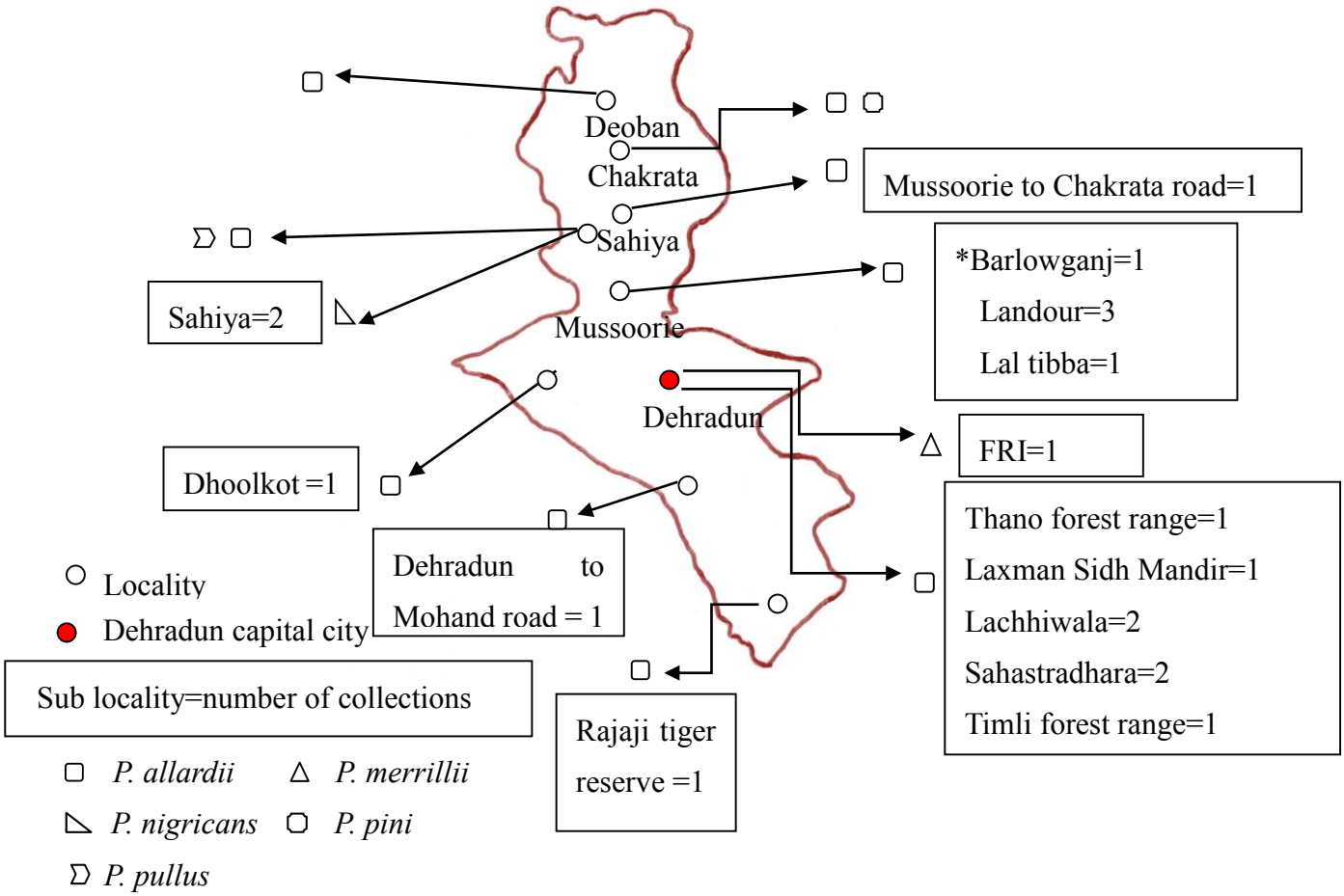

Table 1. Current status and previous reports of new records from India (from Uttarakhand highlighted in bold)

Sr. No.	Species	Current status [2]	Earlier reported by/under genus–state	Remarks
1.	***P. allardii***	*P. allardii* (Bres.) S. Ahmad (1972)	[4]/*Fomes*–Western Himalayas [5]/*Fomes*–Himachal Pradesh [6]/*Phellinus*–West Bengal [7]/*Phellinus*–Kerala [8]/*Phellinus*–Maharashtra [9]/*Phellinus*–Maharashtra [10]/*Phellinus*–**Uttarakhand (Chamoli and Rudraprayag)** [11]/*Phellinus*; Himachal Pradesh [12]/*Phellinus*–**Uttarakhand(NDBR)** [13]/*Phellinus* –**Uttarakhand (Dehradun)**	Rereport
2.	***P. merrillii***	*P. merrillii* (Murrill) Ryvarden (1972)	[14]/*Fomes*–Bengal [15]/*Fomes* –Assam and West Bengal [4]/*Fomes*–Assam [8]/*Phellinus*–Maharashtra [16]/*Phellinus* –Maharashtra [9]/*Phellinus*–Maharashtra [10]/*Phellinus*–**Uttarakhand (Udhamsingh-Nagar)** [12]/ *Phellinus*–**Uttarakhand(NDBR)**	New to district Dehradun
3.	***P. nigricans***	*P. nigricans* (Fr.) P. Karst. (1899)	[10]/*Phellinus*–Arunachal Pradesh and Sikkim	New to Uttarakhand
4.	***P. pini***	*Porodaedalea pini* (Brot.) Murril (1905)	[4]/*Fomes*–Western Himalaya [5]/*Fomes*–Himachal Pradesh [17]/*Fomes*–Himachal Pradesh [18]/*Phellinus*–Himachal Pradesh and Jammu & Kashmir [10]/*Phellinus*–**Uttarakhand (Tehri)** [11]/*Porodaedalea*–Himachal Pradesh [12]/*Porodaedalea*–**Uttarakhand(NDBR)**	New to district Dehradun

5.	***P. pullus***	*Fulvifomes pullus* (Berk. & Mont.) Y.C. Dai (2010)	[2]/*Fulvifomes*–Out of India (South East Asia, Subtropical and warm temperate zones in China (Yunnan), Japan (Kyushu), Madagascar and Vietnam	New to India

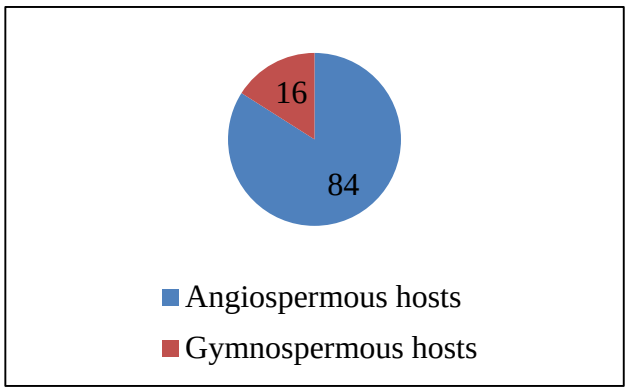

Fig. 3 Host diversity (%) of 25 collections found in association with 21 angiospermous and 4 gymnospermous hosts.

The percent host diversity of 21 collections associated obligatory with angiospermous hosts and 4 collections associated obligatory with gymnospermous hosts is shown in (Figures 4; A).

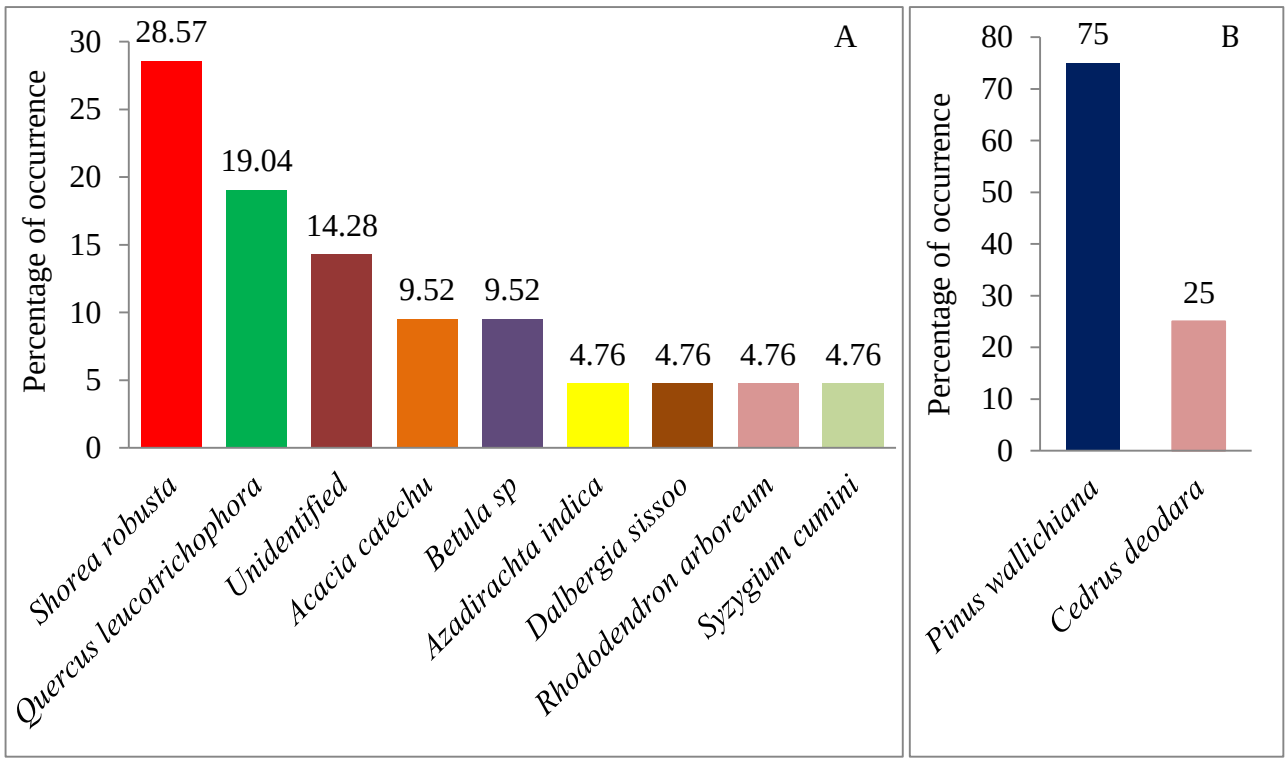

Fig. 4 (A) Host diversity (%) of 21 collections occurred associated with angiospermous hosts; (B) Host diversity (%) of 4 collections found associated with gymnospermous hosts.

Out of the 5 species of *Phellinus*, 3 (60%) have been found in obligate association with angiospermous hosts, 1 (20%) in obligate with gymnospermous host and 1 (20%) with both angiospermous and gymnospermous hosts (Figure 5; Table 2).

Table 2. Host diversity of 5 species of *Phellinus* reported in the present study

Species	Host	Type of host	Number of collections
P. allardii	*A. catechu*	Angiosperm	2
	C. deodara	Gymnosperm	3
	D. sissoo	Angiosperm	1
	R. arboreum	Angiosperm	1
	S. cumini	Angiosperm	1
	S. robusta	Angiosperm	6
	Q. leucotrichophora	Angiosperm	4
	Unidentified	Angiosperm	2
P. merrillii	*A. indica*	Angiosperm	1
P. nigricans	*B.* sp.	Angiosperm	2
P. pini	*P. wallichiana*	Gymnosperm	1
P. pullus	Dead decaying stump	Angiosperm	1

Total: 25 collections, Angiospermous hosts = 21, Gymnospermous hosts = 4

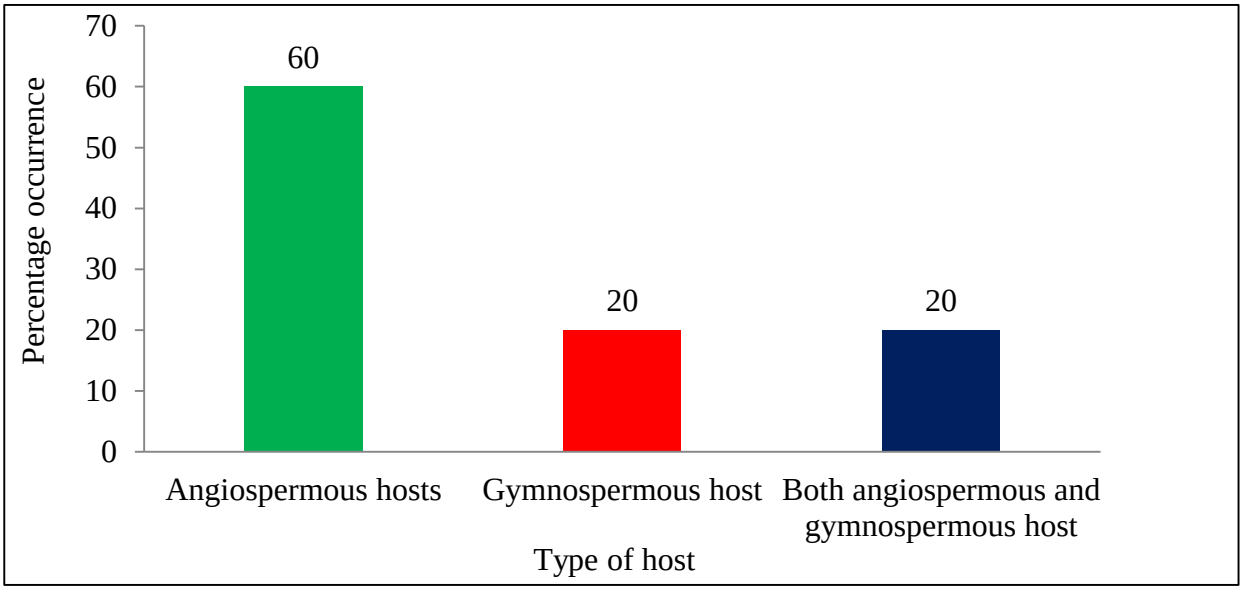

Fig. 5 Host diversity (%) of 5 species of *Phellinus*.

4. CONCLUSION

The present work adds one new record of *Phellinus* (*P. pullus*) to Indian fungal flora, two new records (*P. nigricans* and *P. pullus*) to Uttarakhand and four new records (*P. merrillii, P. nigricans*, *P. pini* and *P. pullus*) to Dehradun with their host diversity.

CONFLICT OF INTEREST

Authors have no conflict of interest.

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