

First report of Aphyllophorales Diversity of Dang Forest from Western Ghats of Maharashtra, India

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ABSTRACT

Aphyllophorales diversity of Dang forest region of Nashik District, Maharashtra, India was explored for the first time. The present study reported 18 species namely; *Microporous vernicipes*, *Schizophyllum cumini*, *Ganoderma gibbosum*, *Ganoderma tropicum*, *Inonotus hispidum*, *Trametes elegans*, *Favolus tenuiculus*, *Polyporus alveolaris*, *Inonotus subhispidus*, *Podoscypha petalodes*, *Auricularia cornea*, *Trametes globosus*, *Lenzites betulina*, *Trametes aesculin*, *Inonotus radiatus*, *Ganoderma enigmaticum*, *Pinopohra polygonia* and *Pinopohra incarnata* belonging to 9 different families of Aphyllophorales from five different regions under investigation. The key characters of fruiting body of fungal specimens viz., shape, gills, color, cap, texture, surface, margin, mycelium, hyphae and basidiospores were studied. The region wise diversity of members of Aphyllophorales were recorded. The current work is an update on the diversity of members of Aphyllophorales from the study area. The complied information on fungal specimens can be a significant source for exploration of fungi for their diverse applications.

Key words: Taxonomy, Aphyllophorales, Dang Forest, Nashik, Western Ghats.

Introduction

Aphyllophorales is a significant order within the phylum Basidiomycota, with 1200 species that may be found worldwide in both tropical and temperate climates (Alexopoulos *et al.*, 2002). After Postuilled, Rea suggested the order Aphyllophorales, which is often referred to as "Wood rooting fungi." The fruiting body is clubbed, flattened, tooth-shaped, and can be sometimes non-poroid or poroid (Ranadive *et al.*, 2013). The Aphyllophorales lack gills but do have

holobasidia (Alexopoulos *et al.*, 2002). Aphyllophorales are natural scavengers and decomposers, and they are essential to ecosystems. They include bioactive substances that aid in the synthesis of polysaccharides, which are active secondary metabolites, as well as the wood-degrading chemicals cellulose, hemicellulose, pectin, and lignin found in fruiting bodies.

Certain Aphyllophorales species have antibacterial activity and can also have capacity to manufacture antibiotics (Zjawiony *et al.*, 2004). Studies and

data on Indian Aphylllophorales fungus were first reported by Koltzsch in 1832 (Ranadive *et al.*, 2013). The Polypores study of Kerala region has revealed data on 80 species of Polypores belonging to 32 genera from 3 families (Ganodermataceae, Hymenochaetaceae, and Polyporaceae) (Leelavthy *et al.*, 2000). Research on and releases of Indian Aphylllophorales were place in Tamil Nadu, Kerala, Maharashtra, Western Bengal, and the Himalaya during the mid-1900s. Natarajan and Kolandavelu investigated and reported over 1077 species of fungus from India, including 39 new species of Polyporales (Natarajan *et al.*, 1985). Following the variety's study by many Indian mycologists, Bakshi (1971), Dhanda (1977), Singh (1987), Hakimi (2008), Bhosale (2011), Ranadive *et al.* (2011), Sharma (2012), Ranadive (2013), Mali *et al.* (2016), Kaur *et al.* (2017), Chouse *et al.*, 2020, and Gore *et al.*, 2021). A Checklist of 170 Aphylllophorales species from different parts of Pune District, Maharashtra, that belong to Poroid 10 and Non Poroid 86 Families was published by Ranadive (Ranadive *et al.*, 2011). Hakimi *et al.*, (2013) conducted a study on 110 taxonomies of Aphylllophorales and released the results online. Studies on the variety of Aphylllophorales from the Latur area were conducted by Chouse and Mali (Chouse *et al.*, 2020). Based on morphological and microscopic data, Gore and Mali investigated and published 37 species of Aphylllophorales from the Marathwada region (Gore *et al.*, 2021).

Six of Maharashtra's districts are known to feature aphylllo-fungal flora, only 20.5% of the Aphylllophorales are found in various regions of Maharashtra, over 80% of the territory unexplored for intensive study in the diversity of this prominent group (Chouse and Mali *et al.*, 2016).

The investigation on Aphylllophorales diversity from the unexplored Dang forest region of Nashik District, Maharashtra, India, is the main emphasis of this work. In order to help prepare the fungal flora of the Nashik District. This work will create the awareness among the tribal populations to prevent damage of diversity, and will help to explore the bioactive potential research of Aphylllophorales fungi in future investigations.

Materials and Methods

Survey of Study Area

Aphylllophorales species were surveyed and col-

lected from five distinct locations in the dang region of the Nashik district in the Indian state of Maharashtra. It is situated between longitudes 73053' and 53002' south and latitudes 20049' to 94'700 west. The dang forest is home to a diverse biodiversity and spans over 1764 square kilometers. A continuous forest that borders the state of Maharashtra lies on the eastern side of Dang Forest, connecting the forest areas of Nashik and Dang districts. There is a 41.66 percent ratio of total forest area to geographical area. The state of Maharashtra borders the forest on three sides: in the south, Surgana; in the north, Peth; and in the west, Saputara. The forest is a hotspot in the western part of Nashik District.

Collection The fresh fruiting bodies of eighteen distinct species of macrofungi were sampled at five different places in the Nashik District's Dang Forest. Notes were made on the host, location, date of collection, and geographic details. The samples were stored without a host in a butter paper container.

Photographic Documentation The specimens were photographed in situ, using the Sony camera (8X) equipped with Tokina 100 mm macro lens.

Staining and Mounting stained and studied in 10% KOH, Cotton Blue, and Melzer's reagent.

Microscopic Examination All collected specimens were sundried before being examined under 100x magnification (Olympus CX41) in the laboratory by free hand thin section cutting of basidiome with sharp razor blades. Each specimen was given a detailed description in terms of macroscopy and microscopy, which was then compared to published literature or the type material for identification (Ranadive *et al.*, 2013).

Results

The eighteen species of aphylllophorales, which are classified into nine families, were identified through fieldwork and survey in five distinct areas within the Dang Forest region (Table 1).

Taxonomic study of collected specimens identified by earlier literature and keys from various authors were used to determine the correct taxonomic identity. Authors viz. Bakshi, (1971), Stewart (1972, 1980), Ryvarden and Johansen (1980), Gillbertson and Ryvarden (1986), Gottlieb and Wright (1999), Sharma (2000), Hakimi (2013), Ranadive (2013) were used.

Table 1. The list of species of Aphyllophorales collected, classified into families, host, location and sample code in five distinct areas within the Dang Forest region.

Sr. No	Fungal Species	Host	Location	Sample Code
1	<i>Microporous vernicipes</i> (Fr.)	<i>Mangifera indica</i> Branch	Barhe	S39
2	<i>Schizophyllum Cumini</i> (Fr)	<i>Tectonia grandius</i> Bark	Barhe	S40
3	<i>Inonotus hispidum</i> (Fisch)	<i>Ficus racemosa</i> Stem	Barhe	S42
4	<i>Polyporus alveolaris</i> (Fr)	<i>Carissa carandas</i> , Stem	Umbarthan	S45
5	<i>Inonotus subhispidus</i> (Peg)	<i>Terminalia arjuna</i> Stem	Umbarthan	S46
6	<i>Trametes globossa</i> (Pers)	<i>Tectonia grandius</i> Stem	Saputara	S47
7	<i>Lenzites betulina</i> (L.ex Fr.)	<i>Anogeissus latifolia</i> Stem	Saputara	S48
8	<i>Trametes aesculin</i> (Pers.) Larsen 1974	<i>Terminalia arjuna</i> Bark	Karanjul	S50
9	<i>Inonotus radiatus</i> (Fr)	<i>Ficus racemosa</i> Stem	Karanjul	S51
10	<i>Ganoderma enigmaticum</i> (unidentified)	<i>Acacia nilotica</i> Stem	Karanjul	S52
11	<i>Pinopohra Polygonia</i> (Fr.) Cooke 1879	<i>Lantana indica</i> , Branch	Hatgarh	S53
12	<i>Pinopohra incarnate</i> (Fr.) Karst. 1889	<i>Lantana Camera</i> , Stem	Hatgarh	S54
13	<i>Favolus tenuiculus</i> P. Beauv 1806	<i>Mangifera indica</i> Stem	Umbarthan	S55
14	<i>Podoscypha petalodes</i> (Berk) 1959	Eucalypts sps	Umbarthan	S57
15	<i>Trametes elegans</i> (Berk) 1950	<i>Terminalia arjuna</i> Stem	Barhe	S58
16	<i>Ganoderma tropicum</i> (Jungh).	<i>Tamarinds indicia</i> Stem	Barhe	S59
17	<i>Ganoderma gibbosum</i> (Blume) 1897	<i>Ficus bengalensis</i> Stem	Barhe	S60
18	<i>Auricularia cornea</i> (Ehrenb)	<i>Tectonia grandius</i> Stem	Umbarthan	S61

Taxonomic Observations

S-39 *Microporous vernicipes* (Fr.) Kunt. Rév. gen. Pl. 3:494, 1898. Fruiting body is flattered, funnel shape, dark chocolatey, stipate, solitary, annual, stipe is round, Pileus 3.1 to 7 cm in diameter, 1.2-3mm thick. When fresh it is glabrous, shiny and after dry it becomes duller. Context is pure white, thin, with an entire, round, margin is glabrous. Pore is small, homogenous, size is 4-7 per mm. Mycelium are septate, trimetric, and generative hyphae with clamp connection. Basidiospore is amyloid, smooth.

S-40 *Schizophyllum Cumini* (Fr) Bagchee and Bakshi, 1950. Fruiting body is fan shape, small, sessile, Pubescent, Farinaceous, Dimidiate, undulating waves of tightly packed corals, loose Chinese fan. Splits gills vary from creamy yellow to pale white in color. The cap is small, 1x 1.5cm wide with dense yet spongy body texture. Upper surface context is whitish, globular. Margin is wavy with appear lobed. Mycelium are Septate, Hyphal type is generative with clamp connection. Basidiospore are ellipsoid.

S-42 *Inonotus hispidus* (Pilát) Wagner and Fisch, 2002. The fruiting body are flattered, sessile, color is yellowish, annual to perennial, effused-reflexed, coriaceous fleshy to woody hard, arrangement are concentrically grooves, from center towards bands will be visible by naked eye, when dry pileus be-

comes small to medium sized, dimidiate. Upper surface is glabrous, color yellowish to dark reddish brown. The hymenophore are poroid, brown. Hyphal system is generative.

S-45 *Polyporus alveolaris* (Fr.) Bond and Sing, 1941. The Fruiting body is annual, stipitate and sessile, circular up to 3 cm wide and 1.5-2 mm thick. The upper surface of fruiting body has flattened, pale yellow, azonate, glabrous. Margin are smooth, concolorous. The Surface of poreare white to tan, diamond-shaped, 1.5-2 per mm tube context is pale yellow. Hyphae are dimictic, generative hyphae, thin-walled, rarely branched, with clamp connection. Basidiospores shape are cylindrical.

S-46 *Inonotus subhispidus* Peg Reid, 1964. Fruiting body are flattened, leathery, glabrous, sessile, annual, Solitary, color is dark brown to pale yellow, Basidiospore size are 4x3.5cm. Pileus surface are concentrically zone, dark brown to pale yellow, margin is incurved when dry. Pore shape are round, 1.5mm. Hyphae are dimictic, generative, thick walled, basidia not seen.

S-47 *Trametes globossa* (Pers. ex Pers.) Fr. 1838. Fruiting body are annual, solitary, imbricate, confluent, Basidiocarp size are 6 x 5cm, attached with broad base. The Upper surface of fruiting body has Concentrically stipulatebut growthirregular, when fresh fruiting body seen coriaceous while

flesh, hard and pliable when dry, almost round to applanate, flabelliform. Hyphal system is trimetric, generative hyphae, basidia not seen.

S-48 *Lenzites betulina*. (L. ex Fr.) Fr. 1838. Fruiting body are annual, Solitary, imbricate, confluent, attached with board base, often centrally stipites but growth irregular, coriaceous while fleshy, hard, and pliable when dry, almost round to applanate. The upper surface of fruiting body has concentrically zone, dark brown to light brown. Margin are smooth, incurved, uneven. Pore tubes size is 1.6 mm long, Homogenous towards margin, angular, round When young. Hyphal system trimitic, Generative, thin slightly thick walled, septate with clamp connection.

S-50 *Trametes aesculin* (Pers.) Larsen, 1974. Fruiting body are solitary, annual, imbricate, effused reflexed to pileate, attached with a broad base, The Upper surface of fruiting body is concentrically grooved, highly velutinate, smooth glabrous, uneven dark brown. Margin are smooth, entire, velutinate. Pore surface is dark brown, pore not visible to naked 7.1 x 4.5cm. Context yellowish white, concolorous with pore tubes. Types of Hyphe are dimitic, generative with clamp connection, septate, branched.

S-51 *Inonotus radiatus* (Fr.) Karst. 1889. Fruiting body are solitary, leathery, kidney shaped to semi-circular, annual, Solitary, Size is 4.5X 2 cm. The color of fruiting body are yellowish brown or black. Margin are entire and thin, wrinkled. When fruiting body young color is yellowish brown after dry dark brown. The upper surface of fruiting body has grey to yellowish color with angular pores, size of pore is 3.5-4mm. Sometimes shape of these body surfaces are appearing toothed. Hyphal system is monomitic, thin walled, absent of clamp connection. Basidiospore shape are ellipsoid, brownish.

S-52 *Ganoderma enigmaticum* (Unidentified). Fruiting body are solitary, lactate, color is reddish to dark brown, stipitate with a globular upper pileus, perennial, size is 6.5 X 4.2cm, upper surface of fruiting body has covered by cream soft non-poroid tissue showing obvious continuous to hymenophore beneath the pileus, hymenophore are white to creamy turning pale brown, stipe columnar, Border of hymenophore is very thickened and yellowish brown, blunt, undulate to lobate, young basidiome bulbous. The context is reddish to dark brown. Pore shape are round and 1-2mm. Hyphal type are trimitic, generative hyphae not seen, thin walled,

Basidiospore are ellipsoid.

S-53 *Pinopohra Polygonia* (Fr.) Cooke, 1879. Fruiting body are sessile, flattened, annual, resupinate, membranaceous, odorless, and tasteless when fresh, up to 10.5 x 6.2 mm. The Hymenial surface is smooth, occasionally cracked, and rose to pale pinkish grey. The margin is sterile, indistinct and is rose to pinkish grey. Hyphal system monomitic, generative hyphae with clamp connection. Basidiospores are ellipsoid, colorless, thin-walled.

S-54 *Pinopohra incarnate* (Fr.) Karst. 1889. Fruiting body are sessile, cracked, annual, thick, resupinate and attached to the substratum, smooth or generally papillose to 0.3 mm thick, The surface of hymenial is smooth, occasionally cracked. Margin are orange color and indistinct and is white color, Hyphal system monomitic, generative hyphae, thick walled.

S-55 *Phellinus arctostaphyli* Ryv. 1984. Fruiting body are sessile, thick, glabrous, color is grayish brown to dark brown, azonate, perennial, sessile, applanate to ungulate, size is 1-9.5 cm wide and 1-3.2 cm thick. The upper surface of basidiome having glabrous and crustose, grayish, sulcate, becoming blackened. The margin color is concolorous to light brown and shape are rounded. context reddish brown. Hyphae system are of fibrous context parallel, types of hyphae are skeletal hyphae thick-walled, aseptate, with rare branching. Basidiospores shape are ovoid.

S-56 *Favolus tenuiculus* P. Beauv, 1806. Fruiting body is fleshy, glabrous, stipate, Hairy, Stalk are long, colour is white, size 5X2X2.4mm thick. The upper surface of basidiome consist of white colour at margin with small hair, entire. Hymenophore are

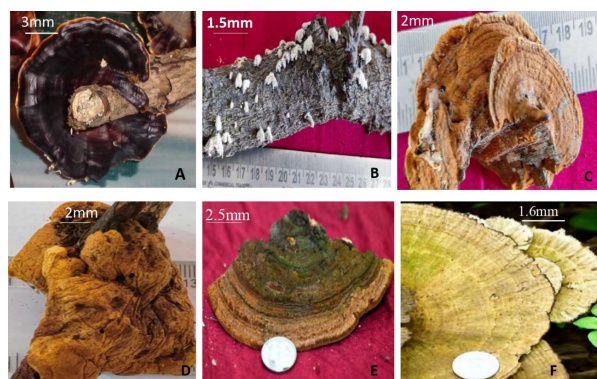


Fig. 1. Study of Basidiosomes : A-*Microporous vernicipes* (Fr.), B-*Schizophyllum Curmini* (Fr), C-*Inonotus hispidum* (Fisch), D-*Polyporus alveolaris* (Fr), E-*Inonotus subhispidus* (Peg), *Trametes globososa* (Pers).

homogenous, pore hexagonal shape. Type of hyphae are skeletal, colourless, spore is cylindrical.

S-57 *Podoscypha petalodes* (Berk) 1959. Fruiting body are Small to medium-sized, Funnel shaped, annual, pseudoinfunduliform, thin, spatulate, size 15-58 mm high, 5-3.5 mm wide. Margin are entirely wavy, frequently curling inward, laterally confluent and often forming rosette-like fruit bodies. The cap surface of fruiting body has minutely pubescent, varying from golden brown to light brown, brownish yellow, becoming light brown to chestnut brown after drying, with concentric zones. Type of hyphae is generative, basidiospore are ellipsoid.

S-58 *Trametes elegans* (Berk) 1950. Fruiting body annual, Solitary, imbricate, confluent, attached with board base, often centrally stipites but growth not uniform, coriaceous while fleshy, hard, and pliable when dry, almost round to applanate. Pileus surface concentrically zone, dark brown to white. margin uneven, smooth, incurved. Pore tubes pale orange, uniform, 2.5 mm long, Homogenous towards margin, Pore angular, round when young. Hyphal system trimitic. Generative hyphae hyaline, thin slightly thick walled, septate with clamp connection.

S-59 *Ganoderma tropicum* (Jungh). Fruiting body sessile, lathery, semicircular, kidney shape, annual, cap is flat, Color is Dark brown at the base, slightly brownish red in the center, reddish grey extending

to the margin, light yellow to yellow under the basidiocarp, and greyish yellow to brown close to the tube layer on the upper surface of the pileus. Size are 8X4X3mm thick. The pileus is glabrous, glossy, shiny, smooth. Upper surface laccate, dark reddish, Margin blunt, rounded, brown white. Pore surface creamish to milky coffee, Pore 2.5 per mm, rounded. Hyphal System dimitic, generative hyphae 2.5 μ m diameter, hyaline, thin walled, with clamp connection; skeletal hyphae 5.8 to 7.5 μ m diameter, brown coloured, thick walled, Basidiospore are yellowish brown.

S-60 *Ganoderma gibbosum* (Blume) 1897. Fruiting body flat, stalk, leather, fan shape, semicircular, kidney shape, annual or perennial, non-laccate, size is 15x10x5mm thick, color is dark chocolatey with white. The upper surface orbicular, subflabellate, fan shaped, Margin are entire thick with whitish color, pileus white at the border, slightly dark chocolatey at the center, and slightly greyish at the base. Type of hyphae generative with clamp connection and basidiospore are ellipsoid with yellowish color.

S-61 *Auricularia cornea* (Ehrenb). Fruiting body are gelatinous when fresh, resurpinate and effused-reflexed, free pileus lobed, margin undulate. Size of this up to 4 cm, 1-4 mm thick, upper surface villose, distlctly and arrangement are concentrically zone with wide whitish zones, thin bands in the central pileup surface. hymenophore surface are venose



Fig. 2. Study of Basidiosomes : G-*Lenzites betulina* (L.ex Fr.), H-*Trametes aesculin* (Pers.), I-*Inonotous radiatus* (Fr), J-*Ganoderma enigmaticum*, K-*Pinopohra polygonia* (Fr.), L-*Pinopohra incarnate* (Fr.).

with folds, becoming dark greyish blue upon drying. Hyphal type generative, basidiospores are cylindrical shape.

Discussion and Conclusion

Aphyllorphales, which cause wood rot, are the subject of relatively little investigation, especially in developing nations like India. The majority of research on Aphyllorphales in India has been conducted from northern areas, such as Bengal and the Himalaya, with scanty work from the south (Ranadive *et al.*, 2012). Research on Aphyllorphales was first conducted in Maharashtra by Ranadive *et al.* (2011) in the Pune district, they collected 126 specimens. The Maharashtra State inventory has 256 species of Aphyllorphales fungus, with 170 species from 10 poroid families and 86 species from 20 non-poroid families (Ranadive *et al.*, 2010).

According to Indian literature on the variety of Aphyllorphales, 1175 species, 52 families, and 190 genera have been recognised. 126 species from fifteen distinct locations in the western ghat of Maharashtra's Pune district were examined, along with twenty species of Aphyllorphales, which are categorised into eight families and fourteen genera according to morphological and microscopic traits (Randive *et al.*, 2013). The species were identified using a standard key.

According to Randive (2014) on the basis of macro-microscopic characteristics, three new Poroid Aphyllorphales species have been found in the Pune district. Sharma *et al.*, (2015); studied 28 species from the families Hymenochaetaceae, 12 species of the genera Hymenochaete, 15 species of *Phellinus*, and 1 species of *Inonotus* have been identified in India. In the Maharashtra regions of Parbhani and Nanded, 500 specimens of Aphyllorphales were gathered by Raibole and Mali (2012). He then presented 303 species that are categorised as being in the Basidiomycota according to ecological, taxonomic, and geographic data. In addition, he found eighteen additional species that are classified as red listed. Eleven macrofungi from the Hymenomycetes group of the Phylum Basidiomycota were gathered during the survey conducted in the Palampur area of Himachal Pradesh. Eleven macrofungals from Himachal Pradesh were discovered by morphological examination. According to Patil (2017), 24 species of macrofungi from the basidiomycetes clavarioid, cantharelloid, agaricoid, hydroid, and

poroid have been published during survey and field visitation of various parts of Kolhapur district State Maharashtra. Ten of these species are said to be new to the state of Maharashtra, nine are found to be new records (additions) to the fungus of India, and nine are said to be present on hosts that have not yet been identified. Kezo *et al.* (2019). Three families- the Ganodermataceae, Meripilaceae, and Polyporaceae- are represented by the twenty-four Polyporales specimens that were gathered from Chennai. The eleven species are distributed over six genera. A new species belonging to the order Aphyllorphales has been identified based on taxonomic description, based on specimens obtained from three areas in Chennai.

Phellinus belongs to the Aphyllorphales order and the Hymenochaetaceae family. According to Gore *et al.* (2021), 17 genera and 18 species may be identified using both macroscopic and microscopic traits. A collection of wood-decaying fungus from the Paithan tehsil in the Indian district of Aurangabad (M.S.). The variety of wood-rotting fungus from Maharashtra's Latur area was then recorded, resulting in 34 genera and 47 species (Gore *et al.*, 2021).

In the current investigation, 18 new specimens of Aphyllorphales belongs to 9 different families. Six species, including *Microporous vernicipes*, *Schizophyllum Cumini*, *Ganoderma gibbosum*, *Ganoderma tropicum*, *Inonotus hispidum*, and *Trametes elegans*, were identified from the Barhe section of Dang Forest. *Favolus tenuiculus*, *Polyporus alveolaris*, *Inonotus subhispidus*, *Podoscypha petalodes*, and *Auricularia cornea* are the principal five species that



Fig. 3. Study of Basidiosomes : M-*Favolus tenuiculus* P. Beauv, N-*Podoscypha petalodes* (Berk), O-*Trametes elegans* (Berk) P-*Ganoderma tropicum* (Jungh), Q-*Ganoderma gibbosum* (Blume), R-*Auricularia cornea* (Ehrenb).

have been reported in the Umbarthan area. Two species have been identified from the Saputara: *Trametes globossa* and *Lenzites betulina*. Three species of Aphyllophorales, *Trametes aesculin*, *Inonotus radiatus* and *Ganoderma enigmaticum* were found in the Karanjul village area. *Pinopohra Polygonia* and *Pinopohra incarnate* are two species rich in diversity found in the Hatgarh village region. In summary, the wood-rooting fungus ecology in the Dang Forest region of Nashik district, Maharashtra state, is unique. During the study, it was found that many different places were significantly affected due to excessive human activity. There is an urgent need for the conservation of Aphyllophorales fungus through proper protection from the Maharashtra government in order to stop some of these species from existing in the near future.

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Conflict of interest

The authors declare no conflicts of interest

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