

## ON THE BASKET STINKHORN MUSHROOM *PHALLUS MERULINUS* (PHALLACEAE) IN MANGALORE, KARNATAKA, INDIA

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The mushroom family Phallaceae (commonly called stinkhorns) comprises 77 species belongs to 21 genera (Kirk et al. 2008). The genus *Phallus* is cosmopolitan in the tropics (e.g., Australia, China, Hawaii, India, Malaysia, Mexico, South America, Thailand and Taiwan) (Lee 1957; Grgurinovic et al. 2001; Li et al. 2002; Barrett & Stuckey 2008; Hemmes & Dsejardin 2009; Dash et al. 2010; Mohanan 2011). Among the Phallales of southern Australia, 76% are soil saprophytes, 29% are litter saprophytes and 10% are ecotomycorrhizal (Grgurinovic et al. 2001). In India, *Phallus* species are known from the eastern Himalaya (Sikkim, Churra and Khasi), West Bengal (Santhiniketan), Odisha (Kutrumali), Maharashtra (Khandala), Karnataka (Kodagu and Shimoga) and Kerala (Anamudishola, Athirappally, Erampadam and Sholayar) (Bhagwat et al. 2005; Bakshi & Mandal 2006; Abrar et al. 2007; Swapna et al. 2008; Dash et al. 2010; Mohanan 2011).

All Phallaceae members begin their development with a gelatinous spherical or oval basidium, however, their developed structures show drastic variations in pattern and color. For instance, some have no indusium (basket or skirt) (e.g., *Phallus anamudii*) and some possess white or colored indusium (e.g., *Phallus*

*indusiatus* and *P. merulinus*) (Mohanan 2011). Similarly, the structure and color of gleba (cap) also differ from one another. *Phallus indusiatus* (commonly known as bamboo fungus) is wide spread in the tropics and considered to be an edible mushroom in China and commercially cultivated since 1979 (Huang 2002). Interestingly, the highest mycelial growth was seen during the cultivation of *P. indusiatus* on bamboo leaf as the sole substrate (Cheong et al. 2000).

On routine forays to investigate mushrooms at the Mangalore University Campus, our attention was drawn towards 3ha of a 20 year-old arboretum (12°48'50"N & 74°55'38"E) established with the support of the McArthur Foundation (Shetty & Kaveriappa 2001). The arboretum encompasses 57 tree species, two bamboo species and 23 shrub species of the Western Ghats (some of them are endangered). We collected a *Phallus* sp. growing in the basins of the monocots of the arboretum during the monsoon (August–October 2011). *Phallus* has been considered as a partial saprobe by Ainsworth et al. (1971) and this genus accounts for 168 records in 'Index Fungorum' (<http://www.indexfungorum.org/names/names.asp>). The present note deals with *Phallus merulinus* found in the arboretum. Besides the arboretum, this fungus is known in the basins of organically cultivated monocots (e.g., coconut and banana) during the monsoon and post-monsoon seasons. The description of this fungus is based on the observations of several individuals in and around the arboretum and the dimensions are based on the mean of 10 mature basidiocarps.



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*Dictyophora merulina* Berk. *Intellectual Observer* 9: 404 (1886)

*Clautriavia merulina* (Berk.) Lloyd, Synopsis of the known Phalloids: 24 (1909). *Mycol. Writings* 3, fig. 19 (1909)

*Dictyophora irpicina* Pat. *Bull. Soc. Mycol. Fr.* 14: 190 (1898)

*Phallus irpicinus* (Pat.) Lloyd. *Mycol. Notes* (26): 331 (1907); *Mycol. Writings* 2 (1907)

*Phallus merulinus* (Berk.) Cooke (*Grevillea* 11 (58): 57, 1882)

Basionym: *Dictyophora merulina* Berk. (1866)

*Phallus merulinus* (Berk.) Cooke has expanded from solitary basidiocarp (egg), partially embedded in soil or decomposing leaf litter, subglobose, 2.6x3.2 cm, egg white, 0.1cm thick elastic volva attached to substrate with conspicuous 2-3 white rhizomorphs (4–6x0.1–0.2 cm) and mature basidiocarp 10.6cm high. Gleba (cap) yellowish-grey, subglobose, 2.6x2.9 cm, with or without volval remnants, lower margin wavy, incurved towards the stipe, apex round to conical with an apical pore (which opens up widely later), sticky, gelatinous, surface smooth and partially undulate. Indusium (basket) white, semielastic and forming polyhedral to round net, 9.4cm in diameter, margin wavy and hangs down to two-thirds of the stipe. Stipe (stalk) white, pitted, cylindrical to partially fusoid, slightly tapering at apex with bulbous base, 9.2x2.3 cm, hollow, spongy and wall composed of chambers partially opened outwards. Partial veil white, inconspicuous on the stipe. Volva egg white outside, light caramel inside, 3.2x3.8 cm. Basidiospores long-ellipsoid, 2.9–3.5x0.8–1.3  $\mu\text{m}$ , subhyaline and smooth.

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**Substrates and growth:** Substrates of *Phallus merulinus* are usually the dead monocot debris embedded in soil in the basins of the monocots [(*Caryota urens* L., *Cocos nucifera* L., *Ensele superbum* (Roxb.) Cheesman, *Musa paradisiaca* L., *Ochlandra scriptoria* (Dennst.) C. Fischer and *O. travancorica* Benth. ex Gamble)]. Usually the unopened basidiocarps are prominently visible in the evening (17:00–19:00 hr) and fully matured mushrooms are seen next day early morning, requiring about 6–8 hr to transform from egg to matured mushroom. Conspicuous basidium emerges, enlarges by rupturing (Image 1a), the stipe extension takes place in 3–4 hr (Image 1b-d), indusium emerges in the next 2–3 hr and the indusium fully opens up within 1–2 hr (Image 1e). Subsequently (within 4–5 hr) the indusium shrinks, stipe



**Image 1.** Different stages of *Phallus merulinus*: (a) conspicuous ruptured egg white basidium (note red eyed *Drosophila* on the left top corner); (b) top and (c and d) side views of near mature mushrooms possessing volval remnants on gleba (note conspicuous volva with light caramel color inside in figure d); (e) fully matured mushroom showing conical shaped gleba with opened apical pore (note distribution of *Drosophila* on the gleba, indusium and stipe); (f) partially shrunken indusium with bent stipe before being pressed to soil. (© Mr. Madhu S. Kandikere)

bends and presses into the soil in the next 2–3 hr (Image 1f). Unlike other *Phallus* sp. (e.g., *P. indusiatus*), none of the matured individuals of *P. merulinus* collapsed due to their own weight in our observations. The indusium of *P. merulinus* is shorter than *P. indusiatus* and thus there are less chances to collapse (Reid 1977). The cap of *Phallus merulinus* is smooth unlike conspicuous reticulations in *P. indusiatus* (Burk & Smith 1978). The life cycle of *P. merulinus* in our study was approximately 25–30 days, which includes vegetative and reproductive

phases. *Phallus merulinus* was devoid of specific odor. The red-eyed *Drosophila* was the major insect attracted by this mushroom at egg stage, their congregation was highest on gleba than on stipe and indusium facilitating spore dispersal. Some red and black ants were also attracted towards the mature basidiocarp.

**Metabolites:** A variety of metabolites has been reported from *P. indusiatus* (e.g., enzymes, polysaccharides, non-volatile compounds and antioxidants). Cellulase and amylase were active at 45°C and the activity of the latter was comparable to potent thermophilic *Bacillus* sp. (Bakshi & Mandal 2006). Tyrosinase inhibitor (5-hydroxymethyl-2-furfural) could serve as skin depigmenting and lightening agent (Sharma et al. 2004; Parvez et al. 2006). Two glucans were isolated from *P. indusiatus* [b (1-3)-D-glucan; (1-6)-branched (1-3)-b-D-glucan (T-5-N)] (Hara et al. 1982; Wang et al. 2009) and fucomannogalactan (glycan) has been considered an immunomodulator (Wasser 2002; Zhang et al. 2007). The polysaccharides isolated from *P. indusiatus* also showed antitumor activities (Ukai et al. 1983). Non-volatile taste components have been reported by Guo et al. (2005). Total polyphenols were considered to be the major antioxidant components by Mau et al. (2002). Excellent reducing power, radical-scavenging effects and ferrous ion-chelating effects have been reported (Mau et al. 2002). Hot water extract also showed good antioxidant properties (Oyetayo et al. 2009). Ker et al. (2007) hypothesized that the soluble polysaccharide and monosaccharide profiles (e.g., galactoglucan, galactan, riboglucan, myoinositol and mannogalactans) influence the antioxidant capabilities, which in turn are responsible for other biological activities like anti-inflammatory, immune-enhancing and anticancer properties. Riboglucan (801 kDa) of *P. indusiatus* exhibited the most potent antioxidant activity. Ker et al. (2007) also indicated that a large amount of myoinositol has good immunobioactivity. Hot water extract also showed broad spectrum antibacterial and antifungal principles (Oyetayo et al. 2009). *Phallus indusiatus* is historically known to treat many inflammatory, gastric and neural disorders since 618AD in China (Ker et al. 2011). As seen in *P. indusiatus*, alternatively a wide range of bioactive metabolites of medicinal and therapeutic potential are likely to exist in *P. merulinus*.

**Conclusions:** Degradation and fragmentation of forests lead to a considerable decline of the diversity of flora and fauna. After flora and fauna, saprophagous fungi constitute the third important component of forest ecosystems involved in detritus transformation, turnover and mineralization. Compared to flora and

fauna, our knowledge on the diversity, distribution and impact of forest detritus degradation by fungi is meager. Rehabilitation of forest communities needs considerable duration as macrofungi prefers old-growth microhabitats than new microhabitats (Norden & Appelqvist 2001; Brown et al. 2006). If we attempt to preserve the gene pool of macrofungi in situ, we need to preserve the old-growth forests, which are endowed with ample quantity of diverse detritus (e.g., wood stubs, fallen logs, twigs/bark/leaves and termite mounds) suitable for fungal existence and perpetuation. The occurrence of *P. merulinus* in the 20-year old arboretum of Mangalore University justifies its preference for old-growth forests for its growth and perpetuation.

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