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Research Article

Emergence of a Veiled Lady (*Phallus indusiatus* Vent.) in moist habitat under sal forest in the Wildlife Institute of India, Uttarakhand

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Phallus indusiatus **is a tropical fungus that is often referred to as the 'Veil of Bride' or 'Crinoline stinkhorn'. It can be identified by its phallic form and veil-like appearance. It generally appears after heavy rains and grows in damp, dark areas with decomposing organic materials, such as decaying stumps and thickets of bamboo. It has been reported in tropical regions such as South America, Asia, and Africa. The fungus has a tall, horn-like stipe and a fetid smell and sticky gleba, attracts insects for the purpose of dispersing its spores. It was recently observed for the first time at the Wildlife Institute of India in Dehradun. The species is vital to the ecosystem because it breaks down organic matter, improves soil fertility and assists in nutrient cycling as well as enhance biodiversity.**

Keywords: *Doon valley, Indrajal fungus, medicinal, mutualistic relationship, Phallus*

Introduction

Etienne Pierre Ventenat (1757-1808), a French naturalist, published the first official description of the stinkhorn fungus in 1798. There are *ca.* 77 species and 21 genera in this family (Kirk *et al*., 2008). *Phallus* has 181 taxa (IF, 2020), however, based on the molecular data in GenBank (Li et al., 2016), a taxonomic study of *Phallus* described only 13 species (excluding forms and varieties) viz., *P. atrovolvatus, P. cinnabarinus, P. echinovolvatus, P. hadriani, P. haitangensis, P. impudicus, P. indusiatus, P. mengsongensis, P. multicolor, P. rubrovolvata, P. rugulosus, P. serrata* and *P. ultraduplicatus*. There are currently eight species of *Phallus* reported to be present in India (Gogoi and Prakash, 2014). This fungus generally grows in tropical areas across Africa

Figure 1 *Phallus indusiatus* distribution across the world. (Source: https://redlist.info/iucn/species_view/245788)

South America (e.g., Argentina, Brazil, Colombia, Guyana, Venezuela), Central America (Panama, Costa Rica), North

Communis Biologica
1 (1) 1-8
DOI:

America (Mexico) and Asia (Indonesia, India, Southern China, Japan, Nepal, Malaysia, Taiwan, Singapore, Sri Lanka, Republic of Korea) at temperatures between 21° and 25° C in moist bamboo thickets (https://en.wikipedia.org/wiki/Phallus_indusiatus#cite_note-Smith_2005-42). Due to its widespread records, especially in the Neotropics, it is classified as Least Concern (LC) as per the Global Fungal Red List (https://redlist.info/iucn/species_view/245788/; Figure 1).

Materials and methods

The Wildlife Institute of India's campus, situated in a valley between the Shivaliks and Lesser Himalaya, boasts rich biodiversity with a mosaic of natural scrub, woodland and various successional stages of *Shorea robusta* forest, forming various habitat types (https://wii.gov.in/biodiversity). The Wildlife Institute of India campus has a diverse range of species, including 616 plant species (58 trees, 65 shrubs, 357 herbs and climbers, 71 grasses, 27 sedges), 20 mammals, 22 snakes, 4 turtles, 10 fish, 90 butterflies, 190 moths, 102 spiders, 26 ants and 18 beetles (borer).

Figure 2 Location (yellow dot) of Phallus indusiatus (red circle) in Wildlife Institute of India, Uttarakhand, India.

Results

Based on literature review *Phallus indusiatus* is identified by its phallic form and veil-like

At the Wildlife Institute of India Campus, Dehradun, *Phallus indusiatus* is being reported first time (Figure 2), which is found near a water channel along the side of a rotten stump of *Triadica sebifera* (L.) Sm. (Syn. *Sapium sebiferum* (L.) Roxb.) under bamboo thickets. The frequency of its sighting was on 31 July, 2024 (1 individual), 5 August, 2024 (2 individuals), 7 August (1 individual) and 16 August, 2024 (1 individual; Figure 3) in the morning only and by evening almost consumed by insects and flies or degenerate due to rains and the temperature varies from 26 to 32° C (WII Meteorological station) at the site.

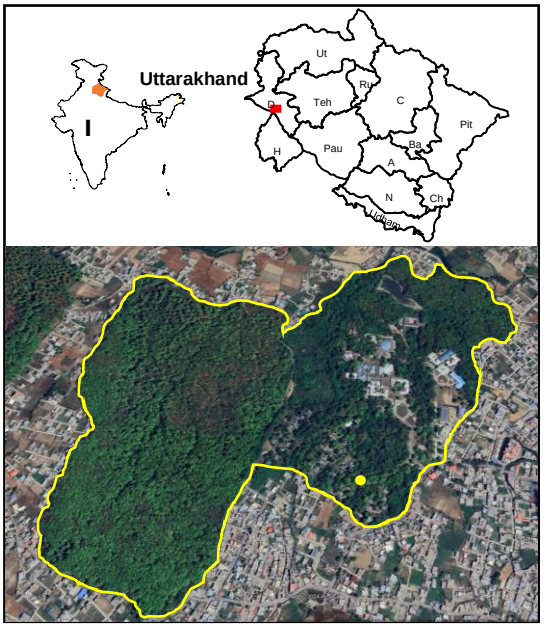

Figure 3 In-situ observations of mature individuals of *Phallus indusiatus* at WII campus, Dehradun (A: 31 July, B: 5 August, C: 7 August and D: 16 August, 2024)

appearance, a tropical fungus that is often referred to as the 'Veil of Bride' or 'Crinoline stinkhorn'. The entire process from egg rupture to consumption of gleba took place nearly 2 days and the development of veil is

just a few minutes *ca.* 20-25 minutes (pers. observation), while the gleba was consumed within 1-1.5 hours by 4-5 Mediterranean fruit flies (*Ceratitis capitata*) and by evening it was disintegrated.

Synonyms

Dictyophora callichroa Moller and *Phallus duplicatus* Bosc.

Etymology

Since several of the mushrooms in this group have phallic shapes, Carl Linnaeus called the genus *Phallus*. The Latin word for 'wearing an undergarment', *indusiatus*, refers to the lace-like indusium. Greek words *diktyon* (net) and *phero* (to bear) were the source of the previous genus name, *Dictyophora*, meaning 'bearing a net' (Desvaux, 1809; Liddell and Scott, 1940). *Phallus indusiatus* is also known by a number of common names, including 'basket stinkhorn' (Arora, 1986), 'long net stinkhorn/crinoline stinkhorn' (Hall, 2003), 'taja-de-cobra' in the inner regions of the Brazilian Amazon (Santana *et al*., 2019), 'netted mushroom' and 'ladies skirt', and in Odisha, India 'Indrajal fungus' (Dash et al., 2010). The Chinese term 'bamboo mushroom' refers to its typical growth habitat (Ying et al., 1987), but the Japanese refer to it as *Kinugasatake*, named after the wide-brimmed hats with dangling silk veils (Inoki, 2006)..

Habit

It is a saprobic fungus (Ainsworth et al., 1971) appears immediately after heavy rains. It consists of hyphae, which together form the mycelium and when two groups of mycelium conjugate under favourable conditions, a fruiting body develops (Radford, 1982). It grows beneath the soil intermittently with the formation of reproductive structures called 'eggs', a conspicuous rhizomorph at the base existing in the substratum on dead tree trunk. The fruiting body grows quickly once the peridium of the egg ruptures, which is odourless and edible and soon produces a horn like structure emerges within minutes. A lacy white veil descends almost to the ground within a day, eventually turning yellowish and lasting few days (Tuno, 1998). The fungus produces a sticky spore mass with a fetid smell to attract flies, which then help disperse its spores (Radford, 1982; Jonathan et al., 2008), while the smell can be detected from a considerable distance within the forest. Several studies have documented the interactions involving different insects, such as Tan (2008) focused on flies (Diptera), Oliveira and Morato (2000) examined stingless bees (Hymenoptera), Yamashita et al. (2018) investigated beetles (Coleoptera) and butterflies (Lepidoptera), while Hawkeswood et al. (2020) and Santana and Couceiro (2024) explored various mycophagous invertebrates. A study conducted by Santana and Couceiro (2024) in Brazilian Amazon forest reported that a total of 333 insects associated with *P. indusiatus*, which were largely visited by stingless bees for foraging, while insect carried the highest number of spores.

Macromorphological characters

The macromorphological characters of *Phallus indusciatus* has been described (Dash et al., 2010; Gogoi and Prakash, 2014), whereas the details of the measurements of each part, are measured by the author at the site (Figure 4).

Fruiting body: It generally measures from 18 to 25 cm tall, with a stipe and a cap develop during the night (Tuno, 1998).

Gleva/Receptaculum (pileus/cap/gills): reticulated (pitted and ridged) surface thick cap (width 2.5-2.8cm and length 2.6-3.2cm), greenish-black, shiny layer with adhesive and an opening (mouth) on the tip (Arora, 1986). The raised honeycomb texture of the cap is

Communis Biologica
1 (1) 1-8
DOI:

visible beneath the gleba. As soon as the cap emerges from the egg, insects attack it and eat the gleba. Unlike most mushrooms, it produces a sticky, spore mass with fetid smell to attract insects, which aid in spore dispersion. Some of the sticky gleba adheres to the legs of the insects; that is how the spores get carried from one location to another.

Spore: the slimy gleba, dark olive colour, contains yellowish spores (ellipsoidal to cylindrical, smooth).

Stalk: creamy white, cylindrical (diameter 2.5-3.2cm at base and 1.8-2.2cm towards the tip, length: 10-14cm) and remains for just a day or two once the gleba is consumed

Veil of indisium (coat): whitish polygonal or round, a lace-like skirt (netted veil; length 10-13cm and width towards lower side 17-23cm), turns into golden/pale yellow towards end and very short lived.

Volva (cup): white club like structure at the base (width 2.4-2.7cm and length 2.9-3.6cm).

Nutrient composition

The nutrients and mineral elements in *Phallus industiatus* are: water content 90.9%, fat 4.7%, crude fibre 6.03%, carbohydrate 0.064%, protein 4.813%, vitamin C 2.286%, ash content 10.402%, Ca 0.099%, Mg 0.053%, Fe 0.001%, Al 1.012% and Si 1.596% as reported by Sitinjak (2017). Moreover, these components are heterogeneously distributed in space and time (Wertheim et al., 2000), while insects disperse the fungal spores.

Figure 4 A mature fruiting body of *Phallus indusiatus* (A), Gleba (B), Mediteranean fruit flies feeding on gleba (C), Mediteranean fruit fly (D), Stalk (E), indusium (F), Volva (G) and disintegrated indusium and stalk (H)

Habitat

Phallus indusiatus generally occurs in tropical climates on the rich amorphous litter in shady and moist habitats, where it benefits from the consistent humidity and organic richness of the environment. The shaded, damp conditions near the moist areas with decomposed wood and leaf litter of bamboo are ideal habitat for this fungus, as they help maintain the high humidity necessary for its fruiting body to emerge. In such environment, the Veiled Lady's fruiting body appears rapidly after rainfall, taking advantage of the decomposed organic matter for nourishment. The proximity to wet areas ensures that the surrounding soil remains moist, further facilitating the fungal growth and spore dispersal. This setting exemplifies the intricate relationship between the fungus, its substrate and the surrounding environmental conditions, highlighting the role of heavy rains in enhancing its ecological niche. The eggs are hypogeous when young and become epigeous at maturity, as discussed by Alexopolous et al. (1996). The mature basidiocarp with fetid smell lasts barely a few hours (Gogoi and Prakash, 2014).

Ecological role

As the species play a vital role in an ecosystem by enhancing soil health and biodiversity by decomposing organic matter, recycling nutrients, aiding plant growth and forming crucial mutualistic relationships with insects. Insects and fungi have a mutualistic relationship that dates back at least 100 million years (Schmidt et al., 2010). Insects assist spread fungal spores through mycophagy, while fungi provide vital carbohydrates, proteins, vitamins, and lipids (Lundgren, 2009). By decomposing dead plants, recycling nutrients, simplifying organic molecules for better plant growth (Lindahl and Tunlid, 2015) and aiding in the binding of soil particles to increase aeration and water retention (Marschner, 2011) fungi improve the health of the soil. It contributes significantly to ecosystem biodiversity and nutrient cycling by providing support for a variety of microbes and insects through the decomposition of organic materials (Rillig and Mummey, 2006).

Culinary Use

In Eastern Asia, *Phallus indusiatus* is a valued and historically rare delicacy, renowned for its purported aphrodisiac properties. It is traditionally served at special events, such as royal banquets and diplomatic functions, where it is appreciated for its delicate texture and flavour. Commonly used in rich chicken soups and stir-fries, the dried mushroom requires rehydration prior to cooking. *P. indusiatus* is both consumed as a food item and utilized in traditional Chinese medicine, noted for its high protein and fibre content, as well as its bioactive compounds with antioxidant and antimicrobial properties. In certain regions of China and Hong Kong, it is consumed as a vegetable. The cost of dried *P. indusiatus* ranges from US$ 10 to 20 per kilogram (Huang, 2002), while in India due to its fetid smell, people do not eat it.

Medicinal use

Since the Tang dynasty, *Phallus indusiatus* has been utilized in traditional Chinese medicine for the treatment of inflammatory conditions, gastrointestinal disorders, and neurological diseases. Among the *Miao* people, it is used to address ailments such as injuries, coughs, dysentery and leukaemia. Clinically, *P. indusiatus* is prescribed for conditions including laryngitis, fever, diarrhoea, hypertension, and as an adjunct in anticancer therapies (Ker et al., 2011). It is also recognized for its medicinal properties, including antioxidant and antimicrobial activities (Oyetayo et al., 2009; Dai et al., 2009), while the edible portion of *P. indusiatus* exhibits a range of therapeutic

Communis Biologica
1 (1) 1-8
DOI:

effects, such as antioxidant, immunological, anti-diabetic, hepatoprotective, neuroprotective, anti-fatigue, antitumor, and anticancer activities (Mazumder et al., 2022) and antimicrobial and anti-inflammatory properties (Habtemariam, 2019).

Cultivation

Since 1979, *Phallus indusiatus* has been commercially cultivated in China, particularly in Fujian Province. Advances in cultivation techniques have reduced production costs and increased availability. By 1998, China was producing ca. 1100 metric tons, utilizing agricultural waste such as bamboo sawdust under optimal conditions of 24° C and 90-95% humidity (Yang and Jong, 1987).

Cultural

Across various regions, the species has cultural significance, such as in Mexican divinatory ceremonies, considered sacred in New Guinea, its smell attracts hunters as mentioned for *Yoruba* religion in Nigeria and the *Igbo* people consider it a 'beautiful mushroom' according to an ethnomycologist, R. G. Wasson (https://www.inaturalist.org/taxa/54591-Phallus-indusiatus).

Discussion

Though, it is reported earlier also from Corbett Tiger Reserve by Pooran Goswami in September, 2022 (https://www.facebook.com/groups/sanctuaryasia/posts/10160414 86431103 /?_rdr) and a specimen of *Dictyophora phalloidea* Desv. Dehradun, Fl. of North-Western Himalaya examined by Dash et al. (2010) is kept at Lower Plant Division, Central National Herbarium, CAL, Howrah, West Bengal was collected by McKinnon (1897). In India, it has been reported from various states viz., A & N Islands, Assam, Goa, Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal by various workers (Bakshi and Mandal, 2006; Dash et al., 2010; Gogoi and Parkash, 2023; Bhagwat et al., 2005; Swapna et al., 2008; https://indiabiodiversity.org/species/show/240330).

Conclusion

In a nutshell, *Phallus indusciatus* plays a crucial role in ecosystems by decomposing organic matter, such as leaf litter and dead plant material. During the rainy season, their activity intensifies as increased moisture accelerates the decomposition process. This decomposition not only recycles nutrients back into the soil but also supports plant growth and maintains soil health. In the context of climate change, shifts in precipitation patterns and increased temperatures can alter fungal activity and decomposition rates. These changes can impact nutrient availability and soil structure, potentially affecting plant communities and overall biodiversity. However, the adaptability of fungi allows them to thrive in varied conditions, contributing to ecosystem resilience and helping to sustain diverse life forms. As climate change continues to influence environmental conditions, understanding and preserving fungal diversity becomes essential for maintaining ecosystem balance and supporting insect biodiversity.

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Author contributions

BSA examined specimens and drafted the manuscript and gave the final approval for publication.

Conflicts of interests

The author declares that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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Communis Biologica
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