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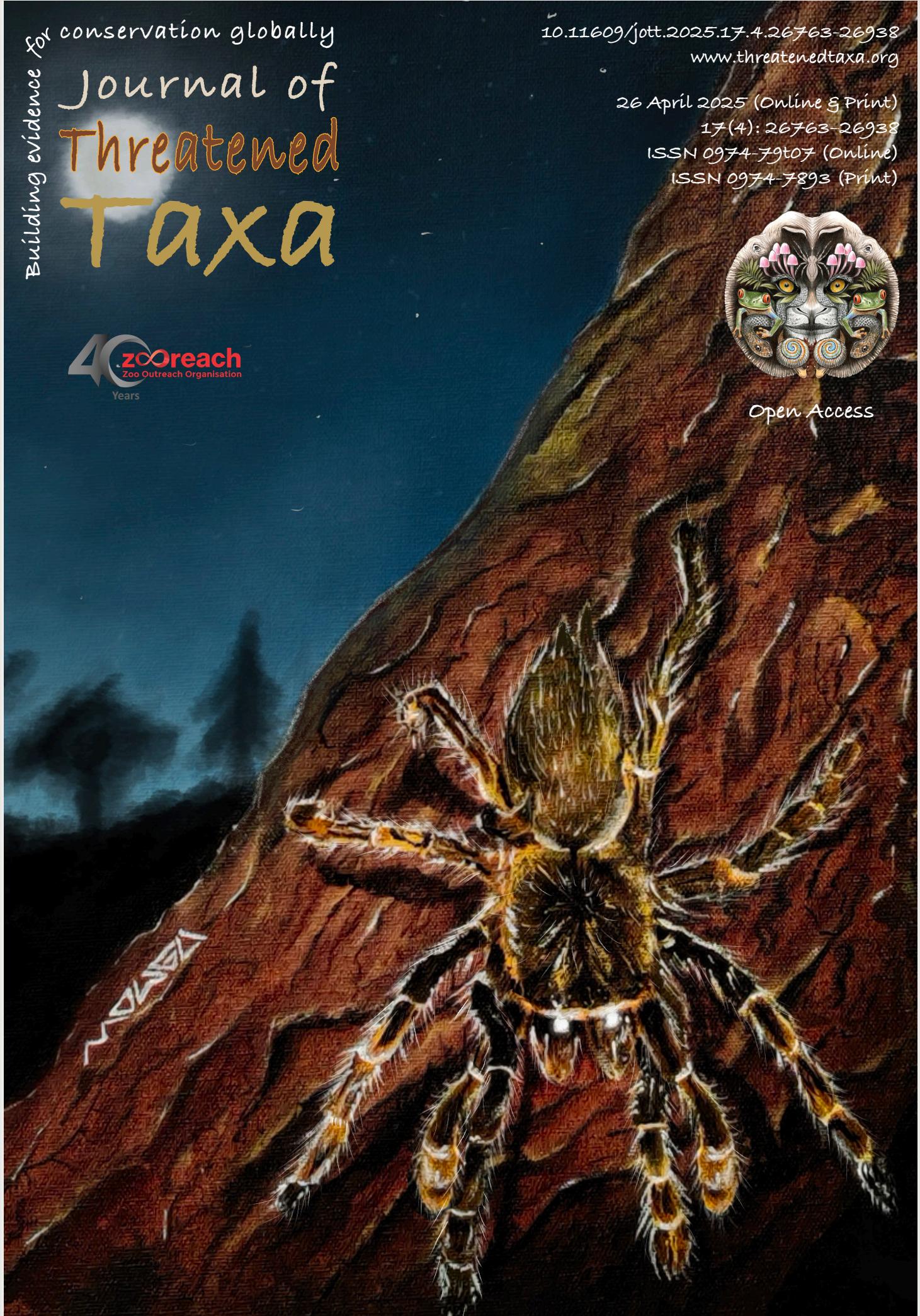
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Cover: Nilgiri Large Burrowing Spider *Haploclastus nilgirinus*. Acrylic on canvas. © Aakanksha Komanduri.



## Rediscovery of *Phallus aurantiacus* Mont. from India and new distribution record from Odisha, India

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**Abstract:** *Phallus aurantiacus* Mont., a distinctive species of stinkhorn fungus within the family Phallaceae, is documented with detailed morphological features along with coloured illustrations for the first time from the state of Odisha, India. This notable range extension significantly expands the known distribution of the species within the Indian subcontinent.

**Keywords:** Biodiversity, India, macro-fungi, Odisha, phallus stinkhorns, taxonomy.

'Stinkhorn' refers to a broad range of macro-fungi with a distinctive horn-shaped slimy top. Stinkhorn is an artificial term for several genera and some eye-catching ones are *Aseroe* Labill, 1800, *Clathrus* P. Micheli ex L., *Claustula* K.M.Curtis, *Colus* Cavalier & Séchier, 1835; *Ileodictyon* Tul. & C.Tul., 1844, *Kobayasia* S.Imai & A.Kawam, *Laternea* Turpin, *Lysurus* Fr., *Mutinus* Fr., *Phallus* Junius ex L., *Pseudocolus* Lloyd, 1900. Fischer

created the order Phallales, which included the stinkhorns (family Phallaceae) and lattice stinkhorns (family Clathraceae) mushrooms. Both families produce epigaeous, spongy, fleshy bodies that allow them to expand rapidly as they absorb water from their environment. These taxa have fragrance which lures small insects, especially flies, which subsequently spread the spores. Insects have been known to perform the typical mycophagous behaviour on stinkhorns for almost a century, and almost all Phallaceae and Clathraceae species rely on them to spread their spores (Fulton 1889).

There has been a great deal of interest in *Phallus*, commonly known as stinkhorns, by mycologists because of their distinctive morphological phalloid basidiomata with bell-shaped to campanulate receptacles, cylindrical, hollow and spongy pseudostipes, saccate volva with

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a few simple or branched rhizomorphs, presence or absence of latticed indusium and the noticeable foetid or nauseating smell in most taxa (Li et al. 2020). The genus *Phallus* accounted for 107 records in Index Fungorum with 31 species as of 2016 and 212 records in the Mycobank as of 2025 (Li et al. 2016). However, to date only two species have been reported from Odisha: *P. multicolor* (Berk. & Broome) Cooke (Mahapatra et al. 2013) and *P. indusiatus* Vent. (Dash et al. 2010).

The third record of *Phallus* member as *P. aurantiacus* described in this article is recovered from Chandaka, Odisha. Stinkhorns are saprobic fungi that grow in areas that have organic matter and they grow naturally on Chandaka's roads, a part of Eastern Ghats situated in Odisha, showing dry deciduous woodland and the roads and trails that cross the protected area exhibit signs of habitat fragmentation. These mushrooms develop on a buildup of litter that is made up of bamboo shavings and litter. The goal of this study is to shed light on the remarkable biodiversity of the area.

## MATERIAL AND METHODS

The morphological determination was performed on the basis of freshly gathered fruiting bodies following the methods described previously (Montagne 1841; Oso 1976; Kuo 2019) along with ex situ photography with the help of a digital camera. The dimensions, form, and colour of the taxonomic characters were recorded. For

describing colour of basidiomata no specific colour codes were followed and it was given on the basis of general observation. The samples were kept in formaldehyde for further examination following which the sample was dried at 40–50 °C in a hot air oven before being put in airtight ziplock bag with a few moth balls and deposited in the Regional Plant Resource Center, Bhubaneswar, India, with accession number 8643. Methun Handbook of Colour (Kornerup & Wanscher 1978) were used to refer the colour code.

For microscopic examination, dried specimens were mounted with 5% KOH in order to rehydrate and examine the tissues of taxonomic importance followed by thin sections mounted in phloxine, cotton blue and Melzer's reagent successively. An optical Carl Zeiss Axiolab 5 microscope equipped with an Axiocam 208 camera was utilised, as described previously by Kuo 2019. Microscopic examination of hyphae/cells and spores with taxonomic significance were done under 40X and 100X objectives. Measurements were taken of 30 basidiospores and 10 hyphae randomly from different sections.

## RESULT AND DISCUSSION

### Taxonomy

***Phallus aurantiacus* Mont., Annls Sci. Nat., Bot., sér. 2 16: 277 (1841) (Image 1)**

Immature basidiomata (egg) range from 20–35 x 10–

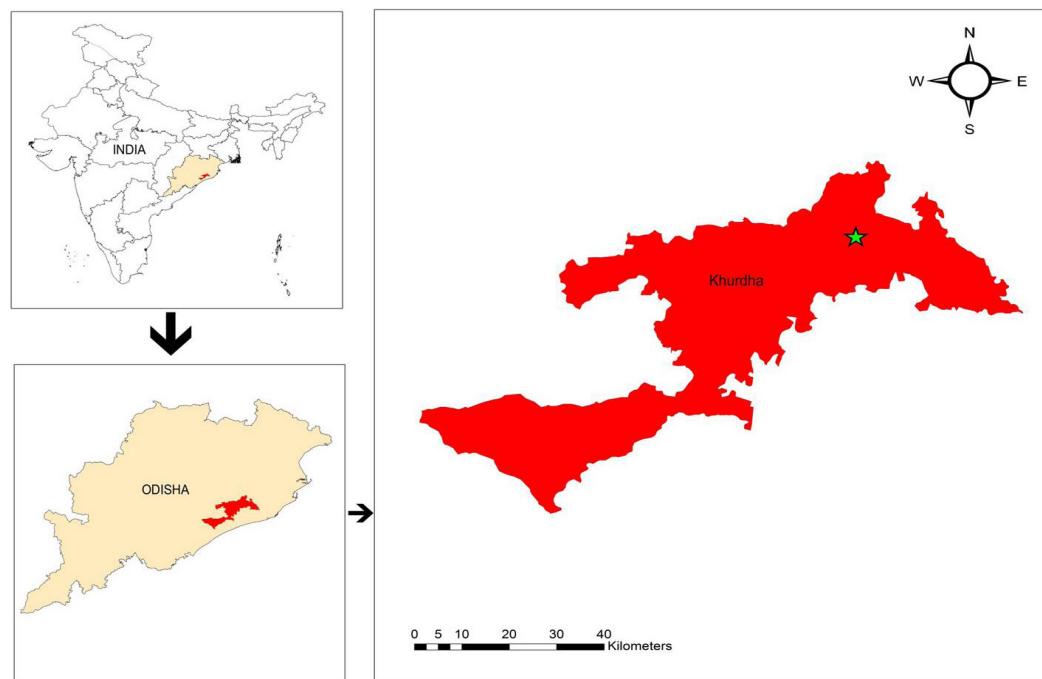


Figure 1. Location of *Phallus aurantiacus* Mont. in Odisha State of India along with habitats.

25 mm, exhibit a globose to subglobose to oval shape. They are situated below moderately branched, white-coloured rhizomorphs extending 50–60 mm in length, anchoring the eggs in a subterranean position within the soil. The exoperidium is characterized by its papery thin to membranous texture, presenting a coloration ranging from white (A1) to yellowish brown (5D8). The mesoperidium measures 5–6 mm in width, appearing thick and gelatinous with an olivaceous grey hue, while the endoperidium is papery thin and slightly darker than the mesoperidium. The gleba, approximately 8–9 mm wide, is slimy or sticky, exhibiting an olive brown (4D6) colouration surrounding the unexpanded, thick, chalky white (A1), narrowly hollow immature pseudostipe with a yellowish-orange (4B7) to yellow ochre (5C7) lumen, which develops into a pseudostipe with maturity. Dehiscence occurs through an apical irregular slit.

In fully matured basidiomata, the pseudostipe measures 110–130 × 15–20 mm and terminates apically with a head measuring 15–20 mm in length. The head is partially elongated, conical to fusiform in shape, and clearly distinguished from the pseudostipe. It is wider than the pseudostipe and has a single-chambered wall, opening internally and continuing externally. The surface of the head is rugulose with parenchymatous processes forming pockets, displaying colors ranging from orange (6B7) to pale orange (6A3), occasionally interspersed with a few delicate bands of whitish (A1) universal veil material. The cylindrical stalk, covered by a volva and slightly narrowing towards the base, is perforated throughout by pockets formed by pseudoparenchymatous processes. Similar to the head, its wall consists of a single chamber, opening externally and continuing internally. The gleba adheres mostly or entirely to the head except for the marginal apex, exhibiting a sticky or slimy texture and colours ranging from dark purple (14F8) to olive (4F8). The volva, measuring 20–30 mm in diameter, varies in colour from white (A1) to light brown (7D5), emitting an unpleasant odour.

Basidiospores measure  $4.0 \times 2.4 \mu\text{m}$ , displaying an ellipsoid to sub-cylindrical shape with a smooth, thin-walled, hyaline, inamyloid, and acyanophilic structure. Pseudostipe cells range 37–65  $\mu\text{m}$  in diameter, appearing irregularly sub-globose with a smooth, thick-walled (1–2  $\mu\text{m}$  thick), hyaline, inamyloid, and acyanophilic composition. Volva hyphae measure 2–6  $\mu\text{m}$  in width, presenting a thin-walled, smooth, hyaline, inamyloid, and acyanophilic structure.

**Ecology:** Uncommon in the study areas, gregarious to caespitose, in association with herbaceous elements

such as *Bambusa bambos* (L.) Voss., *Chromolaena odorata* (L.) R.M.King & H.Rob., *Justicia japonica* Thunb., *Mimosa pudica* L., etc. and are part of the associated floristic population of the present species on the litter-covered clay or sandy soil in moderately shady places along with shrub population of the area and also seen in local bamboo vegetation.

**Known distribution:** Recorded from India, Africa (from Nigeria to South Africa after Oso BA 1976).

**Specimen examined:** India, Odisha, Chandaka Road, Bhubaneswar, Near Deras Dam, Chandaka, Bhubaneswar, Khordha, 20.3102 °N & 85.6908 °E, alt. 83 m, 15 August 2023, on the soil with litter.

## DISCUSSION

Members of the genus *Phallus* characteristically exhibit perforated apex, serrated margin bear digitiform, reticulate and half-free cap/ supported by cellulose-perforated orange colour stipe which arises from greyish-white bulbs having white rhizomorphs. Our specimens have sufficient macro and microscopic taxonomic features like orange colour fruiting bodies bearing olivaceous brown gleba at the apex macroscopically. At the same time, ellipsoid to subcylindrical spores with  $4.0 \times 2.4 \mu\text{m}$  are fairly similar to the circumscriptions provided by Montagne 1841 and Oso 1976 and Kuo 2019 successively. *P. rubicundus* (Bosc) Fr. and *P. rugulosus* (E.Fisch.) Lloydare taxa like *P. aurantiacus* and may easily be misidentified with the present one in the field. However, *P. rubicundus* has a thicker pink to red stem and a more consistently bell-shaped head whereas *P. rugulosus* is slenderer and, when fresh, presents a redder shade of orange (Kuo 2019).

While *P. indusiatus*, a mushroom used in Chinese cuisine, has been reported from Odisha (Dash et al. 2010) to the best of our knowledge, *P. aurantiacus* has not been reported from Odisha, and this is the second report in white literature after Montagne reports the macro fungus from Pondicherry Botanic Garden of south India in 1841 (Montagne 1841). After scrutiny of list and references on Phalleles of India (Butler & Bisby 1931; Bilgrami et al. 1979, 1981, 1991; Sarbhoy et al. 1996; Jamaluddin et al. 2004; Bisht 2008; Panda et al. 2019; Mahapatra et al. 2013, 2024; Manoharachary et al. 2022) we conclude this species as rediscovery after 138 years for the Indian Mycobiota. Although, two varieties of *Phallus aurantiacus* var. *aurantiacus* or *Phallus aurantiacus* var. *discolor* have been described in the past, we did not attempt to further characterise the present specimen owing to lack of robustness of current phylogenetic frameworks in Phallales to confidently support formal



Image 1. a—Habitat of *Phallus aurantiacus* Mont. ex situ | b & c—habit | d—habit of immature basidiomata (bulb) ex situ | e—vertical section of bulb showing exoperidium, mesoperidium, endoperidium, gleba, and pseudostipe | f—volva and basal part of stalk | g—head supported by pseudostipe (stalk and hollow nature) | h—basidiospores | i—pseudoparenchymatous cells of stipe under phase contrast microscopy. Bars h & i = 20  $\mu$ . © Malay Prithviraj Sahoo & Prabhat Kumar Das.

recognition of subspecies or varieties (Melandra et al. 2021; Luangharn et al. 2024). This finding contributes to the overall knowledge of fungal biodiversity in Odisha and underscores the need for further mycological exploration in this region. Understanding the ecological and distributional patterns of fungi, especially those as intriguing as *P. aurantiacus*, is essential for conservation efforts and the preservation of ecosystems where these organisms play vital roles. This discovery is a testament to the ongoing discoveries awaiting mycologists in India, highlighting the importance of continued research to unveil the rich fungal diversity in this country.

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