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Stinkhorns: two new distribution report and morphological study of dog stinkhorn (*Mutinus caninus*) and jacaranda stinkhorn (*Itajahya galericulata*) from Rajasthan, India

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ABSTRACT

Stinkhorns are a group of fungi (family Phallaceae, order Phallales), known for their phallus-like, foul-smelling fruiting bodies. Their characteristic smell attracts flies and other insects, which help disperse the spores. Two new distribution reports of species of stinkhorn (*Mutinus caninus* and *Itajahya galericulata*) have been identified and described from the state Rajasthan, India. The samples were collected from Maharshi Dayanand University, Ajmer, Rajasthan, India, during the monsoon season ranging from June to September, 2025. To verify its identity, habitats, distribution and morphological characteristics (color, size, and shape of fruiting body, gleba, cap, stem) were studied. Calyptra is present in *Itajahya galericulata* but absent in *Mutinus caninus*. The morphological characteristics of the collected specimens were compared with the earlier reported specimens from Europe, South America, Africa, and India. The identification shows no previous reporting of the two species of *Mutinus caninus* and *Itajahya galericulata* from Rajasthan to date. However, the two Phallaceae species have been reported from India including Tamil Nadu and Gujrat states.

Keywords: *Itajahya galericulata*, *Mutinus caninus*, Phallaceae, Rajasthan, Stinkhorns

1. INTRODUCTION

The kingdom Fungi includes diverse macro and microorganisms ranging from mushrooms, molds, yeasts, rusts, and smuts. These fungal forms inhabiting diverse habitats are known to contribute remarkably in earth's essential systems and lifecycles. In addition, they are known to contribute significantly in economic and industrial sectors such as medicines, agriculture, research, cosmetics, alcohol, brewery, and many more (Stajich et al., 2009). Macrofungal communities since years are known to play an essential role in ecosystem functioning and stability. Several ecological roles such as mutualists, saprotrophs, and decomposers are vitally known to be played by the macrofungi (Zeb et al., 2023). The macrofungi such as mushrooms provide ecosystem stability and functioning such as nutrition, disease resistance, and abiotic and biotic stress tolerance. The environment is known to inhabit diverse

categories, including poisonous, edible, medicinal, and non-toxic. These all contribute to different ways to ecosystem regulation and cycling processes (Tedersoo et al., 2020; Zeb et al., 2023).

Stinkhorns belong to the family Phallaceae, easily recognized by their unusual shapes and intense, often foul odor reminiscent of rotting meat or dung. These mushrooms can appear suddenly in gardens, mulch, lawns, and other places rich in decomposing organic matter. Common genera include *Phallus*, *Mutinus*, *Dictyophora*, *Itajahya* and others. Stinkhorns were considered toxic, due to their unpleasant smell. In contrast to other mushrooms, stinkhorns disperse its spores releasing a fragrant and viscous fluid at the tip and attract flies and other insects, which work as carriers for the spores (Govindaraj et al., 2016; Kuo, 2006).

First described as *Phallus caninus* by William Hudson in 1778, transferred to *Mutinus* by Elias Magnus Fries in 1849. The currently accepted name of this species is *Mutinus caninus*, the synonyms of which include *Phallus caninus* Huds., *Phallus inodorus* Sowerby, *Ithyphallus inodorus* Gray, and *Cynophallus caninus* (Huds.) Berk (Arora, 1986). The species was reported as a new record for southern India, particularly from the Loyola College campus and other sites in Chennai, Tamil Nadu, during the southwest and northeast monsoon seasons (Dutta et al., 2012; Govindaraj et al., 2016).

The name *Itajahya* derives from the Itajai River, in the region of Brazil where it was originally discovered. *Itajahya galericulata* was first described by Alfred Møller from Brazil in 1895 (Long & Stouffer, 1943). It is rarely recorded, but has been found in Bolivia, New Mexico, Arizona, South Africa, and central Australia, where it has not been identified since 1983. The first evidence in Asia was recorded in Vadodara, Gujarat, India (Patel et al., 2018).

The objective of the present study is to understand the morphological study of the macrofungal community, particularly stinkhorns of the family Phallaceae (Table 1). The two stinkhorn species, mainly *Mutinus caninus* and *Itajahya galericulata*, were collected, described, and reported from central Rajasthan, India, in the monsoon season (June to September), 2025.

Table 1: A comparative description of *Mutinus caninus* and *Itajahya galericulata*

Characteristic	<i>Mutinus caninus</i>	<i>Itajahya galericulata</i>
General Morphology	Phallus-shaped fruitbody, cylindrical 10–12 cm tall, pale yellow-orange, emerges from egg-like base.	Cylindrical, characterized by a distinctive, hat-like structure, the Calyptra, making it fairly easy to recognize, mature basidiome up to 15 cm; emerges from “egg” stage.
Habitat	Deciduous/coniferous woods, on soil, wood debris, leaf litter, often in groups.	Subtropical to tropical forests, associated with Fabaceae trees (e.g., <i>Jacaranda</i> , <i>Pithecellobium</i>) and <i>Azadirachta</i> tree
Egg/Immature Stage	Off-white egg (2–4 cm high), tough peridium, gelatinous inner layer.	Greyish-white immature eggs, outer peridium has four layers, mucilaginous.
Volva	Present as a sack at the base (remains of the split egg).	Egg peridium remains at the base; often four-layered.
Stipe	Hollow, fragile, pitted, columnar, pointed tip.	Hollow, white, spongy stipe, up to 15 cm long.
Gleba	Olive-brown, slimy, smelly tip (spore mass), attracts insects.	Mucilaginous, olive-green gleba covers apex, foul smell.
Spore Characteristics	Cylindrical to ellipsoid, smooth, hyaline; typically, 4–5 × 1.5–2 μm (Govindaraj et al., 2016)	Basidiospores 5–7 × 2–3 μm, cylindrical, hyaline, thin-walled, smooth (Patel et al., 2018).
Dispersal Mechanism	Insects (especially flies/ants) attracted by odor to gleba, pick up and disperse spores.	Same mechanism: produces strong odor to attract insects (especially flies) for spore dispersal.

Toxins	Not known to be toxic; no evidence of dangerous compounds.	No reported toxins; not associated with poisoning cases.
Culinary/Other Uses	Edible in the 'egg' stage but not recommended; sometimes cooked in the eastern US.	Not edible or used; no records of culinary or medicinal uses

2. MATERIAL AND METHODS

The Ajmer district in Rajasthan exhibits a rich diversity of fungi. Ajmer district supports a variety of wild and cultivated mushroom species, owing to its distinct semi-arid climate and diverse organic substrates. It is called the heart of Rajasthan and is surrounded by the Aravali Mountains (Latitude 26° 27' N, Longitude 74° 42'E), situated on the lower slopes of Taragarh hill. The specimens were collected from the campus of Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India, with 26°30' N latitude and 74°40' E longitude during the monsoon season from June to September, 2025. The university was established on August 1, 1987, and is situated near the village of Ghooghra, approximately seven kilometres from the city of Ajmer.

The campus was selected based on the large area of approximately 766 acres, with rich biodiversity and an abundance of flora and fauna. Ajmer receives around 550-600 mm of rainfall per year. The monsoon brings the majority of rainfall from July to September. The monsoon season in India creates the perfect blend of humidity (80-90%) and moderate temperatures (15-30°C) that support rapid and healthy mushroom growth. The selected locations for mushroom collection were based on the diversity and abundance of flora.

Collection of samples

The stinkhorns were collected from Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India, during the monsoon season using random sampling methods. Fresh fruiting bodies were collected into a sterile polyethylene bag for further taxonomic study in the laboratory and photographs were taken in its natural habitat. The samples collected were further analysed to measure the length and size of the cap, volva, and stipe, and spores. The collected stinkhorns were stored in airtight glass containers and preserved in FAA fixative (Formalin-Acetic Acid-Alcohol) (Kladnik, 2013) at the Plant Pathology laboratory, Department of Botany, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India. The slimy gleba from the mature cap was collected using a sterile tool, and a small sample of the gleba was placed on paper, set aside, allowed to air dry for spore printing, and preserved in the laboratory for future study.

Identification of samples

The identification of samples were based on habit, habitat, odour, and morphological characteristics such as color, size, shape, and texture of pileus (cap), gleba, veil, stipe, volva, spore, presence or absence of indusium or veil (calyptra) (Bessey, 1950; Dutta et al., 2012; Govindaraj et al., 2016; Long & Stouffer, 1943; Marshall, 2008; Verma et al., 2018).

3. RESULTS

Two species of stinkhorn were collected and identified. Both species were found to be new records for the study area, as well as Rajasthan, India, and are described below.

3.1. *Mutinus caninus* (Dog stinkhorn)

Mutinus caninus (dog stinkhorn) is a saprobic woodland fungus recognized for its thin, phallus-shaped fruitbody with a dark tip (Fig. 1a). Matures into a spike-like structure with a slimy spore mass (gleba) that emits an unpleasant odor to attract insects (e.g., flies and ants) for spore dispersal.

Habit and Distribution: It grows on bamboo, decomposed wood, leaf debris, and soil debris. Eggs (immature fruitbodies) are gregariously dispersed in soil and widely distributed across Europe (Britain, Ireland, mainland Europe from Scandinavia to the Mediterranean), Asia, and eastern North America. Found in India, including as a new record from Southern India (Tamil Nadu), growing under bamboo, on decomposed wood, and in leaf debris.



Figure 1. Stinkhorn mushrooms (A) *Itajahya galericulata*, (B) *Mutinus caninus*

Synonyms: *Phallus caninus* Huds., *Phallus inodorus* Sowerby, *Ithyphallus inodorus* Gray, *Cynophallus caninus* (Huds.) Berk

Taxonomic classification

Kingdom: Fungi

Division (Phylum): Basidiomycota

Class: Agaricomycetes

Order: Phallales

Family: Phallaceae

Genus: *Mutinus*

Species: *Mutinus caninus* (Huds.)

Description: The 'egg' from which the Dog Stinkhorn develops is completely buried in soil and difficult to find until the stipe emerges from the egg. The pale, whitish egg appeared to have a spherical and oval shape, that is 1-3 cm in height and 1-2 cm in breadth. The white mycelial cords of tiny root-like structures, called rhizomorphs, were often noticeable under the egg. The fruiting body is phallus-shaped, yellow-orange, and 6 to 12 cm in length. The white-yellow stipe has a cylindrical shape, spongy, net-like, and hollow structure. The stipe size range was 6 to 13 cm in height and a diameter between 1 and 1.5 cm. The tip is covered by a conical yellow-white head, which has a shiny, slimy substance, a smelly coating called gleba, that contains the spores. The cap is honeycombed beneath the gleba (Fig. 1b). Spores are oblong, smooth, $4\text{-}5 \times 1.5\text{-}2 \mu\text{m}$. The gleba, dark olive in color, contains pale yellow spores. Once insects have consumed the gleba, the tip of the stinkhorn turns orange-yellow or white-yellow, and the complete fruitbody decays rapidly; there is usually nothing left within three or four days. The volva-like remains of the 'egg' often appear above the ground once the fruitbody is fully developed (Fig. 2).

3.2. *Itajahya galericulata* (Jacaranda stinkhorn)

Itajahya galericulata (Jacaranda stinkhorn) is characterized by a distinctive, hat-like structure, the Calyptra, making it fairly easy to recognize.

Habit and Distribution: *Itajahya galericulata* is a saprobic fungus, decomposing dead organic matter. It grows on soil rich in organic debris, especially where Jacaranda or other dead roots are present. The collected samples were found under the *Azadirachta* tree. Reported from Brazil, Paraguay, Bolivia (South America); South Africa; India (Gujarat); Texas and the southwestern United States.

Synonyms: *Phallus galericulatus*



Figure 2. Morphological features of *Mutinus caninus* fruiting body: (A-B) Mature fruiting body with cap and egg (volva), (C-D) Different-sized fruiting bodies, (D-E) Cap and hollow stipe

Taxonomic classification

Kingdom: Fungi

Division: Basidiomycota

Class: Agaricomycetes

Order: Phallales

Family: Phallaceae

Genus: *Itajahya*

Species: *Itajahya galericulata* Möller (1895)

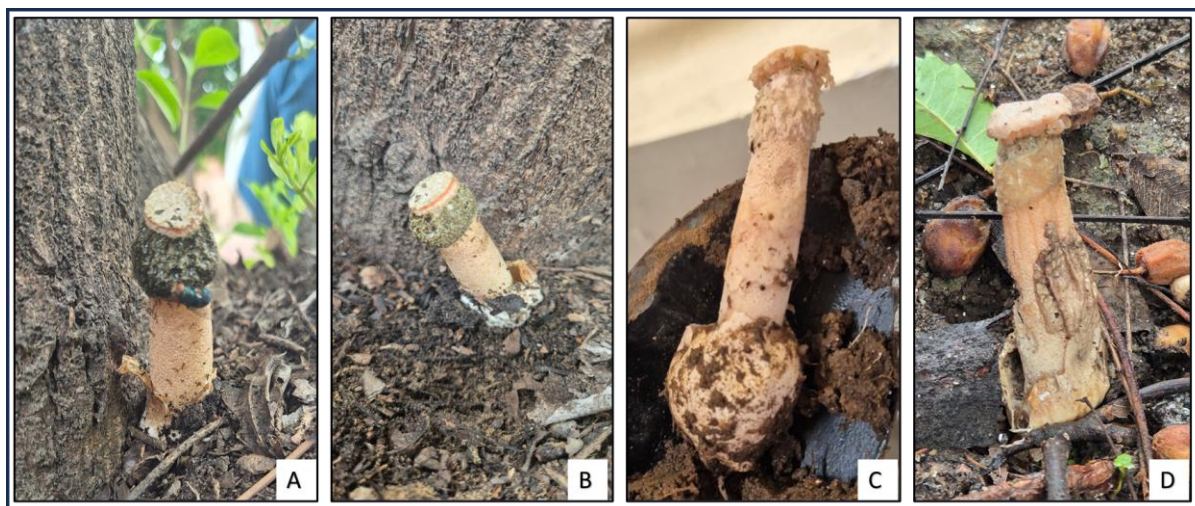


Figure 3. Morphological features of *Itajahya galericulata* fruiting body: (A-B) Mature fruiting body with dark brown to black spore slime and gleba, (C) Fruiting body with volva and calyptra, (D) Decaying fruiting body

Description: A greyish-white "egg" which is spherical to oval shape, smooth surface, gelatinous, 2-3 cm high and 3-5 cm wide (Fig.3a, b, & Fig.4). The fruiting body is phallus-shaped, cylindrical, yellow-white, 9-12 cm high, 3-4.5 cm thick. The stipe is yellow-white, hollow, spongy-like in appearance, chambered, 6-8 cm high, 3-4 cm wide (Fig. 3 c, d). A volva (sac-like structure) is present at the base

of the stipe, attached to thin whitish rhizomorphs (Fig. 5). The head has a “wig-like” appearance, 3–4.5 cm high and 3–4 cm wide, and often appears dark brown to black spore slime. The spore slime is foul-smelling, attracting insects for spore dispersal. The gleba is a spore-bearing structure, greenish-brown in color. A unique sterile tissue structure called calyptra (a large cap-like patch of whitish tissue) at the apex of the gleba, a distinguishing feature of the *Itajahya* genus. Spores are smooth, $4 \times 2 \mu\text{m}$, elongated-ellipsoid, and hyaline in KOH.

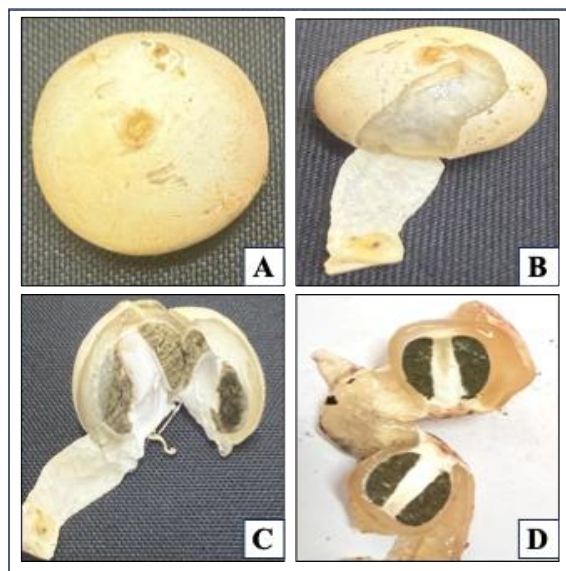


Figure 4. The early developmental stage of stinkhorn as a small, white, egg-like structure. A-B: Egg stage, C-D: Gleba development (the spore-bearing mass)



Figure 5. Mature Fruiting body, calyptra, and volva, attached to thin whitish rhizomorphs

4. DISCUSSION

Edward Burt (1896) published a developmental study in *Annals of Botany* in which an investigation was conducted on the anatomical stages of *Mutinus caninus* fruit body formation, reflecting early research on its life cycle (Burt, 1896). Flegler and Hooper (1980) described the ultrastructure of its development, including differentiation of tissues and the unusual eight-spored basidia (a unique reproductive feature) (Flegler & Hooper, 1980). Govindaraj et. al., (2016) reported the first detailed record of *Mutinus caninus* in

Southern India, describing its morphological and microscopic traits, habitat (often under bamboo and decomposing wood), seasonality, reproductive ecology, and role in attracting insects for spore dispersal (Govindaraj et al., 2016). Similarly, Masroor et al., (2022) reported *Mutinus caninus* from Gaya district (Bihar). The study was conducted in the month of June, 2021 where identification was done based on the morphological characteristics of the mushroom species (Masroor et al., 2022). Similar documentation and morphological characteristics were noticed and confirmed in reported species from leaf and soil debris from M.D.S. University, Ajmer in the monsoon season, 2025.

The collected *Itajahya galericulata*'s unique morphological characters (notably the calyptra). The collected stinkhorn in this study, whose morphological identification confirmed that the stinkhorn fungus collected belongs to *Itajahya galericulata*. It is less widely reported, and recent molecular phylogenetic studies support the identification of this rare fungus in India, where it may have been introduced with the arrival of tree species (Patel et al., 2018). Originally described from Brazil (Möller, 1895); also found in South Africa, and with further reports from Texas and South America (Marincowitz et al., 2015). Marincowitz et al., (2015) suggested that in South Africa, *I. galericulata* commonly occurs closely associated with the root system of *Jacaranda mimosifolia*. This fungus was previously reported from Vadodara, Gujarat (India) by Patel et al., (2018). They identified and confirmed *I. galericulata* based on morphology and molecular identification, including DNA sequences (ITS, LSU, ATP6). They also found that this stinkhorn occurs in close association with trees of the Fabaceae family: *Pithecellobium dulce* and *Prosopis juliflora*. The present report suggests that *I. galericulata* is found in close association with *Azara indica*.

5. CONCLUSION

Stinkhorn fungi produce a characteristic foul-smelling, gelatinous gleba. This odor attracts insects, which feed on the gleba and subsequently disperse the fungal spores, aiding reproduction and further colonization. The study and collection of *Mutinus caninus* and *Itajahya galericulata* provide valuable insights into fungal diversity, community dynamics, conservation, and ecosystem functioning. Their collection is also important for taxonomic, molecular, and ecological research, helping to understand their distribution, interactions, and evolutionary relationships. Both species are saprobic fungi, meaning they decompose dead organic matter, such as wood and plant debris, contributing to soil formation and the recycling of essential nutrients within ecosystems.

Authors contributions

The field study was a collaboration work done by Renu Jangid and Shruti Ojha. The manuscript writing, morphological and microscopic study conducted by Renu Jangid. The concept design and data analysis done by Shruti Ojha. The manuscript was analysed and reviewed by Arvind Pareek.

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Conflict of Interest

The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Informed consent

The study was conducted in the Department of Botany, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India with the consent of the department and university. The authors provide consent of the research work.

Ethical approval & declaration

In this article, as per the plant associated fungi regulations followed in the Department of Botany, Maharshi Dayanand Saraswati University, Ajmer, Rajasthan, India; the authors observed the distribution and morphological study of dog stinkhorn (*Mutinus caninus*) and jacaranda stinkhorn (*Itajahya galericulata*) from Rajasthan, India. The ethical guidelines for plant materials (plant associated fungi) & National Biodiversity Authority Guidelines are followed in the study for observation, identification & experimentation.

Data and materials availability

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

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