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## Taxonomy of gasteroid fungi from some arid regions of Punjab, Pakistan

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### Abstract

In order to record the biodiversity of gasteroid fungi from dry parts of the country, five gasteroid fungi viz., *Battarrea phalloides*, *Montagnea arenarea*, *Phallus roseus*, *Pisolithus tinctorious*, and *Podaxis pistillaris* were collected, characterized, illustrated, and discussed.

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## Introduction

Although gasteroid mycota in dry regions of Pakistan have been studied by a few mycologists in Pakistan (Ahmad 1952; Ahmad *et al.*, 1997; Razzaq and Shahzad, 2004; Iqbal *et al.*, 2006, Sultana *et al.*, 2007), still a less is known about the taxonomy of this group from these regions.

In present investigation, five gasteroid taxa have been reported. All of the taxa are being described from different but dry regions of Pakistan. Study sites include three major arid districts viz., Bahawalpur, Chakwal, Mianwali, and Lahore of Punjab province, Pakistan. Two gasteroid fungi are reported from district Bahawalpur, one taxon *Battarrea phalloides* was reported from Cholistan desert of Bahawalpur. This desert is the driest and hottest region of the country and receives about 12 cm of rainfall annually (Akbar *et al.*, 1996). Second taxon, *Podaxis pistillaris* is reported from Lal Sohanra Park of district Bahawalpur. Lal Sohanra Park is a national Park of district Bahawalpur consisting of an area of 51590 km<sup>2</sup>. Climate of the area is subtropical continental type, characterized by low rain fall and humidity, and high temperatures. Soil type is made up of alluvial deposits with low sand dunes. (Khan and Mian, 2011, Hameed *et al.*, 2002). Previously, five taxa, viz., *Montagnea arenaria*, *Phallus roseus*, *Phellorinea herculeana* and *Schizostoma laceratum*, and *Tulostoma volvulatum*, have been reported from this region (Ahmad, 1952, Yousaf *et al.*, 2012). *B. phalloides* is new record to the region.

District Lahore is a semi-arid region with dry climate. It receives heavy precipitation during monsoon in July and August and has extreme hot, long summers and warm winters. Eight gasteroid fungi have been reported from this district previously, which includes two species of genus *Protuberia* (*P. clathroidea*, *P. marucuja*), one of each genera *Cyathus* (*Cyathus limbatus*), *Lycoperdon* (*L. pusillum*), *Lysurus* (*Lysurus pakistanicus*), *Phallus* (*P. roseus*), *Simblum* (*S. sphaerocephalum*) and *Tulostoma* (*Tulostoma*

*amicola*) (Ahmad *et al.*, 1997). *Pisolithus tinctorious*, and *Podaxis pistillaris*, collected in this study are new records for district Lahore.

Chakwal is a barani district and has an average rainfall of 22 to 25 inches (Ahmad *et al.*, 2009). District Chakwal has dry deciduous scrubby vegetation and lies in the subtropical, semi-arid zone (Qureshi *et al.*, 2009; Ahmad *et al.*, 2010). This district has never been explored to check the diversity of gasteroid fungi. *Montagnea arenaria* and *Podaxis pistillaris* are described as first reports from Chakwal.

Mianwali district, situated in the north-west of Punjab province, Pakistan has arid habit with extreme climates. There is no report of gasteroid fungi from this district previously. *Phallus roseus* is a first report of any gasteroid fungus from this region.

## Materials and methods

Basidiomata collected during rainy seasons, were dried and labeled. Morphological features (e.g., endoperidium, exoperidium) were observed macroscopically using a stereomicroscope (Meiji Techno EMZ-5TR) and studied under an optical microscope (Nikon YS 100) at high magnification (1600x). Glebal material was examined when mounted in lacto-phenol, trypan blue and 5% KOH medium. Illustrations of microscopic characters were prepared with the aid of a camera Lucida (Ernst Leitz Wetzlar Germany) equipped with an optical microscope.

Specimens were identified with the help of literature (Coker & Couch 1928, Bottomley 1948, Ahmad, 1952, Miller & Miller 1988, Ellis and Ellis 1990, Pegler & Spooner 1995). All of the specimens have been deposited in the collection of gasteroid fungi at the LAH Herbarium, Department of Botany, University of the Punjab, Lahore, Pakistan.

**Results**

*Taxonomy*

1. ***Battarrea phalloides* (Dicks.) Pers.**,  
Syn. meth. fung. (Göttingen) 1: xiv, 129  
(1801)

*Basidiomata* consists of spore case and a stalk, up to 170 mm long. *Spore case* discoid, concave edges curving inward towards the stalk. *Peridium* double. *Exoperidium* cream to light brown, thin, semi-deciduous, rough due to adherent sand particles. *Endoperidium* thick. *Stalk* tough, woody, scaly, firmly attached to underside of spore case, 155 mm long, pale yellow, encrusted with sand particles. *Volva* lost during collection. *Gleba* reddish brown, pulverulent, exposed by rupturing of peridium. *Basidiospores* globose to sub-globose, ornamented, finely verrucose, up to 7 µm in diam.

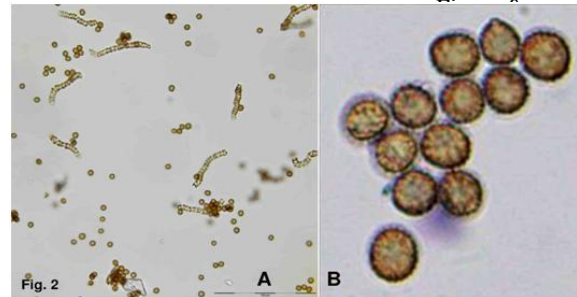
**Zeller SM.** 1943. North American Species of Galeropsis, Gyrophragmium, Longia, and Montagnea. *Mycologia* 35(4), 409- 442.



**Fig. 1 (A–B).** *Battarrea phalloides*: **A.** A mature basidioma **B.** Illustrations of basidiospores. Bar. A = 1 cm. B = 5 µm.

*Material examined*

PAKISTAN: Punjab, Bahawalpur district, Cholistan desert, 29 Sep. 2005, **B**solitary, among grass, on ground, at 461m (1512ft). a.s.l., A. R. Niazi. ARN108. (LAH290805)



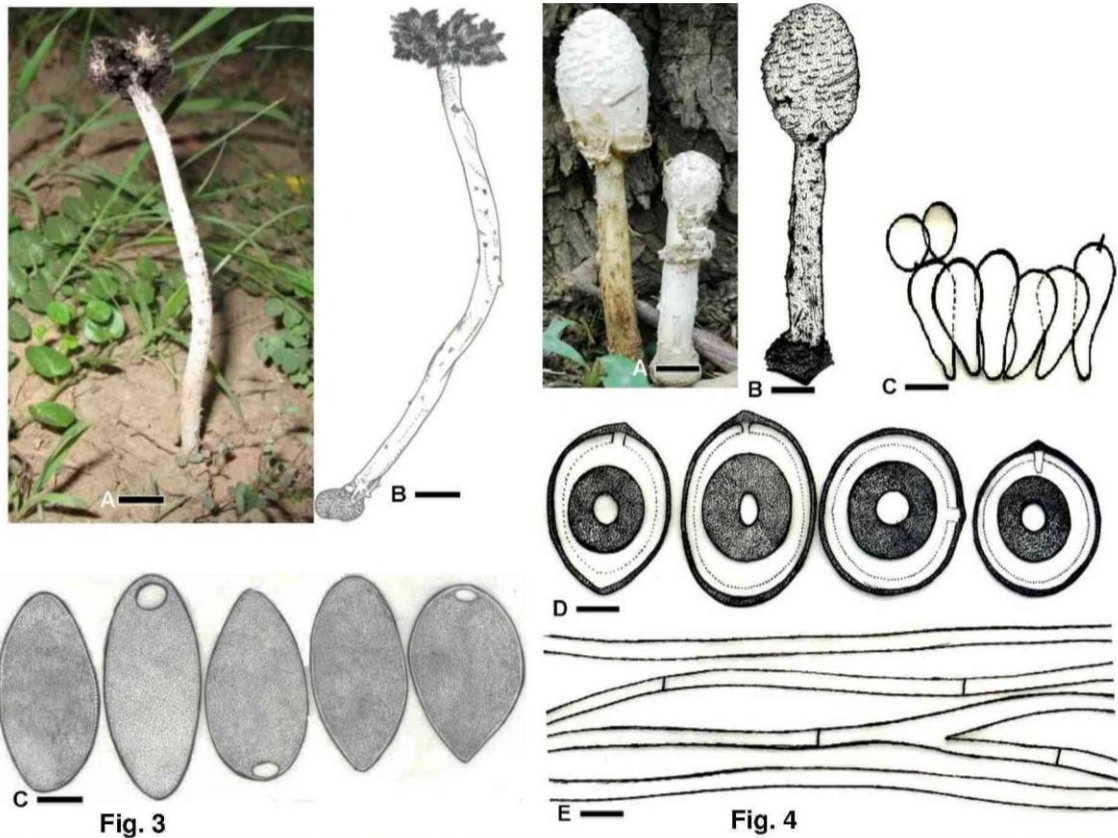
**Fig. 2 (A–B).** *Battarrea phalloides*: **A.** LM photograph of basidiospores and elators at 40×. **B.** LM photograph of basidiospores at 100× showing rough ornamented surface. Bar. A = 50 µm. B = 6 µm.

*Comments*

*Battarrea*, a cosmopolitan genus, was first established by Persoon in 1801 by describing *B. phalloides*, its type species (Esqueda *et al.*, 2002). *B. phalloides* is commonly called as scaly stalked puff ball (Arora, 1986), usually found growing solitary to gregarious in arid, semi-arid to desert environments (Martin *et al.*, 2013). It has been reported previously as *B. stevenii* by Ahmad from Peshawar in 1952. It is a new record to Cholistan desert, Bahawalpur.

2. ***Montagnea arenaria* (DC.) Zeller** [as '*arenarius*'], *Mycologia* 35(4): 418 (1943)

*Basidiomata* hypogeous, stipitate at maturity, up to 140 mm tall. *Pileus* 18 mm high × 28 mm broad, in the form of expanded disc, with lamellae extending from it. *Disc* grayish black, 13 mm in diam., dissected into 4–5 irregular rays, each ray consisting of numerous radial lamellae, lamellae black with grayish tint. *Stipe* 13 cm high, whitish, hollow, hard, scaly; scales with brownish tint, ridges and furrows present, more prominent towards the pileus, tapers upwards. *Vovla* sub-globose, up to 1 cm high, 1.2 cm broad, encrusted with soil particles.



**Fig. 3 (A–C).** *Montagnea arenaria* **A.** A basidioma **B.** Line drawing of a basidioma **C.** Basidiospores. Bar. A & B = 2 cm, C = 5.7  $\mu\text{m}$ . **Fig. 4 (A–F):** *Podaxis pistillaris*. **A.** Basidiomata **B.** Line drawing of a basidioma **C.** Basidia **D.** Basidiospores **E.** Capillitial hyphae. Bar. A & B = 2.7 cm, **C** = 20  $\mu\text{m}$ , **D** = 4.7  $\mu\text{m}$ , **E** = 5  $\mu\text{m}$ . **Fig. 5 (A–B):** *Pisolithus tinctorious* **A.** A basidioma **B.** L.S. of basidioma. Bar. A & B = 0.8 cm.



**Fig. 6 (A–D). *Phallus roseus*.** A. Basidiomata and eggs B. A mature basidioma C. Line drawing of L.S. of an egg D. Illustration of Basidiospores. Bar. A = 1.5 cm. B & C = 1.2 cm. D = 5  $\mu$ m.

*Basidiospores* blackish brown, with prominent germ pore, ovoid,  $11.6\text{--}16.5 \times (3.6\text{--}) 7.4\text{--}8.55 \mu\text{m}$ .

*Material examined*

PAKISTAN: Punjab, Lahore, University of the Punjab, New Campus, 25 June. 2011, solitary, among grass, on ground, at 217m (712ft). a.s.l., N. Yousaf. PUG01. (LAH290806). Chakwal, on ground, 6 July, 2012, 498m (1634ft).a.s.l., R. Fatima. RF1. (LAH290807)

*Comments*

*Montagnea arenarea* is a type species of the genus. This genus was first established by Fries in 1836 (Baseia and Milanez, 2002) and considered closely related to *Coprinus* (Redhead et al. 2001, Simpson and Grgurinovic, 2001). It is worldwide in distribution and found growing solitary or in groups with an adaptation to arid and sandy places (Zeller 1943; Rauschert, 1964; Kreisel, 1971; Reid and Eicker, 1991; Chen, 1999; Minter et al., 2001; Baseia and Milanez, 2002; Madrid and Muñoz, 2006; Nieves-

Rivera and Aime, 2006; Dörfelt & Gube, 2007). It is previously reported from Ladhar, Lahore, Muzaffargarh, Palla, Panjnad, Sheikhupura, Pakistan (Ahmad, 1952). It is a first report of this fungus from district Chakwal but reported second time from district Lahore of Paksitan.

**3. *Phallus roseus* Delile, Hist. Nat. 2:300, 1823.**

*Egg* off white to light pink, sub-globose, rough, membranous, up to 80 mm in diam. and 60 mm high. *Basidiomata* gregarious, up to 80 mm tall and 20 mm wide at the top and up to 45 mm at the base; attached to the substratum by white, thick, branched rhizomorphs. *Receptaculum* consists of pileus and stipe. *Pileus* sub-globose, up to 20 mm high and 35 mm in dia., hollow, with sticky glebal mass. *Gleba* olivaceous turning grey with age, smell foetid when collected, sticky and wet. *Stipe* off white to light pink, spongy, rough, hard, up to 30 mm in diam., tapering towards the pileus. *Calyptra* extended at the top of the pileus, irregular shaped, pinkish, up to 20 mm high. *Volva* up to 45 × 45 mm in diam., off-white, rough, membranous, gelatinous inside.

*Basidiospores* olivaceous, ellipsoid.

*Material examined*

PAKISTAN: PUNJAB, Lahore, University of the Punjab, Quaid-e-Azam campus, ca. 217m a.s.l., gregarious, on ground, 15 Aug. 2010, 10 July, 2011, 15 July 2012, 21 July 2013. N. Yousaf (LAH 108210, Duplicate in AH 39160). Mianwali, 12 August 2013, in groups, on bare ground, under *Acacia* sp. at 210m a.s.l., N. Yousaf (LAH 290808).

*Comments*

Genus *Phallus* contains morphologically different species which remained focus of interest for the mycologists (Andersson, 1989, Kreisel, 1996; Calonge, 2005; Calonge *et al.*, 2008, Sarasini, 2005; Baseia *et al.*, 2006). It is distributed worldwide (Liou and Hwang 1936; Kobayasi 1938, 1942; 1965a, b; Ito 1959, Yoshimi and Hongo, 1989; Guzmán *et al.*, 1990,

Kreisel, 1996; Li *et al.*, 2004, Kasuya *et al.*, 2007, Yamamoto and Yamamoto, 2007; Kasuya, 2008). According to Calonge (2005) total no. of published species is twenty five. Many new species of this genus have been reported in recent years (Calonge and Kreisel, 2002; Baseia *et al.*, 2003, Calonge *et al.*, 2005; Li *et al.*, 2004, Calonge *et al.*, 2008). *Phallus roseus* has previously been reported as *Itajahya rosea* (Delile) E. Fisch. by Ahmad in 1952. This species is adapted to arid to semi-arid regions in Pakistan. It has been reported previously from Bahawalpur state (Palla), Gunjranwala, Ladhar, Lahore, and Sheikhpura (Ahmad, 1952). Moreno *et al.* (2009) recently described *Phallus calongei*, a new species from Lahore, Pakistan. It grows abundantly in groups among the grass. It is first record of *P. roseus* from district Mianwali.

**4. *Pisolithus tinctorius* (Mont.) E. Fisch., (1900)**

*Gasterocarp* 50–60 mm in diam. × 60–70 mm in height, sub-globose to globose, attached by a solid pseudostipe that is typically buried below ground; pseudostipe up to 30 mm long, basally attached to the substratum by thick, yellowish mycelial strands encrusted with soil particles; ostiole lacking. *Exoperidium* off-white to brownish, smooth, eventually peeling away in patches to expose the endoperidium. *Endoperidium* dark grayish brown, firm, rugulose, eventually cracking apart apically to allow dehiscence. *Gleba* pale to reddish brown, interior lined with thick tramal plates that create chambers, these containing dark brown, granular pseudo-peridioles; pseudo-peridioles composed of hyphal aggregations containing spores, distributed throughout the gleba, more apparent at the base of the gasterocarp and becoming pulverulent toward the apex.

*Basidiospores* globose to subglobose, apedicellate, yellowish brown in water mounts, 7.0–10.5 μm in diam. (ornamentation included or 6.5–8.8 μm excluding ornamentation), strongly verrucose (verrucae up to 2 μm), sterigmatal remnants present in mounts. *Capillitium* lacking. *Pseudoperidiole hyphae*

up to 1.8–4.8  $\mu\text{m}$  in diam., thin walled, hyaline, septate and branched. *Exoperidium* composed of branching, septate hyphae, clamp connections present. *Endoperidium* composed of unbranched, septate, unclamped hyphae.

#### Comments

Genus *Pisolithus* is worldwide in distribution (Marx 1977; Kammerbauer *et al.*, 1989; Chambers and Cairney, 1999; Cairney and Chambers, 1997; Cairney *et al.*, 1999; Anderson IC, 1999; Anderson *et al.*, 2001; Moyersoen and Beever, 2004; Leonard *et al.*, 2013). It is well known for its ectomycorrhizal nature with broad range of host trees mostly with *Eucalyptus* sp. (Bâ *et al.*, 1994; Tagu *et al.*, 1996; Diaz *et al.*, 1997; Martin *et al.*, 2002; Turjaman *et al.*, 2004). It is reported only from Karachi by Razaq and Shahzad, 2004. It is new record for district Lahore.

5. ***Podaxis pistillaris*** (L.) Fr. [as 'Podaxon'], Syst. mycol. (Lundae) 3(1): 63 (1829) Fig. 4.

*Basidiomata* stipitate, 85–135 mm tall, scattered to gregarious. *Pileus* 30–50 mm high, 14–18 mm broad, off-white, ovoid, scaly, margins leaving the stipe with age, curved upwards in mature specimens; *outer layer* not persistent, fragile, soft, composed of furfuraceous scales, peeled off with age; *Inner layer* smooth, light to dark brown, papery to membranous. *Gleba* pulverulent, dark brown to black with age. *Stipe* 8–10 mm high, 5 mm in diam., whitish, rough, scaly, hollow, attached to the substrate by a bulbous base, heavily encrusted with soil particles.

*Basidiospores* dark brown, sub-globose to ovoid, thick walled, double walled,  $8.2\text{--}12.7 \times 7.3\text{--}11.6 \mu\text{m}$ , apical thickness (up to 3.5  $\mu\text{m}$ ), germ pore well marked, sterigmal remnants absent from mounts. *Capillitial hyphae* hyaline to pale brown, branched, septate, fragile, thin walled hyphae.

#### Material examined

PAKISTAN: Punjab, Lahore, University of the Punjab, New Campus, 5 July, 2011, 13 July, 2013, 23 August, 2013, solitary or in groups, among grass, on ground,

at 217m (712ft). a.s.l., N. Yousaf. (LAH290810); Bahawalpur, Lal Sohanra Park, 18 August, 2013, on ground, 461 m (1512ft); Chakwal, 15 July, 2012, at 498 m (1,634 ft) a.s.l., among grass, R. Fatima; Lahore, Bakhar mandi, Dubanpura, M. Anees, 20 June, 2013, in groups. MA1; Chakwal, Neela Dulha, 13 Aug. 2013, along the road side, at 498 m (1,634 ft) a.s.l., N. Yousaf (LAH290810).

#### Comments

*Podaxis pitillaris* is the type species of the genus and is commonly called as desert shaggy mane because its young fruiting bodies have close similarity with shaggy ink cap mushroom (*Coprinus comatus*) though resemblance is only superficial (Smith, 1973; Hopple and Vilgalys, 1994, Moncalvo *et al.*, 2002, Keirle *et al.*, 2004). It exhibit a secotoid habit and is found growing solitary or in groups in arid and semi-arid regions (Masse, 1890, Morse, 1933, Dring, 1973, Keirle *et al.*, 2004, Muhsin, 2012). It is characterized by larger basidiomata with a pileus, stalk and bulbous base. It is collected in large numbers during monsoon from arid regions Pakistan. It is first report of *P. pistillaris* from Chakwal, Lahore and Bahawalpur districts.

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