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Glimpses of Rare and Infrequent Macrofungi in Southwest India

Namera Chinnappa Karun[1,2], Kandikere Ramaiah Sridhar[2]*

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Author Affiliation:
[1,2] Western Ghats Macrofungal Research Foundation, Bittangala, Virajpet, Kodagu, Karnataka, India
[2] Department of Biosciences, Mangalore University, Mangalagangotri, Mangalore, Karnataka, India

***Corresponding author**
Department of Biosciences, Mangalore University, Mangalagangotri, Mangalore, Karnataka, India
Email: kandikeremanasa@gmail.com

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ABSTRACT

Macrofungi, or mushrooms, constitute an essential living segment worldwide, which serves humankind in terms of nutrition, health, industrially valued materials, and environmental preservation. This study encompasses descriptions and illustrations of 40 rare, infrequent species of macrofungi (33 basidiomycetes and six ascomycetes) occurring in the Western Ghats and southwest India. Coffee agroforests possess the highest number of fungi (13 spp.), followed by scrub jungles (11 spp.), reserve forests, shola forests (7 spp. each), and botanical gardens (6 spp.). Among the substrates, soil possesses the highest number of fungi (23 spp.), followed by woody litter (13 spp.). Among the macrofungi, up to 11 species are mycorrhizal, nine species are edible, and six species are medicinal. Six species also possess dual values (edible and mycorrhizal). Although as many as 23 species are inedible, their economic significance can be explored. Further insights on rare or infrequent macrofungi in southwest India are warranted.

Keywords: Coast, Mushrooms, Mycorrhizae, Sand-dunes, Scrub jungles, Western Ghats

1. INTRODUCTION

Like the flora and fauna, fungi constitute a vital segment of the global ecosystem. The global estimate of fungi ranges from 2.2 to 3.8 million (Hawksworth and Lucking, 2017; Hyde et al., 2024). Macrofungi are highly diverse, have wide distribution in various ecosystems, occur in different habitats, and grow on varied substrates. Recent macrofungal estimates range from 220,000 to 380,000 (Hawksworth, 2019). Besides ecosystem services (organic matter decomposition, biogeochemical cycles, mycorrhizal association with tree species, and endophytic in different plant parts), they significantly contribute towards human nutrition, medicine, cosmetics, bioremediation of pollutants, insect control, and raw material for industrially valued biomaterials (Sridhar and Deshmukh, 2021a, b).

Forests of the Indian subcontinent (Western Ghats and Himalayas) are the hotspots of biodiversity of macrofungi (Manoharachary et al., 2006). According to Mueller et al., (2007), the macrofungal global estimate of ranges between 53,000 and 110,000 species. Hawksworth (2019) predicts that the Indian subcontinent is rich in macrofungi and awaits the discovery of up to 15,300 species.

Several major diversity surveys were carried out in recent years in a variety of ecosystems of southwest India: Western Ghats (e.g., Natarajan et al., 2005; Brown et

al., 2006; Leelavathy et al., 2006; Manimohan et al., 2007; Pradeep and Vrinda, 2007; Swapna et al., 2008; Kumar and Manimohan, 2009; Mohanan, 2011; Vrinda and Pradeep, 2011; Senthilarasu, 2014; Aravindakshan and Manimohan, 2015; Karun and Sridhar, 2016a; Senthilarasu and Kumaresan, 2016; Latha and Manimohan, 2017; Vinjusha and Kumar, 2024); scrub jungles, plantations and botanical gardens (e.g., Karun and Sridhar, 2014b; Greeshma et al., 2016; Pavithra et al., 2016); coastal sand-dunes (Ghate et al., 2014; Ghate and Sridhar, 2016a); mangroves (Ghate and Sridhar, 2016b). This study aims to report the rare, infrequent macrofungi occurring in different habitats of the Western Ghats, scrub jungles, and coastal sand-dunes in Karnataka of southwest India.

2. SAMPLING LOCATIONS

A total of eight sampling locations in three biomes are surveyed for the occurrences of macrofungi in southwest Karnataka (Western Ghats: reserve forests, shola forests, sacred groves, and coffee agroforests; west coast: scrub jungles, plantations, botanical gardens, and coastal sand-dunes). The sampling locations surveyed for macrofungi in the Western Ghats include reserve forests (12°8'N, 75°47'E; 897 m asl), shola forests (12°28'N, 75°37'E; 608 m asl), sacred groves (12°13'N, 75°46'E; 891 m asl), and coffee agroforests (12°7'N, 75°52'E; 846 m asl) of the Western Ghats of Karnataka. Sampling locations in the coastal region of Karnataka include scrub jungles, botanical gardens, and arboretum (12°48–49'N, 74°54–55'E; 28.4–112.4 m asl). The coastal sand-dunes surveyed on the southwest coast of Karnataka include Someshwara, Thannir Bavi, and Kaup (12–13°42–53'N, 74°44–51'E).

3. MACROFUNGI

A total of 40 species of macrofungi (33 basidiomycetes and seven ascomycetes) were sampled from three biomes (Western Ghats, scrub jungles, and coastal sand-dunes) consisting of four forests (reserve forests, shola forests, and sacred groves), scrub jungles, plantations, botanical gardens, and coastal sand-dunes. Each specimen was deposited in WGMRF (Western Ghats Macrofungal Research Foundation), Bittangala, Virajpet, Kodagu District, Karnataka, with accession numbers.

Morphological descriptions of 40 species with the nature of the fruit body, color, and other specific features are provided. Description includes annual/perennial, substrate, taste, odor, edibility, mycorrhizal, and medicinal. Measurements of fruit bodies and spores are provided. Their habitats, references, and accession numbers along with figures, are presented (Figures 1 to 40).

***Agaricus augustus* Fr.**

Large to massive fruit body, whitish-brown/pale-yellow/creamish-brown, fibrillose to squamulose agaric with concentric rings of brown fibrous scales on the cap, pinkish to chocolate-brown gills, and pale silky (apex) to wooly to scaly (base) stipe possessing a white, broad superior ring and slightly bulbous base (Figure 1).

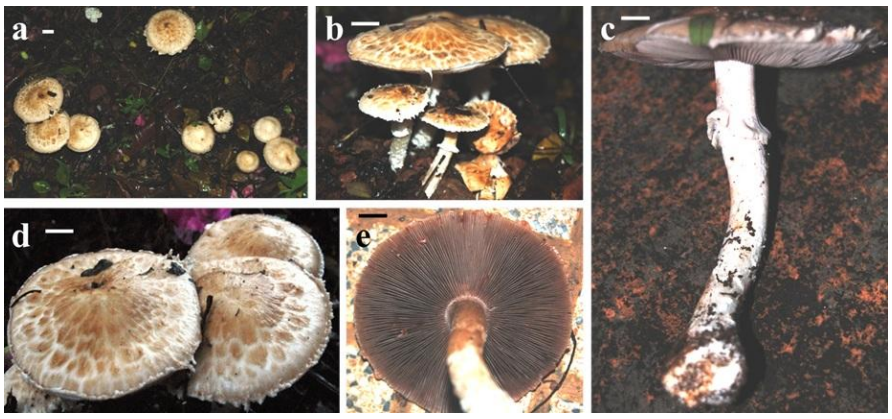

Figure 1. a and b: Habitat of *Agaricus augustus* on soil; c: whole basidiocarp; d, an upper surface of pileus; e: the pattern of gills. Scale bar, 1 cm.

Annual, infrequent, particolous, with a mealy, almond-like odor, a non-distinctive taste, and edible and ectomycorrhizal. Pileus 8.2–10.3 cm in diameter and stipe 9.2–15.1 cm tall × 1.0–1.9 cm broad (apex)/2.0–3.5 cm (base). Basidiospores are ellipsoidal to almond-shaped, chocolate-brown, smooth, and 6.6–7.9 × 3.9–5.3 µm.

Notes: Ectomycorrhizal with *Areca catechu* and *Delonix regia* trees in scrub jungles of southwest Karnataka (Karun and Sridhar, 2014b). Accession # AgauWGMRF.

***Aleuria rubra* L.R. Batra**

Small to medium fruit body, delicate, purple to yellowish-orange disc-like apothecium with fertile hymenial layers on upper smooth surface, smooth to spongy pinkish-white sterile lower/outer surface, and sessile (Figure 2).

Annual, rare, lignicolous, with a taste and odor not distinctive, inedible. Scattered or in small clusters on rotting logs and branches of *Syzygium cumini*. Apothecia 1.6–4.8 cm in diameter × 0.2–0.3 cm thick. Asci cylindrical, 8-spored, and 360–445 × 15.8–17.1 µm. Ascospores are hyaline, ellipsoidal, warty to coarsely reticulated, non-septate, uniseriate, and 22.4–30.2 × 10.5–14.7 µm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # AlruWGMRF.

Figure 2. a: Habitat of *Aleuria rubra* on a log; b: a cluster of fruit bodies; c: underneath view of apothecium. Scale bar, 1 cm.

***Amanita angustilamellata* (Höhn.) Boedijn**

Medium to large fruit body, greyish-brown agaric with deeply sulcato-striate surface on cap to almost mid-way to center, whitish gills, and central hollow pale-brownish orange stipe immersed in white volval sac (Figure 3).

Annual, rare, particolous, with a taste and odor not distinctive, and inedible. Scattered in small groups or solitary on soil and ectomycorrhizal. Pileus 4.4–6.9 cm and stipe 10.2–12.9 cm tall × 0.7–1.1 cm thick (above)/1.6–1.8 cm thick (volva). Basidiospores are hyaline, smooth, subspherical/subglobose, and 10.5–12.5 × 10.5–11.8 µm.

Notes: Found in scrub jungles, botanical gardens, and arboretum as ectomycorrhizal with *Vateria indica* in southwest Karnataka (Greeshma et al., 2016; Pavithra et al., 2016). Accession # AmanWGMRF.

Figure 3. a: Habitat of *Amanita angustilamellata* on soil; b: young basidiocarp; c: nearly matured basidiocarp; d: an upper side of pileus; e: the pattern of gills. Scale bar, 1 cm.

Amanita griseofarinosa **Hongo**

Medium to large fruit body, shaggy, pale, greyish-brown agaric with dense, appressed (hemp-like), creamish-orange/creamish-yellow fibrillose squamules over on the surface of the cap and stem (washed off during rain), creamish-white gills, and a central hollow stipe bearing a bulbous rooting base and a large floccose pendant-like annulus flaring at the apex (Figure 4).

Annual, rare, particolous, with a taste and odor not distinctive, and inedible. Scattered in small groups or solitary on soil as ectomycorrhizal. Pileus 6–11.1 cm and stipe 11.1–22.6 cm tall × 0.7–1.2 cm thick (above)/1–1.7 cm thick (below)/1.2–2.6 cm thick volva. Basidiospores are hyaline, smooth, subspherical/subglobose, and 7.9–8.5 × 6.8–7.3 μm.

Notes: Found in scrub jungles and ectomycorrhizal with *Cocos nucifera* and *Spathodea campanulata* in southwest Karnataka (Karun and Sridhar, 2014b). Accession # AmgrWGMRF.

Figure 4. a: Young and matured basidiocarps of *Amanita griseofarinosa*; b and c: emerging fruit bodies; d and e: mature fruit bodies; f: an upper side of pileus; g: the pattern of gills. Scale bar, 1 cm.

***Ascocoryne cylichnium* (Tul.) Korf**

Small fruit body, gelatinous, purple-brown/pinkish-purple saucer-like apothecium on a short and stout stem with fertile hymenial layers on an upper smooth surface and a finely granular sterile lower surface narrowing beneath to form a rudimentary stem/false stem/sessile (Figure 5).

Annual, rare, humicolous/particolous, taste and odor not distinctive, and inedible. Scattered on humus soil along with mosses.

Apothecium 0.8–1.6 cm diameter × 0.2–0.4 mm thick. Asci cylindrical, 8-spored, and 341–368 × 8–10 μm. Ascospores are hyaline, smooth, ellipsoidal, septate, biseriate, and12.4–14.4 × 5.2–5.6 μm.

Notes: Found in the coffee agroforest and reserve forests of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # AscyWGMRF.

Figure 5. a: Habitat of *Ascocoryne cylichnium* on soil; b–d: immature and mature apothecia. Scale bar: 1 cm.

***Astraeus odoratus* Phosri, Walting, M.P. Martin & Whalley**

Small to medium fruit body, coarsely fibrous to arachnoid, brownish-grey to orange-brown structure with brownish-grey endoperidial body/spore sac surmounting an orange-brown, star-shaped, fissured mosaic-like cracked and reflexed exoperidial base that raises the spore sac above the substrate (Figure 6).

Annual, rare, particolous, with a taste and odor not distinctive, and edible. Scattered or in small groups on soil as ectomycorrhizal. Fruit body 4.5–7.5 cm in diameter × 3.4–5.4 cm tall. Basidiospores are ornamented, purple-brown, spherical, warty, and 7.9–12.5 × 8.5–13.2 μm (including ornamentation).

Notes: Found in fire-impacted scrub jungles as ectomycorrhizal with *Hopea ponga* in southwest Karnataka (Greeshma et al., 2016). Accession # AsodWGMRF.

Figure 6. a: Group of tender basidiocarps of *Astraeus odoratus*; b: inner view of tender basidiocarp; c: inner view of partially matured basidiocarp; d: matured basidiocarps; e: the lower side of matured basidiocarps; f: spent basidiocarps. Scale bar, 1 cm.

***Boletinellus merulioides* (Schwein) Murrill**

Figure 7. a–f: Habitats of immature and mature basidiocarps of *Boletinellus merulioides* on soil; g: underneath of pileus; h: the pattern of pores of the underneath of pileus. Scale bar, 1 cm.

Medium to large fruit body, yellowish-orange, soft to puffy irregular bolete with characteristic dark-yellow, fertile, networked to spongy pore-bearing under the surface and eccentric stipe and bruising olive to bluish-green (Figure 7).

Annual, infrequent, humicolous/particolous, taste not distinctive, odor almond-like, edible when young and just matured. Solitary or in small to large groups on humus soil under *Cassine glauca* as ectomycorrhizal. Pileus 10.1–21.9 cm in diameter and stipe 4.2–8.9 cm tall × 1.8–4.4 cm thick. Basidiospore are smooth, ellipsoidal to ovoid, yellowish-brown, and 6.1–7.4 × 4.9–5.5 µm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # BomeWGMRF.

***Clavaria rosea* Dalman**

Small to medium fruit body, pinkish-red to rose-pink, erect, club-shaped to fusiform to vermiform, laterally compressed unbranched spindle with smooth striate surface, blunt to almost notched tips, and narrowing below into a smooth cylindrical stem (Figure 8).

Annual, rare, particolous, with a taste and odor not distinctive, inedible, and scattered on soil amongst grasses. Basidiomata are hyaline, smooth, ellipsoidal, and 3.9–8.4 cm tall × 0.2–0.7 cm thick. Basidiospores are 5.5–6.6 × 2.6–3.4 µm.

Notes: Found in grasslands of scrub jungles in southwest Karnataka (NCK: unpublished observation). Accession # ClroWGMRF.

Figure 8. a and b: habitats of *Clavaria rosea* on grassland; c–f: various stages of fruit bodies with rhizoids. Scale bar, 1 cm.

***Clavaria zollingeri* Lév.**

Small to medium fruit body, delicate, purple-pink to purple-violet, repeatedly but loosely branched coral-like with antler head-like branches bearing dichotomously pointed to bluntly forked tips and merging below into a more pallid stout stem (Figure 9).

Annual, rare, particolous, with a taste and odor not distinctive, inedible, small groups, or solitary in soil amongst leaf litter in shola forest vegetation. Basidiomata are variable in diameter, 4.9–9.2 cm tall × 0.2–0.5 cm thick. Basidiospores are hyaline, ellipsoidal, smooth, and 4.2–5.5 × 3.9–4.6 µm.

Notes: Found in the grasslands of the shola forest of the Western Ghats of Karnataka (NCK: unpublished observation). Accession # ClzoWGMRF.

Figure 9. a: Habitat of *Clavaria zollingeri* on soil; b–f: various stages of basidiocarps. Scale bar, 1 cm.

***Clavulinopsis laeticolor* (Berk. & M.A. Curtis) R.H. Petersen**

Small to medium fruit body, erect, stalked, yellowish-orange to bright golden-yellow, unbranched club to clavate to spathulate with typically rounded to laterally compressed to grooved surface, blunt tips/apex, and narrowing below into a short to medium stem (Figure 10).

Annual, rare, particolous, with a taste and odor not distinctive, inedible, and in small groups or solitary in soil amongst leaf litter in shola forest vegetation. Basidiomata 8.9–15.4 cm tall × 0.4–0.9 cm thick. Basidiospores are hyaline with a yellow tinge, smooth, broadly ellipsoidal to sub-spherical, and 3.9–5.3 × 3.9–4.7 μm.

Notes: Found in the shola forest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # CllaWGMRF.

Figure 10. a–c: Habitats of *Clavulinopsis laeticolor* on soil; d–f: various stages of basidiocarps. Scale bar, 1 cm.

***Cookeina tricholoma* (Mont.) Kuntze**

Small to medium fruit body, irregular, deeply shallow to funnel-shaped, scarlet-orange cup/apothecium with characteristic long whitish spines/hairs around the cup margin, fertile hymenial layers, an inner viscid to smooth surface, narrowing below into short to long and centric to excentric stipe (Figure 11).

Annual, infrequent, lignicolous, with a non-distinctive taste, odor, and edible (Praxedes et al., 2023). Found on rotting twigs and wood of *Bambusa* sp., *Canarium strictum, Dysoxylum malabaricum, Euodia lunu-ankenda, Toona ciliata*, and *Vateria indica*. The apothecial cup measures 1.3–2.3 cm in diameter × 2.2–3.6 cm long. Stipe 0.3–0.5 cm in diameter and 0.4–2.8 cm tall. Asci 289–342 µm long × 18.4–21.0 µm in diameter. Ascospores are hyaline, smooth, and fusiform and measure 26.8–31.6 × 11.8–16.3 µm.

Notes: Found on woody litter in the shola forest and sacred groves of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # CotrWGMRF.

Figure 11. a and b: Habitat of *Cookeina tricholoma* on logs; c: an upper view of apothecia; d: side view of apothecia. Scale bar, 1 cm.

***Filoboletus manipularis* (Berk.) Singer**

Small to medium fruit body, hygrophanous, viscid, shiny, whitish (young) to greyish brown (mature), conico-campanulate agaric with tessellate/reticulated (young) to smooth (mature) surface, concolorous poroid/tubulate (young) to network to reticulated (mature) spongy pore-bearing undersurface and long, slender, hollow, and longitudinally striate to pruinose stipe (Figure 12).

Annual, rare, lignicolous, taste and odor not distinctive, edible when young. In caespitose clusters on rotting twigs of *Madhuca longifolia*.

Pileus 1.8–3.8 cm in diameter and stipe 2.2–4.2 cm tall × 0.2–0.4 cm thick. Basidiospore are subspherical, hyaline, smooth, and 5.3–7.2 × 5.2–6.5 µm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # FimaWGMRF.

Figure 12. a–c: Habitat of *Filoboletus manipularis* on twigs; d: an upper view of pileus; e and f: the pattern of gills. Scale bar, 1 cm.

***Ganoderma colossus* (Fr.) C.F. Baker**

Medium to large fruit body, shiny to varnished, black, fan-shaped bracket with radially wrinkled and concentrically grooved upper surface, fertile, whitish pore-bearing under surface, and sessile to substipitate (Figure 13).

Perennial, infrequent, lignicolous, with a taste and odor not distinctive, inedible, and medicinal. Solitary or scattered on a degrading stub of *Acacia mangium*.

Basidiomata 5.1–9.9 cm in diameter (horizontal) × 3.8–12.2 cm in diameter (vertical) × 0.6–2.7 cm thick. Basidiospores are yellowish-brown/pale-brown, oval to broadly ellipsoidal, smooth to finely ornamented, and 13.2–17.1 × 9.2–10.5 µm.

Notes: Found on trunks of *Areca catechu* plantations of southwest Karnataka and the coffee agroforest of the Western Ghats (Karun and Sridhar, 2014a). Accession # GacoWGMRF.

Figure 13. a–c: Basidiomata of *Ganoderma colossus*; d: side view; e: lower view; f: the pattern of pores. Scale bar, 1 cm.

***Geastrum lageniforme* Vittad.**

Small, coarsely fibrous to arachnoid, brownish to creamish-brown structure with a brownish endoperidial body/spore sac surmounting a creamish-brown, star-shaped to petal-like to saccate, exoperidial base that raises the spore sac above the substrate (Figure 14).

Annual, rare, lignicolous or particolous, with taste and odor not distinctive, inedible, gregarious, or in small to large troops on soil with embedded decaying twigs/bark.

Basidiomata 1.9–4.3 cm in diameter × 1.6–2.7 cm tall. Basidiospores are ornamented, dark brown, spherical, with fine spines, and 2.4–3.2 μm (inclusive of ornamentation).

Notes: Found on decaying twigs and bark of *Pongamia pinnata* of scrub jungles of southwest Karnataka (Karun and Sridhar, 2014a). Accession # GalaWGMRF.

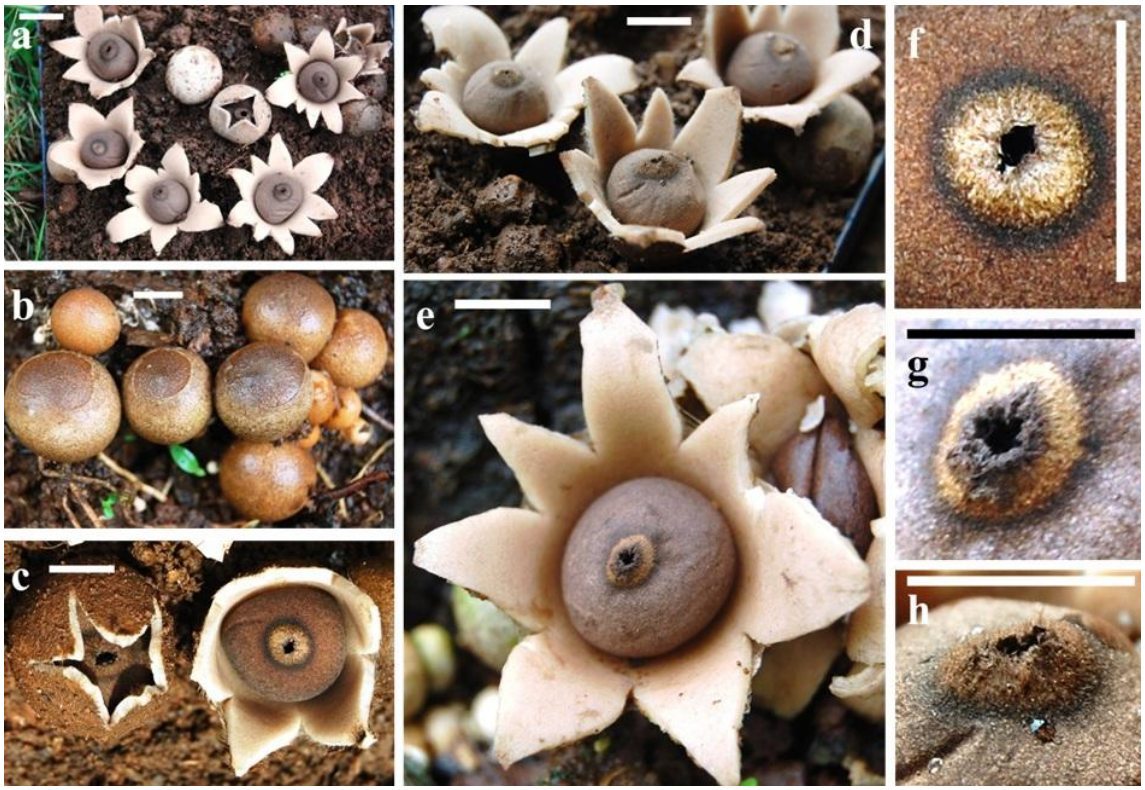

Figure 14. a: Habitat of *Geastrum lageniforme* on soil; b and c: immature basidia; d and e: mature basidia; f–h: the pattern of pores. Scale bar, 1 cm.

***Geastrum triplex* Jungh**

Small to medium fruit body, coarsely fibrous to squamulose, greyish-brown to pinkish-brown structure with greyish-brown endoperidial body/spore sac surmounting a pinkish-brown, star-shaped, and reflexed exoperidial base that raises the spore sac above the substrate on a saucer-like platform (Figure 15).

Annual, rare, particolous, with a taste and odor not distinctive and an immature fruit body edible (Arora, 1986). Scattered or in small troops on soil, many tree species are ectomycorrhizal. Basidiomata 4.6–8.6 cm in diameter × 3.1–5.4 cm tall. Basidiospores ornamented, brownish, spherical, spiny, and 4–4.7 μm (inclusive of ornamentation).

Notes: Found in scrub jungles as ectomycorrhizal in *Terminalia paniculata, Artocarpus heterophyllus, Canarium strictum*, and *Mangifera indica* trees, botanical gardens, and arboretum of southwest Karnataka (Karun and Sridhar, 2014a, 2014b; Greeshma et al., 2016; Pavithra et al., 2016). Accession # GetrWGMRF.

Figure 15. a: Habitat of *Geastrum triplex* on soil; b–d: immature basidia; e and f: mature basidia; g–i: the pattern of pores. Scale bar, 1 cm.

***Gyrodontium sacchari* (Spreng.) Hjortstam**

Medium to large fruit body, shiny to smooth, orange-brown to greyish-brown brackets to lobed to tufts with soft to puffy upper surface, possessing characteristic greenish-brown, fertile, cylindrical pegs underneath and sessile with a short and stout stem (Figure 16).

Annual, rare, lignicolous, odor mealy/almond-like, taste not distinctive, edible based on tribal knowledge. Solitary or in tufts on standing dead *Caryota urens* and on bark crevices of live *Terminalia catappa.* Basidiomata 3.2–20.2 cm in diameter × 0.5–2.3 cm thick. Basidiospores are oval to ellipsoidal, smooth, greenish-yellow/yellowish-brown, and 3.4–4.7 × 2.6–3 µm.

Notes: Found on the rotten trunk of *Caryota urens* in the reserve forest of the Western Ghats in Karnataka (Karun and Sridhar, 2016b). It was found on the base of *Terminalia catappa* in an arboretum in southwest Karnataka (Karun and Sridhar, 2016b). Accession # GysaWGMRF.

Figure 16. a and b: Habitat of *Gyrodontium sacchari* on standing dead tree base; c–e: various stages of basidia; f: the pore pattern underneath basidiomata; g: enlarged peg-like structures underneath basidiomata. Scale bar, 1 cm.

***Hericium cirrhatum* (Pers.) Nikol.**

Large fruit body, thick, whitish/creamish, semicircular to lobed to shell-shaped tufts with short to long bristly-hairy upper surfaces, possessing characteristic pinkish-white, fertile and deadaloid to lamellate to deeply incised flattened tiered teeth underneath and sessile (Figure 17).

Annual, rare, lignicolous, mealy/almond-like odor, taste not distinctive, edible based on tribal knowledge, and medicinal. Solitary or in tufts on bark crevices of live *Euodia lunu-ankenda*. Basidiomata 2.2–10.9 cm in diameter × 0.5–3.3 cm thick. Basidiospores are oval, hyaline, smooth, and 9.8–11.2 × 7.2–8.2 μm.

Notes: Found on the tree trunk of the live endemic tree *Euodia lunuankenda* in the reserve forest of the Western Ghats of Karnataka (Karun and Sridhar, 2016b). Accession # HeciWGMRF.

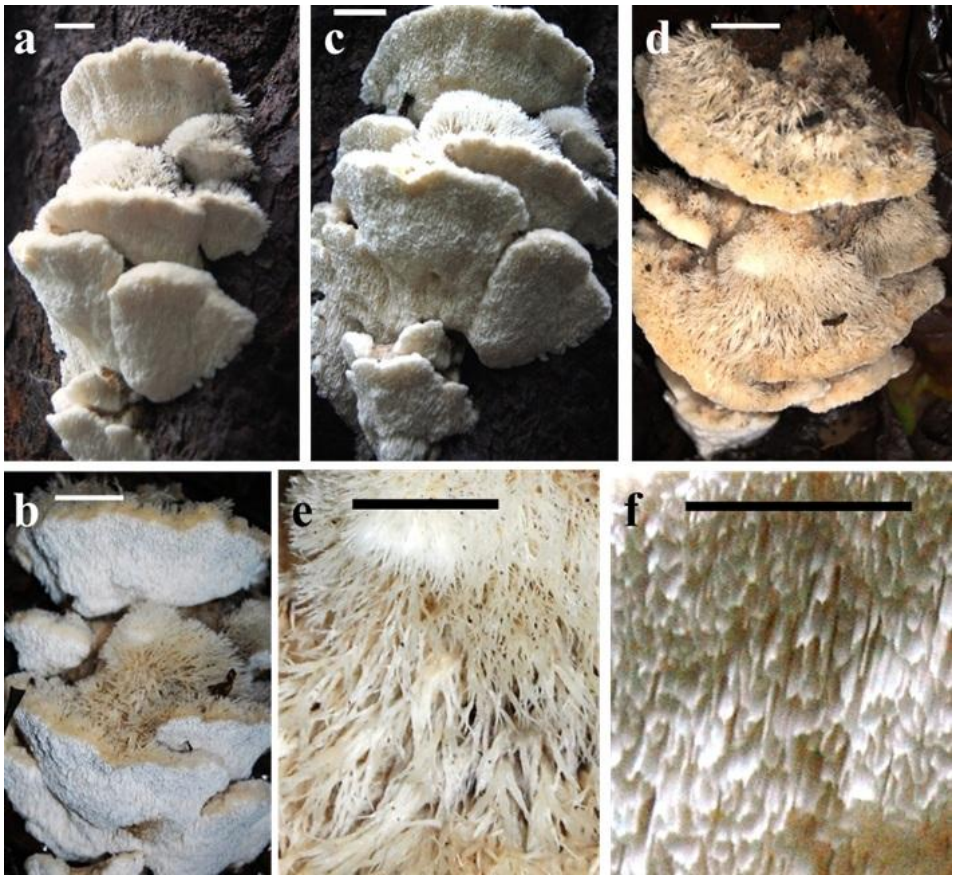

Figure 17. a: Habitat of *Hericium cirrhatum* on canopy bark; b–d: various stages of basidia; e: enlarged woolly upper surface basidiomata; f: enlarged teeth-like structures of basidiomata. Scale bar, 1 cm.

***Hygrocybe astatogala* (R. Heim) Heinem.**

Small to large fruit body, viscid, reddish-orange to reddish-brown, umbonate agaric slowly blackening with age or on bruising with black appressed fibrils and translucently striate cap, pale-yellowish orange gills blackening with age, and reddish-orange to yellowish-orange to creamish fibrillose stipe tapered at apex (Figure 18).

Annual, infrequent, particolous, with taste and odor not distinctive, and inedible. Scattered or in small groups on soil and mycorrhizal. Pileus 2–8 cm in diameter and stipe 4–10 cm tall × 0.4–0.8 cm thick. Basidiospores are hyaline, smooth, subglobose to broadly ellipsoidal, and 7.4–9.6 × 4.4–5.8 μm.

Notes: Found in scrub jungles and botanical gardens as ectomycorrhizal in southwest Karnataka (Greeshma et al., 2016; Pavithra et al., 2016). Accession # HyasWGMRF.

Figure 18. a: habitat of *Hygrocybe astatogala* on soil; b: various stages of basidia; c: an upper surface of pileus; d and e: the pattern of gills. Scale bar, 1 cm.

***Inocybe viridiumbonata* Pegler**

Small to medium fruit body, fibrillose-squamulose, creamish-brown to yellowish-brown umbonate agaric with darker radial scaly fibers on the cap, grayish to cinnamon-brown gills, and central, reddish-brown, tinted, and fibrillose stipe (Figure 19).

Annual, rare, particolous, with a taste and odor not distinctive, and inedible. Scattered in small to large groups or solitary on soil and ectomycorrhizal with *Canarium strictum* and *Euodia lunu-ankenda*. Pileus 4.5–8.2 cm pileus and stipe 6.1–9.4 cm tall × 0.6–1.1 cm thick. Basidiospores are brown, warty to nodular, broadly ovoid, and 8.4–9.9 × 5.5–6.8 μm.

Notes: Found in sacred groves and reserve forests of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # InviWGMRF.

Figure 19. a: Habitat of *Inocybe viridiumbonata* on soil; b: immature basidium; c: mature basidium; d: an upper surface of pileus; e: the pattern of gills. Scale bar, 1 cm.

***Lentinus polychrous* Lév.**

Medium to large fruit body, pale, creamish-orange to grayish-brown, velvety to camel leathery agaric to polypore with funnel-shaped to infundibuliform pileus bearing minute reddish-brown recurved fibrillose squamules on the surface and incurved hispid margin, decurrent yellowish-brown/golden-yellow gills, and pale centric to excentric velutinate stipe (Figure 20).

Annual to perennial, infrequent, lignicolous, with a taste and odor not distinctive, inedible, and medicinal. Scattered or in small or large caespitose clusters on logs.

Pileus 6–18 cm in diameter and stipe 6–12 cm tall × 0.6–1.4 cm thick. Basidiospores are hyaline, smooth, cylindric to flask-shaped, and 8.2–9.8 × 4.4–5.8 μm.

Notes: Found in *Areca catechu* plantation and logs of *Terminalia catappa* and *Hopea ponga* in southwest Karnataka (Karun and Sridhar, 2014b). Accession # LepoWGMRF.

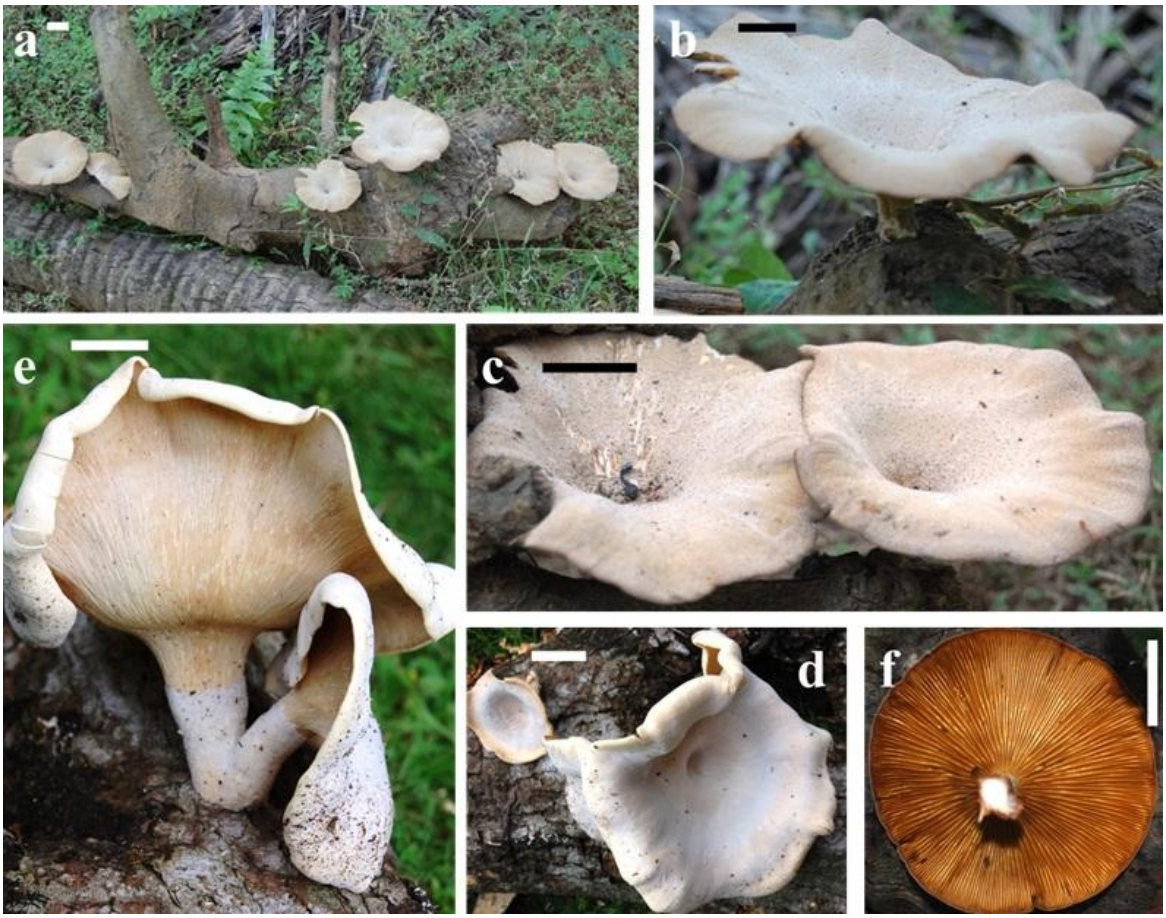

Figure 20. a: Habitat of *Lentinus polychrous* on log; b–d: an upper part of pileus; e and f: the pattern of gills. Scale bar, 1 cm.

***Lepiota thrombophora* (Berk. & Broome) Sacc.**

Small to medium fruit body, pale, conico-campanulate to convex, umbonate agaric bearing densely crowded yellowish-brown appressed granular squamules on the cap, whitish gills and central hollow, white stipe with reddish tints, and membranous annulus attached at the apex (Figure 21).

Annual, rare, particolous, with a taste and odor not distinctive, and inedible. In small groups on soil under *Memecylon umbellatum*. Pileus 2.8–4.6 cm in diameter and stipe 4.2–5.6 cm tall × 0.5–0.8 cm thick. Basidiospores are hyaline, smooth, ellipsoidal, and 13.1–15.8 × 3.3–4.2 μm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # LethWGMRF.

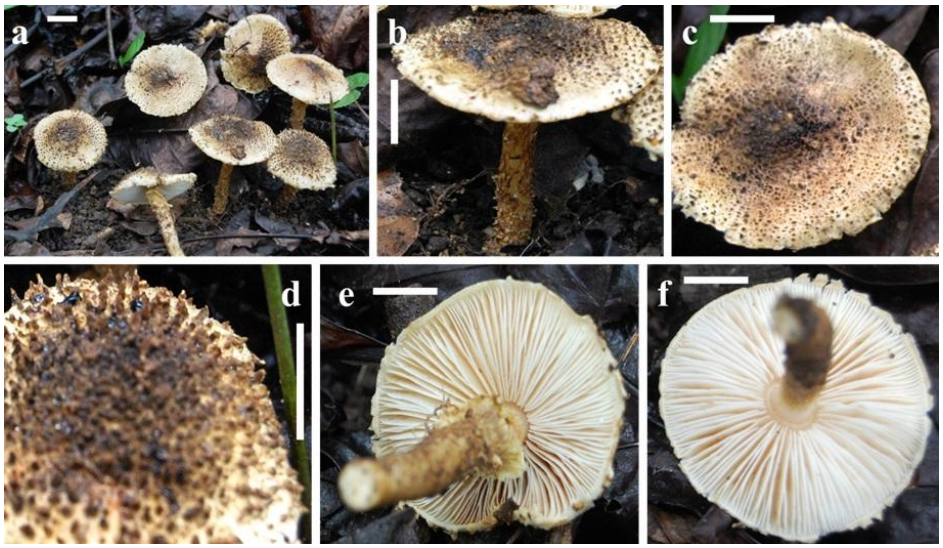

Figure 21. a and b: Habitat of *Lepiota thrombophora* on soil; c and d: top view of pileus; e and f: the pattern of gills. Scale bar, 1 cm.

***Lysurus brahmagirii* C. Mohanan**

At first, partially submerged/hypogeous white egg firmly attached to substratum by rhizomorphs. At maturity, the epigeous egg cracks open into a phallic extrusion with a pseudostipe studded in volval matrix and surrounded by a fertile fold of an arm-like conical head with foul-smelling dark brown slime (Figure 22).

Figure 22. a: Habitat of *Lysurus brahmagirii* on soil; b: tender basidiocarp with rhizoids; c–g: different stages of fruit body. Scale bar, 1 cm.

Annual, rare, humicolous to particolous, with taste and odor not distinctive, and inedible. Solitary or in groups under *Mangifera indica* and *Syzygium cumini* trees.

Head 1.8–2.2 cm in diameter × 2.3–2.6 cm tall, pseudostipe 1.5–1.8 cm in diameter, 8.5–14.5 cm tall, at apex 2.5–2.9 cm in diameter at base (inclusive of volva). Basidiospores are cylindrical-ellipsoid, hyaline, smooth, and 3.4–5.2 × 1.3–2.1 μm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a, 2019). Accession # LybrWGMRF.

***Macrolepiota rhacodes* (Vittad.) Singer**

Large fruit body, fleshy, greyish-brown, shaggy agaric decorated with dark-brown, broad, fibrous, slightly reflexed shaggy scales on the cap, bears whitish to bruising-red gills and whitish eccentric stipe tinged with pinkish-brown with a movable ring and slightly bulbous base (Figure 23).

Annual, rare, particolous, with a taste and odor not distinctive and inedible when mature, solitary or scattered on soil. Pileus 8–15 cm in diameter, stipe 10–14 cm tall × 1.5–2.4 cm thick (above)/1.8–3.3 cm thick (below). Basidiospores are hyaline, smooth, and ellipsoidal and 8.2–11.8 × 6.2–6.8 μm.

Notes: Found in severely disturbed coastal sand-dunes and *Areca catechu* plantations of southwest Karnataka (Ghate et al., 2014). It was also found in the coffee agroforest of the Western Ghats (Karun and Sridhar, 2014b). Accession # MarhWGMRF.

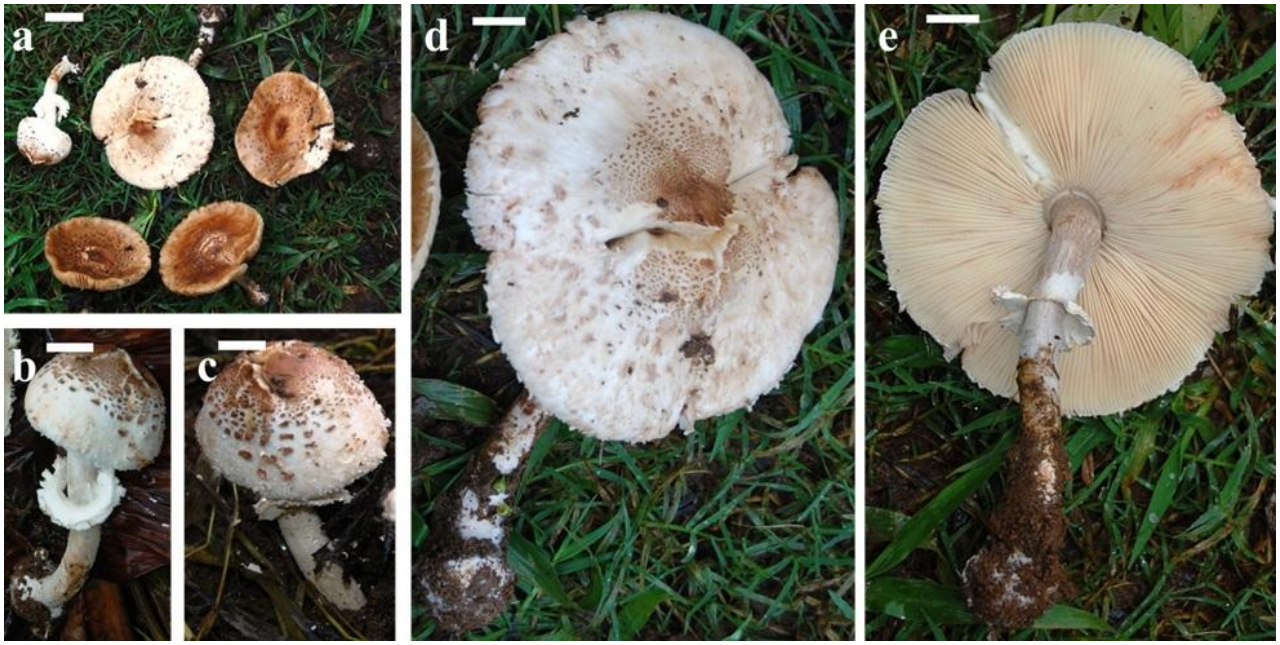

Figure 23. a: Habitat of *Macrolepiota rhacodes* on soil; b: basidiocarp with a partial veil; c and d: top view of pileus; e: the pattern of gills. Scale bar, 1 cm.

***Ophiocordyceps nutans* (Pat.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora**

Small, cylindrical to elongated to club-shaped fruit body/ascoma/stroma possessing a finely warty orange-red fertile head, bearing perithecia wholly embedded in stromatal tissue and extending and narrowing below into a long, slender, sterile black stem (Figure 24).

Annual, rare, entomophagous, with a taste and odor not distinctive, inedible, and medicinal. Solitary or in pairs from bodies of dead insects. Perithecia (excluding fertile heads), 1.7–3.8 cm tall × 0.15–0.3 cm thick, and fertile heads 7.5–16.5 cm tall × 0.1–0.17 cm wide. Asci are cylindrical, elongated, characteristically bulged at the tip, and measure 363–429 long × 4.6–5.0 μm wide. Ascospores elongated, fusiform, smooth, hyaline, parallel stacked, multiseptated, and breaking into a large number of one-celled cylindrical or barrel-shaped fragments with blunt ends and measuring 9.2–13.2 × 1.9–2.6 μm.

Notes: Found in coffee agroforest as entomophagous on stink bug *Halyomorpha halys* (sucking insect of *Cassina galuca*) of the Western Ghats of Karnataka (Karun and Sridhar, 2013, 2016a). Accession # OpnuWGMRF.

Figure 24. a: Habitat of *Ophiocordyceps nutans* on stink bugs *Halyomorpha halys* among leaf litter; lump of fruit bodies; c–e: stroma developed on *H. halys*; f: magnified fertile head. Scale bar, 1 cm.

***Otidea alutacea* (Pers.) Massee**

Small to medium fruit body, delicate, creamish to creamish-orange, irregular split saucer-/cup-like apothecium with fertile hymenial layers on inner smooth surface, farinose sterile outer surface, and sessile (Figure 25).

Annual, rare, lignicolous, with a taste and odor not distinctive and inedible. Scattered on degrading spathe of *Areca catechu*. Apothecium 3.4–4.8 cm in diameter × 3–7 cm tall. Asci cylindrical, 8-spored, and measuring 258–281 × 16–18 µm. Ascospores are hyaline, smooth, ellipsoidal, non-septate, uniseriate, and 18.4–23.7 × 10.5–14.5 µm.

Notes: Found on spathe *Areca catechu* plantation in southwest Karnataka (Karun and Sridhar, 2014b). Accession # OtalWGMRF.

Figure 25. a and b: Habitat of *Otidea alutacea* on spathe of *Areca catechu*; c and d: an upper region of apothecia; e and f: the lower region of apothecia. Scale bar, 1 cm.

***Panus similis* (Berk. & Broome) T.W. May & A.E. Wood**

Small to medium fruit body, purple-brown, velvety to leathery agaric, polypore with wine glass to funnel-shaped to deeply infundibuliform cap bearing radially plicate-sulcate surface, densely ciliated incurved margin, pinkish-white decurrent gills, and dark central velutinate stipe firmly attached to substratum (Figure 26).

Annual, rare, lignicolous, with a taste and odor not distinctive and inedible. Solitary or in small to large caespitose clusters on degrading logs of *Olea dioica*. Pileus 2.9–6.9 cm in diameter, stipe 4.2–6.4 cm tall × 0.65–0.8 cm wide. Basidiospores are hyaline, smooth, ellipsoidal, and 5.2–5.8 × 2.6–2.9 μm.

Notes: Found on wood in scrub jungles in southwest Karnataka (Greeshma et al., 2016). It was also found in the shola forest of the Western Ghats (NCK: unpublished observation). Accession # PasiWGMRF.

Figure 26. a: Habitat of *Panus similis* on a log of *Olea dioica*; b and c: top view of pileus; d and e: the pattern of gills. Scale bar, 1 cm.

***Phallus merulinus* (Berk.) Cooke**

At first, partially submerged/hypogeous greyish-brown to ash-brown eggs are firmly attached to the substratum by rhizomorphs. At maturity, the epigeous egg cracks open into a phallic extrusion with a white pseudostipe studded in volval matrix, surrounded by a fertile head, covered with foul-smelling dark olive-brown slime and white or bone-white netted indusium covered beneath the head like a long skirt (Figure 27).

Annual, infrequent, and particolous with taste and odor are not distinctive and edible. Small groups or solitary in soil under *Cocos nucifera* and *Musa paradisiaca*.

Head 2.2–2.4 cm in diameter × 3.6–3.8 cm tall, pseudostipe 14.5–15.2 cm tall × 1.7–1.9 cm in diameter at apex/3.8–4.2cm diameter at base (inclusive of volva). Basidiospores are hyaline, smooth, cylindrical-ellipsoid, and 3.1–3.9 × 1.0–1.5 μm.

Notes: Found in *Areca catechu*, *Cocos nucifera* plantations, and the basin of *Musa paradisiaca* in southwest Karnataka (Karun and Sridhar, 2014b, 2019). Accession # PhmeWGMRF.

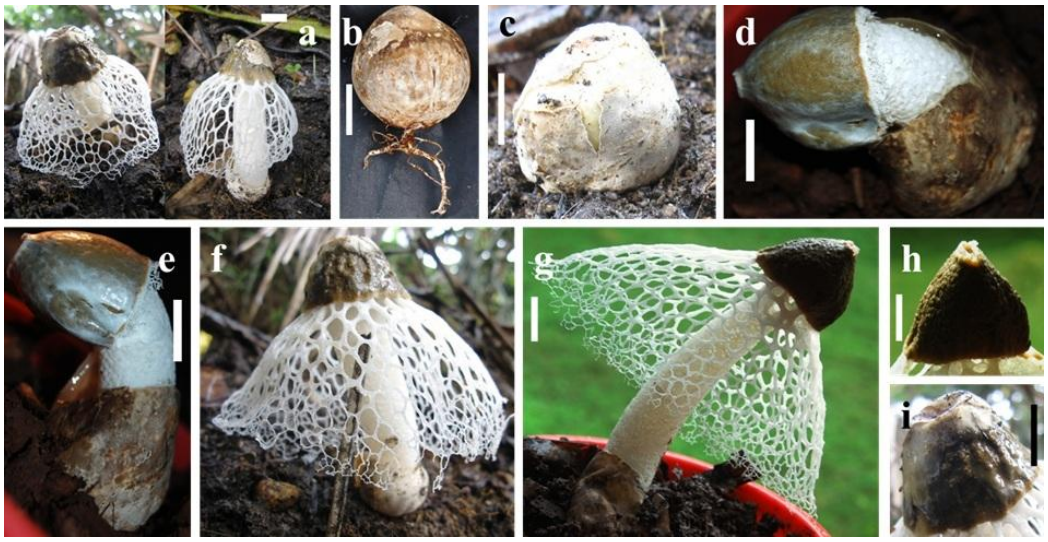

Figure 27. a: Habitat of *Phallus merulinus* on soil; b and c: tender basidiocarp with rhizoids; d and e: emergence from volva; f and g: mature fruit bodies; h and i: nature of fertile heads. Scale bar, 1 cm.

***Phlebopus portentosus* (Berk. & Broome) Boedijn**

Medium to large fruit body, olive-brown bolete with smooth to puffy cap, greenish-yellow fertile spongy pore-bearing under surface, and central orange-brown stipe with a swollen base (Figure 28).

Annual, particolous, infrequent with non-distinctive taste, almond-like odor, ectomycorrhizal, and edible when young. Solitary or in small groups on soil under *Coffea arabica*. Pileus 9.8–18.2 cm in diameter, stipe 6.5–9.8 cm tall × 1.3–5.2 cm wide at the top/2.4–9.2 cm thick at the base. Basidiospores are smooth, ellipsoidal, brown, and 7.2–9.2 × 5.2–6.6 µm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # PhpoWGMRF.

Figure 28. a: Habitat of *Phlebopus portentosus* on soil; b: a bunch of fruit bodies; c: top view of pileus; d: the pattern of pores underneath pileus; e: magnified pores of pileus. Scale bar, 1 cm.

***Podosordaria elephantis* J.D. Rogers & Y.M. Ju**

Small fruit body, orange-brown, reticulated to grooved, round head decorated with innate, black, papillate, punctured ostioles bearing perithecia and wholly embedded in stromatal tissue with sterile pedestal (Figure 29).

Annual, rare, coprophilous, and odor and taste not distinctive, inedible. Gregarious or in small troops on elephant dung. Perithecia 1.1–2.2 cm tall, stalk 0.15–0.2 cm wide, and fertile head 0.3–0.4 cm wide. Asci cylindrical/club-shaped, 8-spored, 89.4–121 × 4.5–5.3 µm. Ascospores are black, smooth, fusiform, non-septate, uniseriate, flattened at one side with a distinct cleft, and measure 9.2–0.5 × 4.4–4.7 µm.

Notes: Found on elephant dung in the reserve forest of the Western Ghats of Karnataka (Karun and Sridhar, 2015a, 2016a). Accession # PoelWGMRF.

Figure 29. a and b: Habitat of *Podosordaria elephantis* on elephant dung; c–e: mature perithecia emerged from elephant dung. Scale bar, 1 cm.

***Polyporus arcularius* (Batsch) Fr.**

Small to medium fruit body, orange-brown to greyish-orange, elastic to leathery, funnel-shaped to depressed to infundibuliform cap bearing hairy/ciliated margin with fertile, whitish, angular to radially elongated pore bearing undersurface, pale and centric to excentric fibrillose stipe (Figure 30).

Annual, rare, lignicolous, almond-like odor, taste not distinctive, and edible. In small groups or clusters on rotting twigs and logs of *Ficus exasperata*. Pileus 1.3–3.0 cm in diameter and stipe 1.4–2.6 cm tall × 0.1–0.3 cm wide. Basidiospores are hyaline, smooth, cylindrical, and measure 6.6–9.2 × 3.9–5.3 µm.

Notes: Found in the coffee agroforest of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # PoarWGMRF.

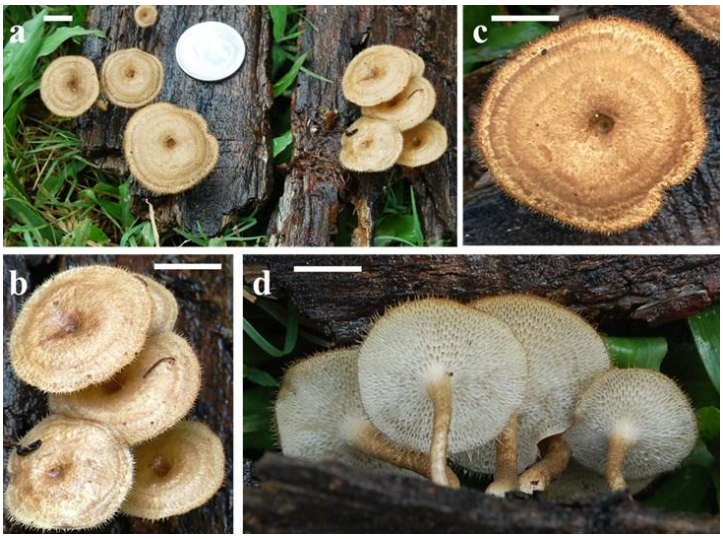

Figure 30. a: Habitat of *Polyporus arcularius* on a logs of *Ficus exasperata*; c and d: top view of pileus; e: the pattern of gills. Scale bar, 1 cm.

***Psilocybe coprophila* (Bull.) P. Kumm.**

Small fruit body, reddish-brown to golden-brown, bell-shaped to convex, umbonate agaric with a detachable viscid doomed cap with stipe and gills greyish-brown (Figure 31).

Annual, rare, coprophilous, odor and taste not distinctive, and hallucinogenic. Solitary or in small groups on elephant dung. Pileus 1.7–4.7 cm in diameter and stipe 3.6–7.3 cm tall × 0.3–0.7 cm wide. Basidiospores are purple-brown, smooth, lemon-shaped to broadly ellipsoidal with an apical germ pore and 10.8–12.9 × 7.4–9.2 μm.

Notes: Found in the shola forest and reserve forest of the Western Ghats of Karnataka (Karun and Sridhar, 2015a, 2016a). Accession # PscoWGMRF.

Figure 31. a: Habitat of *Psilocybe coprophila* on elephant dung; b–f: emerging basidia; g–i: an upper view of pileus; j: the pattern of gills. Scale bar, 1 cm.

***Ramariopsis kunzei* (Fr.) Corner**

Small, delicate, erect, creamish-white, repeatedly but loosely branched coral-like fruit body bearing antler head/stag horn-like branches with pointed to blunt forked tips and arising from slender to broad stem (Figure 32).

Annual, infrequent, particolous to lignicolous, with taste and odor not distinctive, and inedible. In dense clusters on soil amongst grasses in shola forests, sacred groves, and rarely on rotting logs of the *Canarium strictum* reserve forest. Basidia are 6.1–8.9 cm tall × 0.2–0.3 cm thick (variable diameter). Basidiospores are hyaline, subglobose to broadly ellipsoidal, finely spiny/echinulate, and 3.3–4.2 × 2.9–3.6 μm.

Notes: Found in the grassland of shola forest and sacred groves of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Accession # RakuWGMRF.

Figure 32. a–c: Habitat of *Ramariopsis kunzei* on soil; d–f: various stages of fruit bodies. Scale bar, 1 cm.

***Scleroderma areolatum* Ehrenb.**

Small to medium fruit body, yellowish-brown, rigid rounded structure covered with smooth appressed dark-brown scales leaving a dotted and netted pattern and attached below to the substrate by thick mycelial cords. On maturity, the thin, tough, and leathery outer peridium breaks open by an irregular pore or fissure, revealing the inner purple-grey to ash-grey powdery gleba (Figure 33).

Annual, rare, particolous, ectomycorrhizal, taste excellent, odor almond-like, and edible. Solitary or scattered on soil under *Acacia auriculiformis*, *A. mangium*, *Artocarpus heterophyllus*, *Canarium strictum*, *Dysoxylum malabaricum*, *Macaranga peltata*, and *Schefflera racemosa* as mycorrhizal. Head 5.3–7.8 cm in diameter × 5.1–7.9 cm wide. Basidiospores are dark brown, spherical, decorated with spines, and 7.9–8.6 μm (including ornamentation).

Notes: Found in sacred groves of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). Found as ectomycorrhizal with *Acacia auriculiformis*, *A. mangium*, and *Macaranga peltata* in scrub jungles of southwest Karnataka (Karun et al., 2022). Accession # ScarWGMRF.

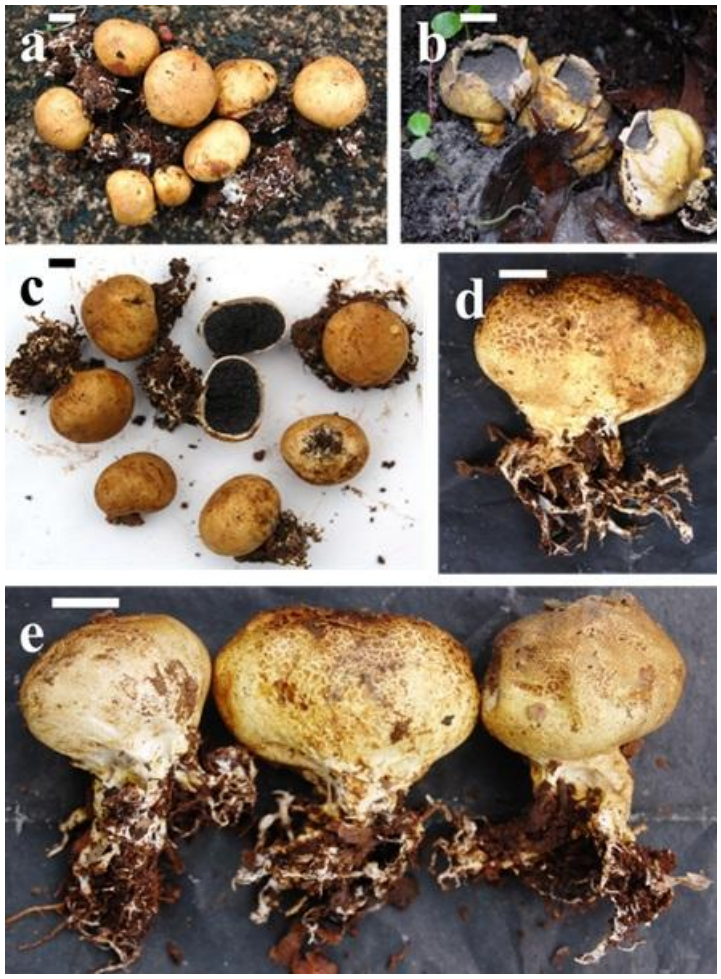

Figure 33. a and b: Habitat of *Scleroderma areolatum* on soil; c: a bunch of basidiocarps; d and e: mature basidiocarps. Scale bar, 1 cm.

***Scleroderma bovista* Fr.**

Figure 34. a: Habitat of *Scleroderma Bovista* on soil; b: a bunch of basidiocarps; c and d: mature basidiocarps; d: basidiocarp with rhizoids; f: basidiospore mass on a ruptured basidium. Scale bar, 1 cm.

Small fruit body, orange-brown to yellowish-orange, hard, spherical, irregularly subspherical structure covered with smooth to granular appressed reddish-brown scales leaving a dotted and netted pattern and attached below to the substrate by dense mycelial cords. On maturity, the thin, tough, and leathery outer peridium breaks open by an irregular pore or fissure, revealing the inner pale-brown powdery gleba (Figure 34).

Annual, rare, particolous, ectomycorrhizal, with taste and odor not distinctive and inedible. In small to large clusters and groups on soil in paddy fields. Head 2–5 cm in diameter × 2–4 cm wide. Basidiospores are brown, spherical, decorated with spines, and 8.4–9.6 µm (including ornamentation).

Notes: Found in association with grasses and weeds in abandoned paddy fields (Karun et al., 2022). Accession # ScboWGMRF.

***Simblum periphragmoides* Klotzsch ex Hook.**

At first, a partially submerged/hypogeous creamish-white to creamish-orange egg is firmly attached to the substratum by rhizomorphs. At maturity, the epigeous egg cracks open into a phallic extrusion with a creamish-white pseudostipe studded in volval matrix and surrounded by a fertile, hollow, lattice spherical head covered with foul-smelling greyish-brown slime (Figure 35).

Annual, rare, particolous, with a taste and odor not distinctive, and inedible. In small groups or solitary in the soil surrounding the basins of *Bambusa* sp. and *Cocos nucifera*. Basidiomata 7.5–12 cm tall × 2.5–3.1 cm in diameter and head 2.6–3.2 cm in diameter × 2.3–2.8 cm tall. Basidiospores are hyaline, smooth, ellipsoidal, and measure 3.7–4.9 × 1.8–2.4 µm.

Notes: Found among the bamboo thickets and *Cocos nucifera* plantation in B'Shettigeri of the Western Ghats of Karnataka (Karun and Sridhar, 2019). Accession # SipeWGMRF

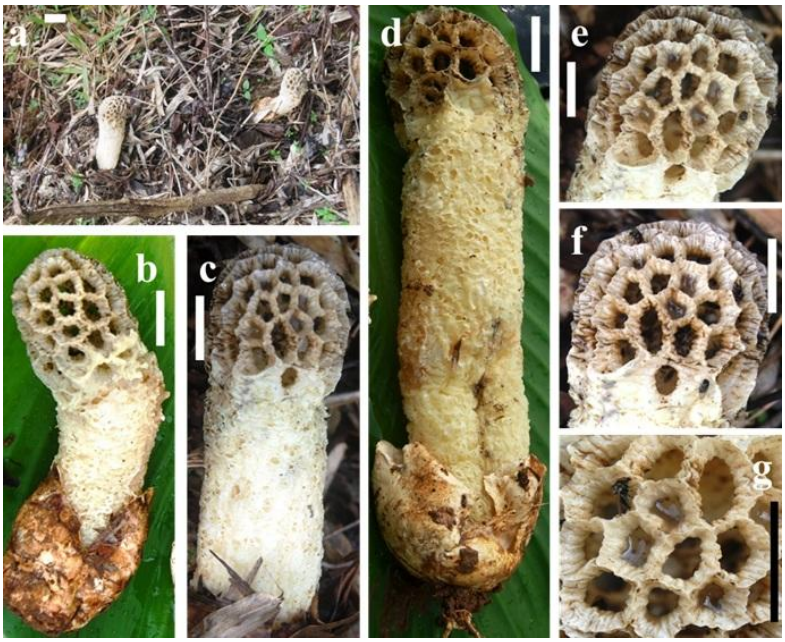

Figure 35. a: Habitat of *Simblum periphragmoides* basin of *Bambosa* sp.; b and c: emerging fruit bodies; d: mature fruit body; e–g: the pattern of fertile head. Scale bar, 1 cm.

***Termitomyces heimii* Natarajan**

Medium to large fruit body, viscid to shiny, whitish, broad umbonate agaric with silky to fibrillose cap bearing greyish/greyish-brown umbo, pinkish-white gills, and whitish long central annulate stipe extending to long pseudorrhizae beneath the soil (Figure 36).

Annual, rare, particolous, excellent taste, almond-like odor, and edible. Solitary or in small groups on termite mounds. Pileus 9–17 cm, stipe 9–21 cm tall × 2.5–3.8 cm wide, swollen base 3.5–5.5 cm in diameter, and pseudorrhizae 15–25 cm long. Basidiospores are smooth, broadly ellipsoidal, hyaline, and 5.5–6.8 × 4.2–4.6 µm.

Notes: Found in reserve forests, coffee agroforests, grasslands, and paddy fields of the Western Ghats of Karnataka (Karun and Sridhar, 2016a). It was also found in the medicinal plant garden in southwest Karnataka (Karun et al., 2024). Accession # TeheWGMRF.

Figure 36. a: Habitat of *Termitomyces heimii* on termite mound; b and c: view of pileus with umbo; d: a bunch of basidiocarps with stipe and pseudorhiza; e: top view of pileus. Scale bar, 1 cm.

***Termitomyces schimperi* (Pat.) R. Heim**

Medium to large fruit body, viscid to shiny, whitish agaric lacking mucronate umbo with thick, brown to rust-brown plate-like/flake-like concentric velar squamules on the cap, creamish-white gills, and whitish long central annulate stipe extending to a long pseudorrhizae beneath the soil (Figure 37).

Annual, infrequent, particolous, infrequent, excellent taste, almond-like odor, and edible. Solitary or in small groups on termite mounds. Pileus 8–15 cm, stipe 8–18 cm tall × 1.5–2.5 cm wide, swollen base 3–5 cm in diameter, and pseudorrhizae 15–25 cm long. Basidiospores are smooth, broadly ellipsoidal, hyaline, and 8–10.6 × 5.2–7.8 μm.

Notes: Found in termite mounds of severely disturbed coastal sand-dunes of southwest Karnataka (Ghate et al., 2014). It was also found in bunds of abandoned paddy fields of the Western Ghats of Karnataka (NCK: unpublished observation). Accession # TescWGMRF.

Figure 37. a and b: Habitat of *Termitomyces schimperi* on termite mounds; c and d: emerging fruit bodies; e: a bunch of fruit bodies; f: nearly mature fruit body with stipe and pseudorhiza; g: top views of the pileus; h: nature of partial veil; i: the pattern of gills. Scale bar, 1 cm.

***Tremella reticulata* (Berk.) Farl.**

Small to medium fruit body, gelatinous to shiny to soft, erect, hyaline or bone-white, irregularly multiple branched, fern-like fruit body bearing hollow cartilaginous erect lobes, fleshy mucoidal core, and sessile (Figure 38).

Annual, infrequent, lignicolous, with a taste and odor not distinctive and edible. Solitary or in small to large clusters in rooting logs of *Acacia mangium* and *Persea americana* trees. Fruit body 3.4–7.8 cm in diameter × 3.1–5.4 cm tall × 0.2–0.4 cm thick. Basidiospores are hyaline, smooth, apiculate, broadly ovate, and 5.2–7.9 × 5.2–6.0 µm.

Notes: Found on wood and in *Acacia* plantations, arboretum, and scrub jungles in southwest Karnataka (Karun and Sridhar, 2014b; Greeshma et al., 2016). It was also found in the reserve forest of the Western Ghats of Karnataka (NCK: unpublished observation). Accession # TrreWGMRF.

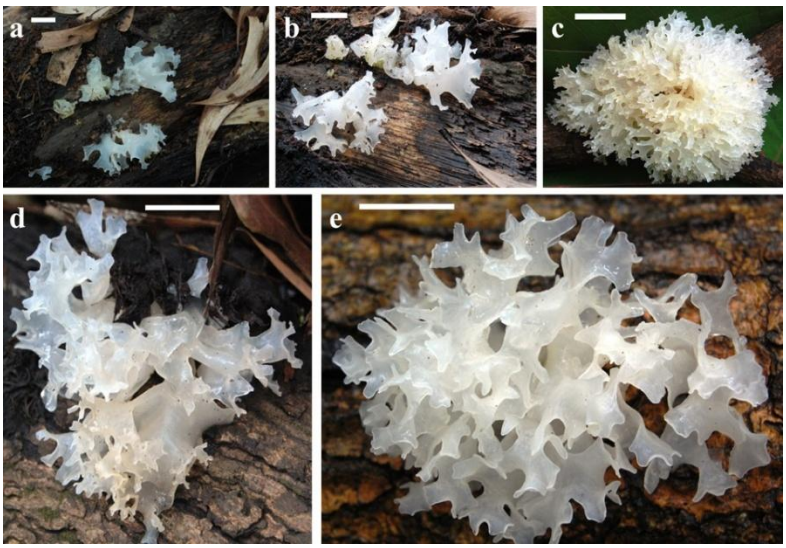

Figure 38. a and b: Habitat of *Tremella reticulata* logs of *Acacia mangium*; c–e: nature of basidia. Scale bar, 1 cm.

***Volvariella volvacea* (Bull.) Singer**

Medium to large fruit body, greyish-brown, campanulate to convex, subumbonate agaric with densely fibrillose to silky to radially rimose cap, pinkish gills, and long pale fibrillose stipe embedded inside creamish orange/orange-brown bag-like volva (Figure 39).

Annual, infrequent, humicolous, infrequent, taste not distinctive, odor almond-like, edible when young. Solitary or in small to large groups on decaying paddy straw. Pileus 6–15 cm, stipe 5–18 cm tall × 1.0–1.8 cm wide, and volva 2–3.5 cm tall × 2–3.8 cm wide. Basidiospores are smooth, ovoid to ellipsoidal, hyaline/pink, and 5.6–6.8 × 4.3–4.8 μm.

Notes: Found on dumped paddy straw in B'Shettigeri of the Western Ghats of Karnataka (NCK: unpublished observation). Accession # VovoWGMRF.

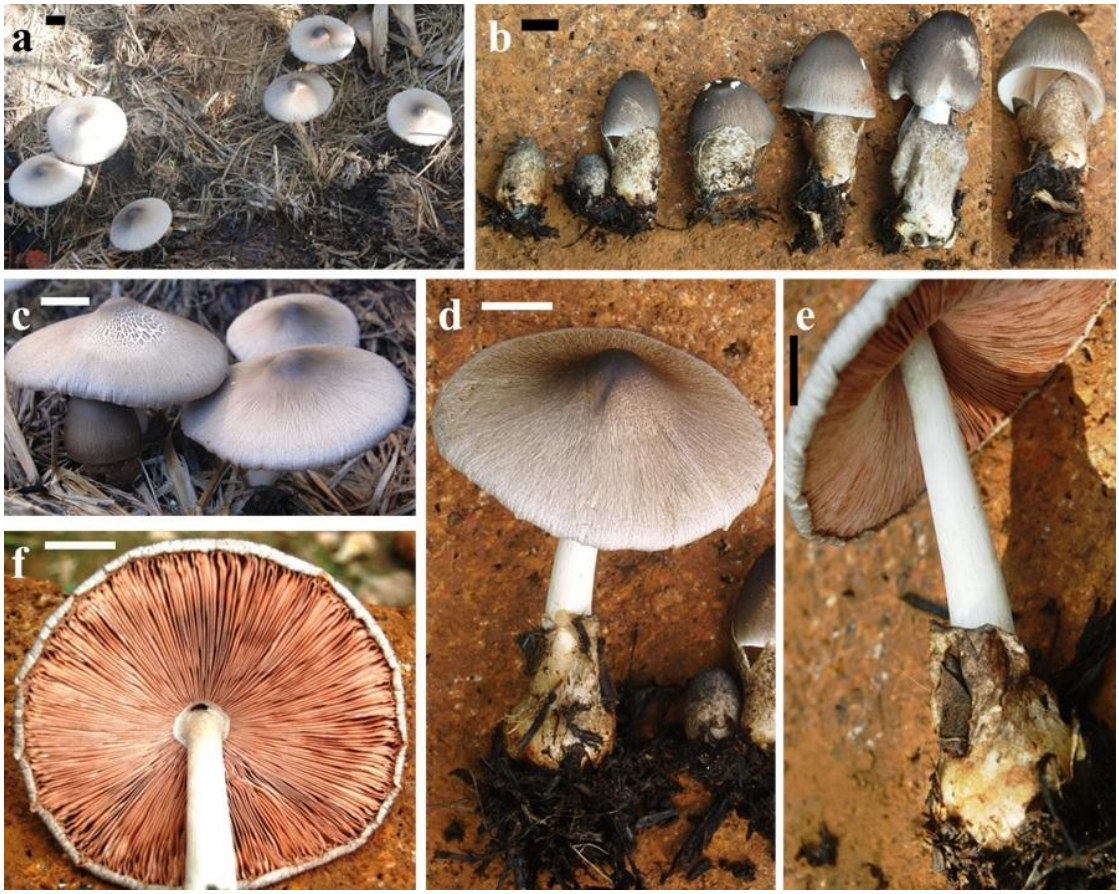

Figure 39. a: Habitat of *Volvariella volvacea* on paddy straw; b: stages of basidiocarp; d and e: mature fruit body with rhizoids; f: the pattern of gills. Scale bar, 1 cm.

***Xylaria polymorpha* (Pers.) Grev.**

Small to medium fruit body, black, irregularly club-shaped stroma/structure with fertile warty upper surface bearing perithecia wholly embedded in stromatal tissue and narrowing below/beneath into a brownish-black, short, stout, and more or less cylindrical stem (Figure 40).

Annual to occasionally perennial, infrequent, lignicolous, with a taste and odor not distinctive, inedible, and medicinal. Arising in small to large tufts on rotting logs of *Pongamia pinnata*, *Terminalia bellirica*, and *Toona ciliata*. Perithecia 3.2–8.4 cm tall × 0.8–2.2 cm wide. Asci cylindrical, long, stipitate, 8-spored, and 165–210 × 8–14 μm. Ascospores are purple-brown, ellipsoid-inequilateral/fusiform with a cleft on one side, aseptate, uniseriate, and 10.5–14.5 × 3.9–4.7 μm.

Notes: Found in the woody litter (*Terminalia bellirica* and *Toona ciliata*) in the coffee agroforest and shola forest of the Western Ghats of Karnataka (Karun and Sridhar, 2015b, 2016a). It was also found on decaying bark and woody parts in the canopy of *Pongamia pinnata* in scrub jungles (NCK: unpublished observation). Accession # XypoWGMRF.

Figure 40. a–c: Habitat of *Xylaria polymorpha* on dead wood of *Terminalia bellirica*; d–g: various features of fruit bodies. Scale bar, 1 cm.

4. DISCUSSION

Macrofungi are essential life forms in southwest India owing to climatic conditions, different habits, and substrates (Mohanan, 2011; Aravindakshan and Manmohan, 2015; Latha and Manimohan, 2017; Ranadive et al., 2022; Vinjusha and Kumar, 2024). Details of macrofungal habitats, substrates, and the economic value of mushrooms found in our study are given in Table 1. Many species are edible, inedible, and mycorrhizal. However, some species have dual significance, like edibility and mycorrhizal features.

Table 1. Occurrence of rare and infrequent macrofungi in southwest India.

Mushroom	Habitat	Substrate	Remarks
Agaricus augustus	Scrub jungles	Soil	Edible and mycorrhizal
Aleuria rubra	Coffee agroforests	Logs	Inedible
Amanita angustilamellata	Botanical gardens	Soil	Inedible and mycorrhizal
Amanita griseofarinosa	Scrub jungles	Soil	Inedible and mycorrhizal
Ascocoryne cylichnium	Coffee agroforests	Soil and humus	Edible
Astraeus odoratus	Scrub jungles	Soil	Edible and mycorrhizal
Boletinellus merulioides	Coffee agroforests	Soil and humus	Edible and mycorrhizal
Clavaria rosea	Scrub jungles	Soil	Inedible
Clavaria zollingeri	Shola forests	Soil	Inedible
Clavulinopsis laeticolor	Shola forests	Soil	Inedible
Cookeina tricholoma	Shola forest and sacred groves	Soil and woody litter	Edible
Filoboletus manipularis	Coffee agroforests	Woody litter	Edible
Ganoderma colossus	*Areca* plantation and coffee agroforests		Inedible and medicinal

Geastrum lageniforme	Scrub jungles	Soil and woody litter	Inedible
Geastrum triplex	Scrub jungles, plantations and botanical gardens	Soil	Edible and mycorrhizal
Gyrodontium sacchari	Reserve forests and botanical gardens	Woody litter	Edible
Hericium cirrhatum	Reserve forests	Woody litter	Edible and medicinal
Hygrocybe astatogala	Scrub jungles and botanical gardens	Soil	Inedible and mycorrhizal
Inocybe viridiumbonata	Reserve forests and sacred groves	Soil	Inedible and mycorrhizal
Lentinus polychrous	*Areca* plantation	Woody litter	Inedible and medicinal
Lepiota thrombophora	Coffee agroforests	Soil	Inedible
Lysurus brahmagirii	Coffee agroforests	Soil and humus	Inedible
Macrolepiota rhacodes	*Areca* plantation, coffee agroforests and coastal sand-dunes	Soil	Inedible
Ophiocordyceps nutans	Coffee agroforests	Insects	Inedible and medicinal
Otidea alutacea	*Areca* plantation	Lignicolous	Inedible
Panus similis	Shola forests and scrub jungles	Woody litter	Inedible
Phallus merulinus	Plantations	Soil	Edible
Phlebopus portentosus	Coffee agroforests	Soil	Edible and mycorrhizal
Podosordaria elephantis	Reserve forests	Elephant dung	Inedible
Polyporus arcularius	Coffee agroforests	Woody litter	Edible
Psilocybe coprophila	Reserve forests and shola forests	Elephant dung	Inedible and medicinal
Ramariopsis kunzei	Shola forests and Sacred groves	Soil and woody litter	Inedible
Scleroderma areolatum	Sacred groves and scrub jungles	Soil	Edible and mycorrhizal
Scleroderma bovista	Grasses and weeds	Soil	Inedible and mycorrhizal
Simblum periphragmoides	Bamboo thickets and coconut plantations	Soil	Inedible
Termitomyces heimii	Reserve forests, coffee agroforests, grasslands, paddy fields and botanical gardens	Termite mounds	Edible
Termitomyces schimperi	Paddy fields and coastal sand-dunes	Termite mounds	Edible
Tremella reticulata	Reserve forests, scrub jungles, *Acacia* plantations and botanical gardens	Woody litter	Edible
Volvariella volvacea	Village premises in Western Ghats	Composting paddy straw	Edible
Xylaria polymorpha	Shola forests, coffee agroforests and scrub jungles	Woody litter	Inedible and medicinal

Macrofungi found in southwest India have been classified based on habitats, substrates, and usefulnes (Figure 41). Coffee agroforests possess the highest number of macrofungi (13 spp.), followed by scrub jungles (11 spp.), reserve forests (7 spp.), shola forests (7 spp.), and botanical gardens (6 spp.). The rest of the four habitats consist of 1–4 spp. Among the substrates, soil possesses maximum fungi (23 spp.), followed by woody litter (13 spp.). The remaining four substrates possess 1–3 spp. As many as 23 species are inedible; however, their economic significance needs to be established. Up to 11 species are mycorrhizal, nine species are edible, and six species are medicinal.

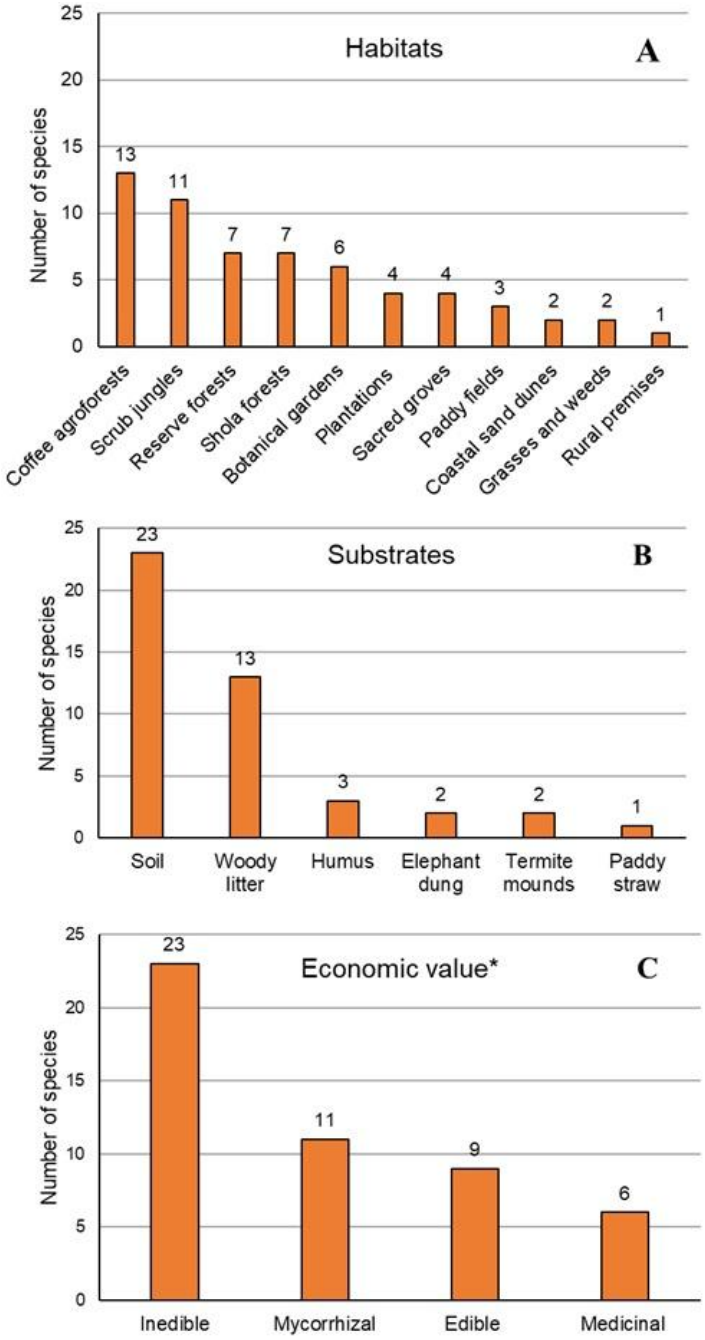

Figure 41. A, Number of species found in different habitats; B, Number of species found on different substrates; C, Number of species possess economic value (*, economic significance of 23 species is yet to be recognized).

5. CONCLUSION

Macrofungi constitute an essential segment of our ecosystem as they serve humankind in terms of nutrition, medicine, industrially valued biomaterials, and environmental conservation. Our study revealed 40 rare and infrequent species (33 basidiomycetes and seven ascomycetes) in selected areas of the Western Ghats (reserve forests, shola forests, sacred groves, and coffee agroforests) and the west coast (sacred groves, plantations, botanical gardens, and coastal dunes). The coffee agroforests possess the highest macrofungi (13 species), followed by scrub jungles (11 species). Soil is inhabited by a maximum of 23 species, followed by woody litter (13 species). Up to 23 species are inedible (needs focus on their usefulness), 11 species are mycorrhizal, nine species are edible, and six species are medicinal. This study warrants further focus on rare and infrequent mushroom species occurring in southwest India.

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Author contribution

Namera Chinnappa Karun: Conceptualized the study and carried out field and laboratory studies; Kandikere R. Sridhar: Conceptualized, carried out a partial field study, reviewed, and drafted the manuscript.

Informed consent

Not applicable.

Ethical approval & declaration

In this article, as per the plant associated Macrofungi regulations followed in the Western Ghats Macrofungal Research Foundation, Bittangala, Virajpet, Kodagu, Karnataka, India; the authors observed a total of 40 species of macrofungi (33 basidiomycetes and seven ascomycetes) were sampled from three biomes (Western Ghats, scrub jungles, and coastal sand-dunes) consisting of four forests (reserve forests, shola forests, and sacred groves), scrub jungles, plantations, botanical gardens, and coastal sand-dunes. Each specimen was deposited in WGMRF (Western Ghats Macrofungal Research Foundation), Bittangala, Virajpet, Kodagu District, Karnataka, with accession numbers. The ethical guidelines for plant materials (plant associated Macrofungi) & National Biodiversity Authority Guidelines are followed in the study for species collection & identification.

Conflicts of interests

The authors declare that there is no conflict 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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