

Check list of Tremellales and Clavariales from Telangana and Andhra Pradesh

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ABSTRACT

Fungi are eukaryotic, achlorophyllous living organisms specifically having chitinous cell wall, absorptive nutrition and these characters raised them to the level of kingdom Mycota. The world of fungi is a fascinating field and a form of source of biological diversity and metabolites. Fungi have been studied since long times from India. Fungi belonging to zoosporic fungi, hyphomycetes and rust fungi have been worked out at length from Telangana state (TS) and Andhra Pradesh (AP), but very few studies are made on higher fungi and more so on Tremellales and Clavariales. In view of this, the authors have taken up the survey of the fungi belonging to the above groups and taxonomic account of ten such fungi is presented based on phenotypic and microscopic characters along with the key.

Key Words: Andhra Pradesh, Clavariales, Telangana, Tremellales.

INTRODUCTION

Fungi are cosmopolitan and ubiquitous in distribution besides occupying prime place in the living world after insects (Manoharachary *et al.*, 2005). India has been bestowed with diversified soil conditions, forests and climatic zones, hence, has been cradle for the fungi. Around 1.5 to 6.5 million has been the estimates for fungi (Hawksworth and Lucking, 2017). Of which 1, 55, 000 have been identified upto species level. In India, around 35,000 species of fungi have been identified of which only 5-7% have been cultured (Manoharachary *et al.*, 2005). Macrofungi is an important group, and such higher fungi is essentially a synthesis of mushroom ligands, myths, cultures and folklore besides being reinforced by mushroom biology and science. Higher fungi are reported as decomposers, symbionts and root infecting pathogens having evolved with plant life through ages. The diversity of higher fungi reflects their lineage and evolution (Subramanian, 1995). Members belonging to orders Tremellales and Clavariales form important group of higher fungi. Tremellales also known as 'Jelly Fungi' are mostly saprophytic and few are parasitic. Basidiocarps are well organized and appear as inconspicuous horny crusts when dried and usually bright to black coloured (Martin, 1944). They appear as gelatinous masses after the

rain. Clavarioid fungi are also known as 'Coral Fungi' due to their coralloid type of growth. Several macrofungi have been reported from India from time to time (Thind and Dev, 1956; Thind *et al.*, 1982; Atri *et al.*, 2005; Natarajan *et al.*, 2005; Arya *et al.*, 2008; Swapna *et al.*, 2008; Syed *et al.*, 2008; Kaviyarsan *et al.*, 2009, 2022; Dwivedi *et al.*, 2012; Pushpa and Purushothama, 2012, Vrinda *et al.*, 2012; Das and Das, 2014; Lakhnupal, 2014; Verma and Pandro, 2018; Kumar *et al.*, 2019; Dattaraj *et al.*, 2020; Roy *et al.*, 2022; Nanu and Kumar, 2024). A preliminary survey of higher fungi has been done from Telangana and Andhra Pradesh by Krishna *et al.*, (2015), Manoharachary and Nagaraju, (2017), and Srinivasarao and Nagadesi (2021). However, the above research works did not report jelly fungi and coral fungi from Telangana and Andhra Pradesh, respectively.

STUDY SITES

Andhra Pradesh has a diverse topography with three major regions: the Coastal Andhra region, the Rayalaseema region and the Eastern Ghats. Andhra Pradesh experiences varying annual precipitation patterns primarily influenced by the southwest monsoon. The state observes three distinct seasons: a scorching summer from March to June with temperature often exceeding 95°F (35°C) and even reaching 104°F (40°C) in the central region, while night temperature fall below 70°F (20°C) mainly in

the far southwest; a tropical rainy season from July to September; and a relatively cooler winter from October to February, where January temperatures range from 86 to 95°F (30 to 35°C) across most areas except the northeastern portion. In winter drop below about 60°F (15°C) only in the extreme northeast. Telangana State is situated on the Deccan Plateau, in the central stretch of the eastern seaboard of the Indian Peninsula. Dry deciduous, scrub Jungle forests and mixed forest types are distributed in districts of Rangareddy, Khammam, Medak, Mahabubnagar, Warangal, Nizamabad and Adilabad. The annual rainfall is between 900 to 1500 mm in Northern Telangana and 700 to 900 mm in Southern Telangana, from the southwest monsoons. Telangana is a semi-arid area and has a predominantly hot and dry climate. Summer start in March, and reach peak in May with an average high temperature to the 42°C (108°F) range. The monsoon arrives in June and lasts until September with about 755 mm (29.7 inches) of precipitation. A dry, mild winter starts in late November and lasts until early February with little humidity and an average temperature of 22–23°C (72– 73°F) range.

MATERIAL AND METHODS

A survey was conducted during December 2020 to November, 2021 for the collection of different macrofungi from the forest regions of Nirmal (Dist. Adilabad), Mannanur (Dist.Mahaboobnagar), Narsapur (Dist. Medak) of Telangana State and forest regions of Damuku (Dist. Visakhapatnam) of Andhra Pradesh (**Figure 1**). Fruiting bodies were collected from humid soil, dead wood, litter, tree trunks and other substrates. Morphological and microscopic features of fruit-bodies form the basis of their identification. The fresh fruiting bodies were sampled after taking photographs, and the morphological characters such as shape, size, colour, texture etc., were recorded. The steps followed are preparation of type specimen is collection including spore print, documentation and preservation. Drying of specimens, herbarium preparation, detailed morphological and anatomical studies were followed (Kaviyarasan *et al.*, 2009). Identification of collected macrofungi is done by using the manuals (Bandoni, 1987; Pat and Ed Grey, 2018). The specimens thus collected were deposited at Osmania University Fungal Herbarium (OUFH) at the Department of Botany, Osmania University, Hyderabad.



Figure 1: Forest collection sites of macrofungi from Telangana and Andhra Pradesh

● - Collection sites

RESULTS

Fungi belonging to the orders Tremellales and Clavariales collected from different forest regions of Telangana state and Andhra Pradesh were studied and identified based on macro and micromorphological characters. The identified species are: *Calocera viscosa* (Pers.) Bory,

Auricularia auricula-judae (Bull.) Quel., *Phleogena decorticate* G.W. Martin., *Scytinopogon angulisporus* (Pat.) Corner., *Ramaria stricta* (Pers.) Quel., *Ramaria zippellii* (Lev.) Corner., *Ramaria obtusissima* (Peck.) Corner., *Clavaria filiola* Corner., *Ramariopsis kunzei* (Fr.) Corner and *Clavulinopsis frutricula* Corner (**Table 1**).

Table 1: List of macrofungi collected from the forest regions of Telangana and Andhra Pradesh.

Sl. No	Fungal name	Family	Habitat	Geographic location	Type of forest	OUFH No.
1.	<i>Calocera viscosa</i> (Pers.) Bory	Dacrymycetaceae	Rotten wood	Nirmal, Adilabad Dist. TS	Tropical dry deciduous forest	162
2.	<i>Auricularia auricula-judae</i> (Bull.) Quel	Auriculariaceae	Living tree trunk (<i>Sesbania</i> sp.)	Narsapur, Medak Dist. TS	Tropical dry deciduous forest	163
3.	<i>Phleogena decorticate</i> G. W. Martin	Phleogenaceae	Dead Tree	Damuku, Vishakapatnam Dist. AP	Tropical semievergreen forest	164
4.	<i>Scytinopogon angulisporus</i> (Pat.) Corner	Clavariaceae	On litter	Damuku, Vishakapatnam Dist. AP	Tropical semievergreen forest	165
5.	<i>Ramaria stricta</i> (Pers.) Quel	Clavariaceae	On dead Leaves and humus	Damuku, Vishakapatnam Dist. AP	Tropical semievergreen forest	166
6.	<i>Ramaria zippellii</i> (Lev.) Corner	Clavariaceae	On the ground	Damuku, Vishakapatnam Dist. AP	Tropical semievergreen forest	167
7.	<i>Ramaria obtusissima</i> (Peck.) Corner	Clavariaceae	On leaf litter	Narsapur, Medak Dist. TS	Tropical dry deciduous forest	168
8.	<i>Clavaria filiola</i> Corner	Clavariaceae	On soil	Mannanur, Mahaboobnagar Dist. AP	Tropical dry deciduous forest	169
9.	<i>Ramariopsis kunzei</i> (Fr.) Corner	Clavariaceae	Humus soil	Damuku, Vishakapatnam Dist. AP	Tropical semievergreen forest	170
10.	<i>Clavulinopsis frutricula</i> Corner	Clavariaceae	On soil	Mannanur, Mahaboobnagar Dist. AP	Tropical dry deciduous forest	171

Note: OUFH: Osmania University Fungal Herbarium

Taxonomy - Tremellales

Dacrymycetaceae

Basidiocarp white or bright coloured (yellow, orange or red). Gelatinous, horny or dry, simple or branched, viscid, without a distinct stem. Hymenium amphigenous. Basidia elongate, furcate or bilobed, each lobe bearing on single one-spored sterigma. Spores oblong, curved and septate on germination.

1. Basidiocarp awl shaped or at least the tips acute, simple or slightly branched.....*Calocera*
 - i) Branches more or less vertical, repeatedly dichotomous, orange, the rooting base paler,

very common on rotten wood.....*C. viscosa* (Pers.) Bory

Auriculariaceae

Basidiocarp ear shaped and marked with vein-like ridges; the convex surface with a greyish velvety powdered appearance most apparent when the basidiocarps are partially dried; basidia elongate, transversely 3-septate.

1. Basidiocarp gelatinous, cartilaginous, semi-circular, ear shaped, pallid or rosy to dark brown in colour. Hymenium smooth. Basidia four celled. Basidiospores cylindrical..*Auricularia*
 - i) Which occurs singly, yellow brown to reddish brown, up to 4 cm broad, and resembles a

human's ear, occur on living trees.....*A. auricula-judae* (Bull.) Quel

Phleogenaceae

Basidiocarp erect, consisting of a short stalk bearing a globose head filled with powdery mass (spores). The whole plant less than 10 mm. Globose head covered by a thin fragile peridium. Basidia four-celled.

1. Spores brown or dark brown, borne internally in a powdery mess. Basidia are 3-sepate, no epibasidia formed..... *Phleogena*

i) The entire plant less than 5 mm occurs on dead stumps, trees and logs..... *P. decorticata* G.W. Martin

1. *Calocera viscosa* (Pers.) Bory, *Dictionnaire Classique D'histoire Naturelle*, 4:196 (1823).

Basidiocarp occurring on wood, golden colour, erect, simple, slightly branched, firm, gelatinous, horny when dry, becoming gelatinous when wet, awl shaped or cylindrical, up to 35 mm height. Hymenium covering most of the basidiocarp. Basidia one celled but two forked at the apex, two spored. Basidiospores up to 15 µm, cylindrical, slightly curved, becoming one septate at germination.

Specimens examined: On rotten wood, Nirmal, Dist. Adilabad, TS., on 23rd July, 2020 – OUHF No.162.

2. *Auricularia auricula-judae* (Bull.) Quel. *Enchiridion fungorum* (Paris), 207(1886).

Basidiocarp occurring only on wood, gelatinous, rigid and brittle when drying, reviving when wet semicircular or ear-shaped, attached by a lateral point, rosy to dark brown or black in colour, 35 mm diam. Hymenium smooth. Basidia cylindric, unilateral, 4 -celled, the three lower cells producing each a lateral sterigma, the terminal cell an apical sterigma. Basidiospores one celled, up to 18 µm. Cylindric, often curved germinating by a germ tube.

Specimens examined: On living tree (*Sesbania* sp.) in the forest region of Narsapur Dist. Medak, AP., on 25th August, 2020 – OUHF No. 163.

3. *Phleogena decorticata* G.W. Martin, *University of Iowa Studies in Natural History*, 18(3):69 (1944).

Basidiocarp occurring on decorticated wood, dry, greyish white or brown, stalked, capitate, small, entire, plant with head up to 5 mm high. Stalk 3 mm high. Head sub-globose, 2 mm in diam. which is sometimes flattened or contorted, enveloped by a thin fragile peridium. Basidia in dense clusters on the head. Basidia are 3 septate, clavate or cylindric. No epibasidia formed. Basidiospores sessile, sub-globose, thick walled, brown, 6-7.8 x 6-6.8 µm.

Specimens examined: On dead tree in the forest region of Damuku, Dist. Vishakapatnam, AP., 9th December, 2020 – OUHF No. 164.

Clavariales

Clavariaceae

Fructifications radial or rarely flattened or coral shaped, usually fleshy, waxy or gelatinous, hyphae generally inflating. Hymenium amphigenous, spores mostly coloured, fructifications mostly branched.

1. Fruit bodies with flattened branches, tough, coriaceous or horny, hyphae not inflating, often thick walled, spores angular echinulate, white, fruit bodies white, yellowish, branched in one plane, secondarily distorted..... *Scytinopogon*

i) Chalk white. Hyphae mostly 2-4 µm wide, rarely up to 10 µm spores 5.5-7 3.5-4 µm. Slightly angular..... *S. angulisporus* (Pat.) Corner.

2. Fructifications radial, usually fleshy, waxy, hyphae generally inflating. Spores yellow or ochraceous smooth, ellipsoid, rarely sub globose, guttulate, terrestrial or lignicolous.....*Ramaria*

i) Mycelial hyphae dimitic, spores 7-11 x 3.5-5 µm nearly smooth to minutely rough, brown, flesh unchanging hyphae, thick walled clamped..... *R. stricta* (Pers.) Quel

ii) Humicolous, fruit body yellow, tips white or purple brown when bruised, spores echinulate, 9-13.5 x 3-4.5 µm; spines on spores 1-2 µm long..... *R. zippellii* (Lev.) Corner

iii) On litter, fruit body tan white, Basidiospores 10.4 -12.0 x 3.0 -5.0 µm brown, ellipsoid, papillate.....*R. obtusissima* (Peck.) Corner

3. Fructifications simple or branched; generally fleshy, hyphae typically inflating. Basidia clavate, 4-spored; Hyphae without clamps, mostly secondarily septate; spores smooth, aguttate or multiguttate..... *Clavaria*
 i) Fructifications 15 mm high or less, white, spores 4.5-5 x 4 µm stem pellucid, soft, brittle, hymenium not thick..... *C. filiola* Corner
4. Fructifications branched, fleshy, hyphae clamped, not secondarily septate, spore mostly 1-guttulate minutely echinulate or verrucose..... *Ramariopsis*
 i) Fruit body branched, pallid 3-5 cm long; apices acute, spores sub globose, less than 6 µm long..... *R. kunzei* (Fr.) Corner
5. Fructifications simple or branched, fleshy and somewhat brittle, a few gelatinous or tough, white, rarely coloured, yellow or pink..... *Clavulinopsis*
 i) Fructifications branched; up to 2 cm high, spores smooth, 4-5 x 2.5-3.5 µm *C. fruticula* Corner

4. *Scytinopogon angulisporus* (Pat.) Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No.1*, 1:648 (1950).

Fructifications 20 x 14 cm gregarious or, generally densely caespitose, palmately and fastigiately branched from a flattened trunk like base immersed in the ground, chalk white, hymenium thickening up to 300 µm behind the growing tips. Basidia 20-35 x 5.5 -7 µm white, ellipsoid, thick-walled, verruculose or echinulate, hyphae monomitic clamped. Cystidia none.

Specimens examined: From the ground in the forest region of Damuku, Dist. Vishakapatnam, AP., on 9th November, 2021 – OUHF No. 165.

5. *Ramaria stricta* (Pers.) Quel. *Flora mycologia France (Paris)*, 464 (1888).

Fructifications 70 mm tall, gregarious, caespitose, erect, pallid yellow or ochraceous, tips clear yellow, stem distinct pale, arising from a white mycelial felt or thread like rhizomorphs, branches numerous, much branched, dichotomous, erect, fastigiate, elongate, acute, flesh white or yellowish. Hymenium waxy, spores 7-9.5 x 4.5 µm, rusty ochraceous, oblong. Basidia 30-35.5x7-10 µm. Hymenium absent from the upper side of the

branches, sub-hymenium composed of thin-walled hyphae. Mycelial hyphae 2.5 -5 µm wide, with slightly thickened walls monomitic, hyaline, branched, septate, septa at long intervals, clamped.

Specimens examined: From dead leaves and humus amid mosses in the forest region of Damuku, Dist. Vishakapatnam, AP., on 12th December, 2020 – OUHF No. 166.

6. *Ramaria zippellii* (Lev.) Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No. 1*, 1:632 (1950).

Fruit body dry, opaque, velvety, trunk present, branched, trunk 35 mm long, nearly 10 mm thick, tinged with red, dilated above and divided into 2 or 3 branches, branches coarse, ochraceous or dirty yellow, giving off short, irregular branchlets of the same colour, sometimes trifid above, ultimate branchlets all emerginate: Mycelium tuberous, several mm thickness. Basidia 40-45 x 7-10 µm, subclavate. Spores 10-15 x 5-8 µm, deep ochraceous to ferruginous ochraceous, echinulate with acute colourless spines, pip-shaped, 1-2 guttulate.

Specimens examined: From ground in the forest region of Damuku, Dist. Vishakapatnam, AP., on 9th December, 2020– OUHF No. 167.

7. *Ramaria obtusissima* (Peck.) Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No.1*, 1:609 (1950).

Fruiting body up to 18 x 12 cm scattered, erect, large sized, massive, radial, profusely branched, fleshy, smooth glabrous, pallid or tan white, on drying reddish brown, base massive, short, giving rise to stout main branches at ground level, branching polycotomous below, dichotomous above, ultimate branchlets bifid or crowded, very minute 4 mm long apices blunt, flesh white. Hymenium spread all over. Basidia 5.0-9.6 µm. Wide, clavate, basidiospores 10.4-12 x 3.0 -5.0 µm. Pale brown, ellipsoid, papillate, hyphae monomitic, long, hyaline, thin walled, branched and septate.

Specimens examined: From leaf litter in the forest region of Narsapur, Dist. Medak, AP. on 18th July, 2021– OUHF No. 168.

8. *Clavaria filiola* Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No.1*, 1:691 (1950).

Fructifications 7-15 mm high, very small, white simple, cylindrical and sub-acute to sub-clavate. Stem 3.5- 0.5 mm base abrupt, sub-fibrillose, distinct from the fertile head, spores 4.5 -5 x 4 µm white, smooth, sub-globose, with vacuolate oleaginous or cloudy contents, not guttate. Basidia 20 -30 x 6 -8 µm without clamps, sterigmata 4, caulocystidia filiform unbranched, aseptate, thin walled scattered, more numerous near the base or the stem, absent from the upper part. Hyphae 4-8 µm wide in the flesh, the cells 30-200 µm long, thin walled, slightly inflated without clamps.

Specimens examined: Collected from bare soil in forest region of Mannanur, Dist.Mahaboobnagar, AP. solitary or in small groups on 3rd September, 2021 – OUHF No. 169.

9. *Ramariopsis kunzei* (Fr.) Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No.1*, 1:640 (1950).

Fructifications 2.5-6.5 cm tall gregarious usually caespitose with 2-8 fruit bodies in a cluster, profusely branched, fleshy, smooth, trunk white, radial, branches radial, dichotomous, 3-5 times branched, unequal. Hymenium spread all over except the sterile apices and the sterile trunk. Basidia 25-32 x 4-8 µm, clavate, sterigmata 2-4. Basidiospores hyaline, globose to subglobose papillate, echinulate. Hyphae monomitic, hyaline, thin walled, branched, clamped, sometimes not clamped.

Specimens examined: From humicolous soil in the forest region of Damuku, Dist. Vishakapatnam, AP. on 9th December, 2020 – OUHF No. 170.

10. *Clavulinopsis fruticula* Corner. Monograph of *Clavaria* and allied Genera, *Annals of Botany Memoirs No.1*, 1:694 (1950).

Fructification up to 20 mm high, solitary or gregarious, dichotomously branched, white becoming pale ochraceous from the base upward, then pale brownish ochraceous on the stem and lower parts of the branches, the acute tips white. Stem tomentose at the base, branches cylindrical, tips acute, waxy, fleshy. Hyphae with thin thickened walls, clamped or slightly constricted at the septa, short celled. Basidia 20-25 x 4.5-6.5 µm, simple vacuolate, long, stout, spores white, smooth, pip-shaped, 4.5-3 µm with one guttate.

Specimens examined: Collected from soil in the forest region of Mannanur Dist. Mahaboobnagar, AP. on 3rd September, 2021 – OUHF No. 171.

DISCUSSION

Tremellales and Clavariales commonly known as jelly fungi and coral fungi respectively, form a small group of macrofungi. Tremellales are saprophytic, with a few species as parasitic and have oval to globose basidia with a single basidiospore supported by an elongated sterigma. Clavariales have cylindrical branches that grow vertically upwards, with the hymenium growing on the outer surface. Jelly fungi are reported by Alvarenga et al. (2016) and Clavarioid fungi by Corner (1966, 1970) respectively. Although many reports on macrofungi from Telangana and Andhra Pradesh are available (Krishna et al., 2015; Manoharachary and Nagaraju, 2017, Srinivasarao and Nagadesi, 2021), reports on jelly fungi and coral fungi are less from India (Prabhu et al., 2016; Verma and Pandro, 2018, Mahamulkar et al., 2002; Prakash, 2021) and more so from Telangana and Andhra Pradesh. In this article we reported 10 fungi viz., *Calocera viscosa* (Pers.) Bory, *Auricularia auricula-judae* (Bull.) Quel., *Phleogena decorticata* G. W. Martin, *Scyrtinopogon angulisporus* (Pat.) Corner, *Ramaria stricta* (Pers.) Quel, *Ramaria zippellii* (Lev.) Corner, *Ramaria obtusissima* (Peck.) Corner, *Clavaria filiola* Corner, *Ramariopsis kunzei* (Fr.) Corner, *Clavulinopsis fruticula* Corner and all these form new additions to the fungi of Andhra Pradesh and Telangana, respectively.

Most of the jelly fungi are edible and are commonly used as ingredients in desserts and soups. They contain various chemical constituents with medicinal and nutritional benefits. Due to the presence of polysaccharides and steroids in them, they exhibit antitumor and anti-inflammatory properties (Hall et al., 2003). Some of the members are also utilized as adsorbent in oil-water emulsion separation (Yang et al., 2014). Some of the coral fungi are also edible such as species of *Ramaria* (Sharma and Gautam, 2017). contain amino acids, minerals etc. (Sharma and Gautam, 2017), fatty acids, alkaloids, saponins, terpenoids, coumarins, and cardiac glycosides (Aldred, 2008; Dattaraj et al., 2020). Presence of these bioactive molecules show therapeutic properties such as antimicrobial,

antiviral, anti-parasitic, antioxidant, radical scavenger, anticancer, anti-inflammatory, immune system enhancer and anti-hyperlipidemia (Wasser, 2017).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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