

Tapping Unexplored Macrofungi: Occurrence and Distribution of *Amanita*, *Russula* and *Termitomyces* Species in the Different Forest Divisions of Odisha, India

Abstract

A systematic study was done on the wild mushroom species of the forest regions of Odisha with the objective to generate information on macrofungal diversity at different forest divisions of Odisha. Six major forest divisions of Odisha viz. Northern tropical semi evergreen forest (Site-1), Northern tropical dry deciduous forest (Site-2), Secondary moist miscellaneous semi evergreen forest (Site-3), Northern tropical semi evergreen forest (Site-4), Mixed forests having combination of Northern tropical semi evergreen forest and Tropical moist deciduous forest (Site-5), Tropical dry deciduous forest and Northern tropical semi evergreen forest (Site-6) were the sites for experiment emphasizing on *Amanita*, *Russula* and *Termitomyces* species. Nineteen different macrofungal populations were observed where 6 species of *Amanita*, 8 species of *Russula* and 5 species of *Termitomyces* were recorded from different habitats. *Russula brevipes*, *Russula rosea* and *Russula lepida* were very luxuriantly present in (Site-5). The distribution frequency was the highest (53.84%) in *Amanita vaginata* among all other species of *Amanita*. The *Amanita craseoderma* and *Amanita chrysoleuca* were observed with the least distribution (2.56%). *Termitomyces* occurred in many places of Odisha and was considered as a palatable mushroom. Occurrence of *T. eurrhizus* was the highest (30.76%) in Odisha forests while *Termitomyces microcarpus* showed the least distribution (2.56%). The findings of the study have concluded that the (Site 1,5,6) can be a potential site for the mushroom hunters.

Keywords: macrofungi, biodiversity, *amanita*, *russula*, *termitomyces*

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Introduction

Mushrooms are the key entities in the forest ecosystems being saprobic in nature. Mushroom belongs to the kingdom fungi, phylum Basidiomycetes, class Basidiomycetes and they are noted for producing fruiting bodies. There are millions of mushroom species in the world that grow in the wild forest and are classified into two groups, namely, the edible mushroom and non edible mushroom.^{1,2} Mushrooms are a large group of organisms playing a significant role in the environment. Mushrooms in daily life are mostly seen as a food product. Sporocarps are non-uniform in distribution varying from a few scattered fruiting bodies to concentrated clusters of numerous fruit bodies.³ This situation makes the grid method unreliable for the diversity studies of macrofungal population.

The biodiversity of mushrooms of Odisha has still not been well investigated due to a lack of experts. Although many of them have been widely recorded in Odisha together with information for edibility of various species, most of the names of reported species refer to species collected from the American or European species. The mushrooms available in different forest division are not well defined. Medicinal mushrooms have an established history of use in traditional oriental therapies. Modern clinical practice in different countries like Japan, China, Korea, and other countries continues to rely on mushroom derived preparations. Mushrooms have been used for many years in oriental culture as tea and nutritional food because of their special fragrance and texture.⁴ The scientific community in

searching for new therapeutic alternatives has studied many kinds of mushrooms and has found variable therapeutic activity such as anti-carcinogenic, anti-inflammatory, immunosuppressor and antibiotic.^{5,6} Collection of mushrooms and its consumption is a traditional practice in rural and tribal zones of Odisha such as in different forest zones and surrounding areas. In many cases, the collections of mushrooms are for the self-consumption rather than for the commercial value except few cases. Particularly, climatic conditions and diverse flora are the main causes for the development of macrofungal diversity. These facts have facilitated to the present study to locate mushrooms in the different area of forest divisions of Odisha.

Materials and Methods

Study area

A systematic plan was made to study certain sites like Northern tropical semi evergreen forest, Northern tropical dry deciduous forest, Secondary moist miscellaneous semi evergreen forest, Northern tropical semi evergreen forest, Mixed forest having combination of Northern tropical semi evergreen forest and Tropical moist deciduous forest, Tropical dry deciduous forest and Northern tropical semi evergreen forest for the presence and level of frequency to find these mushrooms. Six forests sites namely, Banei, Baliguda, Koraput, Similipal, Kalahandi and Chandaka of Odisha were surveyed for the presence of Mushrooms.

Sampling

Mushrooms were collected from vegetation zones and plant associations which included grassland, dead woody trunks, termite nests and anthills. Mushroom samples were collected by using an iron axe, spade, graduated measuring scale and paper bags. An axe was used to draw out the inner attachment of the mushrooms and a sharp spade for plucking mushroom fruit bodies. The samples thus taken were kept in paper bags in order to handle them without any desiccation and bring them for identification.

Collection and preservation

Fruiting bodies were removed from the substratum attentively to avoid damage to the basal region of the macrofungi to reveal volva, buried substrata, any bulb or attachment. The soil was removed by a brush.^{7,8} Formalin solution was used to preserve the samples as well as dried in the hot air oven at 50-60°C and kept in the polybags with dichlorobenzene to avoid microbial attack and long term preservation. Before the collection, the habitat of respective mushrooms was well monitored for the perfect identification. All the mushrooms were brought to the laboratory and identified by observing all the macro morphological characteristics.

Identification

Collected macrofungi were identified on the basis of size, shape, colour, odour, texture, presence and absence of lamella and volva etc. In case of Pileus margin, colour, consistency, gill arrangement were observed. In case of stipe, rings, stuffness, presence of rhizoid and other different type of attachment of the base of the stipe were taken into consideration for identification.

Data analysis

The species were listed according to corresponding hosts viz. plants, termite comb, anthill and grassland with scattered leaf litter. Species frequency of different mushrooms was estimated in accordance with the scale including two or more collecting sites; at least one of them with numerous basidiocarps. The frequency and distribution of all the three species of special interest (considered to be rare in the literature or with lack of distribution data in Odisha) were also discussed.

Results and discussion

The texture of the soils was sandy and loamy, including large variation in the floral diversity. It had a subtropical monsoon and humid climate with an average annual rainfall of 1500mm, and temperature range of 20-38°C and humidity range of 58-88% in semi evergreen forests except in few forest sites where dry deciduous forest cover was present (Figure-1).

The study has listed five different types of *Termitomyces*. The frequency of distribution of *T. heimii* was the highest (20.51%) in (Site-2,6) regions where as it was completely absent in (Site-4) region.⁹ *T. eurhizus* was the maximum found mushrooms among the different *Termitomyces* species. Among five study sites, three of the study sites showed the higher in mushroom population (30.76%) where as these were absent in (Site-4) (Table 1) (Table 2) (Figure 2) (Figure 3). *Termitomyces clypeatus* ranked the second highest mushroom in the survey study (28.22 %) with an ample amount in Site-5 when compared with (Site 1,4,6) whereas no patch of this species was recorded in (Site-2). *T. heimii* was often spotted by (Site-5,6) where it was picked up by the local tribes and eaten as food. A few patches of

T. medius were recorded in all the forests except in (Site-1,2) with a frequency of 7.64 % which was scarce when compared to other species. The least population frequency was recorded in *T. microcarpus* (2.56 %) which was found only in (Site-3,5). The distribution behavior of these mushrooms were similar to the findings of Karwa et al.,¹⁰ in the forest regions of Central India. The knowledge about species of the genus *Amanita* in which many of them are ectomycorrhizal with forest trees, is limited and only a few species have been reported from India.^{11,12} Not surprisingly the population of *Amanita* in the Odisha region especially in (Site-5) was very high, may be due to the diverse vegetation and elevated land sites.¹³ The frequency of occurrence of *Amanita vaginata* was maximum among all other *Amanita* species (95.84%) being the highest in (Site-1,5) regions followed by (Site-2,6). It has been also found that *A. vaginata* was luxuriantly present in all the forest divisions of Odisha. *Amanita pantherina* was found with the less population of mushroom when compared with the above varieties. It was not found in the (Site-1,3,4,6) regions due to which its occurrence frequency was only 5.12% (Figure 4). *Amanita loosii* ranked second highest found mushrooms in the forest divisions studied (17.94%). The habitat of mushroom found in the (Site-5) supported that there was a luxuriant growth of *A. loosii* and served as food of choice among the tribal. However, (Site-6) also showed an appreciable occurrence of this mushroom when compared with the other three regions where there was complete absence of this mushroom. The occurrence frequency of *A. caesarea* was 7.69 % which was solely present in (Site-5). According to the present study, a very few habitat supports its growth and hence this may be a suspected cause of very scarce in Indian context. The reasons for the lower distribution of this variety of mushrooms in the above mentioned sites may be due to the climatic conditions and vegetation. The presence of *Amanita chrysoleuca* and *Amanita craseoderma* was completely different and notable when related to the occurrence of *A. loosii* and *A. pantherina* i.e. they were completely absent in all other regions except Site-1. The findings of Walker et al.¹⁴ & Baptista et al.,¹⁵ showed that the number of macrofungal species were very well correlated with the temperature, humidity, and organic matter content which reflected its consistency with present results.

Data on fungal distribution and biodiversity are fragmentary, certain patterns are robust and are worthy of future consideration. Temperature and moisture are prerequisite factors for hunting mushrooms hence rainy season where temperature and moisture in the environment supports the growth of macrofungi was considered for the survey. Hurdles from seasonal variation such as rainfall variably affects fungal diversity, even their extreme diversity renders their inventorization difficult.¹⁶ Macrotermitinae termite showed obligate symbiosis with the genus *Termitomyces*, however the beneficial relation and mode of association between both of them are not clearly known. Several studies explained that *Termitomyces* can play a significant role in the degradation of cellulose to smaller units that can be used by the fungus growing termites.¹⁷⁻²¹ The distributions of these mushrooms are extensively found in Indian context at different forest regions.²²⁻²⁵

The published data on *Russulaceae* from the ecological aspect are sparse and insufficient.²³ All the species of these fungi are thought to be obligatory symbionts which in turn form ectomycorrhizal relation with many plants of Gymnosperms and Angiosperms family. This association is also reported to provide a barrier against the pathogenic attack.²⁶⁻²⁸ *Russula lepida* was the highest distributed mushroom in all the regions of Odisha forests especially in the (Site-1,5,6) (76.92 %) followed by (Site-2,4) (Figure 5) (Figure 6). *R. rosea* was the second

highest occurred mushroom (71.79%) in the varied forest divisions. (Site-1,5) showed the highest number of this macrofungi. *R. brevipes* was luxuriantly distributed among the (Site-5,6) forests where as it was moderately distributed in the (Site-1,2). The frequency of the occurrence of *R. xerampelina* and *R. nigricans* was nearly equal, where former as well as later was highly abundant in (Site-5) (28.22% and 28.20% respectively). *R. vesca* and *R. aurata* was the least occurred mushroom among all other *Russula* species studied, which was only found in the (Site-1). The frequency of distribution of *R. virescens* was 7.69 % which occurred in (Site-1,6). The presence of large spherical cells, 'sphaerocysts' in stipe is an important characteristic feature

distinguishing the members of *Russulaceae* from other mushrooms.²⁹ All the *Russula* species were found through the early rainy season to the late rainy season during cool and humid climatic conditions and were distributed either in the form of dense clusters or as a shelving masses on the dead decaying leaf litter scattered in the grasslands mainly near the *Shorea robusta* trees. This may be a probable host for this organism. This observation matches with the findings of Karwa et al.,⁹ who found that availability of macrofungal species greatly depends upon availability of a particular type of decomposing matter along with its current state.

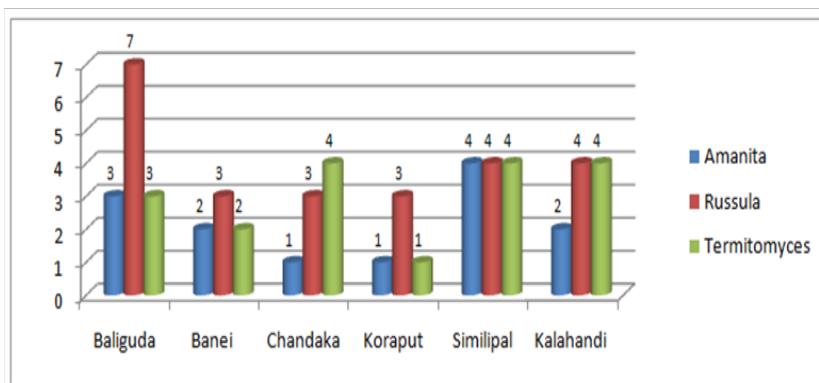


Figure 1 Occurrence of number of mushrooms species in different forest of Odisha

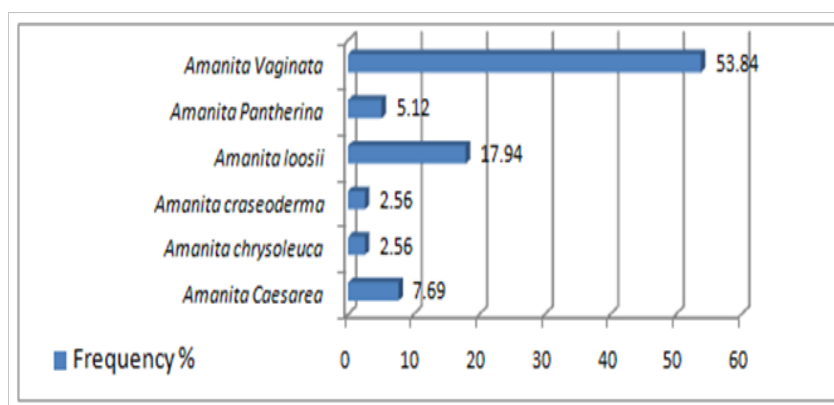


Figure 2 Frequency (%) of occurrence of Amanita in Odisha Forests

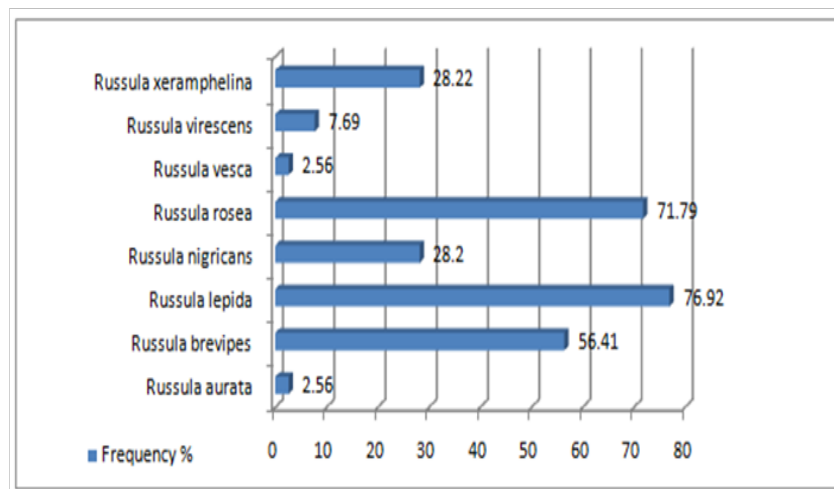


Figure 3 Frequency (%) of occurrence of Russula in Odisha Forests.

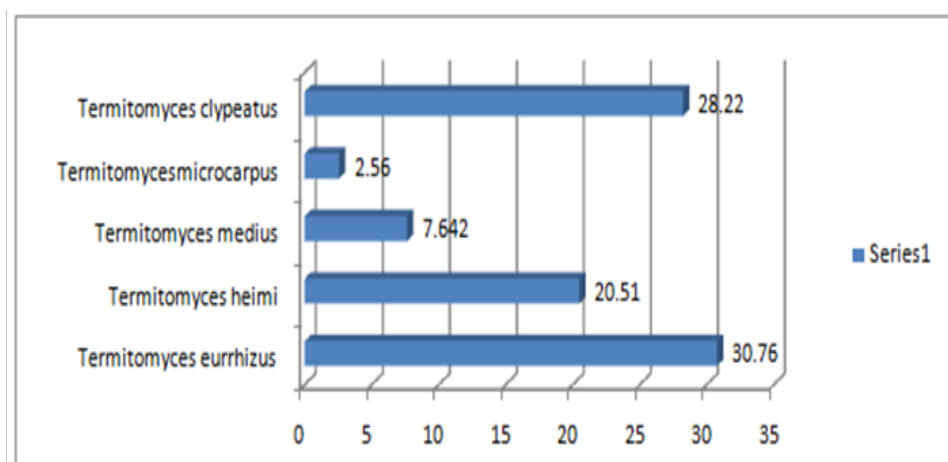


Figure 4 Frequency (%) of occurrence of *Termitomyces* in Odisha Forests.



Figure 5 Map of Odisha representing different sites of the collection of Mushrooms.

Table I Occurrence of wild mushrooms in different forests of Odisha

Species and Forest Area	Baliguda	Banei	Chandaka	Koraput	Similpal	Kalahandi
<i>Amanita Caesarea</i>	-	-	-	-	+	-
<i>Amanita chrysoleuca</i>	+	-	-	-	-	-
<i>Amanita craseoderma</i>	+	-	-	-	-	-
<i>Amanita loosii</i>	-	-	-	-	+	+

Table Continued..

<i>Amanita Pantherina</i>	-	+	-	-	+	-
<i>Amanita Vaginata</i>	+	+	+	+	+	+
Species and Forest Area	Baliguda	Banei	Chandaka	Koraput	Similipal	Kalahandi
<i>Russula aurata</i>	+	-	-	-	-	-
<i>Russula brevipes</i>	+	+	-	+	+	+
<i>Russula lepida</i>	+	+	+	+	+	+
<i>Russula nigricans</i>	-	-	+	-	+	-
<i>Russula rosea</i>	+	+	+	+	+	+
<i>Russula vesca</i>	+	-	-	-	-	-
<i>Russula virescens</i>	+	-	-	-	-	+
<i>Russula xerampelina</i>	+	-	-	-	+	-
<i>Termitomyces eurrhizus</i>	+	+	+	-	+	+
<i>Termitomyces heimi</i>	+	+	-	-	+	+
<i>Termitomyces medius</i>	-	-	+	+	+	+
<i>Termitomyces microcarpus</i>	-	-	+	-	+	-
<i>Termitomyces clypeatus</i>	+	-	+	-	-	+



Figure 6 Representing the field photograph of Mushrooms.

Table 2 Occurrence frequency of wild mushrooms in different forests of Odisha

Baliguda	Banei	Koraput	Similipal	Kalahandi	
No. of sites collected	9	6	9	10	6
<i>Amanita Caesarea</i>	0	0	0	33.33	0
<i>Amanita chrysoleuca</i>	11.11	0	0	0	0
<i>Amanita craseoderma</i>	11.11	0	0	0	0
<i>Amanita loosii</i>	0	0	0	66.66	16.66
<i>Amanita Pantherina</i>	0	16.66	0	11.11	0
<i>Amanita Vaginata</i>	88.88	33.33	22.22	77.77	33.33
<i>Russula aurata</i>	11.11	0	0	0	0
<i>Russula brevipes</i>	33.33	33.33	11.11	100	100
<i>Russula lepida</i>	100	33.33	33.33	100	100
<i>Russula nigricans</i>	0	0	22.22	90	0
<i>Russula rosea</i>	100	50	22.22	100	66.66
<i>Russula vesca</i>	11.11	0	0	0	0
<i>Russula virescens</i>	22.11	0	0	0	16.66
<i>Russula xerampelina</i>	33.11	0	0	80	0
<i>Termitomyces eurrhizus</i>	22.22	50	0	50	50
<i>Termitomyces heimi</i>	22.22	33.33	0	20	33.33
<i>Termitomyces medius</i>	0	0	11.11	10	16.66
<i>Termitomyces microcarpus</i>	0	0	0	10	0
<i>Termitomyces clypeatus</i>	22.22	0	11.11	70	16.66

Conclusion

Thus, by summarizing previous scientific findings and present knowledge it may be concluded that mushrooms are an integral part of the forest ecosystem as they make micronutrients available as food for their partner. This survey study identified the presence of some uncommon but edible mushrooms species in the study areas. Diversified results were observed throughout the survey studies which lead to the conclusion that changes in vegetation structure and tree species composition play an important for the species diversity, especially in the case of *Russula* which was scattered in the leaf litter embedded over the grassland. Change in the diversity of a *Russula* species of mushroom was not much related with altitude which may be the determining reason for macromycetes diversity and other macrofungi. The distribution of *Amanita* species may be an organism of interest whose population greatly varied with the change in altitude. The changing an ecosystem either by deforestations or by environmental driven policies adversely affects germination of delicate fungi. The changes in forest composition due to geographical succession, disturbance thus, directly interfere with the fructification of sporocarps, hence abundance and diversity of plant interactive mushrooms especially ectomycorrhizal fungi which mainly rely on carbohydrates from their tree hosts will be adversely effected. This type of study correlates with the climatic change and floral diversity, thus, growth of macrofungi may be considered as a parameter for monitoring the ecological succession and other adverse urbanization effect such as environmental pollution.

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Conflict of interest

The author declares no conflict of interest.

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