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RESEARCH ARTICLE

Ecology and Ethnomycological Study of Some Wild Mushrooms in Tropical Riverine Forest, Lumbini Province, West Nepal

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Highlights

- Tropical riverine forest of Rupandehi district is rich in wild mushroom flora
- There were twenty-three species, with *Russula* having the most widespread distribution
- Ecologically, 12 species were mycorrhizal, 10 were saprophytic, and 1 was parasitic.
- Ten species were found to be edible while three were poisonous.
- The locals used *X. subtomentosus, P. cinnabarinus*, & *A. arvensis* for medical purpose.

Abstract

Mushrooms are an integral part of the forest ecosystem. The forest's tree species diversity and humid environment during the monsoon period favor the ideal growth of a diverse group of mushrooms. A study was conducted in a tropical riverine forest named Sukhaura Hariyali Community Forest at Makrahar, Rupandehi, Lumbini province, to investigate the diversity of ethnomycological use of wild mushrooms. An opportunistic sampling method was used for the collection of wild mushroom samples. Thirty-three specimens of wild mushrooms were collected, and twenty-three species from sixteen genera belonging to twelve families were identified. The ethnomycological significance of collected species was also explored from the study sites. Among the surveyed species, Russula (five species) was the most widely distributed in the studied area. The ecological preference of the species revealed that a maximum of twelve species were mycorrhizal, ten species were found saprophytic, and a single species (Fomes fomentarius) was found parasitic. Ten species were found to be edible, while poisonous and inedible mushrooms comprise three and seven species respectively. Agaricus arvensis, Pycnoporus cinnabarinus, and Xerocomus subtomentosus, were found to be used by locals for therapeutic purposes. The study provides the baseline data for macrofungal diversity, ecology, wild mushroom exploration, and their use.

Keywords: *Indigenous knowledge, Macrofungal diversity, Medicinal mushroom, Poisonous mushrooms, Tropical riverine forest*

Introduction

Mushrooms are also known as the fungi that produce spore-bearing fruiting bodies (sporocarps) that are visible to the naked eye. In a forest ecosystem, fungal diversity is a crucial component of biodiversity and is principal decomposers, soil nutrient recyclers, parasites, and symbionts and also help to communicate between the plants through chemical signals [1-4]. Mushrooms produce various pigments, metabolites, and minerals that have biological activities and health benefits, but some also have potential toxicity [5-7].

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Defining the global population of fungi is a difficult task for mycologists worldwide. The most current plausible estimate of fungal numbers, based on several methods, was between 11.7 and 13.2 million species; however, only 150,000 fungal species have been recognized so far [8,9]. The total number of mushrooms forming species has been estimated at between 53,000 and 110,000 [10] from which approximately 14,000 species have been officially described to date [11]. According to Devkota and Aryal [12], there are 1291 mushroom species (Ascomycota 165 species and Basidiomycota 1126 species) in Nepal, with 159 edible mushrooms, 74 medicinal and 100 poisonous species. Among these, 34 mushroom species are endemic to Nepal.

Mushrooms are highly nutritive, used as excellent food sources to alleviate malnutrition in developing countries, and as priced delicacies in developed countries. Wild edible mushrooms have long used as a food source among Nepalese ethnic groups and are considered as a high-valued non-timber forest product (NTFPs) [13]. They are naturally renewable and underutilized resources that serve as a significant source of income for rural communities [14]. The collection and use of wild edible mushrooms vary depending on the community [15]. These are gathered and sold for food and other purposes. Folk taxonomic research on fungi is crucial because its many species are on the verge of extinction [16]. To protect the use and applications of edible mushrooms, traditional mycological knowledge is valuable and passed down from generation to generation [17].

Nepal is dedicated to conserving its biodiversity as per the national need and in the spirit of the Convention on Biological Diversity [18]. For this exploration of biological diversity and its documentation on indigenous value is essential. However, limited research has been conducted on mushroom diversity and traditional knowledge in the southern part of Nepal [19]. Identifying mushrooms is challenging due to limited reference samples and skill, especially in the tropics [20]. This research aims to document the diversity of wild mushroom and its traditional knowledge among local indigenes at Makrahar, Rupandehi district.

Material And Methods

Study area

The field study was conducted at Sukhaura Hariyali Community Forest, Makrahar (27°34’36” N-27°39’36” N, 83°30’00” E-83°33’14” E; Altitude 160-195m above sea level) with 189 hectares of land, Rupandehi district, West Nepal (Fig 1). The study area has a tropical climate with heavy annual rainfall (average 1391mm). The average maximum temperature of this location is 39.6°C and the average minimum temperature is 10.4°C (Source: http://www.mfd.gov.np/city?id=29). Phytogeographically, the area lies typically in a tropical riverine belt composed of the naturally degraded forests of *Shorea robusta* (Sal) with *Dalbergia sissoo* (Sisau), *Acacia catechu* (Khayar), and other associated species.

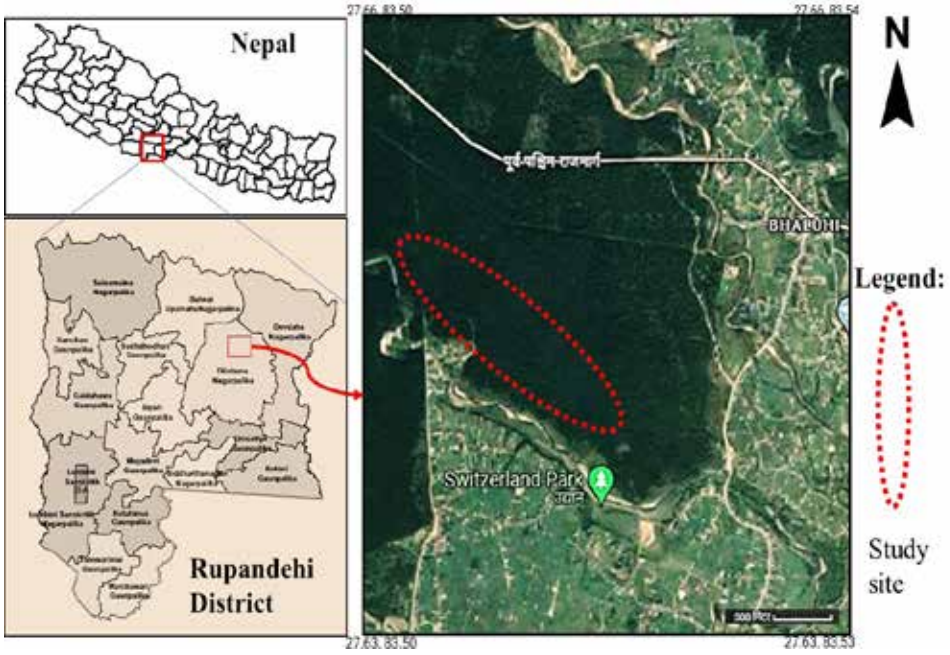

Fig 1. Map showing the study area of tropical riverine forest (Sukhaura Hariyali Community Forest, Lumbini Province, west Nepal).

Collection of samples

The field study was conducted two times (August 2016 and June 2017) in Sukhaura Hariyali community forest, Makrahar, Rupandehi. An opportunistic sampling method was performed, and conspicuous specimens were collected precisely from the study area following Mueller et al. [21]. The samples collection was entirely based on their sexual reproductive structure [22]. Their ecology with latitude, longitude, and altitude were recorded. The mushrooms were photographed (Phot plates 1) in their natural habitats before they were collected. Attempts were made to collect all the developmental stages of the basidiocarps to have an idea of all morphological characters. The collected specimens were cleaned with the help of a brush and placed in separate wax paper bags.

Identification and preservation of the specimens

The collected samples were examined in the laboratory (Central Department of Botany, Tribhuvan University, Kathmandu, Nepal) based on the sporocarp morphology and spore print [23]. The cynophilicity and amyloidity of spores were observed [24, 25]. Then according to their characteristics, they were identified with the help of relevant literature [26, 27], web surfing and concerning expertise. The nomenclature of identified specimens was based on the Index Fungorum database (https://www.indexfungorum.org/). All the voucher specimens were preserved in liquid preservative (25:5:70 ml; rectified alcohol + formalin + distilled water) [28] and deposited in same laboratory.

Exploration of ethnomycological knowledge

Indigenous people use forest resources including mushrooms for their daily life (as food and therapeutic applications). Ethnomycological data were collected using PRA (participatory rural appraisal) technique [29], where, focus group discussion with the local people was also conducted. A semi-structure questionnaire was used in the interview and the questions were specially designed to attain information on ethnomycological knowledge of wild mushrooms (edibility, uses, culinary, identification method). Each interview session was aided with photographs of targeted fleshy mushrooms and dried mushroom samples.

Results and Discussion

Macrofungal diversity

In the survey, 23 species of wild mushrooms (Basidiomycotina, 22 species and Ascomycotina, one species) from five orders belonging to 12 families and 16 genera were recorded with their brief descriptions (Table 1 and Photo plate 1). Agaricales (9 species) was the largest order followed by Russulales (6 species), Boletales (4 species), Polyporales (3 species), and Xylariales (1 species) (Fig 2).

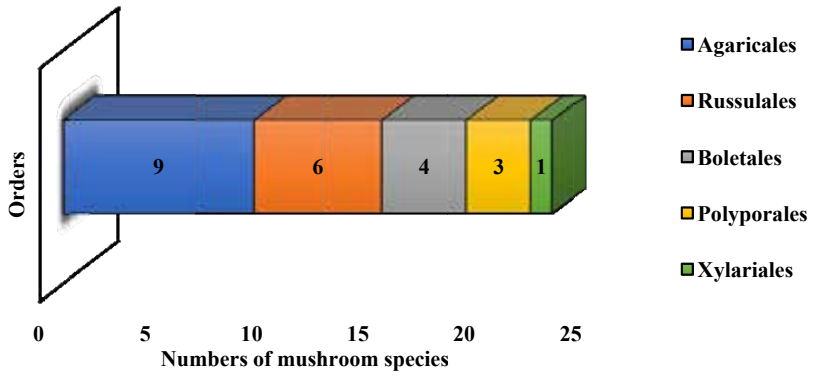

Fig 2. Contribution of macrofungal orders in tropical riverine forest, Rupandehi, west Nepal.

The most represented families were Russulaceae (6 species), Sclerodermataceae (3 species), Agaricaceae, Amanitaceae, Clavariaceae, and Polyporaceae (2 species). Other macrofungal families (Fig 3) such as Boletaceae, Marasmiaceae, Psathyrellaceae, Pleurotaceae, Meruliaceae, and Xylariaceae (1 species each) were represented by single species only. Regarding the generic level of wild mushrooms, *Russula* was the dominating genus with five species which was followed by *Scleroderma* and *Amanita* with three species and two species of wild mushroom respectively. Other genera such as *Agaricus, Lactifluus, Xerocomus,*

Clavulinopsis, Parasola, Fomes, Chlorophyllum, Marasmius, Pleurotus, Pycnoporus, Ramaria, Sparassis, and *Xylaria* were represented by single species only (Fig 4). Many of the wild mushroom species reported in this paper have been identified in the Rupandehi district by Aryal and Budhathoki [19, 30] whereas some of the species were reported from different parts of Nepal [27, 31-34] previously. The majority of mushrooms collected belong to gilled fungi. Species of *Parasola*, *Chlorophyllum*, *Pleurotus*, and *Stereopsis* were found in clusters while other species occurred in scattered patches. In most of the surveyed locales, these mushroom species grow from early spring to late summer, from April to July.

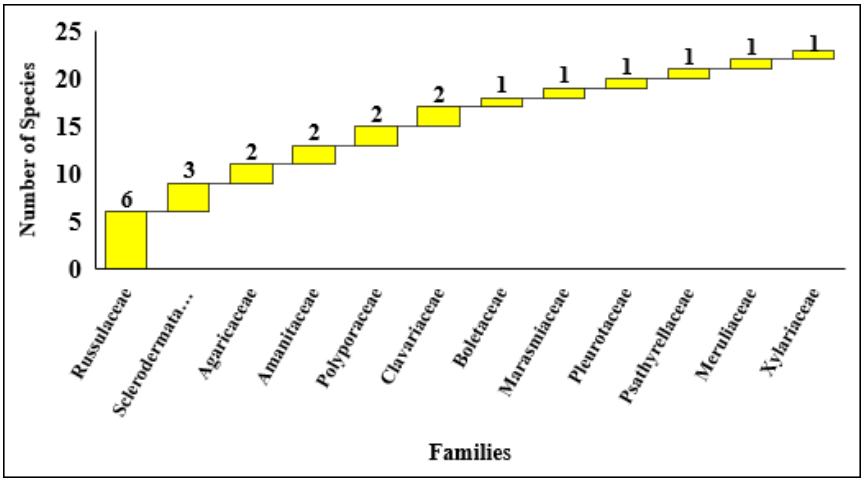

Fig 3. Distribution of macrofungal families in tropical riverine forest, Rupandehi, west Nepal.

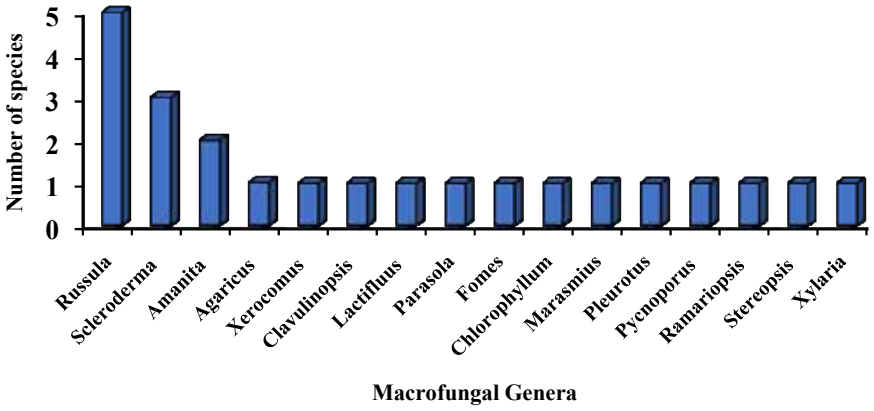

Fig 4. Distribution of macrofungal genus in tropical riverine forest, Rupandehi, west Nepal.

The ecological role i.e., mode of nutrition, of wild mushroom species was mainly dominated by mycorrhizal mushroom (twelve species) and was followed by saprophytic (ten species) and parasitic (one species) (Fig 5). The distribution of wild mushrooms in forests is uneven, possibly due to diurnal weather changes, adaptation to spores and mycelia, and high soil organic matter [35]. However, ectomycorrhizal mushrooms are superior in forests over saprobic and pathogenic mushrooms, as they provide nutrients, water, and photosynthates to host plants, aid in growth, offer resilience to stressors, and protect against pathogenic infections [2-4]. The presence of all trophic groups of wild mushrooms is favored by various forest compositions [33, 36].

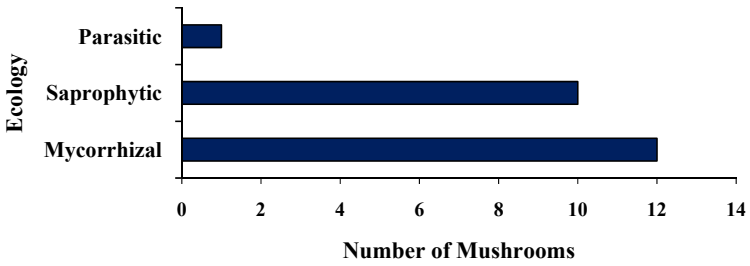

Fig 5. Distribution of macrofungal species according to their ecological role in tropical riverine forest, Rupandehi, west Nepal.

According to Kalntremtziou *et al.* [1], basidiomycetes are important for organic material degradation because they produce lignocellulolytic enzymes. Rapid decomposition rates and the presence of Basidiomycota-related mycorrhizal species in temperate forests may lead to enhanced species diversity [37].

Table 1. Details of wild mushrooms collected in tropical riverine forest of Sukhaura Hariyali Community Forest, Makrahar, Rupandehi district, Nepal.

Mushroom taxa	Order	Family	Use	Ecology	Local name
Phylum: Basidiomycotina					
Agaricus arvensis Schaeff.	Agaricales	Agaricaceae	Medicinal	Saprophytic	Chhate chyau
Amanita fulva (Schaeff.) Secr.	Agaricales	Amaniataceae	Edible	Mycorrhizal	Tahar chyau
Amanita longistriata S. Imai	Agaricales	Amanitaceae	Deadly poisonous	Mycorrhizal	Katle chyau/ Bhoot chyau
Chlorophyllum rhacodes (Vittad.) Vellinga	Agaricales	Agaricaceae	Edible	Saprophytic	-
Clavulinopsis helvola (Pers.) Corner	Agaricales	Clavariaceae	Edible	Saprophytic	Keshari chyau
Fomes fomentarius (L.) Fr.	Polyporales	Polyporaceae	Inedible	Parasitic	-
Lactifluus volemus Fr. (Kuntze)	Russulales	Russulaceae	Edible	Mycorrhizal	-
Marasmius oreades (Bolton) Fr.	Agaricales	Marasmiaceae	Inedible	Saprophytic	-
Parasola plicatilis (Curtis) Redhead et al.	Agaricales	Psathyrellaceae	Poisonous	Saprophytic	-
Pleurotus ostreatus (Jacq. ex Fr.) P.Kumm.	Agaricales	Pleurotaceae	Edible	Saprophytic	Kanye chyau
Pycnoporus cinnabarinus (Jacq.) P.Karst.	Polyporales	Polyporaceae	Medicinal (Ear pain and Mumps	Saprophytic	Rato chyau/ Sindhre chyau
Ramariopsis kunzei (Fr.) Corner	Agaricales	Clavariaceae	Inedible	Saprophytic	-
Russula emetica (Schaeff.) Pers.	Russulales	Russulaceae	Poisonous (used for vomiting)	Mycorrhizal	Ragate chyau
Russula nigricans (Bull.) Fr.	Russulales	Russulaceae	Edible (used as pickles)	Mycorrhizal	-
Russula rosea Pers.	Russulales	Russulaceae	Inedible	Mycorrhizal	-
Russula vesca Fr.	Russulales	Russulaceae	Edible	Mycorrhizal	-
Russula virescens (Schaeff.) Fr.	Russulales	Russulaceae	Edible (after roasting)	Mycorrhizal	-
Scleroderma bovista Fr.	Bolatales	Sclerodermaceae	Inedible	Mycorrhizal	Ande chyau
Scleroderma cepa Pers.	Bolatales	Sclerodermaceae	Edible	Mycorrhizal	-
Scleroderma citrinum Pers.	Bolatales	Sclerodermaceae	Edible (overdose gastric disorder)	Mycorrhizal	Phusphuse chyau
Stereopsis burtiana (Peck) D.A. Reid	Polyporales	Meruliaceae	Inedible	Saprophytic	-
Xerocomus subtomentosus (L.) Quél.	Boletales	Boletaceae	Medicinal	Mycorrhizal	Martep chyau
Phylum: Ascomycotina					
Xylaria hypoxylon (L.) Grev.	Xylariales	Xylariaceae	Inedible	Saprophytic	-

Ethnomycology Knowledge in Makrahar

Most of the collected species was mainly represented by edible mushrooms (ten species) such as *Amanita fulva, Chlorophyllum rhacodes, Clavulinopsis helvola, Lactifluus volemus, Pleurotus ostreatus, Russula nigricans, Russula vesca, Russula virescens, Scleroderma cepa* and *Scleroderma citrinum*. The locals of Makrahar area use these edible species for preparing vegetables and pickles. Meanwhile, the edibility status of *Stereopsis burtiana, Marasmius oreades, Ramariopsis kunzei, Russula rosea, Scleroderma bovista, Xylaria hypoxylon* and *Fomes fomentarius* were inedible. So far, 100 toxic mushrooms have been identified in Nepal [12, 27] and all of these species have been classified as poisonous mushrooms. Species such as *Amanita longistriata, Parasola plicatilis* and *Russula emetica* were found to be poisonous which were also reported as poisonous in previous literature [19, 38]. Similarly, three species of wild mushrooms viz. *Agaricus arvensis, Pycnoporus cinnabarinus* and *Xerocomus subtomentosus* were found to be used for therapeutic purposes by locals of study area (Fig 6). Use of these wild edible mushrooms for various purposes was also explored in previous literatures [19, 34, 38-43] from different part of Nepal. The species of mushroom which were used by locals of Makrahar have many medicinal values (Table 2) such as antioxidant, antibiotic, antiviral, antithrombin, cytotoxic, antitumor, anti-leukemia, anti-inflammatory and so on [44-47].

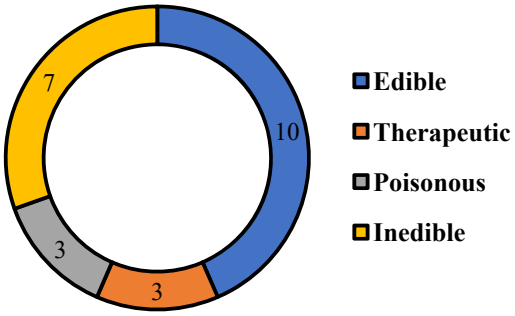

Fig 6. Number of macrofungal species according to their edibility in Sukhaura Hariyali Community Forest, Makrahar, Rupandehi district, west Nepal.

Table 2. Therapeutic use of some medicinal mushroom collected from tropical riverine forest, Rupandehi, west Nepal.

Mushroom Species	Mode of administration *	Therapeutic use **	References
Agaricus arvensis	Used by making paste and soup	Antioxidant, antiviral, immunomodulating, hepatoprotective, nephroprotective, antimicrobial etc.	[45, 46]
Pycnoporus cinnabarinus	Used by making powder and soup	Antioxidant, antibacterial, anti-inflammatory, anti-tumor, free radical scavenging, immune-boosting, insecticidal etc.	[44, 45]
Xerocomus subtomentosus	Dried and used by making soup	Antiviral, Antimicrobial, antioxidant, antifungal, insecticidal etc.	[45, 46]

*Note: Mode of administration is based on field observation and interview. **therapeutic use is based on the previous literatures.

Forest biodiversity supports indigenous tribal people in remote areas, replenishing ecosystems and performing various ecological roles. Documentation of forest biodiversity in social, cultural, and ethnomedicinal practices sensitizes communities and enriches socio-economic life [13]. It also contributes to the upbringing of new industries through local medicines consumption and utilization [48]. The current study on Rupandehi district's wild mushrooms has identified a few species, and further intensive research is needed. The seasonal survey was insufficient to fully examine the diversity profiles, as some species may have fruit bodies lasting for very short period, and for this more frequent field visit might be needed. Therefore, such study should be conducted for longer time more comprehensive information.

Conclusions

This research has aimed to explore wild mushrooms in some previously undiscovered areas in tropical riverine forest. This research identified twenty-three wild mushroom species from six orders, twelve families, and sixteen genera. The largest

order, Agaricales, was discovered first, followed by Russulales, Boletales, and Polyporales. In study site, the majority of wild mushrooms were mycorrhizal. Ten species were found consuming by locals with good edibility value and three species were found to have therapeutic uses. The study provides a foundation for future research on wild mushroom diversity in the area, but a longer and in-depth study is essential to figure out the complete macrofungal wealth of tropical riverine forest.

Acknowledgments

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