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Diversity of Wild Mushrooms in Nagaland, India

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Abstract

The Indian sub-continent is blessed with favorable agro climatic conditions that are suitable to a varied range of fungal species. Though the occurrence of mushrooms is of diverse nature, they are not well studied and documented. Northeastern region of India is one of the biodiversity hotspots. Nagaland is one of the Northeastern states of India. The people of the state highly covet mushrooms and have been a delicacy since time immemorial. The present study documents the macro fungal diversity in various districts of the state. A total of 87 species of wild mushrooms were collected and identified. They are parasitic, saprophytic and ecto-mycorrhizal in habitat. The highest numbers of mushroom species were collected during May–September from the study areas. Of the collected mushrooms, 37 species were identified as edible, 21 species medicinal, 5 poisonous and 37 inedible/unclassified.

Keywords

India, Macro Fungi, Mushroom Diversity, Nagaland, Poisonous, Wild Edible Mushroom

1. Introduction

Mushrooms are seasonal macro fungi and occupy diverse niches in nature in the forest ecosystem. They form macroscopic fruiting bodies such as agarics, boletes, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi. They maybe fleshy, sub-fleshy, leathery or woody and bear their fertile surface either on lamellae or lining the tubes, opening out by means of pores. Agarics are the lamellate members and the tube bearing poroid members are the boletes and polypores (Deshmukh, 2004). About 27,000 fungal species have been reported worldwide (Chang & Miles, 2004) while approximately 850 species of mushrooms are recorded in India (Deshmukh, 2004). Studies on macro fungi have been an area of importance for the scientists in particular and the people in general, because of their role in human welfare, in food industry,

in medicines, and biodegradation (Ozturk et al., 2003). Macro fungi have the longest history of diversity studies of any mycota, but are understudied over the world. Mycologists continue to unravel the unexplored, hidden and fascinating fungal biodiversity as many macro fungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Swapana et al., 2008). It is well known that mushrooms are rich in proteins, vitamins, minerals, fiber, antioxidants and have cholesterol lowering properties and are known as "host defense potentiators" (Wani et al., 2010). Many workers have carried out studies on nutritional analysis of different species of mushrooms where it is reported different species of mushrooms are rich in protein (~30% - 48%), carbohydrate (125% - 40%), fat (1% - 4%), ash (7% - 17%), fiber (16% - 20%) etc. (Pushpa & Purushothama, 2010; Manikandan, 2011).

Due to unsystematic collection of wild mushrooms in forest areas, deforestation and climate change the macro fungal diversity is depleting very fast. Macro fungi are cosmopolitan in nature and occur seasonally in various habitats all over the world. India is one of the top 10 mega biodiversity nations of the world fortunate to have a varied agro climate, abundance of agro wastes, relatively low cost labor and a rich fungal diversity (Borkar et al., 2015). The North Eastern hills of India being the transitional zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions makes the gate way for many of India's flora and fauna. Northeast India is also very rich in mushroom flora (Verma et al., 1995). Very few works on mushroom diversity has been carried out in North Eastern region of India which warrants undertaking study to collect, document and conserve this resource. In the past very few works has been reported from Nagaland (Tanti et al., 2011; Ao et al., 2016). Present study was undertaken to survey the different parts of Nagaland in different seasons for collection of wild mushrooms, identification and documentation. This paper reports the wild macro fungal diversity of Nagaland, India.

2. Materials and Methods

2.1. Study Areas

Nagaland lies in the north eastern part of India with 16,579 sq km geographical area which is surrounded by Myanmar in the East, Assam in the West, Arunachal Pradesh and a part of Assam in the North and Manipur in the South (**Figure 1**). It lies between 93˚20' to 95˚15'E and 25˚10' to 27˚40'N. The state fall under one agro-climatic zone of Mild Tropical Hill Zone and receives South West Monsoon rain in summer and North East monsoon rain in winter with an average recorded annual rainfall ranges between 2000 - 2500 mm. The temperature during summer ranges from 16˚C - 31˚C and drops as low as 4˚C during winter. Regular collection of mushrooms was done in various parts of Nagaland from October 2013-December 2015. Surveys and collections were carried out in forest areas of Kohima, Mokokchung, Tuensang, Wokha and Zunheboto district. In addition, local markets were also surveyed to gather information on the wild mushroom varieties eaten by the local population.

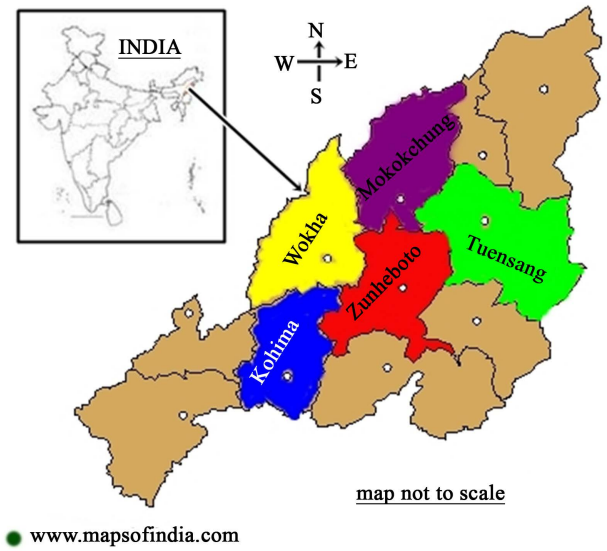

Figure 1. Geographical position of Nagaland.

2.2. Sample Collection

The collected mushroom samples were identified by studying its habitat and various morphological characteristics prior to preservation as described by Roy & De (1996) and with the help of standard manuals (Das & Sharma, 2005; Das, 2009; Philips, 2006). Color codes and terms were used following Crawshay color code (1930). Preservation of the collection specimens were done in 2% and 4% formaldehyde solution (v/v) and deposited as herbarium specimens in the Department of Botany, Nagaland University, Lumami with the accession numbers as mentioned in Table 1.

3. Results

In the present study till this report, a total of 87 species belonging to 50 genera under 38 families were recorded and identified. The detailed information is listed in Table 1 and in Figure 2(a) and Figure 2(b). Of the 87 species, 37 species were identified as edible, 21 species medicinal, 5 poisonous and 37 as inedible/unclassified. The investigation shows that the macro fungi belonging to family basidiomycetes dominate over ascomycetes. The mushrooms were collected between the altitudinal range of 800 m and 2500 m ASL while the collections decreased as the altitudinal range increased. The highest number of species was collected between the altitudinal range of 900 m and 1400 m ASL. The collected species are predominantly found to be parasitic, saprophytic and ecto-mycorrhizal in habitat.

The highest numbers of mushroom species were collected during May-August from the study areas. This period is the active mushroom hunting season of the local people. The local people identify mushrooms based on traditional knowledge which up to some extent is correct but not sufficient as often there are cases of death in the villages due to wrong identification. Present study identifies 37 species of mushrooms out of 87 species to be edible after due consultation of literature, manuals and information collected

Table 1. Wild mushrooms collected from different locations of Nagaland, India.

Accession No.	Name of the species	Class	Family	Habitat	Season of collection	Edibility	Known threat
NUBOT-TA-AA-01	*Auricularia auricula-judae* (Bull.) Quél.	Heterobasidiomycetes	Auriculariaceae	On dead stumps and branches of sub-tropical and temperate trees especially *Alnus*. Grows on both dead and living trees	End May-November	Edible	Threat not known
NUBOT-TA-AP-02	*Auricularia polytricha* (Mont.) Sacc.	Heterobasidiomycetes	Auriculariaceae	In clusters on rotten or dead and decaying stumps and twigs	September-November	Edible	Threat not known
NUBOT-TA-CC-03	*Cantharellus cibarius* (Fr.)	Agaricomycetes	Cantharellaceae	Found under *Lithocarpus* in sub-tropical forests	End June-October	Edible	Threat not known
NUBOT-TA-LP-04	*Lactarius piperatus* (L.) Pers.	Agaricomycetes	Russulaceae	Under sub-tropical semi-evergreen forests	June-October	Edible	Threat not known
NUBOT-TA-LV-05	*Lactarius volemus* (Fr.) Fr.	Agaricomycetes	Russulaceae	Under sub-tropical semi-evergreen forests including pine	June-October	Edible	Threat not known
NUBOT-TA-LE-06	*Lentinula edodes* (Berk.) Pegler	Agaricomycetes	Omphalotaceae	On trunks of Oak trees	June-July	Edible	Threat not known
NUBOT-TA-HC-07	*Hericium cirrhatum* (Pers.) Nikol.	Agaricomycetes	Hericiaceae	On trunks of semi-evergreen and temperate trees	June-July	Edible	vulnerable on Red Data List
NUBOT-TA-DS-08	*Dacryopinax spathularia* (Schwein) G. W. Martin	Dacrymycetes	Dacrymycetaceae	On dead and decaying logs in large groups	June-July	Edible	Threat not known
NUBOT-TA-SC-09	*Schizophyllum commune* Fr.	Basidiomycetes	Schizophyllaceae	On branches of dead wood and cut timber	April-August	Edible	Threat not known
NUBOT-TA-RS-10	*Rusulla senecis* S. Imai	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	June-October	Inedible	Threat not known
NUBOT-TA-RN-11	*Russsula natarajanii* K. Das, J. R. Sharma & Atri	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	June-July	Inedible	Threat not known

Continued

NUBOT-TA-SS-12	*Strobilomyces strobilaceus.* (Scop.) Berk	Agaricomycetes	Boletaceae	Grows in association with semi-evergreen and coniferous trees	June-September	Edible	Threat not known
NUBOT-TA-PC-13	*Pcynoporus cinnabarinus* (Jacq.) P. Karst.	Basidiomycetes	Polyporaceae	Grows on fallen, dead and decaying stumps of trees like *Alnus*	Round the year	Inedible	Threat not known
NUBOT-TA-MX-14	*Microporus xanthopus* (Fr.) Kuntze	Basidiomycetes	Polyporaceae	Grows on fallen branches and twigs	Round the year	Inedible	Threat not known
NUBOT-TA-HR-15	*Hymenochaete rubiginosa* (Dicks.) Lev.	Agaricomycetes	Hymenochaetaceae	On old rotting tree stumps	Round the year	Inedible	Threat not known
NUBOT-TA-TG-16	*Trametes gibbosa* (Pers.) Fr.	Basidiomycetes	Polyporaceae	On dead tree stumps	Round the year	Inedible	Threat not known
NUBOT-TA-TH-17	*Trametes hirsuta* (Wilfen) Pilat	Basidiomycetes	Polyporaceae	On dead tree stumps	Round the year	Inedible	Threat not known
NUBOT-TA-CD-18	*Coprinus disseminatus* (Pers.) J.E.Lange	Agaricomycetes	Psathyrellaceae	In troops around the stumps of dead, decaying wood	June-July	Inedible	Threat not known
NUBOT-TA-AS-19	*Amanita strobiliformis* (Paulet ex Vittad.) Bertill	Agaricomycetes	Amanitaceae	Under sub-tropical semi evergreen forest trees	June-August	Edible	Threat not known
NUBOT-TA-GL-20	*Ganoderma l ucidum* (Curtis) P. Karst.	Agaricomycetes	Ganodermataceae	On trunks and roots of *Quercus* species	Round the year	Inedible	Threat not known
NUBOT-TA-DC-21	*Daldinia concentrica* (Bolton) Cesati & de Notaris	Sordariomycetes	Xylariaceae	On dead wood logs	Round the year	Inedible	Threat not known
NUBOT-TA-BE-22	*Boletus edulis* Bull.	Agaricomycetes	Boletaceae	Under coniferous and semi-evergreen forest types	August-September	Edible	Threat not known
NUBOT-TA-CP-23	*Cortinarius purpurascens* Fr.	Agaricomycetes	Cortinariaceae	Grows in association with semi-evergreen and coniferous woods	Summer	Inedible	Threat not known

Continued

NUBOT-TA-SC-24	*Scleroderma citrinum* Pers.	Agaricomycetes	Sclerodermataceae	On mossy or peaty ground in any forest type	June-September	Inedible	Threat not known
NUBOT-TA-CV-25	*Calocera viscosa* (Pers.) Fr.	Dacrymycetes	Dacrymycetaceae	Grows on dead stumps in temperate evergreen forests	August-September	Inedible	Threat not known
NUBOT-TA-CM-26	*Cordyceps militaris* (L.) Fr.	Sordariomycetes	Clavicipitaceae	Grows singly on ground after parasitizing on the larvae or pupae of butterflies and moths	June-August	Inedible	Threat not known
NUBOT-TA-TI-27	*Tricholoma imbricatum* (Fr.) P. Kumm.	Agaricomycetes	Tricholomataceae	In coniferous woods, especially with pine	July-August	Edible	Threat not known
NUBOT-TA-PP-28	*Pleurotus pulmonarius* (Fr.) Quél.	Agaricomycetes	Pleurotaceae	In clusters on cut timber and fallen logs	June-September	Edible	Threat not known
NUBOT-TA-CM-29	*Crepidotus mollis* (Schaeff.) Staude	Basidiomycetes	Inocybaceae	In groups or overlapping tiers on fallen branches and tree trunks	July-September	Inedible	Threat not known
NUBOT-TA-CL-30	*Crucibulum laeve* (Huds.) Kambly	Basidiomycetes	Nidulariaceae	On twigs, fallen branches and other vegetable remains	June-September	Inedible	Threat not known
NUBOT-TA-AM-31	*Auricularia mesenterica* (Dicks.) Pers.	Heterobasidiom-ycetes	Auriculariaceae	On dead stumps and wood logs.	Round the year	Inedible	Threat not known
NUBOT-TA-LL-32	*Leotia lubrica* (Scop.) Pers.	Leotiomycetes	Leotiaceae	In damp areas in almost all forest types	August-November	Inedible	Threat not known
NUBOT-TA-AV-33	*Amanita vaginata* (Bull.) Lam.	Agaricomycetes	Amanitaceae	Grows singly or numerous in all forest types including coniferous	June-November	Inedible	Threat not known
NUBOT-TA-CF-34	*Clavulinopsis fusiformis* (Sowerby) Corner.	Agaricomycetes	Clavariaceae	Grows in tufts on ground amongst grasses and leaf litters	July-September	Inedible	Threat not known
NUBOT-TA-CF-35	*Clavaria fragilis* Holmsk.	Agaricomycetes	Clavariaceae	Grows in clusters on ground amongst leaf litters and in fields	August-November	Edible	Threat not known

Continued

NUBOT-TA-RC-36	*Russula cyanoxantha* (Schaeff.) Fr.	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	May-August	Inedible	Threat not known
NUBOT-TA-TF-37	*Tremella fuciformis* Berk.	Tremellomycetes	Tremellaceae	On dead or fallen branches of broadleaved trees	September-November	Edible	Threat not known
NUBOT-TA-TV-38	*Trametes versicolor* (L.) Lloyd	Agaricomycetes	Polyporaceae	On dead and decaying tree stumps	Round the year	Inedible	Threat not known
NUBOT-TA-AP-39	*Amanita phalloides* (Vaill. ex Fr.) Link	Agaricomycetes	Amanitaceae	Under sub-tropical semi-evergreen forests	June-August	Poisonous	Threat not known
NUBOT-TA-LS-40	*Lentinus squarrosulus* Mont. Singer	Agaricomycetes	Lentinaceae	On dead stumps of trees like Oak	June-August	Edible	Threat not known
NUBOT-TA-HC-41	*Hygrocybe conica* (Schaeff.) P. Kumm.	Agaricomycetes	Hygrophoraceae	In grass filed after fresh burning of forest	June-July	Edible	Threat not known
NUBOT-TA-RF-42	*Russula fragilis* Fr.	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	June-November	Inedible	Threat not known
NUBOT-TA-RN-43	*Russula nobilis* Velen	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	June-November	Poisonous	Threat not known
NUBOT-TA-RH-44	*Russula heterophylla* (Fr.) Fr.	Agaricomycetes	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests	October-January	Edible	Threat not known
NUBOT-TA-AC-45	*Amanita cokeri* E.-J. Gilbert & Kühner ex E.-J. Gilbert	Agaricomycetes	Amanitaceae	Under sub-tropical semi-evergreen forests	October-January	Poisonous	Threat not known
NUBOT-TA-SL-46	*Suillus luteus* (L.) Roussel	Agaricomycetes	Suillaceae	Under coniferous especially pine	September-November	Edible	Threat not known
NUBOT-TA-HV-47	*Hygrocybe vitellina* (Fr.) P. Karst.	Agaricomycetes	Hygrophoraceae	Amongst damp moss	August-November	Inedible	Threat not known

Continued

NUBOT-TA-XC-48	*Xerocomellus chrysenteron* (Bull.) Šutara	Agaricomycetes	Boletaceae	Under sub-tropical semi-evergreen forests including pine	July-November	Edible	Threat not known
NUBOT-TA-SP-49	*Suillus pictus* (Peck) A.H. Sm. & Thiers	Agaricomycetes	Suillaceae	Under sub-tropical semi-evergreen forests	June-November	Edible	Threat not known
NUBOT-TA-LU-50	*Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	Agaricomycetes	Hygrophoraceae	On fallen twigs in moist woods	June-November	Inedible	Threat not known
NUBOT-TA-LT-51	*Laccaria tortilis* (Bolton) Cooke	Agaricomycetes	Hydnangiaceae	On bare soil in damp woods	August-November	Edible	Threat not known
NUBOT-TA-DS-52	*Dacrymyces stillatus* Nees	Dacrymycetes	Dacrymycetaceae	On damp decaying wood	October-January	Inedible	Threat not known
NUBOT-TA-AA-53	*Aureoboletus auriporus* (Peck) Pouzar	Agaricomycetes	Boletaceae	Under sub-tropical semi-evergreen forests	July-September	Inedible	Threat not known
NUBOT-TA-CA-54	*Crepidotus applanatus* (Pers.) P. Kumm.	Basidiomycetes	Inocybaceae	On fallen branches and twigs in semi-evergreen forests	July-September	Inedible	Threat not known
NUBOT-TA-ME-55	*Mycena erubescens* Höhn.	Agaricomycetes	Mycenaceae	Under semi-evergreen forests including pine	July-September	Inedible	Threat not known
NUBOT-TA-CL-56	*Crepidotus luteolus* Sacc.	Basidiomycetes	Inocybaceae	On fallen branches and twigs in semi-evergreen forests	July-September	Inedible	Threat not known
NUBOT-TA-LC-57	*Lepiota cristata* (Bolton) P. Kumm.	Basidiomycetes	Agaricaceae	In woods and leaf litter	July-September	Inedible	Threat not known
NUBOT-TA-HC-58	*Hypholoma capnoides* (Fr.) P. Kumm.	Agaricomycetes	Strophariaceae	Under sub-tropical semi-evergreen forests	July-September	Inedible	Threat not known
NUBOT-TA-AM-59	*Agaricus moelleri* Wasser	Agaricomycetes	Agaricaceae	Under sub-tropical semi-evergreen forests	June-November	Poisonous	Threat not known

Continued

NUBOT-TA-AF-60	*Amanita fulva* Fr.	Agaricomycetes	Amanitaceae	Under *Castanopsis* and *Lithocarpus* in sub-tropical forests	June-September	Inedible	Threat not known
NUBOT-TA-MG-61	*Melanoleuca grammopodia* (Bull.) Murrill	Agaricomycetes	Tricholomataceae	Grows on leaf mulch or composted soil in fields	June-October	Edible	Threat not known
NUBOT-TA-AA-62	*Aleuria aurantia* (Pers.) Fuckel	Pezizomycetes	Pyronemataceae	Grows in groups on soil amongst grasses or on bare soil or at roadside	August-November	Edible after thorough cooking	Threat not known
NUBOT-TA-MA-63	*Macrolepiota albuminosa* (Berk.) Pegler	Basidiomycetes	Agaricaceae	Grows on termite mounds in grassy fields	May-August	Edible	Threat not known
NUBOT-TA-TH-64	*Termitomyces heimii* Natarajan	Basidiomycetes	Lyophyllaceae	Grows on termite mounds and clayey soil	May-August	Edible	Threat not known
NUBOT-TA-PO-65	*Pleurotus ostreatus* (Jacq) P. Kumm	Agaricomycetes	Pleurotaceae	Grows in clusters on dead or leaving trees	April-September	Edible	Threat not known
NUBOT-TA-AR-66	*Amanita rubrovolvota* S. Imai	Agaricomycetes	Amanitaceae	Grows in association with *Castanopsis*, *Lithocarpus and Rhododendron*	June-October	Inedible	Threat not known
NUBOT-TA-RS-67	*Ramaria stricta* (Pers.) Quél	Agaricomycetes	Gomphaceae	Grows on ground in association with dead tree stumps	August-December	Inedible, Vulnerable on Red Data List	Vulnerable on Red Data List
NUBOT-TA-R-68	*Russula sp.*	Agaricomycetes	Russulaceae	Found to grow only under pine	October-November	Unknown	Threat not known
NUBOT-TA-L-69	*Lentinus sp.*	Agaricomycetes	Lentinaceae	Grows on dead bark of trees	End May-July	Edible	Threat not known
NUBOT-TA-B-70	*Boletus sp.*	Agaricomycetes	Boletaceae	Under *Castanopsis* and *Lithocarpus* in sub-tropical forests	June-October	Unknown	Threat not known
NUBOT-TA-TE-71	*Termitomyces eurhizus* (Berk.) R. Heim	Basidiomycetes	Lyophyllaceae	Grows in groups on ground in mounted soil	July-August	Edible	Threat not known
NUBOT-TA-LP-72	*Lycoperdon perlatum* Pers.	Agaricomycetes	Agaricaceae	Grows in fields, roadsides, in woods and amongst fallen leaf litter	End April-September	Edible when young and white in color	Threat not known

Continued

NUBOT-TA-LS-73	*Laetiporus sulphureus* (Bull.) Murr.	Basidiomycetes	Polyporaceae	Grows on dead stumps as well as living tree trunk of hardwoods and oaks	July-September	Edible	Threat not known
NUBOT-TA-CM-74	*Coprinus comatus* (O.F. Müll.) Pers.	Agaricomycetes	Agaricaceae	Grows singly or in clusters or lines on lawns, wood pieces or on ground	May-September	Edible	Threat not known
NUBOT-TA-PC-75	*Pleurotus citrinopileatus* Singer	Agaricomycetes	Pleurotaceae	In clusters on cut timber and fallen logs	June-September	Edible	Threat not known
NUBOT-TA-TM-76	*Termitomyces microcarpus* (Berk. & Broome) R. Heim	Basidiomycetes	Lyophyllaceae	Grows in groups on termite mounts	July-August	Edible	Threat not known
NUBOT-TA-T-77	*Termitomyces* sp.	Basidiomycetes	Lyophyllaceae	Grows in groups on termite mounts	July-August	Edible	Threat not known
NUBOT-TA-HM-78	*Hygrocybe miniata* (Fr.) P. Kumm.	Agaricomycetes	Hygrophoraceae	Grows in fields, woods or grassy fields	June-August	Inedible	Threat not known
NUBOT-TA-GN-79	*Gloioxanthomyces nitidus* (Berk. & M.A. Curtis) Lodge, Vizzini, Ercole & Boertm.	Agaricomycetes	Hygrophoraceae	Grows in clusters in woods and damp soils	October-November	Inedible	Threat not known
NUBOT-TA-GA-80	*Ganoderma applanatum* (Pers.) Pat.	Agaricomycetes	Ganodermataceae	On trunks and roots of trees	Round the year	Inedible	Threat not known
NUBOT-TA-AV-81	*Amanita virosa* (Fr.) Bertill.	Agaricomycetes	Amanitaceae	In mixed forests	End June-August	Poisonous	Threat not known
NUBOT-TA-G-82	*Geastrum sp.*	Agaricomycetes	Geastraceae	In coniferous forests.	September-October	Inedible	Threat not known
NUBOT-TA-LG-83	*Lactifluus glaucescens* (Crossl.) Verbeken	Agaricomycetes	Russulaceae	Under *Quercus* and *Lithocarpus* in sub-tropical forests	June-September	Inedible	Threat not known
NUBOT-TA-PI-84	*Phallus indusiatus* Vent.	Agaricomycetes	Phallaceae	Grows singly on soil in woods	July-October	Unknown	Threat not known
NUBOT-TA-HC-85	*Hygrocybe cantharellus* (Schwein.) Murrill	Agaricomycetes	Hygrophoraceae	Grows in damp soils and moss	August-October	Inedible	Threat not known
NUBOT-TA-HC-86	*Tremella mesenterica* Retz.	Tremellomycetes	Tremellaceae	Grows on dead woods	June-September	Unknown	Threat not known
NUBOT-TA-HC-87	*Lentinus sajor-caju* (Fr.) Fr.	Agaricomycetes	Polyporaceae	Grows on dead stumps of trees like Oak	May-June	Edible	Threat not known

(a)

(b)

Figure 2. **(a)** Wild mushrooms of Nagaland. **1**. *Agaricus moelleri*; **2**. *Aleuria aurantia*; **3**. *Amanita cokeri*; **4.** *A. fulva*; **5**. *A. phalloides*; **6**. *A. rubrovolvata*; **7**. *A. strobiliformis*; **8**. *A. vaginata*; **9**. *A. virosa*; **10**. *Aureoboletus auriporus*; **11**. *A. auricular-judae*; **12**. *A. mesentrica*; **13**. *A. polytricha*; **14.** *Boletus edulis*; **15**. *Boletus* sp.; **16**. *Calocera viscose*; **17**. *Cantharellus cibarius*; **18**. *Clavaria fragilis*; **19**. *Clavulinopsis fusiformis*; **20.** *Coprinus comatus*; **21**. *C. disseminates*; **22**. *Cordyceps militaris*; **23**. *Cortinarius purpurascens*; **24**. *Crepidotus applanatus*; **25** *C. luteolus*; **26**. *C. mollis*; **27**. *Crucibulum leave*; **28**. *Dacrymyces stillatus*; **29**. *Dacryopinax spathularia*; **30**. *Daldinia concentric*; **31**. *Ganoderma applanatum*; **32**. *G. lucidum*; **33**. *Geastrum* sp.; **34**. *Gloioxanthomyces nitidus*; **35**. *Hericium cirrhatum*; **36**. *Hygrocybe cantharellus*; **37**. *H. conica*; **38**. *H. miniata*; **39**. *H. vitellina*; **40**. *Hymenochaete rubiginosa*; **41**. *Hypholoma capnoides*; **42**. *Laccaria tortilis*; **43**. *Lactarius piperatus*; **44**. *L. volemus*; **45**. *Lactifluus glaucescens*; (b) Wild mushrooms of Nagaland. **46**. *Laetiporus sulphureus*; **47**. *Lentinula edodes*; **48**. *Lentinus sajor-caju*; **49**. *Lentinus* sp.; **50**. *L. squarrossulus*; **51**. *Leotia lubrica*; **52**. *Lepiota cristata*; **53**. *Lichenomphalia umbellifera*; **54**. *Lycoperdon perlatum*; **55**. *Macrolepiota albuminosa*; **56**. *Melanoleuca grammopodia*; **57**. *Microporus xanthopus*; **58**. *Mycena erubescens*; **59**. *Pcynoporus cinnabarinus*; **60**. *Phallus indusiatus*; **61**. *Pleurotus citrinopileatus*; **62**. *P. ostreatus*; **63**. *P. pulmonarius*; **64**. *Ramaria stricta*; **65**. *Russsula nobilis*; **66**. *R. cyanoxantha*; **67**. *R. fragilis*; **68**. *R. heterophylla*; **69**. *R. natarajanii*; **70**. *R. senecis*; **71**. R. sp.; **72.** *Sceleroderma citrinum*; **73**. *Schizophyllum commune*; **74**. *Strobilomyces strobilaceus*; **75**. *Suillus luteus*; **76**. *S. pictus*; **77**. *Termitomyces eurhizus*; **78**. *T. heimii*; **79**. *T. microcarpus*; **80**. *T.* sp.; **81**. *Trametes gibbosa*; **82**. *T. hirsute*; **83**. *T. versicolor*; **84**. *Tremella fuciformis*; **85**. *T. mesenterica*; **86**. *Tricholoma imbricatum*; **87**. *Xerocomellus chrysenteron*.

from the local mushroom harvesters of both the districts (Figure 2(a) & Figure 2(b)). Besides edible, 21 species was identified as medicinal. Present study reveals that some mushrooms are edible as well as medicinal. Mushrooms having economic importance are listed in Table 2 and Table 3. Since the different species grows easily on low cost substratum in the wild, wild edible mushrooms can be cheap source of nutritional food and often regarded as "poor man's meat". It is very clear that mushrooms have the potential to provide healthy diet to rural tribal population in the form of cheap source of proteins, dietary fiber, low cholesterol, minerals and antioxidants. During the present study, it was found that the rural population throughout the state collects the mushrooms from the wild and sells in the market without having a scientific base to separate edible mushrooms from poisonous one. Mushrooms are sold in fresh as well as dry form in local markets at comparatively through away prices compared to international market (Table 4). This is mainly because of lack of scientific knowledge of post harvest processing and packaging. This warrants awareness programme among the local community on collection, processing and packaging of wild mushrooms in order to catch good market price.

4. Discussion

Out of 87 wild mushroom species collected, 82 were identified up to species level and 5 were identified only up to the genus level. Russulaceae is the most represented family (10 species) followed by Hygrophoraceae, Amanitaceae, Polyporaceae (7 species each), Boletaceae (5 species), Agaricaceae, Lyophyllaceae (4 species each), Auriculariaceae, Dacrymycetaceae, Inocybaceae (3 species each), Suillaceae, Ganodermataceae, Tricho-

Table 2. Economic value of collected wild mushrooms.

Category of uses	Mushroom species
Edible	*Amanita strobiliformis, Aleuria aurantia, Auricularia auricula-judae, A. polytricha, Boletus edulis, Cantharellus cibarius, Clavaria fragilis, Dacryopinax spathularia, Hericium cirrhatum, Hygrocybe conica, Laccaria tortilis, Lactarius piperatus, L. volemus, Lentinus squarrosulus, L. edodes, L. sp., Macrolepiota albuminosa, Melanoleuca grammopodia, Pleurotus ostreatus, P. pulmonarius, Russula heterophylla, Schizophyllum commune, Strobilomyces strobilaceus, Suillus luteus, S. pictus, Termitomyces heimii, Tremella fuciformis, Tricholoma imbricatum, Xerocomellus chrysenteron, T. eurhizus, Lycoperdon perlatum, Laetiporus sulphureus, Coprinus comatus, Pleurotus citrinopileatus, Termitomyces microcarpus, Termitomyces* sp., *L. sajor-caju*
Medicinal	*Aleuria aurantia, Auricularia auricula-judae, A. polytricha, Cantharellus cibarius, Coprinus disseminatus, Daldinia concentrica, Ganoderma lucidum, Hygrocybe conica, Lactarius piperatus, Lentinus edodes, L. squarrosulus, Pleurotus ostreatus, P. pulmonarius, Pycnoporus cinnabarinus, Microporus xanthopus, Russula cyanoxantha, Schizophyllum commune, Trametes gibbosa, T. versicolor, Lycoperdon perlatum, L. sajor-caju*
Poisonous	*Amanita phalloides, Russula nobilis, Amanita cokeri, Agaricus moelleri. Amanita virosa*
Inedible/Unknown	*Amanita fulva, A. rubrovolvota, A. vaginata, Auricularia mesenterica, Aureoboletus auriporus, Boletus sp., Calocera viscosa, Clavulinopsis fusiformis, Cordyceps militaris, Cortinarius purpurascens, Crepidotus applanatus, C. luteolus, C. mollis, Crucibulum leave, Dacrymyces stillatus, Hygrocybe vitellina, Hypholoma capnoides, Hymenochaete rubiginosa, Leotia lubrica, Lepiota cristata, Lichenomphalia umbellifera, Mycena erubescens, Ramaria stricta, Russula fragilis, R. natarajanii, R. senecis, R. sp., Sceleroderma citrinum, Trametes hirsute, Hygrocybe miniata, Gloioxanthomyces nitidus, Ganoderma applanatum, Geastrum sp. Lactifluus glaucescens, Phallus indusiatus, Hygrocybe cantharellus, Tremella mesenterica.*

Table 3. List of mushrooms used for different medicinal purpose.

Mushroom species	Medicinal uses
Aleuria aurantia	Used in oral allergen immunotherapy
Auricularia auricula-judae	Anti-tumor, anticoagulant, hypocholesterolemic
Auricularia polytricha	Anti-coagulant, cholesterol lowering
Cantharellus cibarius	Anti-microbial
Coprinus disseminatus	Anti-tumor
Daldinia concentrica	To treat skin allergy and to cure wounds
Ganoderma lucidum	Anti-viral, antibacterial, antifungal, anti-cancer etc
Hygrocybe conica	Anti-tumor
Lactarius piperatus	Anti-tumor, anti-bacterial, anti-oxidant
Lentinus edodes	Anti-tumor, anti-HIV, natural antitode
Lentinus squarrosulus	Used as neutraceutical
Pleurotus ostreatus	Anti-bacterial, hypocholesterolemic, anti-cancer, anti-viral
Pleurotus pulmonarius	Anti-HIV, hyperglycemic
Pycnoporus cinnabarinus	To cure wounds
Microporus xanthopu	To stop child from breast feeding
Russula cyanoxantha	Anti-tumor, anti-oxidant
Schizophyllum commune	Anti-cancer (drug Schizophyllan)
Trametes gibbosa	Anti-inflammatory, anti-tumor, anti-viral
Trametes versicolor	Anti-cancer (drug Krestin), anti-viral, anti-bacterial, anti-fungal
Lycoperdon perlatum	antimicrobial and antifungal (lycoperdic acid)

Sources: Chang & Miles, 2004; Das, 2009; Deshmukh 2004 and present work.

Table 4. Price of some wild edible mushrooms sold in local markets of Nagaland.

Mushroom species	Quantity	Rate (in US $)	Period of availability
Schizophyllum commune (Fr.)	Dried Fresh	3 - 4.5/kg 1 - 1.5/packet	Fresh sold only during the season and dried mushrooms available throughout the year.
Pleurotus species	Dried Fresh	3 - 4.5/kg 1 - 1.5/packet	
Agaricus species	Dried Fresh	3 - 4.5/kg 1.5 - 3/packet	
Termitomyces species	Fresh	1.5/packet	
Russula species	Fresh	1.5/packet	
Auricularia species	Dried Fresh	1.5 - 3/kg 1 - 1.5/packet	
Lactarius species	Fresh	1 - 2/packet	
Lentinus species	Dried Fresh	3 - 4.5/kg 1.5/packet	
Hygrocybe species	Fresh	1 - 1.5/packet	

Source: Mokokchung, Zunheboto market survey (Indian rupee is converted to equivalent USD).

lomataceae, Clavariaceae, Polyporaceae, Pleurotaceae, Tremellaceae, Lentinaceae (2 species each), Omphalotaceae, Hericiaceae, Hymenochaetace, Psathyrellaceae, Cortinariaceae, Sclerodermatacea, Lentinaceae, Hydnangiaceae, Mycenaceae, Strophariaceae, Gomphaceae, Geastraceae, Phallaceae, Pyronemataceae, Leotiaceae, Xylariaceae, Clavicipitaceae, Schizophyllaceae, Nidulariaceae, Cantharellaceae (1 species each). The highest numbers of mushroom species were collected during May-September from the study areas. *Schizophyllum commune*, *Auricularia auricula-judae, A. polytricha, Lactarius piperatus*, *L. volemus*, *Sceleroderma citrinum*, *Termitomyces heimii, Tremella fuciformis, Tricholoma imbricatum Hygrocybe conica* and *Agaricus moelleri* was found to be the most abundant during the season of occurrence.

Indigenous knowledge is used to identify the wild mushrooms by the tribal people, which often lead to wrong identification. The local people identifies mushroom based on phenological characters. Naming of the species is done in local dialect to keep memory and transfer the knowledge from one generation to the next (Tibuhwa, 2013; Ao et al., 2016). Present study identifies 37 species of mushrooms out of 87species to be edible after due consultation of literature, manuals and information collected from the local mushroom harvesters. Mushrooms having economic importance are listed in **Table 2** and **Figure 3**. Mushroom species are the indicators of the forest life support system. The presence or absence of fungal species is a useful biological indicator to assess the damage to the ecosystem. Mushrooms are known to have medicinal and neutriceutical properties and as such have gained much importance globally. Some mushrooms are regarded as neutralceuticals (Ribeiro et al., 2007; Yaltirak, 2009). Different mushroom species grows easily on low cost substratum in the wild, thus, wild edible mushrooms can be a cheap source of nutritious food for the tribal people and often regarded as "poor man's meat". Mushrooms are sold in fresh as well as dry form in local markets during the season. The study of macro fungi is of significance because of its role in human welfare, medical industry, food industry and biodegradation (Ozturk et al., 2003).

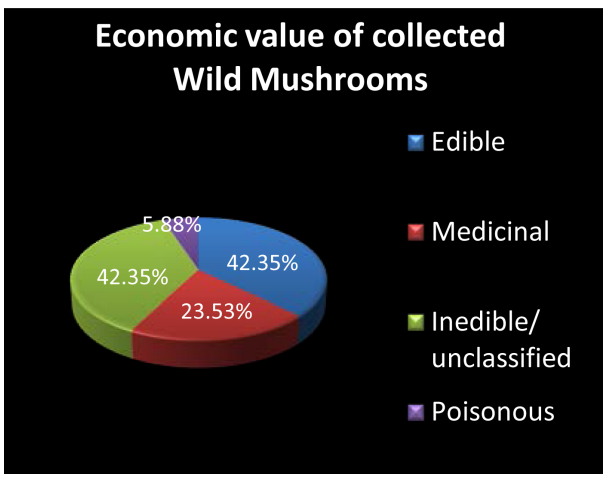

Figure 3. Different uses of wild mushrooms of Nagaland.

5. Conclusion

This is the first ever systematic study on the documentation of wild mushroom diversity of Nagaland. The findings of this study will be a reference database of wild mushroom of the state and will help in future research works.

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