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Wild Mushrooms of Nagaland, India – An Important Bioresource

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Abstract

The need for conservation of fungal diversity has garnered more interest during recent times. Nagaland is a hilly state of north-eastern region in India with varied altitude and agro-climatic conditions. The state is home to a large number of wild fungi including popular edible varieties and has the potential role to improve the rural economy. The present study, concerns with a total number of 141 mushroom species belonging to 80 genera under 44 families of which 52 species are identified to be edible, 10 species as poisonous and the remaining 79 mushrooms are found to be inedible. The rich mushroom wealth of the state is yet untapped so it is high time to study and explore this rich bioresource. This will create avenues for the local people to earn their livelihoods, and also create awareness for conservation and management of this bioresource. The database of wild mushrooms created in this study will help future researchers to make further in-depth study of the potential mushrooms available. Mushrooms are a boon to mankind and should be judiciously exploited for societal benefits across the globe.

Key words – Ascomycetes – basidiomycetes – biodiversity – edible – poisonous

Introduction

Conservation of macro-fungi has garnered additional interest during the last two decades (Chang & Miles 2004). The existence of many fungal species is under threat due to climate change, urbanization, unsystematic exploration and collections, deforestation etc. Fungi are omnipresent, diverse, abundant and ecologically important. Recently, mushroom taxonomic and diversity studies have gained much importance because climate change and habitat destruction has affected the survivability of mushroom species in nature (Bhattacharjee et al. 2015). As estimated ~70,000 species of fungi out of ~1.5 million fungi in existence are identified of which one third is said to be found in India (Wasser 2002, Manoharachary et al. 2005). Though the quantum of this important bioresource is very high, the diversity study is scanty.

The pre-historic collection of edible mushrooms for consumption started by trial and error and continued for a very long time (Atri et al. 1997). Since the early ages, mushrooms have been regarded around the globe as the most delectable and succulent of foods because of its unique taste and flavor (Chang & Miles 1992). Therefore, mushrooms have been valued highly as a nutritious food by humans (Manzi et al. 1999). Besides, mushrooms are considered as ecological indicators and used in reforestation programs (Wongchalee & Pukahute 2012, Andrew et al. 2013). Wild mushrooms are seasonal and one of the important non-wood forest products; provide seasonal food to rural people and also alternative source of income during the mushrooming season (Sysouphanthong et al. 2010). Though the demand for edible and medicinal mushrooms has

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increased over the years but research has not progressed accordingly. It is the need of the hour to explore and identify the wild mushroom resources as they are an integral partner in food security and checking environmental quality. The demand for mushrooms have increased due to awareness of the nutritional and therapeutic value of mushrooms and urges farmers to exploit different wild mushrooms. The nutritional value of wild edible mushrooms is considered higher then fish, meat and most vegetables including its medicinal benefits. Some of the most accepted edible mushrooms globally are *Agaricus bisporus*, *Auricularia* species, *Pleurotus* species, *Lentinula edodes*, *Volvariella volvacea* etc (Bonatti et al. 2004). Currently ~270 mushroom species are known to have therapeutic properties and used as remedies for many diseases, as tonic and aphrodisiac (Wasser & Weis 1999, Boa 2004, Tibuhwa 2013) but the therapeutic potential of mushrooms is yet fully untapped.

Nagaland, a small state of north-eastern region of India has rich mushroom biodiversity but still under studied. Wild edible mushrooms are highly favoured as a source of functional food in Nagaland which forms a vital part of the food culture of all the tribes in the state. The ethnic people collect the wild edible mushrooms species during the mushrooming season which starts from end of April to July for consumption as well as to sell them at the local markets. Since, the mushroom species are identified on the traditional knowledge, wrong identification of the species often leads to poisoning and death of the consuming populace. As mushrooms have become the most important horticultural crop in recent times, it is pertinent to know the mushroom wealth of the state for popularization and commercialization. Conservation of mushrooms can only begin with the knowledge about the food value and environmental challenges. Therefore, keeping in mind the importance of mushrooms, the objectives of the present work was to document the mushroom diversity of Nagaland and its scope.

Materials & Methods

Study Area

Nagaland cover a total geographic area of 16,579 sq km and lies between 93º15′ to 95º15′ E and 25º10′ to 27º4′ N. The calendar year can be divided into 4 seasons: winter (December-February), pre-monsoon (March-April), monsoon (May-September) and retreating monsoon (October-November). The recorded average annual rainfall ranges between 2000-2500 mm. The temperature during summer ranges from 16-34ºC and drops as low as 4ºC during winter. The state forest area is broadly classified into three forest groups based on climatic conditions and altitudes as Tropical, Sub-tropical and Temperate types which are further sub-divided into 9 major types:

1. Tropical forests – Tropical Wet Evergreen Forest, Tropical Semi- Evergreen Forest, Tropical Moist Evergreen Forest (up to1000m).
2. Sub-Tropical Forests – Sub-Tropical Evergreen Broadleaved Forests, Sub-Tropical Mixed Deciduous Broadleaved Forests, Sub- Tropical Alpine Forests (between 1000-1800m).
3. Temperate Forests – Montane Wet Temperate Forests, Temperate Rhododendron Forests, Sub- Alpine Forests (between 1800-3848m).

Sample Collection

Samples were collected from various parts of Nagaland throughout the year. The morphological characters like fruiting body color; size, shape and color of the stipe, pileus and lamellae position; presence of annulus; spore print, type of volva, its habitat, host and location of the mushrooms were recorded after collection and prior to preservation of the mushroom specimens in formaldehyde solution. Phenotypic identification of the collected mushroom samples was done based on morphological characters. Spores were collected through spore prints and observed under microscope to study the spore morphology. The specimens were preserved in 2% (v/v) formaldehyde solution and maintained as herbarium for future references. All the voucher specimens were deposited in the herbarium of Department of Botany, Nagaland University, Lumami, India. For identification of mushrooms, standard manuals and keys were consulted

(Crawshay 1930, Christensen 1943, Pegler 1983, Roy & De 1996, Das & Sharma 2005, Das 2009, Mortimer et al. 2014, Philips 2006). Mycokeys at www.mushroomexpert.com and www.mycokey.com were also consulted for identification. The local markets were surveyed during the season of availability to gather information on the wild mushroom varieties sold (Ao et al. 2016).

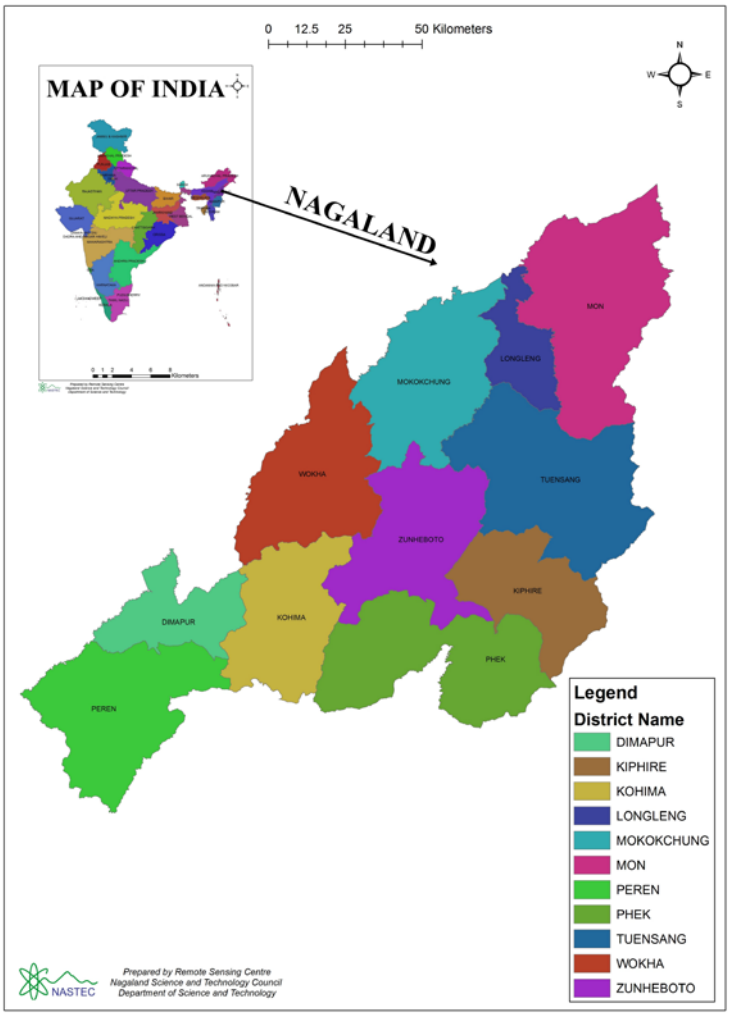

Fig. 1 – The map shows the geographical area of Nagaland.

Results

Nagaland has a forest cover of 75.33% of the state's geographical area according to India State of Forest Report, 2017. Due to various anthropogenic factors, forest cover is declining in the state which has exerted severe threat on the survivability of biodiversity. In the present study, wild mushrooms were collected from different areas of Nagaland covering altitudinal range of 150m ASL to 3000m ASL. It was observed that the mushroom populations decreased as the altitudinal range increased. A total number of 141 mushroom species belonging to 80 genera under 44 families – Russulaceae, Hygrophoraceae, Amanitaceae, Polyporaceae, Boletaceae, Agaricaceae, Lyophyllaceae, Auriculariaceae, Dacrymycetaceae, Inocybaceae, Suillaceae, Ganodermataceae, Tricholomataceae, Clavariaceae, Pleurotaceae, Tremellaceae, Omphalotaceae, Hericiaceae, Hymenochaetaceae, Psathyrellaceae, Cortinariaceae, Sclerodermataceae, Hydnangiaceae, Mycenaceae, Strophariaceae, Gomphaceae, Geastraceae, Phallaceae, Pyronemataceae, Leotiaceae, Xylariaceae, Clavicipitaceae, Schizophyllaceae, Nidulariaceae, Sparassidaceae, Physalacriaceae, Exidiaceae, Bulgariaceae, Entolomataceae, Hymenogastraceae, Clavulinaceae, Helvellaceae, Sarcoscyphaceae and Cantharellaceae have been identified correctly in the present study (Table 1,

Figs 2–5). Out of 141 mushroom species, only 12 species belonged to Ascomycetes class and the remaining mushrooms belonged to Basidiomycetes class. Thus, the field surveys revealed that the mushroom species belonging to Basidiomycetes dominates over Ascomycetes. For identification, morphological observations were carried out as described above and spores were collected through spore prints and observed under microscope. A total of 52 mushroom species were identified as edible, 10 mushrooms were found to be poisonous and the remaining 79 mushrooms were found to be inedible. *Schizophyllum commune*, *Auricularia auricula-judae*, *A. polytricha*, *Lactifluus piperatus*, *Lf. volemus*, *Scleroderma citrinum*, *Termitomyces heimii*, *Tremella fuciformis*, *Tricholoma imbricatum*, *Hygrocybe conica* and *Agaricus moelleri* was found to be the most abundant during the season of occurrence (Ao et al. 2016 & present study). The collected species were predominantly found to be parasitic, saprophytic and ecto-mycorrhizal in habitat.

Discussion

Though mushrooms were found to grow round the year, but healthy growth was observed during May-October. Mushrooms require specific micro-climatic conditions for its growth and during the present investigation; it was observed that the presence and abundance of mushrooms has decreased over time due to anthropogenic factors and climate change. For the formation of mushroom fruit body, climate plays an important factor and change in the morphology, distribution and abundance of fungi is often linked to climatic changes (Diez et al. 2013). Thus, mushrooms can be regarded as indicators of ecosystem damage. Macro-fungi are mostly found in the wet season than the dry season. The dry season is mostly dominated by polypore and bracket fungi like *Trametes gibbosa, T. versicolor, Pycnoporus cinnabarinus* etc; this is due to decreased rainfall and increase in temperature where fleshy macro-fungi are not able to withstand these conditions (Andrew et al. 2013). Ao et al. (2016) reported the market status of few wild edible mushroom species in different markets of Nagaland. It was found that mushrooms are mostly sold in fresh as there is no proper post harvest processing and packaging facility available at present. Besides edible species, a good number of species are reported to be medicinally important e.g., *Auricularia auricula-judae*, *A. polytricha*, *Lentinula edodes*, *Schizophyllum commune*, *Trametes gibbosa*, *T. versicolor*, *Pycnoporus cinnabarinus*, *Microporus xanthopus*, *Coprinus disseminatus*, *Daldinia concentrica*, *Ganoderma lucidum*, *Aleuria aurantia*, *Cantharellus cibarius*, *Hygrocybe conica*, *Lentinus squarrosulus*, *L. sajor-caju*, *Pleurotus pulmonarius*, *Lycoperdon perlatum*, *Flammulina velutipes*, *Cordyceps militaris*, *Tremella mesenterica*, *T. fuciformis* (Chang & Miles 2004, Wani et al. 2010, Ao et al. 2016). Ao & Deb (2019) analyzed the nutritional and antioxidant potential of 10 wild edible mushrooms of Nagaland.

There has been significant progress in mushroom research because of nutritional and medicinal properties. The health benefits of consuming mushrooms and mushroom products have been reported by many workers around the world (Ferreira et al. 2007). Mushrooms are taken as functional food and as a source to develop drugs and nutraceuticals as they possess antioxidant, antitumor and antimicrobial properties (Lakhanpal & Rana 2005). Besides pharmacological properties, mushrooms have become important in human diet due to rich nutritional value, related to high protein and low fat. These wild edible mushrooms are healthy food supplements required to maintain balanced diets as it contains macro as well as micro nutrients and functional minerals. Recently, mushrooms are advocated as a protein supplementary food and also as a low caloric diet food especially for cancer, diabetic and cardiac patients. The State of Food Security and Nutrition in the World (SOFI) has called upon all countries and stakeholders to act together to end hunger and prevent all forms of malnutrition by 2030 as the present scenario is that the number of undernourished people in the world is increasing alarmingly.

In addition to all this, gathering mushrooms from the wild or cultivating and selling gives employment opportunities to the rural people. The spent compost left after mushroom cultivation can also be used as manure. Moreover, thorough explorations of the wild mushrooms are required to study its medicinal properties. The present study revealed that Nagaland is home to a large number of wild mushrooms and proper measures need to be taken for sustainable utilization of this

bioresource. To achieve the goal, there is the need to identify the rich mushroom biodiversity of the state which will help in creating strategies for management and conservation as many factors are affecting the survivability of mushrooms in nature. For the prosperity of society at large, wild edible mushrooms need to be domesticated for sustainable and commercial production.

Table 1 List of wild mushrooms collected and identified during the study

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Agaricus augustus Fr.	Agaricaceae	Found with deciduous or coniferous trees, occasional.	Edible	NUBOT-TA-AA-95
Agaricus moelleri Wasser	Agaricaceae	Under sub-tropical semi-evergreen forests, occasional.	Poisonous	NUBOT-TA-AM-59
Agaricus xanthodermus Genev.	Agaricaceae	Found with deciduous or coniferous trees, meadows or gardens, occasional, vulnerable on Red Data List.	Poisonous	NUBOT-TA-AX-140
Coprinus comatus (O.F. Müll.) Pers.	Agaricaceae	Grows singly or in clusters or lines on lawns, wood pieces or on ground, common.	Edible	NUBOT-TA-CC-74
Lepiota cristata (Bolton) P. Kumm.	Agaricaceae	Found in woods and leaf litter, very common.	Inedible	NUBOT-TA-LC-57
Lepiota felina (Pers.) P. Karst.	Agaricaceae	Found with conifers, uncommon.	Poisonous	NUBOT-TA-LF-103
Leucocoprinus birnbaumii (Corda) Singer	Agaricaceae	Found in tropical areas, uncommon.	Inedible	NUBOT-TA-LB-104
Lepiota lilacea Bres.	Agaricaceae	Found with deciduous and conifers, uncommon.	Poisonous	NUBOT-TA-LL-105
Leucocoprinus brebissonii (Godey) Locq.	Agaricaceae	Found in deciduous woods and flowerpots, occasional.	Inedible	NUBOT-TA-LB-106
Leucocoprinus fragilissimus (Berk. & M. A. Curtis) Pat.	Agaricaceae	Found singly or scattered, in humus or litter, in woods, frequent.	Inedible	NUBOT-TA-LF-107
Lycoperdon perlatum Pers.	Agaricaceae	Grows in fields, roadsides, in woods and amongst fallen leaf litter in mixed wood and conifers, common.	Edible when young and white in color	NUBOT-TA-LP-72
Lycoperdon pyriforme Schaeff.	Agaricaceae	Grows on deadwood of hardwoods or conifers, found scattered or in dense clusters, occasional.	Edible	NUBOT-TA-LP-89
Macrolepiota albuminosa (Berk.) Pegler	Agaricaceae	Grows on termite mounds in grassy fields, common.	Edible	NUBOT-TA-MA-63
Auricularia auricula-judae (Bull.) Quél.	Auriculariaceae	On dead stumps and branches of sub-tropical and temperate trees especially *Alnus*. Grows on both dead and living trees, very common.	Edible	NUBOT-TA-AA-01
Auricularia mesenterica (Dicks.) Pers.	Auriculariaceae	On dead stumps and wood logs, frequent.	Inedible	NUBOT-TA-AM-31

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Auricularia polytricha (Mont.) Sacc.	Auriculariaceae	In clusters on rotten or dead and decaying stumps and twigs, very common.	Edible	NUBOT-TA-AP-02
Lactarius deliciosus (L.) Gray	Russulaceae	Found under sub-tropical semi-evergreen forests including pine, frequent.	Edible	NUBOT-TA-LD-112
Lactarius deterrimus Gröger	Russulaceae	Found under sub-tropical semi-evergreen forests, frequent.	Edible	NUBOT-TA-LD-114
Lactifluus glaucescens (Crossl.) Verbeken	Russulaceae	Under *Quercus* and *Lithocarpus* in sub-tropical forests, frequent.	Inedible	NUBOT-TA-LG-83
Lactifluus piperatus (L.) Pers.	Russulaceae	Under sub-tropical semi-evergreen forests, common.	Edible	NUBOT-TA-LP-04
Lactarius subdulcis (Pers.) Gray	Russulaceae	Found in woods mostly near broad leaved trees, common	Edible	NUBOT-TA-LS-136
Lactifluus volemus (Fr.) Kuntze	Russulaceae	Under sub-tropical semi-evergreen forests including pine, common.	Edible	NUBOT-TA-LV-05
Russula cyanoxantha (Schaeff.) Fr.	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests, frequent.	Inedible	NUBOT-TA-RC-36
Russula fragilis Fr.	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests and conifers, common.	Inedible	NUBOT-TA-RF-42
Russula heterophylla (Fr.) Fr.	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests, occasional.	Edible	NUBOT-TA-RH-44
Russula nobilis Velen	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests, common.	Poisonous	NUBOT-TA-RN-43
Russsula natarajanii K. Das, J.R. Sharma & Atri	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests, occasional.	Inedible	NUBOT-TA-RN-11
Russula ochroleuca Fr.	Russulaceae	Found with conifers, very common	Edible	NUBOT-TA-RO-101
Russula puellaris Fr.	Russulaceae	Found with conifers, frequent.	Edible	NUBOT-TA-RP-102
Russula rosea Pers.	Russulaceae	Found near deciduous trees like beech, frequent.	Inedible	NUBOT-TA-RR-100
Rusulla senecis S. Imai	Russulaceae	Found under *Lithocarpus* and *Castanopsis* in sub-tropical forests, frequent.	Edible but not consumed by the locals	NUBOT-TA-RS-10
Russula sp.	Russulaceae	Found with deciduous and broad-leaved trees, frequent.	Inedible	NUBOT-TA-R-68

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Ganoderma applanatum (Pers.) Pat.	Ganodermataceae	On trunks and roots of trees, occasional.	Inedible	NUBOT-TA-GA-80
*Ganoderma lucidum (*Curtis) P. Karst.	Ganodermataceae	On trunks and roots of *Quercus* species, uncommon.	Inedible	NUBOT-TA-GL-20
Ramaria stricta (Pers.) Quél	Gomphaceae	Grows on ground in association with dead tree stumps, frequent, Vulnerable on Red Data List.	Inedible	NUBOT-TA-RS-67
Cantharellus cibarius (Fr.)	Cantharellaceae	Found under *Lithocarpus* in sub-tropical forests, frequent.	Edible	NUBOT-TA-CC-03
Lentinula edodes (Berk.) Pegler	Omphalotaceae	On trunks of Oak trees, common.	Edible	NUBOT-TA-LE-06
Marasmiellus candidus (Fr.) Singer	Omphalotaceae	Found on fallen branches, amongst leaf litter, uncommon	Inedible	NUBOT-TA-MC-138
Marasmiellus ramealis (Bull.) Singer	Omphalotaceae	Found on old stems, broken twigs, common.	Inedible	NUBOT-TA-MR-137
Calocera viscosa (Pers.) Fr.	Dacrymycetaceae	Grows on dead stumps in temperate evergreen forests, uncommon.	Inedible	NUBOT-TA-CV-25
Dacrymyces chrysospermus Berk. & M.A. Curtis	Dacrymycetaceae	Found under coniferous woods, uncommon.	Inedible	NUBOT-TA-DC-129
Dacrymyces stillatus Nees	Dacrymycetaceae	On damp decaying wood, frequent.	Inedible	NUBOT-TA-DS-52
Hericium cirrhatum (Pers.) Nikol.	Hericiaceae	On trunks of semi-evergreen and temperate trees, uncommon, vulnerable on Red Data List.	Edible	NUBOT-TA-HC-07
Hericium erinaceus (Bull.) Pers.	Hericiaceae	Found on living deciduous trees, occasional, vulnerable on Red Data List.	Edible	NUBOT-TA-HE-132
Schizophyllum commune Fr.	Schizophyllaceae	On branches of dead wood and cut timber, very common.	Edible	NUBOT-TA-SC-09
Geastrum sp.	Geastraceae	In coniferous forests, occasional.	Inedible	NUBOT-TA-G-82
Hymenochaete rubiginosa (Dicks.) Lev.	Hymenochaetaceae	On old rotting tree stumps, uncommon.	Inedible	NUBOT-TA-HR-15
Aureoboletus auriporus (Peck) Pouzar	Boletaceae	Under sub-tropical semi-evergreen forests, frequent.	Inedible	NUBOT-TA-AA-53
Boletus sp.	Boletaceae	Under *Castanopsis* and *Lithocarpus* in sub-tropical forests	Inedible	NUBOT-TA-B-70
Boletus edulis Bull.	Boletaceae	Under coniferous and semi-evergreen forest types, occasional.	Edible	NUBOT-TA-BE-22

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Strobilomyces strobilaceus. (Scop.) Berk	Boletaceae	Grows in association with semi-evergreen and coniferous trees, uncommon.	Edible	NUBOT-TA-SS-12
Xerocomellus chrysenteron (Bull.) Šutara	Boletaceae	Under sub-tropical semi-evergreen forests including pine, frequent.	Edible	NUBOT-TA-XC-48
Cerioporus leptocephalus (Jacq.) Zmitr.	Polyporaceae	Found under dead and decaying tree stumps, common.	Inedible	NUBOT-TA-CL-131
Laetiporus sulphureus (Bull.) Murr.	Polyporaceae	Grows on dead stumps as well as living tree trunk of hardwoods and oaks, uncommon.	Edible	NUBOT-TA-LS-73
Lentinus sajor-caju (Fr.) Fr.	Polyporaceae	Grows on dead stumps of trees like Oak, common.	Edible	NUBOT-TA-LS-87
Lentinus squarrosulus Mont. Singer	Polyporaceae	On dead stumps of trees like Oak, frequent.	Edible	NUBOT-TA-LS-40
Lentinus tigrinus (Bull.) Fr.	Polyporaceae	Grows on dead stumps of trees like Oak, frequent.	Edible	NUBOT-TA-LT-69
Microporus xanthopus (Fr.) Kuntze	Polyporaceae	Grows on fallen branches and twigs, very common.	Inedible	NUBOT-TA-MX-14
Pcynoporus cinnabarinus (Jacq.) P. Karst.	Polyporaceae	Grows on fallen, dead and decaying stumps of trees like *Alnus*, common.	Inedible	NUBOT-TA-PC-13
Trametes gibbosa (Pers.) Fr.	Polyporaceae	On dead tree stumps, common.	Inedible	NUBOT-TA-TG-16
Trametes hirsuta (Wilfen) Pilat	Polyporaceae	On dead tree stumps, common.	Inedible	NUBOT-TA-TH-17
Trametes versicolor (L.) Lloyd	Polyporaceae	On dead and decaying tree stumps, frequent.	Inedible	NUBOT-TA-TV-38
Coprinus disseminatus (Pers.) J.E.Lange	Psathyrellaceae	In troops around the stumps of dead, decaying wood, frequent.	Inedible	NUBOT-TA-CD-18
Coprinellus micaceus (Bull.) Vilgalys, Hopple & Jacq. Johnson	Psathyrellaceae	Found in clusters in decaying woods, common.	Edible	NUBOT-TA-CM-118
Psathyrella piluliformis (Bull.) P.D. Orton	Psathyrellaceae	Found in groups under dead or decaying stumps in sub-tropical forests, common.	Inedible	NUBOT-TA-PP-134
Daldinia concentrica (Bolton) Cesati & de Notaris	Xylariaceae	On dead wood logs, frequent.	Inedible	NUBOT-TA-DC-21
Xylaria hypoxylon (L.) Grev.	Xylariaceae	Found in groups under dead woods, frequent.	Inedible	NUBOT-TA-XH-122
Xylaria polymorpha (Pers.) Grev.	Xylariaceae	Found in groups under dead or decaying woods, frequent.	Inedible	NUBOT-TA-XP-123
Cortinarius purpurascens Fr.	Cortinariaceae	Grows in association with semi-evergreen and coniferous woods, occasional.	Inedible	NUBOT-TA-CP-23

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Scleroderma areolatum Ehrenb.	Sclerodermataceae	Found in moist places on ground under sub-tropical areas, uncommon.	Inedible	NUBOT-TA-SA-108
Scleroderma citrinum Pers.	Sclerodermataceae	On mossy or peaty ground in any forest type, common.	Inedible	NUBOT-TA-SC-24
Arrhenia onisca (Fr.) Redhead, Lutzoni, Moncalvo & Vilgalys	Tricholomataceae	Found scattered in small groups on ground in litter or moss, occasional.	Inedible	NUBOT-TA-AO-115
Lepista nuda (Bull.) Cooke	Tricholomataceae	Found to grow under hardwoods even in gardens, common.	Edible	NUBOT-TA-LN-130
Melanoleuca grammopodia (Bull.) Murrill	Tricholomataceae	Grows on leaf mulch or composted soil in fields, common.	Edible	NUBOT-TA-MG-61
Tricholoma imbricatum (Fr.) P. Kumm.	Tricholomataceae	In coniferous woods, especially with pine, frequent.	Edible	NUBOT-TA-TI-27
Clavaria fragilis Holmsk.	Clavariaceae	Grows in clusters on ground amongst leaf litters and in fields, common.	Edible	NUBOT-TA-CF-35
Clavulinopsis fusiformis (Sowerby) Corner.	Clavariaceae	Grows in tufts on ground amongst grasses and leaf litters, frequent.	Inedible	NUBOT-TA-CF-34
Cordyceps militaris (L.) Fr.	Clavicipitaceae	Grows singly on ground after parasitizing on the larvae or pupae of butterflies and moths, frequent.	Inedible	NUBOT-TA-CM-26
Crucibulum laeve (Huds.) Kambly	Nidulariaceae	On twigs, fallen branches and other vegetable remains, frequent.	Inedible	NUBOT-TA-CL-30
Leotia lubrica (Scop.) Pers.	Leotiaceae	In damp areas in almost all forest types, occasional.	Inedible	NUBOT-TA-LL-32
Tremella fuciformis Berk.	Tremellaceae	On dead or fallen branches of broadleaved trees, common.	Edible	NUBOT-TA-TF-37
Tremella foliacea Pers.	Tremellaceae	Found on dead and decaying logs like *Lithocarpus*, uncommon.	Inedible	NUBOT-TA-TF-116
Tremella mesenterica Retz.	Tremellaceae	Grows on dead woods, common.	Inedible	NUBOT-TA-TM-86
Gloioxanthomyces nitidus (Berk. & M.A. Curtis) Lodge, Vizzini, Ercole & Boertm.	Hygrophoraceae	Grows in clusters in woods and damp soils, common.	Inedible	NUBOT-TA-GN-79
*Hygrocybe cantharellus (*Schwein.) Murrill	Hygrophoraceae	Grows in damp soils and moss, frequent.	Inedible	NUBOT-TA-HC-85
Hygrocybe conica (Schaeff.) P. Kumm.	Hygrophoraceae	In grass fields after fresh burning of forest, frequent.	Edible	NUBOT-TA-HC-41
Hygrocybe miniata (Fr.) P. Kumm.	Hygrophoraceae	Grows in fields, woods or grassy fields, common.	Inedible	NUBOT-TA-HM-78
Hygrocybe vitellina (Fr.) P. Karst.	Hygrophoraceae	Amongst damp moss, frequent.	Inedible	NUBOT-TA-HV-47

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Lichenomphalia umbellifera (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	Hygrophoraceae	On fallen twigs in moist woods, common.	Inedible	NUBOT-TA-LU-50
Amanita cokeri E.-J. Gilbert & Kühner ex E.-J. Gilbert	Amanitaceae	Under sub-tropical semi-evergreen forests, uncommon.	Poisonous	NUBOT-TA-AC-45
Amanita flavoconia G.F. Atk.	Amanitaceae	Found to grow with oaks and other hardwoods including conifers; growing alone or scattered, uncommon.	Poisonous	NUBOT-TA-AF-128
Amanita fulva Fr.	Amanitaceae	Under *Castanopsis* and *Lithocarpus* species in sub-tropical forests, common.	Inedible	NUBOT-TA-AF-60
Amanita phalloides (Vaill. ex Fr.) Link	Amanitaceae	Under sub-tropical semi-evergreen forests, common.	Poisonous	NUBOT-TA-AP-39
Amanita rubrovolvota S. Imai	Amanitaceae	Grows in association with *Castanopsis, Lithocarpus and Rhododendron, Quercus,* etc, occasional.	Inedible	NUBOT-TA-AR-66
Amanita strobiliformis (Paulet ex Vittad.) Bertill	Amanitaceae	Under sub-tropical semi-evergreen forest trees, uncommon.	Edible	NUBOT-TA-AS-19
Amanita vaginata (Bull.) Lam.	Amanitaceae	Grows singly or numerous and found mostly in hardwoods and coniferous, common.	Inedible	NUBOT-TA-AV-33
Amanita virosa (Fr.) Bertill.	Amanitaceae	In mixed forests, occasional.	Poisonous	NUBOT-TA-AV-81
Suillus luteus (L.) Roussel	Suillaceae	Under coniferous especially pine, frequent.	Edible	NUBOT-TA-SL-46
Suillus pictus (Peck) A.H. Sm. & Thiers	Suillaceae	Under sub-tropical semi-evergreen forests, frequent.	Edible	NUBOT-TA-SP-49
Suillus sp.	Suillaceae	Under *Castanopsis* and *Lithocarpus* in sub-tropical forests	Inedible	NUBOT-TA-S-88
Laccaria laccata (Scop.) Cooke	Hydnangiaceae	Found in troops in woods, common.	Edible	NUBOT-TA-LL-109
Laccaria tortilis (Bolton) Cooke	Hydnangiaceae	On bare soil in damp woods, common.	Edible	NUBOT-TA-LT-51
Crepidotus applanatus (Pers.) P. Kumm.	Inocybaceae	On fallen branches and twigs in semi-evergreen forests, occasional.	Inedible	NUBOT-TA-CA-54
Crepidotus luteolus Sacc.	Inocybaceae	Grows on fallen branches and twigs in semi-evergreen forests, occasional.	Inedible	NUBOT-TA-CL-56
Crepidotus mollis (Schaeff.) Staude	Inocybaceae	In groups or overlapping tiers on fallen branches and tree trunks, common.	Inedible	NUBOT-TA-CM-29

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Crepidotus variabilis (Pers.) P. Kumm.	Inocybaceae	Found in groups on fallen tree trunks, twigs and dead stumps, frequent.	Inedible	NUBOT-TA-CV-133
Pholiota aurivella (Batsch) P. Kumm.	Strophariaceae	Found in clusters on living and dead tree stumps of conifers and hardwoods, occasional.	Inedible	NUBOT-TA-PA-113
Psilocybe semilanceata (Fr.) P. Kumm.	Strophariaceae	Found in dense clusters in woods, common, hallucinogenic, common.	Inedible	NUBOT-TA-PS-120
Hypholoma capnoides (Fr.) P. Kumm.	Strophariaceae	Under sub-tropical semi-evergreen forests, common.	Inedible	NUBOT-TA-HC-58
Pholiota highlandensis (Peck) Quadr. & Lunghini	Strophariaceae	Found on ground among debris in forests, occasional.	Inedible	NUBOT-TA-PH-126
Aleuria aurantia (Pers.) Fuckel	Pyronemataceae	Grows in groups on soil amongst grasses or on bare soil or at roadside, common.	Edible	NUBOT-TA-AA-62
Octospora rutilans (Fr.) Dennis & Itzerott	Pyronemataceae	Found in clusters amongst mosses, uncommon.	Inedible	NUBOT-TA-OR-117
Otidea alutacea (Pers.) Massee	Pyronemataceae	Found in clusters on ground in woods, uncommon.	Inedible	NUBOT-TA-OA-91
Clavulina coralloides (L.) J. Schröt.	Clavulinaceae	Found with deciduous or coniferous trees, uncommon.	Inedible	NUBOT-TA-CC-94
Pleurotus citrinopileatus Singer	Pleurotaceae	In clusters on cut timber and fallen logs, frequent.	Edible	NUBOT-TA-PC-75
Pleurotus ostreatus (Jacq) P. Kumm	Pleurotaceae	Grows in clusters on dead or leaving trees, common.	Edible	NUBOT-TA-PO-65
Pleurotus pulmonarius (Fr.) Quél.	Pleurotaceae	In clusters on cut timber and fallen logs, frequent.	Edible	NUBOT-TA-PP-28
Termitomyces eurhizus (Berk.) R. Heim	Lyophyllaceae	Grows in groups on ground near termite mounts, common.	Edible	NUBOT-TA-TE-71
Termitomyces heimii Natarajan	Lyophyllaceae	Grows on termite mounds and clayey soil, common.	Edible	NUBOT-TA-TH-64
Termitomyces microcarpus (Berk. & Broome) R. Heim	Lyophyllaceae	Grows in groups on termite mounts, frequent.	Edible	NUBOT-TA-TM-76
Termitomyces sp.	Lyophyllaceae	Grows in groups on termite mounts, frequent.	Edible	NUBOT-TA-T-77
Phallus impudicus L.	Phallaceae	Found singly or scattered associated with rotting wood in gardens and woods, common.	Inedible	NUBOT-TA-PI-125
Phallus indusiatus Vent.	Phallaceae	Grows singly on soil in woods, common.	Unknown	NUBOT-TA-PI-84
Bulgaria inquinans (Pers.) Fr.	Bulgariaceae	Found in clusters on fallen trunks like *Lithocarpus*, uncommon.	Inedible	NUBOT-TA-BI-121

Table 1 Continued.

Mushroom Species	Family	Habitat and Availability Status	Edibility	Accession No.
Hypholoma fasciculare (Huds.) P.Kumm.	Hymenogastraceae	Found in dense clusters on trunks or stumps with deciduous or coniferous trees, common.	Inedible	NUBOT-TA-HF-96
Helvella crispa (Scop.) Fr.	Helvellaceae	Found in deciduous woods, uncommon.	Poisonous	NUBOT-TA-HC-90
Sparassis crispa (Wulfen) Fr.	Sparassidaceae	Found at the base of tree trunks, uncommon.	Edible	NUBOT-TA-SC-92
Armillaria mellea (Vahl) P. Kumm.	Physalacriaceae	Found in dense clusters on or around tree trunks or stumps with deciduous or coniferous trees, common.	Edible	NUBOT-TA-AM-127
Flammulina velutipes (Curtis) Singer	Physalacriaceae	Found to grow in clusters on decaying trees, survive cold weather, common	Edible	NUBOT-TA-FV-97
Xerula radicata (Relhan) Dörfelt	Physalacriaceae	Found under grasses or leaf debris, common.	Inedible	NUBOT-TA-XR-110
Hemimycena lactea (Pers.) Singer	Mycenaceae	Found in large groups in forest, occasional.	Inedible	NUBOT-TA-HL-99
Mycena erubescens Höhn.	Mycenaceae	Under semi-evergreen forests including pine, occasional.	Inedible	NUBOT-TA-ME-55
Mycena galopus (Pers.) P. Kumm.	Mycenaceae	Found under leaf litter, dead and old tree stumps in woods, common.	Inedible	NUBOT-TA-MG-111
Mycena inclinata (Fr.) Quél.	Mycenaceae	Found in dense tufts or clusters on tree stumps, common.	Inedible	NUBOT-TA-MI-98
Xeromphalina kauffmanii A.H. Sm.	Mycenaceae	Found in clusters on coniferous stumps and logs, frequent.	Inedible	NUBOT-TA-XK-139
Entoloma murrayi (Berk. & M.A.Curtis) Sacc.	Entolomataceae	Found singly or in small groups on ground in litter or humus with conifers and hardwoods, uncommon.	Inedible	NUBOT-TA-EM-119
Pseudohydnum gelatinosum (Scop.) P. Karst.	Exidiaceae	Found under rotting and decaying tree stumps, common.	Edible	NUBOT-TA-PG-124
Cookeina tricholoma (Mont.) Kuntze	Sarcoscyphaceae	Found in clusters on trunks or stumps with deciduous or coniferous trees, uncommon.	Inedible	NUBOT-TA-CT-93
Sarcoscypha sp.	Sarcoscyphaceae	Found on dead tree trunks and old stems, uncommon	Inedible	NUBOT-TA-S-135
Ductifera sucina (Möller) K.Wells	*Incertae sedis*	Found on decayed wood of hardwoods and old stems, uncommon.	Inedible	NUBOT-TA-DS-141

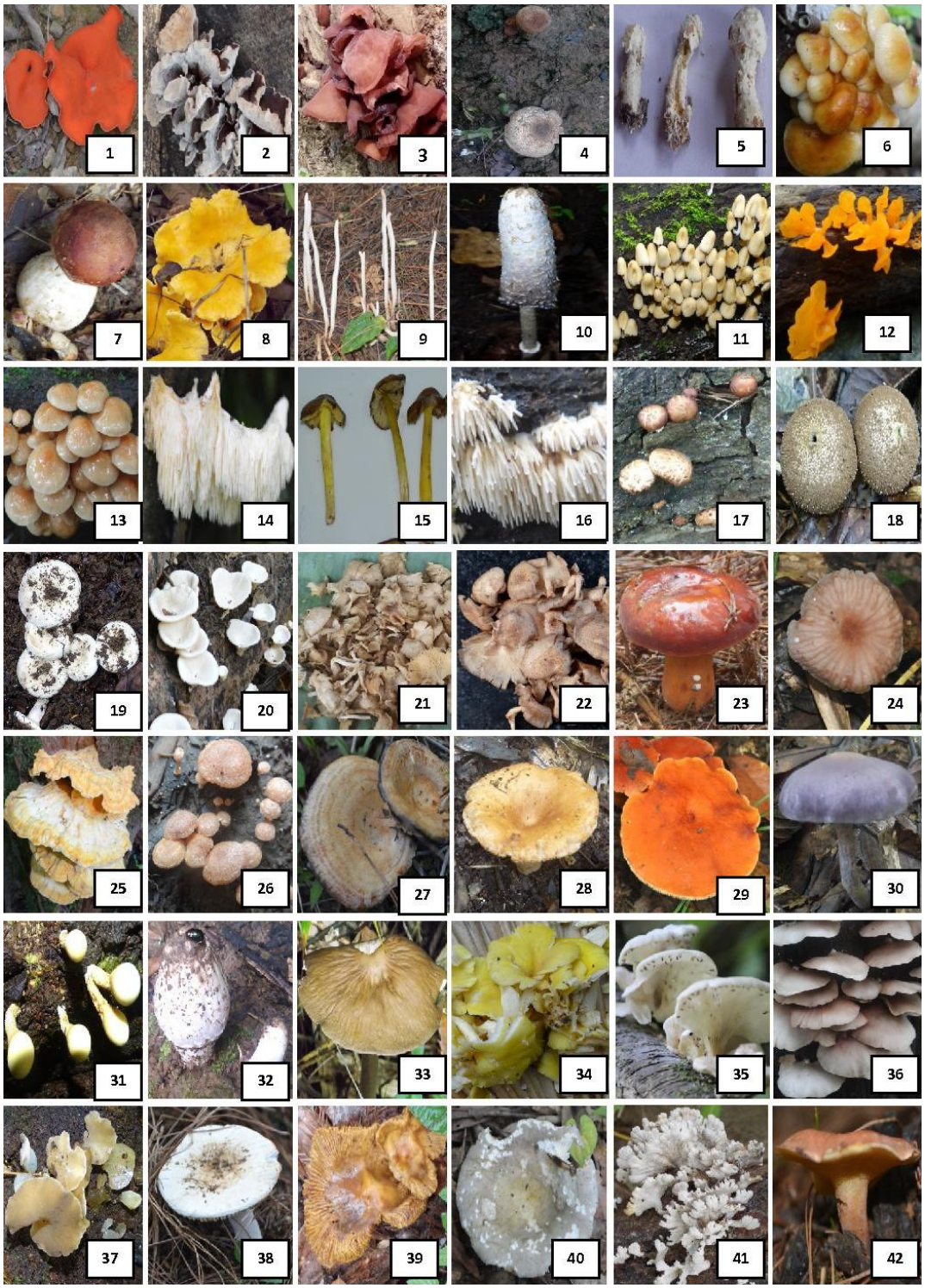

Fig. 2 – Wild edible mushrooms of Nagaland: 1 *Aleuria aurantia*. 2 *Auricularia polytricha*. 3 *Auricularia auricula judae*. 4 *Agaricus augustus*. 5 *Amanita strobiliformis*. 6 *Armillaria mellea*. 7 *Boletus edulis*. 8 *Cantharellus cibarius*. 9 *Clavaria fragilis*. 10 *Coprinus comatus*. 11 *Coprinellus micaceus*. 12 *Dacryopinax spathularia*. 13 *Flammulina velutipes*. 14 *Hericium cirrhatum*. 15 *Hygrocybe conica*. 16 *Hericium erinaceus*. 17 *Lentinula edodes*. 18 *Lycoperdon perlatum*. 19 *Lactifluus piperatus*. 20 *Lentinus sajor caju*. 21 *Lentinus squarrosulus*. 22 *Lentinus tigrinus*. 23 *Lactifluus volemus*. 24 *Laccaria tortilis*. 25 *Laetiporus sulphureus*. 26 *Laccaria laccata*. 27 *Lactarius deliciosus*. 28 *Lactarius deterrimus*. 29 *Lactarius subdulcis*. 30 *Lepista nuda*. 31 *Lycoperdon pyriforme*. 32 *Macrolepiota albuminosa*. 33 *Melanoleuca grammopodia*. 34 *Pleurotus citrinopileatus*. 35 *Pleurotus ostreatus*. 36 *Pleurotus pulmonarius*. 37 *Pseudohydnum*

gelatinosum. 38 *Russula ochroleuca*. 39 *Russula puellaris*. 40 *Russula heterophylla*, 41 *Schizophyllum commune*. 42 *Suillus luteus*.

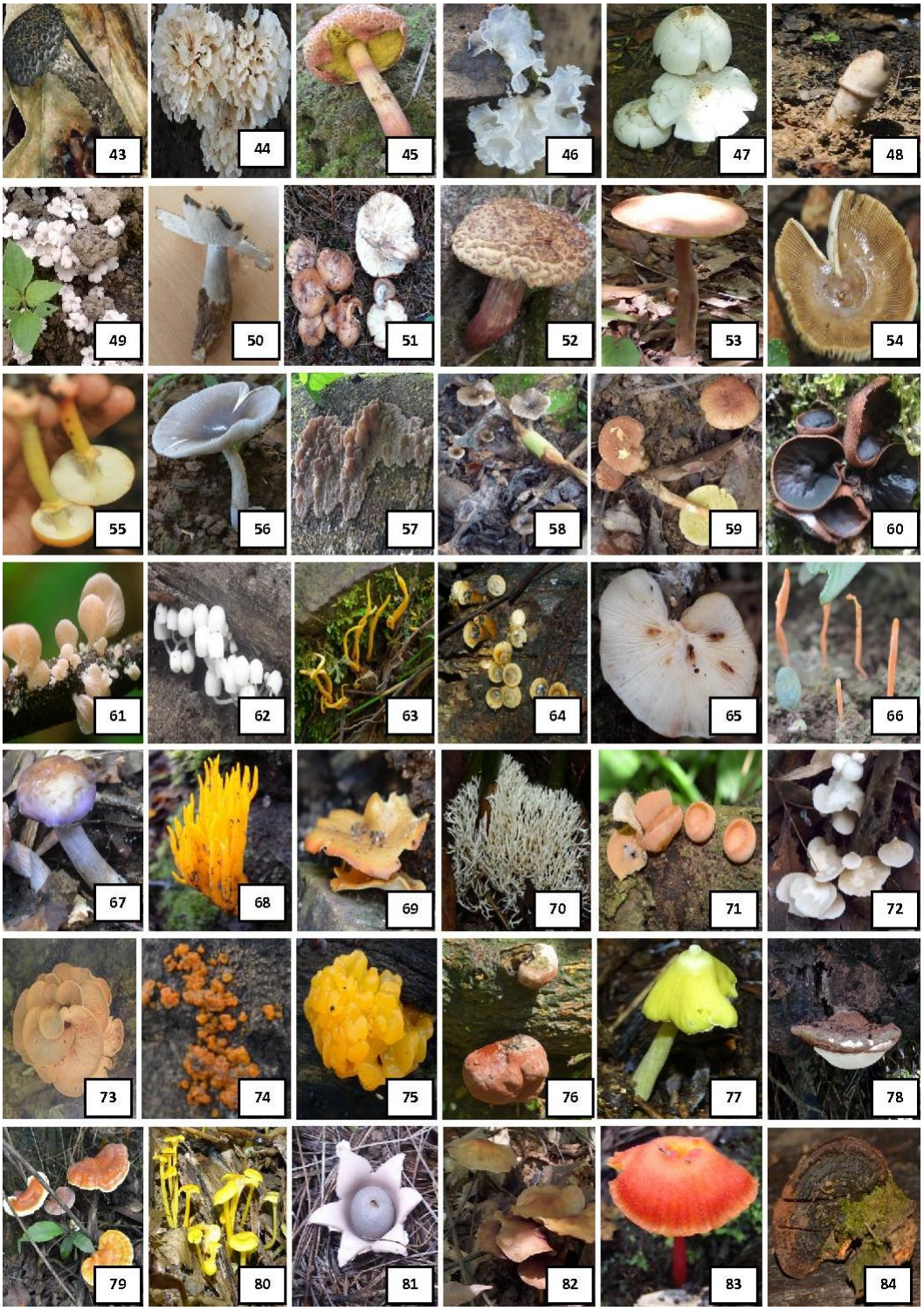

Fig. 3 – Wild mushrooms of Nagaland (Edible – 43-52; Inedible – 53-84): 43 *Strobilomyces strobilaceus.* 44 *Sparassis crispa*. 45 *Suillus pictus*. 46 *Tremella fuciformis*. 47 *Termitomyces heimii*. 48 *Termitomyces eurrhizus*. 49 *Termitomyces microcarpus*. 50 *Termitomyces* sp. 51 *Tricholoma imbricatum*. 52 *Xerocomellus chrysenteron*. 53 *Aureoboletus auriporus*. 54 *Amanita fulva*. 55 *Amanita rubrovolvata*. 56 *Amanita vaginata*. 57 *Auricularia mesenterica*. 58 *Arrhenia onisca*. 59 *Boletus* sp. 60 *Bulgaria inquinans.* 61 *Crepidotus applanatus*. 62 *Coprinus disseminatus*. 63 *Clavulinopsis fusiformis*. 64 *Crucibulum leave*. 65 *Crepidotus luteolus*. 66 *Cordyceps militaris*. 67 *Cortinarius purpurascens*. 68 *Calocera viscosa*. 69 *Cerioporus*

leptocephalus. 70 *Clavulina coralloides*. 71 *Cookeina tricholoma*. 72 *Crepidotus mollis*. 73 *Crepidotus variabilis*. 74 *Dacrymyces stillatus*. 75 *Dacrymyces chrysospermus*. 76 *Daldinia concentrica*. 77 *Entoloma murrayi*. 78 *Ganoderma applanatum*. 79 *Ganoderma lucidum*. 80 *Gloioxanthomyces nitidus*. 81 *Geastrum sp*. 82 *Hypholoma capnoides*. 83 *Hygrocybe miniata*. 84 *Hymenochaete rubiginosa*.

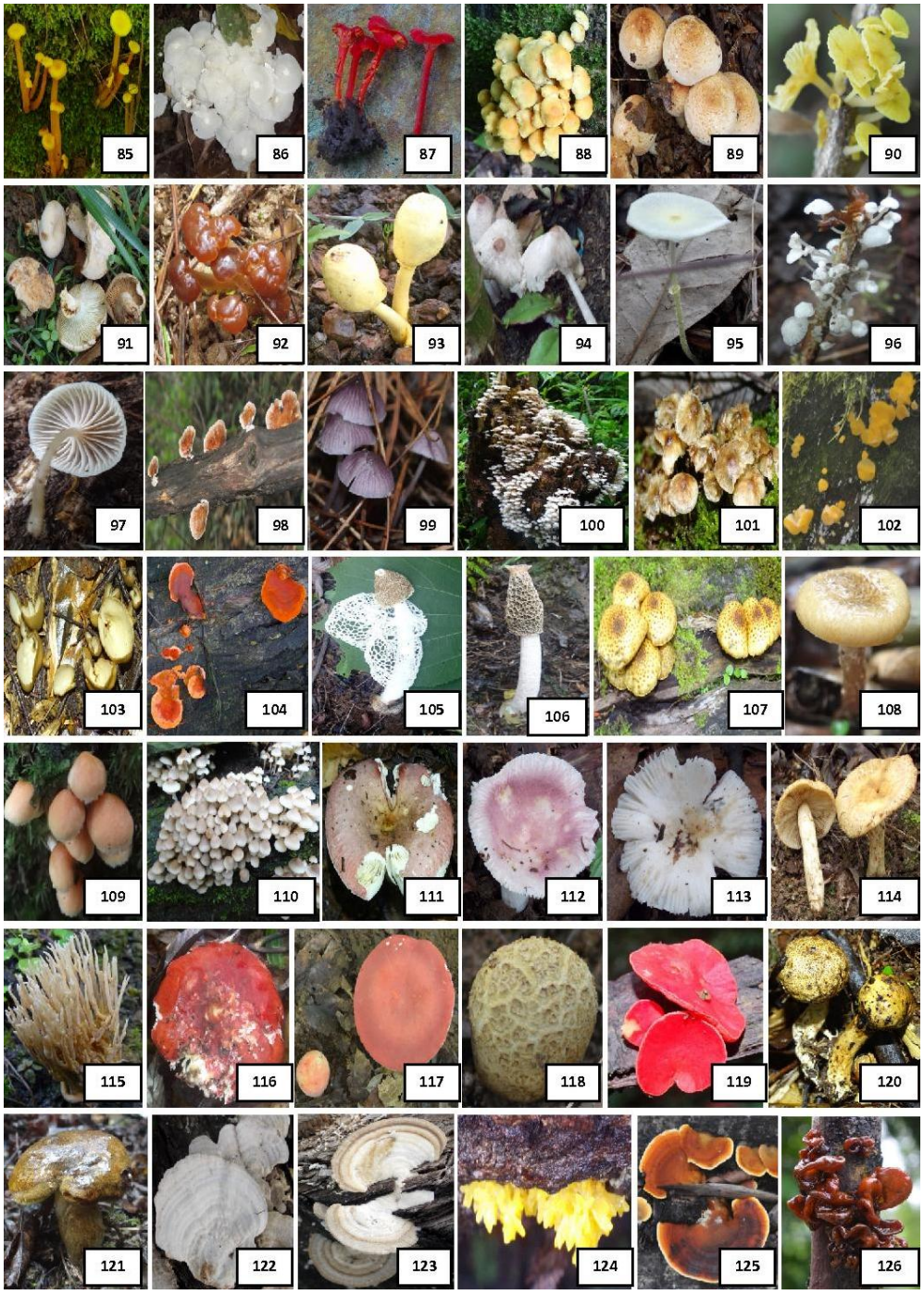

Fig. 4 – Wild mushrooms of Nagaland (Inedible): 85 *Hygrocybe vitellina*. 86 *Hemimycena lactea*. 87 *Hygrocybe cantharellus*. 88 *Hypholoma fasciculare*. 89 *Lepiota cristata*. 90 *Lichenomphalia umbellifera*. 91 *Lactifluus glaucescens*. 92 *Leotia lubrica*. 93 *Leucocoprinus birnbaumii*. 94 *Leucocoprinus brebissonii*. 95 *Leucocoprinus fragilissimus*. 96 *Marasmiellus candidus*. 97 *Marasmiellus ramealis*. 98 *Microporus xanthopus*. 99 *Mycena erubescens*. 100 *Mycena galopus*. 101 *Mycena inclinata*. 102 *Octospora rutilans*. 103 *Otidea alutacea*. 104 *Pcynoporus cinnabarinus*. 105 *Phallus indusiatus*. 106 *Phallus impudicus*. 107 *Pholiota aurivella*. 108 *Pholiota*

highlandensis. 109 *Psathyrella piluliformis*. 110 *Psilocybe semilanceata*. 111 *Russula cyanoxantha*. 112 *Russula fragilis*. 113 *Russula natarajanii*. 114 *Russula senecis*. 115 *Ramaria stricta*. 116 *Russula rosea*. 117 *Russula* sp. 118 *Scleroderma citrinum*. 119 *Sarcoscypha* sp. 120 *Scleroderma areolatum*. 121 *Suillus* sp. 122 *Trametes gibbosa*. 123 *Trametes hirsuta*. 124 *Tremella mesenterica*. 125 *Trametes versicolor*. 126 *Tremella foliacea*.

Fig. 5 – Wild mushrooms of Nagaland (Inedible – 127-130; Poisonous – 131-140): 127 *Xeromphalina kauffmanii*. 128 *Xerula radicata*. 129 *Xylaria hypoxylon*. 130 *Xylaria polymorpha*. 131 *Amanita cokeri*. 132 *Agaricus moelleri*. 133 *Amanita phalloides*. 134 *Amanita virosa*. 135 *Agaricus xanthodermus*. 136 *Amanita flavoconia*. 137 *Helvella crispa*. 138 *Lepiota felina*. 139 *Lepiota lilacea*. 140 *Russula nobilis*. 141 *Ductifera sucina*.

Conclusion

The present investigation shows the wild mushroom diversity of Nagaland, India. The database of wild mushrooms created in this study will help future researchers to make further in-depth study of the potential mushrooms available. Mushrooms are a boon to mankind and should be judiciously exploited for societal benefits across the globe.

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Conflicts of interests

Authors declare that there are no conflicts of interests of any kind.

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