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CHICK LIST OF TERMITE CULTIVATED, SYMBIOTIC AND NUTRITIOUS MUSHROOM (*TERMITOMYCES HEIM*) OF NAGALAND, INDIA

Botany

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ABSTRACT

T*ermitomyces* is a basidiomycetous fungus which forms symbiotic relationship with some termites (Macrotermitinae) is of great ecological and socio-economic importance. This relationship between termite and fungus brings about rapid decomposition of the plant litters particularly in tropical and temperate forests. The fructification (Mushroom) of this fungus is considered a delicacy in all parts of the world wherever it is found. They are the rich source of protein, carbohydrates and many other important compounds and also considered medicinally important. Of the 20 species reported from India, 5 species *T. clypeatus*, *T. heimii*, T. *eurrhizus*, *T. mammiformis* and *T. microcarpus* are available in Nagaland. Proper hunting and conservation strategies of this useful fungus will bring sustenance to the local people.

KEYWORDS

Comb, Nagaland, Symbiosis, Termites, *Termitomyces*, Umbo

INTRODUCTION:

A group of termites found in the tropical and temperate regions Africa and Asia has been growing a fungus for food in their nest for millions of years. This cooperation between termites and fungi is a typical example of mutualistic symbiosis between two organisms which is beneficial for both. In this case, the termites consume plant materials and build their nest (comb) underground with their excreted pseudo faecal materials which are finely broken and half-digested plant materials and inoculate with the spores of the exosymbiont fungus *Termitomyces* species. The fungus grow on it and decomposes the carbon rich complex plant materials such as cellulose and lignin thus turning it into the nitrogen rich fungal biomass that provide the termites with required nutrients (Aanen and Beer 2007). These termitophylic fungi are a monophyletic group of gilled mushrooms currently placed in the family Tricholomataceae which are cultivated through transport of spores by eusocial insects belonging to the sub-family Macrotermitinae using plant materials passing through their guts (Frøslev *et al* 2003).

Aanen and Eggleton (2006) revealed that, cultivation of *Termitomyces* by termites originated in the African rain forest as the main center and migrated to other geographical regions such as Asia and Madagascar. The symbiosis between fungus growing termites and their fungal symbiont has a big impact on most African and Asiatic ecosystems and they play an important role in the ecosystem carbon cycle because, *Termitomyces* is a so-called white rot fungus which can degrade plant material lignin. Although, these fungus growing termites are also found in tropical rain forests, they flourish in Savana ecosystem where their ecological impact is greatest. For example, it has been estimated that, the fungus growing termites are responsible for 90% of the decomposition of wood in some Savana areas in Kenya (Aanen and Beer 2007).

The *Termitomyces* are present in the termite mound all year round in the form of synnemata (white modules) and also in the form of mushroom seasonally during the rainy season for a limited period of time. These mushrooms grows from the underground fungus garden like a closed umbrella pushing through the ground with the help of their toughened tip called as perforatorium or umbo, later the cap open up to form the pileus. A typical *Termitomyces* mushroom includes the world's largest mushroom *Termitomyces titanicus* which has a cap diameter of up to 1m and one of the smallest mushroom *Termitomyces microcarpus* with the cap diameter of about 2cm. The fruiting bodies of these mushrooms are a delicacy in many regions of the world including Nagaland (India) and the regular visitation to old termite mounds by rural woman folk for wild mushroom collection during rainy season is a common sight in these parts of the world. *Termitomyces* mushrooms are nutritionally very rich and economically a valuable natural resource serving as an alternative to plants and animals derived nutrition. For example, *Termitomyces clypeatus* possess significant quantity of protein (31%), carbohydrates (32%), ascorbic acid (10-14%) and antioxidants (Ogundana and Fagada 1982). Some species such as *T. umkowaani* contain much higher level of amino acids such as methionine and cysteine than other commercially cultivated mushrooms making these mushrooms more nutritious than other varieties and could serve as a good protein source for us. Besides nutritional value, many species of *Termitomyces* are reported to possess medicinal properties and have industrial applications (Aanen D and Beer W. 2007)

MATERIAL AND METHOD

Study Area: Nagaland is the sixteenth state of India which lies between 25°6'N and 27°4'N latitude and 93°2'E and 95°15'E longitude. The state is bordered by Myanmar in the East, the state of Assam in the West, Arunachal Pradesh and a part of Assam in the North and Manipur in the South. Nagaland is a mountainous state and the mountain system in the state is an offshoot of the Himalayan mountain system ranging from below 1,000m to mount Saramati which lies 3,840m above sea level. The climate in Nagaland is a typical monsoon type and the vegetation in the state consists mainly of tropical evergreen forests and subtropical deciduous forests.

Material collection and Identification: Surveys were conducted during the rainy seasons in all the major phytogeographical zones of the state between 2014 -2017. During the sample collection, the sporocarps were removed from the substratum with great care, the colour photographs were taken and their morphological characteristics were noted on the collection sheets prepared according to Lodge *et al* (2004). Freshly collected mushrooms were identified based on the diagnostic morphological and microscopic characters given by Purkayastha and Andrilla (1985) and Natarajan (1979).

RESULT AND DISCUSSION: The present study revealed the occurrence of five species of *Termitomyces* in Nagaland and the detail description of each species is given.

Up to 30 species of the genus *Termitomyces* are known and accepted in the 10th edition of the Dictionary of fungi (Frøslev *et al* 2003) and 20 of which are reported from India till date. The state of Kerala possesses the highest number of species (15 species) followed by Goa (10 species), Karnataka (9 species), Maharashtra (3 species) and Tamil Nadu (2 species) respectively (Karun and Sridhar 2013). Of the five species found in Nagaland, *Termitomyces microcarpus* is found to occur in all warm and cold places, *T. clypeatus*, *T. heimii*, T. *eurrhizus* are found in moderately warm places and *T. mammiformis* is found only in warmer regions.

The presence of a pronounced umbo, presence of prominent pseudorhiza, presence of annulus and the solidness and hollowness of the stipe are found to be good diagnostic features for these species.

DESCRIPTION OF THE SPECIES

Termitomyces clypeatus R. Heim
Synonym: *Sinotermitomyces taiwanensis* M. Zang & C.M. Chan
Habitat: On the ground especially on the termite mound during spring and summer

Cap: 4-10cm across, conical, later expanding to convex and flat with a sharp dark brown and spiniform perforatorium. Surface brown to grayish brown, becoming paler towards the margin, dry, silky,

fibrillose with irregularly lobed margin. Lamellae: White to creamy, free, broad, crowded. Context of the pileus is white, thin and fleshy. Stipe: 4-10cm long and 1-2cm thick, cylindrical, central, whitish, fibrillose, striate, solid with a long tapering pseudorhiza and slightly swollen base and annulus absent. Taste not distinctive and odour is pleasant. Spores: 4.5-8.5 x 3.5-5µm, ellipsoid or ovoellipsoid, thin walled and hyaline. Spore print: Brown.

Termitomyces eurrhizus (Berk.) R. Heim.
Synonym. *Agaricus eurrhizus* Berk. *Agaricus sparsibarbis* Berk. And Broome

Habitat: On the ground during spring season. Pileus: 9-12cm, conical, expanding to flat at maturity, broadly umbonate perforatorium. Surface black brown at the center and pale brown towards the margin, glabrous, striate in the margin, slightly viscid when moist, the margin become upturned in the older specimen. Lamellae: free to adnexed, whitish to pinkish and crowded. Context: up to 1cm, becoming thin towards the margin, white coloured, Smell and taste: mild. Stipe: 4-9 x 1.5-3cm, tapering and bulbous at ground level, solid, surface cream coloured, volva and ring absent. Pseudorhiza: up to 39cm, tapering and black in colour. Spores: 6-10 x 4.5-5.5µm, ellipsoid, sub-hyaline and thin walled. Spore print: pink to pale brown

Termitomyces heimii Natarajan
Habitat: On the ground during spring. Pileus: 7-12cm across, white, glabrous, convex to plano convex, margin at first incurved, later upturned and splitting or eroded. Lamellae: White then pinkish, crowded and free. Context: White and fleshy. Stipe: 5-10 x 1.5-2cm, solid, cylindrical, white, fleshy, paler than the pileus, annulus is present at the upper portion of the stipe, scabrous below the annulus, volva absent. Pseudorhiza: Up to 335cm long, dark, tapering at the base and hollow. Spores: 4.5-8 x 3-5µm, ellipsoid, smooth and thin walled. Spore print: Cinnamon brown to pale brown.

Termitomyces mammiformis R. Heim.
Habitat: On the ground. Pileus: 4-10cm across, convex to campanulate and then applanate with mammiform perforatorium. Surface dark, greyish brown at perforatorium and cream to pale greyish in the remaining parts of the pileus. It is covered with pale cream partial veil when young, margin at first incurved which becomes splitting later. Lamellae: Free, crowded, white then becoming pink. Stipe: 3-8 x 1-2cm, cylindrical, hollow, white and glabrous above annulus and pale grey below. Pseudorhiza: 20-35cm long, tapering at the base, cream coloured, smooth, hollow. Annulus: Fleshy, persistent and attached to the upper part of the stipe. Context: White, consisting of thin inflated hyphae. Spores: 6.5-8.5 x 3.5-5µm, ovate to ellipsoid. Spore print: Brown.

Termitomyces microcarpus (Berk. & Broome) R. Heim
Synonym: *Agaricus microcarpus* Berk. & Broome
Habitat: On the ground. Pileus: 0.5-2.5cm across, convex to campanulate, finally expanding to plane with a sharp pointed perforatorium. The surface colour is white to grey, darker at the center, smooth, striate and split at maturity. The context is thin and white. Lamellae: Adnexed, white and then becomes pink, moderately crowded. Stipe: 2-6 x 0.2-0.3cm, slender, cylindrical, white but paler than the pileus, glabrous and lack pseudorhiza and veil. Spores: 6-9 x 3.5-5µm ellipsoid and smooth. Spore print: Pale brown.

CONCLUSION:

The macro-morphological characteristics of *Termitomyces* mushroom are very distinct and provide reliable taxonomic information for identification. Since *Termitomyces* are edible mushrooms and add to the local economy, educating the local population on the nutritional value and other benefits of the mushroom are important. Commercial culturing of these mushrooms like other cultivated mushrooms is not successful till date, proper hunting and conservation strategies will bring sustained utilization of this forest product.

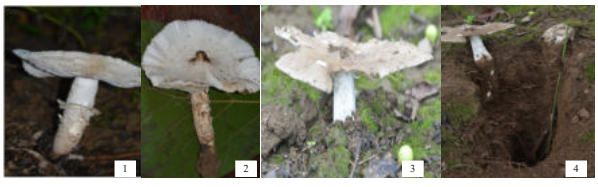

Fig: 1&2, *Termitomyces clypeatus*. 3&4, *T. eurrhizus*

Fig: 5&6. *T.heimii Natarajan*. 7&8, *T. mammiformis*. 9&10 *T. microcarpus*

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