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Full Length Research Paper

Ethnomycology of *Termitomyces* R. Heim in Nepal

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Study on the consumption and uses of edible fungi by selected ethnic tribes/groups in selected geographical regions in Nepal is lacking. This paper highlights the various ways of using *Termitomyces* spp. in Tarai, Siwalik and Midhill in Nepal. The investigation was conducted before, during and after monsoon, from 2010 to 2012. Data were obtained by interacting with members of the ethnic groups used in this study, as well as interviews. It was found that there were nineteen termitomyces taxa, used as food and medicine.

Key words: Distribution, fungi, nutrients, taxonomy.

INTRODUCTION

Wild edible mushrooms are one of the most important non-timber forest products in the world. Due to their vigorous growth in the rainy season, delicious taste and nutritional value, termite mushrooms are mostly used for consumption. Over the last decade, mushrooms have been studied as a novel functional food mainly in South East Asian countries (Adhikari, 2000) and in the world (Khan et al., 2013). Mushrooms have high quality of protein, minerals and vitamins but low fat content (Chaube, 1995). Thus, mushrooms have been used as food since time immemorial.

In Nepal, wild edible mushrooms are one of the most important minor forest products, which are locally traded in local market throughout the country (Adhikari, 2000). Due to the high content of protein (36.8%) in *Termitomyces mammiformis* (Adejumo and Awosanya, 2005), 10 to 14% vitamins (ascorbic acid) in *Termitomyces clypeatus* (Ogundana and Fagade, 1981; Tibuhwa, 2012) and 2.17% minerals (Potassium) in *T.*

albuminosus. Termitophilous mushrooms are very important for their edibility and nutraceutical utility (Aryal, 2015). Previous studies have asserted that the maximum protein content and best amino acid balance are found in mushrooms just before the caps expand (Spores A Field, 2011).

Termitophilous fungi (termite's mushroom) are a monophyletic group of tropical gilled mushrooms belonging to the genus *Termitomyces*. They are unique fungi that grow in close and intimate association with termites. It was described by Heim (1942a,b,c) for a group of termitophilous agarics. Its history begins in Nepal by the reports of *T. eurrhizus* (Singh and Shrestha, 1986). It comprises fungi that live in an obligate symbiosis with termites (commonly known as white ants) of the subfamily Macrotermitinae and order Isoptera. *Termitomyces* spp. was recorded from tropical and subtropical regions of the world (mainly from Africa, and South and South East Asia). However, samples were also recorded in Portugal of Europe and Ecuador of

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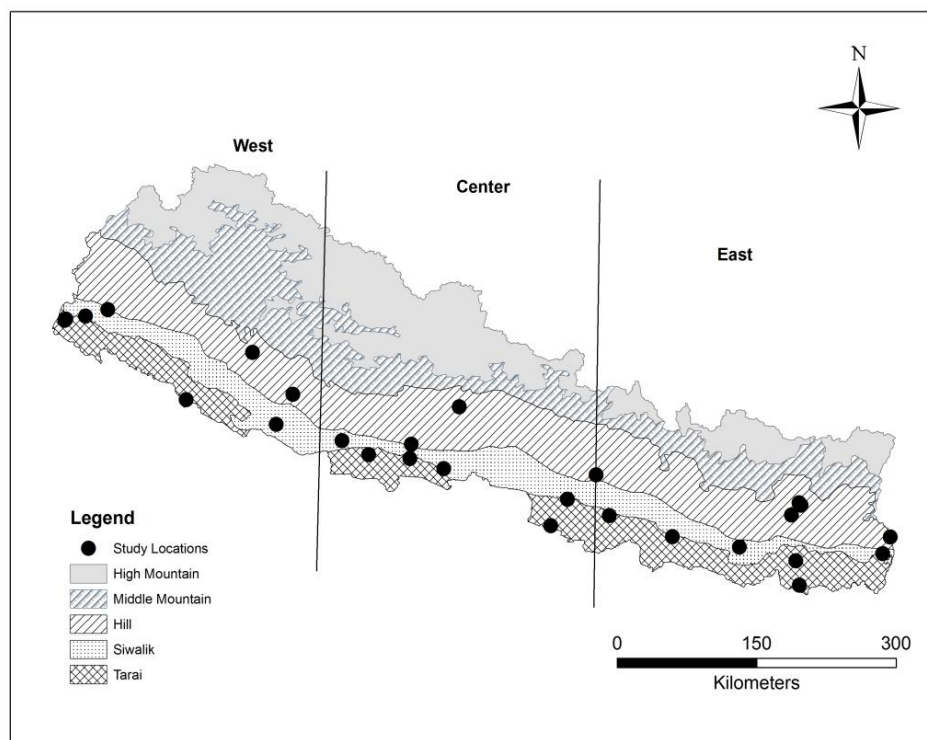


Figure 1. Sample collection sites (Table 3).

South America (Aryal, 2015).

Fruiting bodies of *Termitomyces* spp. are a delicacy in different parts of the world, most importantly in Equatorial region of Africa (Nigeria, Zambia, Zimbabwe, Tanzania, Uganda and Cameroon), South Africa, Madagascar and South-east Asia (India, China, Nepal, Pakistan, Sri Lanka, Thailand, Taiwan, Philippines, Burma, Indonesia and Malaysia) (Heim, 1942c, 1977; Turnbull and Watling, 1999). Several researchers have estimated the nutritional values of fruiting bodies of *Termitomyces* species (Bother and Eicker, 1992).

Termitomyces species are reported to contain higher dry matter, digestible lysine-rich protein, fiber, vitamins and minerals, but contain lower amount of fat and carbohydrates (Jiskani, 2001). They are also rich in important minerals, like phosphorus, potassium, calcium, copper and iron (Aryal, 2015). In place of starch, mushrooms contain sorbitol and linoleic acid (an unsaturated fatty acid). They are an excellent source of folic acid, thiamine, riboflavin, niacin, pantothenic acid and biotin (Manning, 1995). Besides nutritional value, many species of *Termitomyces* possess antioxidant properties and thus have high medicinal value (Tibuhwa, 2012). They also produce a variety of enzymes in culture media useful as additives in food, in leavening of bread, in processing silage and in other industrial applications (e.g., clarification of non-citrus fruit juices) (Khowala et al., 1992).

Based on the above, the study being reported aimed at

determining the various ways of using *Termitomyces* by the different ethnic groups and community inhabiting different eco-zones of Nepal. The main aim of the present study is to document different mushroom types with details of uses emphasizing *Termitomyces* spp.

MATERIALS AND METHODS

The survey of termitomycetes was carried out in Tarai, Siwalik and Midhill during Southwest and post-monsoon seasons (June-November, 2010-2012). *Termitomyces* spp. were recorded in different habitats like mixed plantations, *Acacia*, *Dalbergia*, *Tectona* monoculture forests, Agro pastoral, Community managed Forest, Government managed National Forest, Plantation Forest, Government managed in Protected Area, Sacred groves and natural (evergreen, moist deciduous and Sal) forests (Figure 1). These were conducted on the basis of information obtained from the local informants of varied ethnic groups in different seasons of the years when the study was done. The interviews were also taken based on indigenous knowledge. The specific locations range from Jhapa-Ilam to Kanchanpur-Dadeldhura (latitude of 26°44'08" N and 29°06'32" N and between the longitude of 80°18'02" E and 88°08'27" E; Tables 1 and 2).

Twenty-seven sites (Table 3) were randomly chosen by Randomized Block Design method (RBD). The Participatory rural appraisal (PRA) technique (Freudenberg, 2011) was used for the local people to get information largely on nutritional as well as medicinal aspects. The utility of investigated taxa was explored to examine its nutritional and socio-biological aspect. The number of spots sampled represented 10 to 20% of the study sites (Elliott, 1971). The total of three spots sampled were taken from each topography, ranging east, center and west and Tarai, Siwalik

Table 1. Place of collection, pronouncement and traditional use of *Termitomyces* spp. for the treatment of different types of disease and ailments by the different ethnic groups in the studied area with their morphological characters.

S/N	Name/(Common Name)/Accession Number	Altitude/latitude/longitude	Morphological characters	Uses
1	<i>T. albuminosus</i> (Berk.) R. Heim/(Vend Chhanii)/NHM TU 2-2-1666	475 m/27.00071° N/83.00571° E	Pileus: 9-14 cm in diameter, white, fleshy, surface covered with wrinkles, medium in size, sub conical to expanded, obtusely umbonate, whitish with grayish or brownish scale scattered over the pileus with smooth, incurved margin, perforatorium is slightly raised, black. Pelicles are thick, separable, below it whiter in colour. Lamellae: adnexed, white, dense, free. Stipe: cylindrical, 30 cm × 1 cm, smooth, fibrous, white, solid, with grayish tint, a created upwards cartilaginous outside, Annulus thick, white, persistent. Pseudorrhiza: Significantly long and hollow root like extension, size up to 30 × 1 cm below the ground level. Colour Dark brown, surface cartilaginous, shape hollow, cylindrical tapering toward distal end. Flesh: Whitish in colour, soft and inflated, hyphae nonamyloid, without clamp-connection. Basidiospores: 7.5 × 5.0µm, hyaline, smooth walled, ellipsoid. Basidia: 23.5 × 7.6 µm, tetra sterigmata bearing tetra basidiospore. Spores: Pinkish in colour. Spore: 22.5 × 7.5 µm, nonamyloid, thin walled elliptical, hyaline, smooth. Spore print: Brown in colour. Cystidia: 30.0 × 21.0 µm. Hymenophoral trama: regular	It is edible and its syrup is used for the remedy of measles, yellow fevers.
2	<i>T. aurantiacus</i> (R. Heim) R. Heim/ (Chotki-vend)/NHM TU 2-2-1682	195 m/27.29245° N/83.26236° E	Pileus: Size 10-15 cm, brown to grey towards margin, olivaceous at the apex, umbonate, surface smooth, incurved margin. Lamellae: Free, dense, crowded, white to pale grey. Stipe: Solid, swollen at base, size 7-9 × 2.0-2.5 cm, silvery white, surface smooth, fibrous, annulus absent. Pseudorrhiza: Size 5 × 0.5 cm long, solid, dark brown in colour, surface cartilaginous, solid. Flesh: Soft, thin walled, white, inflated, clamp connection absent, nonamyloid. Spore print: Pink. Basidia: 22.5 × 5.9 µm. Cystidia: 25 × 11.5 µm. Basidiospores: 6.5 × 4.5 µm, ellipsoid. Hymenophoral trama: regular. Its fruiting bodies are very delicate, small among the termite's mushroom.	It is edible, after cooking, it becomes pulp like and has meat like taste; its soup is used as tonic in fever. Dried powder and Black salt (Birenun) are used with hot water, twice a day for recovery or simply to make soup and drink.
3	<i>T. badius</i> Otieno/(Kanayo)/ NHM TU 2-2-1683	502m/27.62584° N/84.05827° E	Pileus: Size 10-14 cm in diameter; umbonate in shape, surface smooth, glabrous, pale grey in colour, radially straight, incurved margin, dark brown; olive in the centre, papillate, umbo. Stipe: Size 5.2 × 0.75 cm long, more or less straight, solid, white, surface smooth, glabrous, absent of annulus. Lamellae: free dense, grey in colour. Pseudorrhiza: Size 5 × 1 cm long, solid, brown in colour, cylindrical, glabrous, smooth. Flesh: whitish, soft, inflated, clamp connection absent, thin walled, inamyloid. Basidia: 24 × 7 µm, clavate, Basidiospores: 4 in number, smooth, hyaline, 6.5 × 3.5 µm, ellipsoidal. Spore print: Pinkish. Cystidia: 19 × 10.5 µm. Hymenophoral trama: regular.	It is edible and its syrup is used for the remedy of constipation, Laziness, Indolence, inactiveness. Dried powder and black salt (Birenun) are used with hot water, twice a day for recovery or simply to make soup and drink.

and Midhill vegetational zone of Nepal. In each spot, 10 Quadrants of size 25 m × 25 m were located. The collection was entirely based on their sexual reproductive

structures. The habit and habitat including ecological parameters were taken by the accessory equipment in appropriate places. This was calculated by the formula:

$$\text{Frequency class} = \frac{\text{No. of plots in which species 'x' occurs}}{\text{Total no. of plot}} \times 100$$

Table 1. Contd.

4	<i>T. clypeatus</i> R. Heim/ (Dewale)/ NHM TU 2- 2-1667	223 m/27.64615° N/83.50928° E	Pileus: 5.5-7.5 cm in diameter plano-umbonate, with a high spiniform dark-grey perforatorium; surface dark brown at centre, generally grey to grayish brown and paling towards margin, smooth and glabrous, striate and radially rimose; margin straight and splitting fissile, irregularly lobed, pileal surface silky; epicutis consisting of slender, repent hyphae. Lamellae: with lamellulae, free, creamy-white, pink with maturity, crowded, with lamellulae, edge entire. Stipe: 7.0-9.0 × 1.2 cm, central, cylindrical, slender; surface at first white to dirty brown, fleshy and fibrous, smooth and glabrous, longitudinally striate, lacking both an annulus and other velar remnants, solid, fibrous, sometimes bulbous besides soil, hollow. Pseudorhiza: size 3.0-5.0 × 1 cm, pale grey in colour, surface smooth, glabrous and fibrous, shape solid, cylindrical, slender bulbous in shape, tapering towards the distal ends. Flesh: context of pileus white, soft, fleshy, of inflated, hyaline thin walled, interwoven hyphae, inamyloid, without clamp connections. Basidiospores: 8.5 × 3-3.5 µm, sub hyaline, thin-walled, obovoid to broadly ellipsoidal, smooth, thin walled. Basidia: 15-16.5 × 5.5-6.5 µm, clavate, sub hyaline and thin-walled, tetrasporic. Spore: hyaline, ellipsoid, non-amyloid, thin-walled, smooth, 10.5-11.5 × 4-5 µm. Spore print: Pink. Cystidia: 20.0 × 10.0 µm. Cheilocystidia: Clavate to pyriform, hyaline, thin-walled. Pleurocystidia: Pyriform, hyaline and thin-walled, rare. Hymenophoral trama: regular, hyaline, thin-walled. Subhymenial layer: narrow consists of branched, repent hyphae.	It is edible and its syrup is used for the remedy of measles, yellow fevers.
5	<i>T. eurrhizus</i> (Berk.) R. Heim/ (Sadaka)/ NHM TU 2-2-1668	262 m/27.69912° N/83.28397° E	Pileus: Conic to flat, fleshy, dark-grayish brown pale towards the margin, without papilla; 20.5-22.0 cm in diameter, at first convex, later expanded with prominent umbo, obtusely rounded perforatorium. Universal veil, are white glabrous, viscid, rugulose adherent to pileal surface in the form of a circular patch with free margins. Scales present on the surface, firm, margin regular, not incurved Lamellae: crowded, with lamellulae, distinctly formed, free to sub adnate, pliable, white, entire, Stipe: Size 20.0 × 1.5 cm long, cylindrical, central, tubular, fibrillose), creamy-white, somewhat tough, bulbous base, solid above ground, hollow below the soil, penetrating the soil to some distance, with a persistent apical annulus Pseudorrhiza: Size 60.0-11.0 × 1.5 cm or more, dark brown in colour, solid, cylindrical with a cartilaginous and widening at certain depth. Flesh: White, inflated, thin walled hyphae, nonamyloid, without clamp connection. Basidia: clavate, 4-spored, 11.66 × 6.9 µm. Basidiospores: Somewhat large, hyaline, ellipsoid, thin walled 6.8-9.3 × 5.1-6.8 µm; Spore: hyaline, ellipsoid, smooth, non-amyloid, thin-walled, 6.0-8.0 × 4.0-5.0 µm. Spore print: pink. Cystidia: 35.0 × 11.5 µm, obovoid to pyriform. Heilocystidia: present, numerous; pleurocystidia: clavate, sometimes ventricose-rostrate above the general level of the hymenium. Cheilocystidia: usually napiform, crowded. Hymenophoral trama: bilateral when young, regular at maturity, with hyaline hyphae. Subhymenial layer: thick, narrow; consist of branch repent hyphae.	It is edible and also used as a lotion for skin diseases with mixing the herb (<i>Cynodon doctylon</i>).
6	<i>T. fuliginosus</i> R. Heim/ (Chuchnari)/ NHM TU 2-2-1676	525 m/27.73321° N/83.65269° E	Pileus: 4.75-5.50 cm in diameter convexoapplanate, smooth, surface grayish brown to yellow brown, perforatorium spiniform, radially fibrillose, sometimes radially striate, entire and incurved margin. Stipe: Buffy-brown, medium cylindrical, 5.0 × 0.9 cm, solid, cylindrical or slightly tapering downward; surface white above and pale brown on the bulb, fibrous, pellicle thick, and below it grey in colour, annulus absent. Pseudozhiza: Present, solid, fibrous, grey to brown in colour and size up to 3.5 × 0.7 cm, cylindrical and widening at certain depth, than narrowing down to the point of attachment to the termite nest, its length determined by the depth of the termite comb Lamellae: free, crowd, white to pink, adnexed Flesh: soft, buffy-brown, hyaline, thin walled, clamp connection absent. Spore print: purplish. Basidia: 30.0 × 0.9 µm, tetra sterigmata bearing tetra basidiospore, clavate. Basidiospores: 8.0 × 4.0 µm ovoid to sub cylindrical or ellipsoid, hyaline, smooth. Cystidia: 25.0 × 19.0 µm. Hymenophoral trama: regular.	It is edible and its soup is used as tonic.

Macroscopic characters and microphotographs of the internal features of systematic importance, the local

name along with their medicinal and traditional use by native people were also noted (Aryal and Budathoki,

2015). All the primary data and samples were brought to the laboratory of Central Department of Botany, Tribhuvan

Table 1. Contd.

7	<i>T. globulus</i> R. Heim & Gooss.-Font./NHM TU 2-2-1677	320 28.97291° 80.18024° E	m/ N/	<p>Pileus: 6.0-9.0 cm diam., sub globose, finally expanding but margin usually remaining incurved, with the perforatorium scarcely developed or nil; surface pale ochraceous brown to tawny brown, paler at margin, glabrous and smooth, radially striate; margin lobed, often splitting. Lamellae: free, narrow, up to 8 mm broad, white to pale pinkish, densely crowded, with lamellulae of three lengths. Stipe: size 6.0 × 1.5 cm, cylindrical, solid; surface cream coloured, fibrous and smooth. Pseudorrhiza: elongate, size up to 6 × 1 cm or more, slender, tawny to rusty brown. Flesh: whitish in colour, firm to spongy, consisting of thin-walled, inflated hyphae, clamp connection absent. Spores: 6.0-8.5 × 3.5-4.5 µm, obovoid to ellipsoid, thin-walled. Spore print: Pinkish. Basidia: 20.0-25.0 × 5.0-7.0 µm, clavate, bears four sterigmata. Cheilocystidia: crowded, polymorphic ranges from globose or pyriform to cylindrical and sub capitate, often septate wall. Cystidia: 28 × 15 µm. Basidiospores: 7.5 × 4.5 µm, ellipsoidal. Pleurocystidia: similar to cheilocystidia. Hymenophoral trama: sub regular, of thin walled, inflated hyphae. Subhymenial layer: interwoven.</p>	It is edible and its fresh extract powder or paste of fruiting bodies is used for wound healing
8	<i>T. heimii</i> Natarajan /(Vavnehi, Bemtee)/ NHM TU 2-2-1669	531 m/27.71434° N/83.57693° E		<p>Pileus: Silky white, turns into the grey to brown-white-creamy in colour, Smooth, size, 7.5-9.0 cm in diameter, convex or campanulate at first, then expanding to plano-umbonate with a patch of veil at the apex, obtuse, perforatorium; surface pale brown to dark brown at centre. Whitish grey at the umbonal, margin incurved and cracking, covered at first by a firm partial veil, which disrupts to form persistent velar squamules at maturity; margin radially striate, often splitting; pileal surface an epicutis consisting of thin walled, repent hyphae. Lamellae: Free, surface white to pinkish cream with age, margin serrulate, crowded, with lamellale. Stipe: size 5.0 × 1.5 cm, central, cylindrical, bulges near the pileus and possess a thick ring, surface creamish white stuffed, and smooth above thick and white persistent annulus, with pale brownish velar squamules below; solid, fibrous. Pseudorrhiza: Significantly long, size 60 × 1.7 cm, up to 15 cm below ground level, fleshy, pale-grey, cylindrical, hollow, terminated by a disk connected to the termite comb; leathery, hollow, surface cream, and widening at certain depth. Flesh: white, fleshy, soft; of inflated, hyaline, thin-walled, septed with clamp connection hyphae. Basidiospores: 6.5 × 4.5 µm, ovoid to ellipsoid, hyphae, non-amyloid, smooth, sub hyaline and thin-walled. Basidia: 17.5 × 6.5 µm, sub hyaline and thin-walled, clavate, with four sterigmata, Spore print: Brown to pinkish grey. Cystidia: 35.0 × 20.0 µm. Cheilocystidia: Occasionally, clavate to pyriform. Pleurocystidia: clavate, similar to cheilocystidia, rare. Hymenophoral trama: regular, hyaline, thin walled, parallel hyphae.</p>	It is edible and its syrup is used for the remedy of jaundice, diarrhoea.
9	<i>T. letestui</i> (Pat.) R. Heim /(Dudhamunte)/NHM TU 2-2-1670	250 m/27.63395° N/83.66433° E		<p>Pileus: size 21.0-22.5 cm, cream to light brown, fleshy, campanulate then convex, eventually fairly expanded, with a conspicuous cylindrical umbo of perforatorium, which is dark brown from the small brown scales about disc. Cutical dry and whitish fairly pale pinkish-gray, squamulose and cracked except toward margin, which is usually appendiculate. Lamellae: white, almost free, crowded, unequal. Stipe: size 12.0-18.0 × 2.0-3.0 cm or more, solid, fusiform, deeply rooting, cream to whitish, pubescent beneath membranous ring and persistent, pendant or sheath like. Pseudorrhiza: 18 × 1.5 cm long, dark in colour, hollow, cylindrical and widening at certain depth. Flesh: whitish, soft, thin walled, interwoven, nonamyloid, hyaline hyphae, clamp connection absent. Spore print: Pinkish. Spores: white, elliptical, smooth, 6.0-9.0 × 3.0-5.0 µm. Basidia: 24.1 × 7.3 µm, tetra sterigmata bearing tetra basidiospore Basidiospores: 7.25 × 3.5 µm, oblong. Cystidia: 36.0 × 15.0 µm.</p>	It is edible and its soup is used for the remedy of Inappetence, Abdominal disorder, Indigestion, Stomach ache.

Table 1. Contd.

10	<i>T. mammiformis</i> R. Heim/ (Thuli Mugañ)/ NHM TU 2-2-1678	130m/27.62274° N/83.65415° E	<p>Pileus: whitish grey to silvery shining, size 4.5-7.5 cm in diameter; smooth, campanulate, mammiform, scrobiculate perforatorium; with a sharply differentiated umbo, margin inflexed, entire, surface pale brown to dark brown at centre, white to creamy elsewhere, covered by firm creamy partial veil when young, attached with some persistent pale grey or pale brown velar squamules when mature; surface or margin with radial fine stripes. Lamellae: free, white to pinkish, crowded with lamellulae. Stipe: size 8.0 × 1.2 cm, central, cylindrical or occasionally slightly enlarged at ground level; Surface white and glabrous above annulus, cream-coloured and with pale brown squamules below; solid, with a pseudorhiza, fibrous, persistent annulus present, persistent. Pseudorrhiza: Size up to 19 × 1.2 cm, cylindrical, pale grey, smooth, terminal with a disk connected to the surface of the termite comb, with blunt end, lathery, hollow; surface creamy. Dark in colour, cylindrical and widening at certain depth. Flesh: white, fleshy and soft, of inflated, hyaline, cylindric, nonamyloid, thin-walled hyphae, clamp connection absent. Spore print: Pink. Basidiophores: 5.5 × 3.5 μm, ovoid to ellipsoid, sub hyaline and thin-walled, smooth, inamyloid. Basidia: 22.1 × 6.5 μm, sub hyaline, thin-walled, clavate, with four sterigmata, club shaped. Cystidia: 45.0 × 15.0 μm. Cheilocystidia: clavate to pyriform, hyaline, thin-walled occasionally with small protuberances. Pleurocystidia: Similar to cheilocystidia, rare. Hymenophorae trama: bilateral in the primordium, regular at maturity, and hyaline, thin-walled, cylindrical hyphae. Subhymenial layer: narrow radial hyphae.</p>	It is edible and used to strengthen the body, for increase in body healing ability and is associated with longevity. Its powder is taken as one table spoon with hot water after dinner till recovery is evident
11	<i>T. microcarpus</i> (Berk. & Broome) R. Heim/ (Jhari, Rai)/ NHM TU 2-2-1671	90 m/27.48136° N/83.44643° E	<p>Pileus: cream white to light grey in colour, with cream dark in centre, smooth with glabrous margin, small spiniform perforatorium, and umbo, without papilla, size 1.0 -3.0 cm in diameter, the cap splits from its margins and resembled the petals of flower. Lamellae: free, white and crowded, thick, turning creamy at maturity. Stipe: central, slender, hollow, white, fleshy-fibrous, smooth, size 3.5 × 0.5 cm, uniformly thick, glabrous, slightly enlarged below soil, absent of annulus and other velar remnants. Pseudorhiza: absent. Flesh: soft, fleshy, whitish, hyaline, thin-walled hyphae, clamp connection present. Basidiospores: 5.0 × 3.0 μm, ellipsoid. Basidia: 10.0-12.0 × 4.0-6.0 μm in size, tetra sterigmata. Spores: sub-globose, smooth, thin-walled, inamyloid, hyaline, 10.0-12.0 × 4.0-6.0 μm. Spore print: pale pinkish. Cystidia: 22.0 × 11.0 μm. Hymenophoral trama: regular, lamellate.</p>	Its fruiting bodies are very delicate, small among the termite's mushroom. They are edible; after cooking, it becomes pulp like and has meat like taste and its soup is used as tonic.
12	<i>T. microcarpus</i> f. <i>santalensis</i> (Berk. & Broome) R. Heim/ (Jhari, Rai)/ NHM TU 2-2-1679	1110 m/28.25742° N/82.37703° E	<p>Pileus: 1-4 cm, whitish to grey in colour, papillate, conic, becoming olivaceous to brown at the papilla non-viscid, smooth, margin thin, incurved, entire, or incised. Lamellae: sinuate, concolourous, arcuate, crowded, with lamellulae of three unequal length; edge entire, smooth, concolourous. Stipe: 3-8 × 0.4-0.6 cm, central, straight, cylindrical, grey in colour, surface smooth, annulus absent. Pseudorrhiza: attenuated at the base to form a long, solid, greyish-brown in colour, size: 5 × 0.3 cm, hollow, slender, cylindrical, surface glabrous, smooth, and widening at certain depth. Flesh: Spongy, whitish, consisting of interwoven hyphae, which are nonamyloid, thin-walled, inflated hyphae, with clamp-connection. Spores: 5.6-7.5 × 4-5 μm, elliptical, hyaline, inamyloid, thin-walled. Spore print: brown. Basidia: 15-20 × 5-7 μm, clavate, bears 4-sterigmata. Cystidia: 24 × 12 μm. Cheilocystidia: abundant, and forming a sterile gill edge, claviform, hyaline, thin-walled. Pleurocystidia: absent. Basidiospores: 6 × 4 μm, ellipsoidal. Hymenophoral trama: sub regular, hyaline, inamyloid, consisting of thin walled hyphae. Subhymenial-layer: well developed, interwoven.</p>	It is edible and decoction of fruiting bodies as soup or curry is given as tonic for stimulating power

Table 1. Contd.

13	<i>T. robustus</i> (Beeli) R. Heim/ (Bagale)/ NHM TU 2-2-1672	578 m/27.76132° N/83.47458° E	Pileus: Size 20.5-21.5 cm in diameter, brownish cream, margin inflexed when young, but flat reflexed or lacerate margin with age, surface smooth, viscid, concentrically scrobiculate or radially ridged, conical to convexo-applanate in shape. Perforatorium partly blackish and sub-mamilate, shape in conical continuation with the cap. Lamellae: densely crowded, whitish, free or sub adnate. Stipe: 18.0 × 3.0 cm thick (above ground), conical, tapering towards downward, pale brown, surface smooth, glabrous, annulus absent. Pseudorrhiza: size 30.0 × 1.5 cm, gradually attenuating to a narrow distal end, dark- brown in colour, cylindrical and widening at certain depth. Flesh: grey, soft, fleshy, easily separable from the cutical, thin walled, nonamyloid, clamp connection absent. Hymenophoral trama: regular. Basidia: 4-spored, club shaped 20.5 × 6.5 µm, clavate. Basidiospores: hyaline, non-amyloid, ovoid to broadly ellipsoidal, smooth walled, 5.5-8.0 × 4.0-4.5 µm. Spore print: pinkish, Cystidia: 25.0 × 12.0 µm. Cheilocystidia: abundant, thin walled, pyriform. Pleurocystidia: present.	It is edible and its syrup is used for the remedy of constipation, laziness, indolence, inactiveness.
14	<i>T. schimperi</i> (Pat.) R. Heim/ (Dhamire)/ NHM TU 2-2-1673	1400 m/27.78258° N/83.52119° E	Pileus: 20.5-21.0 cm, cream white with concentric rings of brown scales, margin incurved. Perforatorium are conical to bullate umbo, in shape, dark grey in colour. Lamella: whitish, dense, crowded and free. Stipe: Size 15 × 2.5 cm, creamy-white in colour, solid, surface smooth, glabrous. Annulus covered by thick membranous of velar remains. Pseudozhiza: Size 17 × 1.6 cm, dark-brown in colour, solid, cylindrical, slender, surface smooth and widening at certain depth. Flesh: whitish, thin walled, filamentous, nonamyloid, hyaline, clamp connection absent. Spore print: pale cinnamon. Basidia: 27.5 × 8.0 µm, tetra sterigmata. Cystidia: 32.5 × 14.5 µm. Basidiospores: 6.5 × 4.5 µm, ellipsoid.	It is edible and its paste is used for the remedy of cut wound, skin diseases.
15	<i>T. striatus f. graiseus</i> (Beeli) R. Heim/ (Kanayo)/ NHM TU 2-2-1675	905 m/27.78524° N/84.64213° E	Pileus: size 4.5-8.5 cm, grey to greyish-brown in colour, conical to convexo-applanate, surface radially striate, margin incurved when young but slightly uplifted when mature. Convex with prominent umbo papilla of brown in colour. Lamella: whitish, crowded, free, smooth, equal edge. Stipe: size 7 × 1.7 cm, fleshy, central, cylindrical, slightly swollen at the middle, solid, concolorous, surface smooth, glabrous, annulus absent. Pseudorrhiza: Size 3-5 × 1 cm, dark-brown in colour, cylindrical slender, smooth, glabrous, fibrous, bulbous and widening at certain depth, than narrowing down to the point of attachment to the termite nest. Flesh: Pale-grey in colour, thin walled, filamentous, nonamyloid, hyaline, clamp connection absent. Basidia: 20.5 × 5.5 µm, tetra sterigmata. Spore print: pinkish cream Cystidia: 37 × 10 µm. Basidiospores: 5.5 × 4.5 µm, ellipsoid.	It is edible and its soup is used as tonic.
16	<i>T. striatus f. ochraceous</i> R. Heim/ (Kalunge)/ NHM TU 2-2-1674	202 m/27.62584° N/83.05827° E	Pileus: Size 4.0-9.0 cm, without or small spiniform papilla of olivaceous in colour, conical to convexo-applanate in shape, surface smooth, incurved margin when young, slightly uplifted when mature, ochraceous in colour. Lamella: Dense, crowded, free, pale yellow in colour. Stipe: size 4 × 1.8 cm, small, fleshy, solid, surface smooth, glabrous, buffy-brown in colour, annulus absent. Pseudorrhiza: pale to dark-brown in colour, cylindrical slender, smooth, glabrous, fibrous, bulbous and widening at certain depth, than narrowing down to the point of attachment to the termite nest. Flesh: whitish, thin walled, cylindrical, nonamyloid, and hyaline. Clamp connection: absent. Spore print: pink. Basidia: 22 × 6.5 µm, tetra sterigmata. Cystidia: 40.5 × 12 µm. Basidiospores: 6.5 × 5.5 µm ellipsoidal.	It is edible and its soup is used as tonic.

mean values were provided, using a high-power microscope (Olympus CX22, magnification 100_x). The literatures on the identification of the samples were given by: Heim (1977), Bels and Pateregetvit (1982), Singer (1986), and Harkonen and Mwassumbi (2003); and are on line data base such as: Biodiversity Library.org, Index

fungorum, Jstor.org, Mycobank.org, tropicos.org). They were documented and prepared on their account with details, containing information on edibility, seasonal availability and nutraceutical relevance (Aryal and Budhathoki, 2014). The specimens are housed in Natural History Museum, Swyambhu, TU., Nepal.

RESULTS AND DISCUSSION

In total, 241 species of Ascomycetes and Basidiomycetes belonging to 19 orders, 45 families and 95 genera were recorded (Table 4). A

Table 1. Contd.

17 <i>Schulzeria umkowaan</i> (Cooke & Masee) D.A. Reid/ (Sangraino)/ NHM TU 2-2-1665	1400 m/27.79268° N/83.53129° E	Pileus: Size 21.0-26.0 cm diameter, campanulate to shallowly convex and later up turned with spiniform to broadly conical umbo perforatorium and straight to incised or split margin when young and uplifted when mature; at first greyish yellow, fading to yellowish brown, radially wrinkled, smooth and viscid or slimy when wet, otherwise dry. Lamellae: white, free, broad, crowded, regular; short gills of three unequal lengths. Stipe: white, surface smooth, fibrillose swollen at the base, extending to rust brown, size 20 × 0.7 cm (epigeal), central, cylindrical, without annulus, long; slightly swollen or bulbous base near the soil surface, Pseudozhiza: Size 12 × 1 cm, and rust-brown in colour, cylindrical and widening at certain depth, than narrowing down to the point of attachment to the termite nest. Surface fibrillose and stuffed. Flesh: Whitish-grey to creamy in colour, moderately thick and fleshy, hyaline, clamp connection absent. Basidia: 22.0 × 7.5 µm, divergence. Spore print: Brownish. Cystidia: 45.0 × 10 µm broadly clavate to pyriform Basidiospores: 6.5 × 4.5 µm, untetra basidiospores, broadly ellipsoidal, divergence, hyaline and smooth.	It is edible and its powders used in mouth-wash for buccal cavity infection, and relief from arthritics pain.
18 <i>T. palpensis</i> sp. nov./ (Bhalu-Mugan)/ NHM TU 2-2-1680	816 m/27.76451° N/83.50959° E	The sample collected on subtropical deciduous hill forest. Pileus: size 9-15 cm, greyish brown pale toward the margin and olivaceous near the umbonal region, umbonate, incurved margin, surface smooth, radially striate, Perforatorium umbo and brown in colour. Lamellae: Free, white, dense. Stipe: size 10 × 2 cm, solid, bulbous base, whitish to pale yellow in colour, surface smooth, fibrillose, absence of annulus. Pseudorrhiza: Size 5 × 0.5 cm, buffy brown in colour, solid, cylindrical. Pseudorrhiza: 5 × 0.5 cm long, solid, brown in colour, cylindrical, surface glabrous, smooth, widening at certain depth, then narrowing down to the point of attachment to the termite nest, its length determined by the depth of the termite comb. Flesh: Grey, soft, inflated, clamp connection absent, nonamyloid. Spore Print: pinkish. Basidia: 17.5 × 6.5 µm. Basidiospores: 4.5 × 3.5 µm, oblong. Cystidia: 25 × 15 µm. Hymenophoral trama: regular.	It is edible and its syrup is used for the remedy of jaundice, diarrhea (Aryal et al., 2016).
19 <i>T. arghakhanchensis</i> sp. Nov./ (Tuse chyau)/ NHM TU 2-2-1681	1261 m/27.86208° N/83.09029° E	The sample collected on subtropical evergreen forest. Pileus: Size 8-16 cm, dark grey to black in colour, bullate-umbonate, surface wrinkled, smooth, entire margin, papilla brown in colour. Lamellae: Free, dense, crowded, white to pale grey. Stipe: Size, 7 × 2 cm, solid, swollen at base, whitish, surface smooth, annulus thin demarcation and persistent. Pseudorrhiza: Size 7 × 0.5 cm long, solid, brown in colour cylindrical, slender, surface glabrous, smooth, and widening at certain depth, then narrowing down to the point of attachment to the termite nest, its length determined by the depth of the termite comb. Flesh: Soft, grey, inflated, clamp connection absent, inamyloid. Spore print: light brown. Basidia: 19 × 6 µm. Basidiospores: 4.5 × 3.5 µm, ovoid. Cystidia: 30 × 17 µm. Hymenophoral trama: regular.	It is edible and its soup is used for the remedy of Inappetence, Abdominal disorder, Indigestion (Aryal et al., 2016).

notable frequency of *Agaricus augustus*, *Macrolepiota procera*, *M. rhacodes*, *Panaeolus sphinctrinus*, *Russula emetia*, *R. foetens*, *R. mairei*, *R. rosaceae*, *R. virescens*, *Cerrena unicolor*, *Daldinia concentrica*, *Lentinus tigrinus*, *Peniophora quercina*, *Pycnoporus cinnabarinus*, *Trametes gibbosa*, *T. hirsute*, *T.*

versicolor and *Tyromyces sambucens* was observed. Out of the total collection, 48.13% macro fungi fall under Agaricales followed by Russulales, Polyporales, Boletales, Cantharellales, Cortinariales, Tricholomatales, Auriculariales, Helotiales, Hymenochaetales, Pezizales, Phallales, Tremellales Aphylophorales,

Leotiales, Lycoperdales, Pleurotales, Sarcomatales and Theleophorales (Figure 2), and it was found that respondents in the urbanized areas (near cities where the data were collected) hardly possessed any information about the edibility of these mushrooms. However, in the rural areas (Table 2), some respondents above

Table 2. Place and date of collection.

SN	Species	Place of Collection	Date of collection
1	<i>Termitomyces albuminosus</i> (Berk.) R. Heim	Gorusinghen-Kapilwastu	2010.08.19
2	<i>T. aurantiacus</i> (R. Heim) R. Heim	Kumhargaddi-Rupandehi	2011.08.04
3	<i>T. badius</i> Otieno	Arunkhola-Nawalparasi	2011.07.24
4	<i>T. clypeatus</i> R. Heim	Karhiya-Rupandehi	2011.08.16
5	<i>T. eurrhizus</i> (Berk.) R. Heim	Saljhandi-Rupandehi	2011.08.04
6	<i>T. fuliginosus</i> R. Heim	Sunwal-6, Bisasaya-Nawalparasi	2010.08.16
7	<i>T. globulus</i> R. Heim & Gooss.-Font.	Shukla-Phanta-Kanchanpur	2011.08.31
8	<i>T. heimii</i> Natarajan	Gairiganun-Chitwan	2011.07.24
9	<i>T. le-testui</i> (Pat.) R. Heim	Basabasahi-Nawalparasi	2011.09.18
10	<i>T. mammiformis</i> R. Heim	Sunwal-6, Bisasaya-Nawalparasi	2011.10.06
11	<i>T. microcarpus</i> (Berk. & Broome) R. Heim	Paklihawa-Rupandehi	2011.09.19
12	<i>T. microcarpus</i> (Berk. & Broome) R. Heim <i>f. santalensis</i>	Dhangwang-1, Aringalependi-Salyan	2011.08.24
13	<i>T. robustus</i> (Beeli) R. Heim	Jugedi-Chitwan	2011.08.10
14	<i>T. schimperi</i> (Pat.) R. Heim	Mashyam-Palpa	2011.08.03
15	<i>T. straitus f. griseus</i> (Beeli) R. Heim	Gairiganun-Chitwan	2011.07.24
16	<i>T. straitus f. ochraceus</i> R. Heim.	Arunkhola-Nawalparasi	2011.07.24
17	<i>Schulzeria umkowaan</i> (Cooke & Masee) D.A. Reid	Kashikharak-Palpa	2011.07.11
18	<i>Termitomyces palpensis</i> sp. nov.	Simaldanda-Palpa	2010.08.04
19	<i>T. arghakhanchensis</i> sp. nov	Thada-Arghakhanchi	2011.07.19

Table 3. Name of Spots.

SN	Name of spots (district name)
1	Kanchanpur-Kailali
2	Dadeldhura
3	Doti
4	Bardiya
5	Surkhet
6	Banke
7	Salyan
8	Dang
9	Puythan
10	Rupandehi-Kapilwastu
11	Arghakhanchi
12	Palpa-Nawalparasi
13	Gulmi
14	Parsa-Bara
15	Makawanpur-Chitwan
16	Kathmandu-Lalitpur
17	Routahat-Sindhuli-Sarlahi
18	Dhanusha-Mahottari
19	Udaypur-Saptari-Sirha
20	Dhankutta
21	Sunsari
22	Terthum
23	Sankhuwasabha
24	Panchthar
25	Morang
26	Jhapa
27	Ilam

Table 4. Number of species and frequency of the studied samples.

Taxa	Tns	SF%
<i>Agaricales</i>	116	48.13
<i>Russulales</i>	44	18.25
<i>Polyporales</i>	38	15.76
<i>Boletales</i>	7	2.90
<i>Canthrellales</i>	5	2.07
<i>Cortinariales</i>	4	1.65
<i>Tricholomatales</i>	4	1.65
<i>Auriculariales</i>	3	1.24
<i>Helotiales</i>	3	1.24
<i>Hymenochaetales</i>	3	1.24
<i>Pezizales</i>	3	1.24
<i>Phallales</i>	3	1.24
<i>Tramelleales</i>	2	0.82
<i>Aphylophorales</i>	1	0.41
<i>Leotiales</i>	1	0.41
<i>Nidulariales</i>	1	0.41
<i>Lycoperdales</i>	1	0.41
<i>Sacromatales</i>	1	0.41
<i>Thelophorales</i>	1	0.41

60 years of age possessed substantial knowhow about their edibility, recipes and medicinal utility, particularly their use as soup for persons suffering with indigestion, jaundice, diarrhoea, fever, physical weakness, muscular pain etc. (Table 1). Because of the importance attached

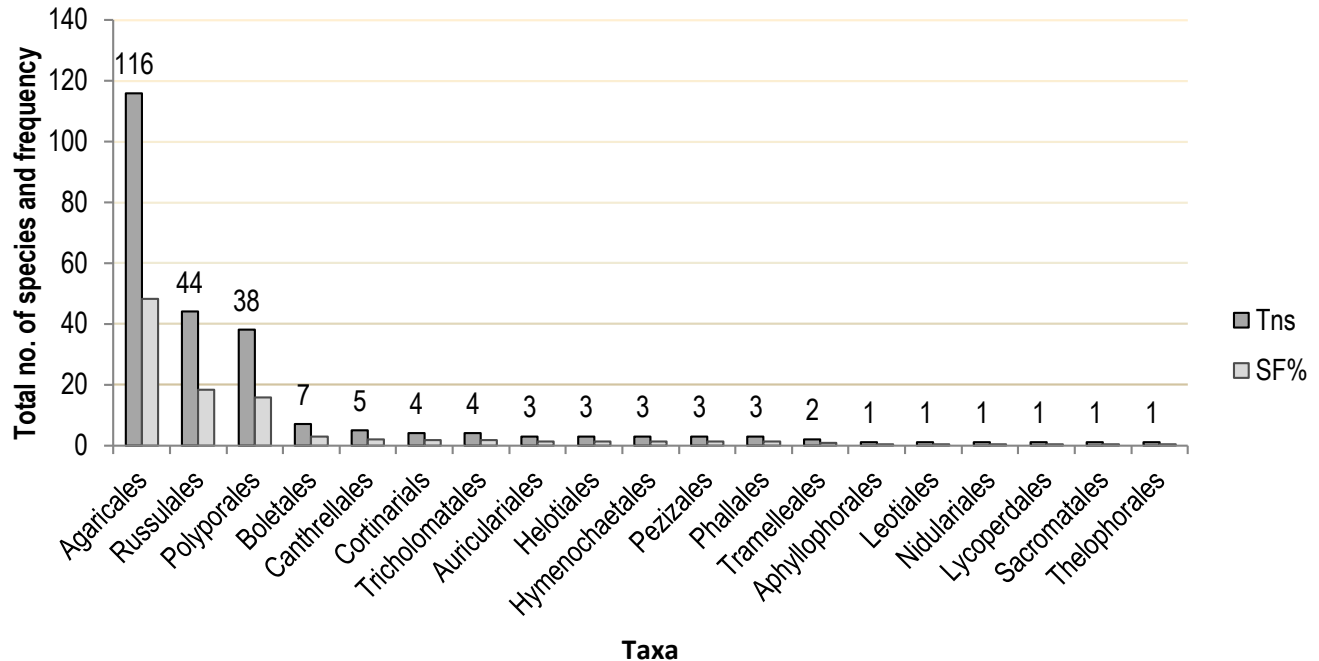


Figure 2. Total No. of species (Tns) and % frequency of groups (SF%) of Ascomycetes and Basidiomycetes.

to these due to their culinary relevance, different species of this genus are popular by variety of their indigenous names in the areas of their occurrence. These are regularly collected during the monsoon season for personal consumption and some of them like *T. albuminosus* (Berk.) R. Heim, *T. eurrhizus* (Berk.) R. Heim, *T. heimii* Natarajan, *T. mammiformis* R. Heim, *T. robustus* (Beeli) R. Heim, *T. schimperi* (Pat.) R. Heim and *T. straitus* R. Heim for commercial sales to local vendors in different parts of the country.

The present study highlights the diversity of mushrooms and their uses in different part in Nepal.

Conclusion

The results of this study revealed that these mushrooms are nutritiously good for consumption. Documentation of food and medicinal use of *Termitomyces* in different social and cultural practices associated with their use in ethno medicinal practices in different parts of the nation is very important to sensitize the communities about the significance of these mushrooms. It plays a vital role in the enrichment of the socio-economic life of the rural as well as urban marginal people. Besides their consumption, the local or indigenous medicine also paves the way for the upbringing new industries. This knowledge provides enough background to appreciate the diversity and their relevance in ecosystem maintenance in general and human welfare in particular. Hence, there is urgent need to take steps to conserve and manage this minor forest product by checking over-

exploitation through enforcement of regulations available under “Convention on International Trade in Endangered Species of Wild Flora and Fauna”.

Conflict of Interests

The authors have not declared any conflict of interests.

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