Wild edible mushrooms depict a dissimilar biogeographical distribution in humid forests of Cameroon.

Abstract
For millennia, wild edible mushrooms (WEM) had always been considered as substantial food and medicinal sources, for local communities, both Bantu and autochthonous peoples. However, few information and sparse data are available on useful mushrooms of Cameroon. A study was undertaken to update the checklist of WEM in humid forests of Cameroon. From mushroom excursions, surveys and inventories, thousand fungal specimens were collected *in situ*, described and identified using key features and references.
Wild edible mushrooms were recruited in three trophic groups. They denoted a dissimilar biogeographical national distribution. Saprophytes and *Termitomyces* were encountered throughout the country; ectomycorrhizal mushrooms occurred in forest clumps, only in three regions: South, Southeast and Southwest. 117 WEM were listed belonging to 17 families and 43 genera, including nearly 22 *Termitomyces*, 32 ectomycorrhizal and 63 saprophyte species. 15 WEM were also claimed to have medicinal properties. This vast mushroom diversity related to various specific habitats and ecological niches. Five fungal groups were considered as excellent edibles. *Amanita* and *Boletus* species were seldom consumed. Most mushroom species were harvested solely for home consumption, with the exception of *Termitomyces*, the only mushroom market. *In fine*, the diversity of WEM was high and poorly known but weakly valorized. To fulfill the Nagoya convention, it is recommended to pursue mycological inventory of macrofungi in Cameroon, including molecular tools and to harness local wild edible saprophyte mushrooms amenable to cultivation.
Key words. ***Amanita*-*Boletus*-Chanterelles-Ectomycorrhizae-Saprophytes- *Suillus granulatus*- *Termitomyces***

Introduction

For millennia, sedentary Bantu and native people of humid forests called Baka in East and Bagyeli in South Cameroon have been eating wild edible mushrooms (WEM), to supplement and diversify their diet (Buyck, 1994, Boa, 2006). In this context, consumption and integral utilization of wild mushrooms constitute long-term traditional and cultural practices. However, communities of wild edible mushrooms (WEM) of Cameroon that represents an important food biodiversity source remain poorly known, weakly valorized and imperceptibly capitalized.
In sub-Saharan Africa, about 2500 species of wild edible macrofungi have been identified (Mueller et al. 2007). A first literature review published usages and relevance of edible mushrooms on diet of local populations of sub-Saharan Africa (Rammeloo et Walleyn, 1993). Several studies reported the abundance of mushroom in Burundi, Ghana and Tanzania (Härkonen et al. 1993, 1994, Buyck, 1994, Townson, 1995,Yongabi et al 2004.). Mushroom significance and usage had been described for the Yoruba community in Nigeria and the pygmies of Central African Republic (Heim, 1936, Oso, 1977, 1975). Data exist on the nutritive value of mushroom species of the Miombo dry forest (Parent & Thoen, 1977; Malaisse, 1997,). Knowledge and utilization of edible mushrooms by Bantu and Bagyeli populations in the rainforests of South Cameroon have been recorded along seasons of the year (Dijk et al. 2003). The nutritive and the medicinal effect of WEM are thus well-known in sub-Saharan Africa since immemorial times. WEM are rich in vitamins (almost the entire B complex, folic acid, ergosterine (pro-vitamin D), thiamin, riboflavin), in minerals such as potassium, phosphorus, cupper, sodium, iron, manganese and calcium, in digestive fibers

(mannoses, polysaccharides, cellulose, chitin fibers), and in proteins of value higher than the best legumes (Buyck, 1996, Oei, 1996).

Wild edible mushrooms are also economically important. For example, in most developed countries, mushroom cultivation of *Agaricus bisporus* (J.F.Lange) Imbach, *A.campestris* (L.) and *Lentinus edodes* (Berk.) Pegler, in North America, Europe and Asia is an important revenue source (Oei, 1996). In these countries, they are as well picked up in autumn by amateur and professional mycologists for selling in large supermarkets and restaurants, thus constituting an old multibillionaire industry in American dollars. In Burundi, women claim rights on portions of land were *Termitomyces* begin to fruit (Buyck, 1994). In Cameroon, old women attentively watch over termite mounds on their land vicinity and forbid anyone to carry away even a piece of mud from it, to prevent *Termitomyces* mushroom running away. Moreover, a particular group of edible mushrooms, symbiotic with roots of some endemic timber species of humid forests (*GIlbertiodendron*, *Microberlinia*, *Tetraberlinia*, *Uapaca*…) have an international worthy market, thus offering an opportunity to develop a mushroom export value chain as well as insuring forest protection and environmental education. Many WEM are used in traditional pharmacopeia in Africa and Asia, to cure blood pressure, tumors and viruses. The edible species *Tremella fuciformis* (Berk.) (locally called "Biyae" in Bulu) and *Tricholoma matsutake* (CV. Head) Sacc (Called Shi'itake in Chinese) cure leukemia in 65% of patients; polysaccharides of *Lentinula edodes* species constitute an immunological stimulant used to cure viral hepatitis and to protect the liver; species of *Ganoderma lucidum* (Curtis ex Fr.) P.Karst and *T. fuciformi*s, have anti diabetis and anti oxydant effects (Oei, 1996, Yongabi et al. 2014).

For Cameroon, the first discoveries of wild edible mushrooms can be traced back up to the 19th century (Hennings, 1895, Heim 1936, 1941, 1942). The first four recognized wild edible species were *Lepiota disciples* (Heim), *Marasmius* spp ; *Mycena* spp and *Lactarius gymnocarpus* (Heim ex Singer) in Ebolowa, South Cameroon. Since then, numerous inventories have been carried out on wild edible macrofungi with or without medicinal effect. These studies had approximately two major periods, from colonial era to the end of the 20th century, and from the first 10 years of the third millennium till nowadays. The objective of this study was to update the checklist of WEM of humid forests in Cameroon, in the bid to contribute to help Cameroon complying with the Nagoya Convention on biodiversity.

2. MATERIALS AND METHODS

2.1. Study sites

Numerous mycological and ethnomycological studies have been carried out on wild edible mushrooms in humid forests of South Cameroon. It is a vast area, below parallel 7th south, with scattered savanna enclaves, small food farms, fallows of *Chromoleana odorata* (L.) R.M.King & H.Rob., and *Imperata cylindrica* (L.) P.Beauv., small cocoa farms, secondary forests at different stages of forest regeneration, skid trails and wood lot parks. It covers six administrative regions, namely, Centre, East, Littoral, North-west, South and South-west (Fig. 1).

Mushroom excursions and inventories were conducted in portions of the dense evergreen humid forests (Letouzey, 1985), including Mount Cameroon mountain forests, Northwest rocky forests (near Fundong), Southwest lowland rainforest, lowland humid forest of the Bipindi-Lolodorf-Akom II triangle, the forest-savanna transition area, along the Obala-Batchenga road, lowland secondary forest of the Centre zone, lowland savannas of the Mbam, highland savannas of Western Highland Plateaus, and lowland Southeast rainforests, near Ngoïla (Fig. 1).

Nearly 40 localities were covered, namely, Abong-Mbang, Abu, Bafia, Bafoussam, Bantoum, Begni, Bipindi, Bintom, Bitchoka, Bityili, Bokito, Buea, Diba, Doumé, Ebebda,

Ebimimbang, Ebom, Ebolowa, Foumban, Fundong, Gribe, Kedia, Koutaba, Lambi, Lobo, Lolodorf, Lomie, Ngat, Ngoïla, Ngovayang, Ngoumou, Nkongabok, Nkongzok, Ntui, Nyangong, Obala,Okola, Tchékos, Tobagne, Touké, Zoka, Zoulabot …

Climate is hot and humid, with ample rainfalls, varying with altitude and latitude. Relative humidity is generally above 80%, year round (Olivry 1986). Geologically, the area varies from Precambrian metamorphic rocks to recent volcanic intrusions (Franqueville 1973). Physico-chemical soil features as well vary from Andosols rich in P to ferrallitic soils, poor in N, P, and K.

2.2. Ethnic groups

During field works, several ethnic groups were encountered, notably, Bantu people of Bakweri, Bakossi, Bamoun, Bamileké, Bassa, Bulu, Ewondo, Eton, Fang, Kom, Konabembe, Maka-kozimé, Manguissa, Ngumba, Osananga, Yambassa, and two autochthonous (often called pygmies) Bagyeli Baka people, living mainly in forest settlements. While the Bantu people live on shift and ing cultivation and collection of Non timber forest products (NTFP) like wild fruits and WEM, during harsh periods, native people live on gathering and hunting NTFP (mostly WEM) as their main subsistence activities.

2.3. Ethnomycology survey

Since 1996 to 2015, surveys were undertaken in numerous villages and forest settlements, with the aid of field assistants. They were selected and trained to assist in conducting ethnomycologycal surveys and to serve as field guides. The survey to assess local perceptions and endogenous knowledge on WEM began with a display of a compendium of identified local WEM. Thereafter, using a questionnaire, an interview was passed individually to a larger number of representative people (men and women as well as youth and old), and to traders in nearby markets with experience on local WEM trading.

2.4. Mushroom collection, description and preservation

Mushroom excursions took place during both rainy seasons (March-June and August-November). Various collecting grounds used by local populations and forest clumps were covered, including undisturbed forest, secondary forests, cocoa plantations, food crop fields, bush fallow, farmers' trails and home gardens. Sometimes, some people spontaneously brought collected specimens for identification during the period the research team spent in a village.

Collected specimens were macroscopically described, photographed in fresh state under daylight, dried for 2-3 days at around 40°C, in a locally made plywood drier. Some specimens were kept fresh in 50% alcohol in a local herbarium. Macroscopic characters described were: the habitus and growth patterns, cap shape and texture, stipe shape, texture, flesh and length, universal and partial veils if present, hymenophora and latex. After drying, microscopic characters of exsiccates were described under microscope by observing spore morphology and volume, spore dimensions, ornamentations, trama and hymenium, basidium and ascum, cystidia, pileus surface, stipe surface, volva dimensions and clamp connections. A database of identified WEM was set up and partial description keys developed for each trophic fungal group using generic characters and specific features, successfully numbered, in cascades.

3. RESULTS

3.1. Diverse habitats

Wild edible mushrooms were collected in various habitats, including: home gardens, young fallow lands, new agricultural fields, small cocoa farms (mostly *Termitomyces microcarpus* (Berk & Broome) R.heim), secondary forests (mostly saprophytes), primary forests outside (saprophytes) and inside the crown of forest clumps (Uniquely ectomycorrhizae).

Substrates also varied including firm soil land, litter (*Armillaria katangensis* Suxmerh.), mud close to rivers, decomposing wood (various saprophytes), termite mounds (Most *Termitomyces*), decomposing palm tree trunks (*Volvariella volvacea* (Bull.) Singer.) and tree roots (Ectomycorrhizae such as *Cantharella* and Lactarius species).

3.2. Dissimilar biogeography

Three trophic groups of wild edible mushrooms were found, with saprophytes and *Termitomyces* occurring all over the country. Symbiotic-tree mushrooms (ectomycorrhizal mushrooms) were found only in the South, East and South-west regions. Ectomycorrhizal mushrooms were exclusively associated with various "Ekop"[1], *Uapaca* tree species, *Gilbertiodendron* spp and *Microberlina bisulcata* A.Chev., respectively. In these spots, they formed small to large forest clumps, sometimes as large as 20 km long stretch X 1-3 km depth, like on the road Lomie to Ngoïla, after crossing the Dja river, in the South-east region.

3.3. Vast abundance and diversity

One hundred and seventeen species of wild edible mushrooms were listed from Cameroon humid forests, belonging to 17 families and 43 genera, including 63 saprophyte, 32 ectomycorrhzal mushroom and *Termitomyces* 22 species (Table 1).

Five groups of wild edible mushrooms were considered excellent edibles, including *Armillaria katangensis*, the 15 *Cantharellus* and *Termitomyces* species, and *Volvariella volvacea* (Bull) Singer. Good edibles were some species of eight genera *Cookeina, Flammulina, Lentinus, Macrolepiota, Marasmius, Psathyrella, Pleurotus,* and *Tremella*. Less collected mushrooms included species of 13 genera: *Collybia, Daldinia, Gymnopilus, Mycena, Pluteus, Polyporus, Ramaria, Russula, Sarcosoma, Schyzopyllium, Sparassis, Stereum,* and *Trametes*. Mushroom species rarely or never collected were genera of *Amanita, Boletus, Craterellus, Gomphus, Lactifluus, Phlebopus, Russula, Suillus,* and *Strobilomyces* species (Table 1).

In general, collected mushrooms were cooked and eaten. Only *Termitomyces* species in year of abundance were sold, fresh or dried, along roadsides and in urban markets. No WEM of Cameroon were sold on supermarkets, restaurants and hotels.

Fifteen species of wild edible mushrooms were also collected for their medicinal properties, including the following genera: *Agaricus, Auricularia, Cookeina, Cyathus, Daldinia, Flavolus, Ganoderma, Pleurotus, Tremella, Termitomyces* and *Russula*.

Only one mushroom species was recognized by populations of the Mount Cameroon area, *Chlorophyllum molydbites* (G. Mey.) Massee, as provoking hallucinations and, sometimes used for mystic incantations by traditional healers (Table 2).

4. DISCUSSION

More than one hundred species of wild edible mushrooms, belonging to three trophic groups, were listed from humid forests of Cameroon. This vast diversity included 58% saprophyte, 28% ectomycorrhizal and 14% *Termitomyces* species. It is the first time that such a high biodiversity in WEM is reported from Cameroon. Our results largely contradict FAO reports (Boa, 2006, Douanla 2007, Tonjock et al. 2011, Ebge et al. 2013). In fact, inventory reports on wild edible mushrooms of Central Africa seem largely inaccurate and deserve to be rapidly updated, with regard to rapid deforestation and genetic erosion of biodiversity in this region. Rural populations of Baleng, near Bafoussam in West Cameroon, seemingly collected a specimen of *Termitomyces titanicus* (Pegler & Piearce), in the mid-1990s. Ten years later when we visited the locality, they claimed not have seen it again since. One of the authors did observe similar trends with the exotic ectomycorrhizal edible mushroom, *Suillus granulates*

[1] The word "Ekop" refered to a group of unnamed Caesalp tree species by forest prospectors (Mouranche and Letouzey 1952.

(L.) Roussel, occurring on pine roots, in Yaoundé and Dschang (Onguene, pers.obs, 2014). Such observations related to the disappearance of wild edible mushrooms were also made in Burkina Faso (Guissou et al. 2008). This phenomenon of mushroom disappearance may suggest early events due to global warming for Cameroon humid forests.

This mushroom inventory was far from complete because it did not include wild edible mushrooms of the Adamaoua and North regions neither exhaustive in several localities. Quite a few collected mushrooms could not be identified to species level. Indeed, our results are limited by lack of a national inventory on wild edible mushrooms of Cameroon, using molecular tools. Therefore, the biodiversity of WEM in Central Africa largely remains ill-known (Onguene 2000, Eyi & Degreef, 2014).

Cameroonian mycological cuisine differed from that of Europeans and Asians. While the latter eat more ectomycorrhizal mushrooms, Cameroon forest-dwellers feed on a mixture of saprophytes, *Termitomyces* and only, two groups of ectomycorrhizal mushrooms. Strikingly, they seldom collected for consumption *Amanita, Boletus* and most ectomycorrhizal mushrooms. Cameroonian WEM basket is nearly similar to that of several sub-Saharan countries such as Burundi, Gabon, Nigeria, DR Congo and Rwanda (Boa, 2006, Degreef et al. 2016, Eyi et al. 2011). Cameroon forest-dwellers feed on three trophic mushroom groups, thus allowing diet complementation and diversification for local populations, year round and, full harnessing of ecosystem continuum in various habitats. Hence, mushrooms' exploitation fosters local populations' strategy for sustainable natural resource management.

The major interest in mushrooms lies in their matchless flavor. It is the essential reason for their success for gourmets and gastronomes. But their palatability is differently appreciated. Four criteria can be used to evaluate mushroom's palatability: Consistency, aroma, taste and aspect (Becker, 1945, Buyck, 1994). Excellent mushrooms have the four qualities. When one of these qualities is missing, the mushroom is qualified as good comestibles. Those with two qualities are ordinary mushrooms and those with only one quality are hardly edible. In humid forest of Cameroon, five mushroom groups from local populations' perceptions are considered as excellent comestibles, notably, the 15 *Cantharellus* and all *Termitomyces* species, the straw mushroom, *Volvariella volvacea* and the saprophyte *A.katangensis*. Our results differ from those of earlier workers of Central African Republic (Kouagou et al. 2016). Several saprophyte species were considered as good comestibles like saprophyte species of the following seven genera *Auricularia, Cookeina, Lepiota, Lentinus, Marasmius, Pleurotus, and Tremella*. Ordinary edible mushroom species included the majority of species (Table 1). One species, *Favolus brasilensis* (Fr.) Fr., the Brazilian polypore, locally called « Ongo », with a slim and tough flesh, not modified upon cooking, was mostly used as a potage during wet evenings. In general, *Amanita, Boletus* species and most ectomycorrhizal mushrooms are seldom collected for consumption by local populations. Autochthonous pygmy people considered that changing color of Boletes after bruising or exposure to air is an obvious sign for their strong toxicity. Such a remark was also claimed in Tanzania (Härkönen, 2002). Toxicity of local mushrooms has been a quest throughout our inventories. During three years of intensive mushroom excursion in the same plots, both authors did not record toxic or poisonous mushroom (Onguene & Kuyper, pers.obs. 2010). Only *C.molybdites* was strongly claimed as a poisonous mushroom by local Bakweri people in the Mount Cameroon region. In the same area, *C. molybdites* was also considered to provoke some deteriorations and hallucinations, or even used for mystic practices by traditional healers (Tonjock et al. 2011). When kept in 50% alcohol, this whitish large mushroom became murky and the solution totally dark.

The habitats and ecological niches of wild edible mushrooms highly varied. For example, the straw mushroom grows only on decomposing palm oil trunk; the unique habitat of *Pleurotus*

tuber-regium (Fr.) Fr is its grayish sclerotium; *A. katangensis* is readily identified in the field as an under-wood mushroom growing on a whitish velvety mycelia carpet; chanterelles and *lactarius* species grow symbiotically on roots of Ceasalps or *Uapaca*'s roots only in specific forest clumps, in rain forests of South, Southeast and Southwest regions (Onguene, 2000, Onguene and Kuyper 2001, Ba et al. 2014, Ebenye et al. 2016). Other edible ectomycorrhizal mushrooms not eaten by local populations of Cameroon were also collected and described from forest clumps, independently of soil types and climate conditions. This attests the strong ecological specificity of ectomycorrhizal edible mushrooms with endemic tree species: no mushrooms, no trees. This simple ecological principle should serve for environmental education in Central Africa in order to boost humid forest conservation and environmental education. Such a pre-emptive action is required since there is no sound technical approach available for artificial regeneration of endemic ectomycorrhizal timber species of tropical humid forests.

Edible ectomycorrhizal mushrooms are potentially high in number in Cameroonian humid forests, largely unknown, though. In this case, 15 *Cantharellus* species are highly appreciated. Local Bantu and Pygmy people systematically eat all chanterelles and give them several local names (in "Bulu Cameroonian language") according to substrate, habitat and taste, namely "Bingobindong, Otsetsa, Otoe, Mebem, Otoye mebem". In a systematic plot sampling for three years, more than 1000 ectomycorrhizal fungal species were collected and nearly 200 species identified from ectomycorrhizal forest clumps. However, most of them are not collected and eaten by local people like species of the following genera *Afroboletus, Amanita, Boletus, Craterellus, Lactarius, Lactifluus, Russula, Tuboseat*a… consumed elsewhere in Africa, Europe and Asia, though (Onguene 2000, Boa 2006, Ebenye et al. 2016). In the context of preventing food insecurity in the midst of poverty, these symbiotic mushrooms could serve as an alternative food source for local populations. In addition, wild edible ectomycorrhizal mushrooms could spur a new value chain in exports of WEM from humid forests of Cameroon, thus providing additional income to poor rural farmers. One kilo of Chanterelle is worth slightly 19 650 CFA francs (30€) in Europe. Hence, a new wild edible mushroom value chain has potential to contribute to forest preservation and ecotourism.

Termite-mutually associated mushrooms, *Termitomyces,* are highly valued by local populations. All *Termitomyces* species are systematically collected and eaten after cooking. Across the country, these species depicted a particular size distribution along ecosystems. Small size *Termitomyces* species prevailed in forest ecosystem while middle size *Termitomyces* species abounded in grass savannas of Highland Plateaus of West Cameroon. (Mossebo et al. 2009). The large sized *Termitomyces schimperi* (Pat.) R. Heim species showed a strong zonal specificity. They occurred only in the forest-savanna transition road, between the cities of Obala and Ebebda (Fig. 1). *T. schemperi*, have been largely observed in sub-Saharan Africa, notably in Benin, Burkina Faso, Gabon, Mozambique, Central African Republic, DR Congo, Senegal, The Gambia, Zambia and Zimbabwe (Walleyn & Rammeloo, 1994, Uaciquette et al. 1996, Boa et al. 2000, Yorou et al. 2002, Eyi et al. 2011, Degreef et al. 2016). In Cameroon it has been observed so far only in a very restricted area, the forest–savanna transition zone, along the Obala-Ebebda road. Confining of *T. schemperi* was also observed in the Kerala state in West India (Kurun and Sridhar 2013). The symbiosis of fungus-growing termites and their associated mutualistic fungi, *Termitomyces,* has a single African origin and secondary domestication of other fungi or reversal of mutualistic fungi to a free-living state has not occurred, thus leading to co-evolution or co-cladogenesis (Rouland-Lefèvre et al. 2002; Aanen et al. 2002, 2007, Wade 2007). Thus, *T. schemperi* together with its associated termite, *Termes bellicosus,* or *Macrotermes michaelsen* (Westhuizen and

Eicker, 1991) developed a strong local ecological niche, likely related to particular rainfall patterns.

Wild edible mushrooms collected are readily eaten after cooking owing to their unpredictability in time and nature. However, *Termitomyces* species are harvested, dried and sold by women and children along road sides and in urban markets. In urban markets of Yaoundé, one specimen of *T. schemperi* is sold fresh 100 – 200 CFA francs (Onguene, Obs.pers., 2014). Hence, the local market of WEM is dominated by *Termitomyces* species. Yet, supermarkets, restaurants and hotels seldom sell local WEM. *Termitomyces* species are also sold fresh on road sides and dried in markets in other cities in sub-Saharan Africa (Buck, 1994; Yorou et al. 2002).

The majority of wild edible and medicinal mushrooms are saprophytes. They belong to 31 genera and 63 species, all potentially amenable to cultivation. Accounting for the high agricultural potential of Cameroon, this plethora of wild edible saprophytes implies a huge potential in valorization of the numerous agricultural wastes, such as maize cobs, rice straw, cotton crabs, sugar cane trashes or coffee kernels. Therefore, edible saprophyte species could have immediate effects on job creation, trading and increasing agricultural revenues to rural women and young unemployed people (Martinez-Carrera et al. 2001). In Vietnam, the straw mushroom is integrated to rice production (Boa, 2006). But, there is still a large deficiency in mushroom spawn, thus limiting cultivation of wild saprophyte mushrooms and valorization of agricultural wastes in Cameroon.

Some species of wild edible mushrooms can have medicinal properties. In this study, 15 such species were recorded as having medicinal virtues. In general, this function always was considered secondary and information detained only by few interviewers. In tropical Africa, usages and practices of WEM in traditional pharmacopeia involve cosmetics, dyes, fumigation of traditional attic, and to tie jewelry (Rammeloo and Walleyn, 1994; Dijk et al. 2003). For Bantu people, *P. tuber-regium* sclerotium could improve lactation in breast feeding women and heals heart palpitations. In East Cameroon, these sclerotia are collected in the forest, and sold by Konambembe Bantu and Baka pygmies to Nigerian traders who export them in Nigeria for trading to traditional healers. In Nigeria and Madagascar, *P. tuber-regium* sclerotium is used as anti poisonous remedy, to make charms for young ladies and to heal chest pains. In Burundi, termite nests are used to heal heart attack (Buyck 2004). *Cookeina sulpices* (Berk.) Kuntze, *C. tricholoma* (Mont.) Kuntze and *Termitomyces lignilosius* can also heal ear inflammation and mumps. Other WEM also relieve numerous pains and aches but information was not released. Our results are consistent with earlier workers (Hem, 1936; Oso, 1977; Walleyn and Rammeloo, 1994; Tonjock et al. 2013). In Benin, Nigeria and Madagascar, several species indicated in Camero Oei, 1996;on, seemed to prevent or even heal many diseases such as ear inflammation, mumps, rheumatism, women infertility, even cancers (Oei, 1996).

Conclusion

In fine, diversity and abundance of useful mushrooms in humid forests of Cameroun are high, yet poorly known and weakly valorized. To fulfill the Nagoya convention signed by Cameroon, it is recommended to pursue mycological inventory of macrofungi of Cameroon, including molecular tools and, to harness local wild edible saprophyte mushrooms amenable to cultivation.

Acknowledgements

The Government of Cameroon through the Institute of Agricultural Research for Development (IRAD) and The Netherland Organization for the Advancement of Science (NWO) financed this study through its Program on biodiversity of disturbed ecosystems. Mr Ambassa-kiki Leopold, senior soil scientist, English-proofed one version of the manuscript.

Numerous rural women and field guides provided field assistance. Two anonymous reviewers are acknowledged.

Literature review

Aanen DK, Eggleton P, Rouland-Lefevre C et al.. 2002. The evolution of fungus-growing termites and their mutualistic fungal symbionts. *Proceedings of the National Academy of Sciences of the United States of America*, 99(23):14887

Aanen DK, Ros VID, Licht HHF et al. 2007. Patterns of interaction specificity of fungus-growing termites and *Termitomyces* symbionts in South Africa. *BMC Evolutionary Biology* 7:115 doi:10.1186/1471-2148-7-115

Ba AM, McGuire KL, Diédhiou AG 2014. Ectomycorrhizal symbioses in tropical and neotropical forests. CRC Press, Boca Ratoon

Becker G 1945. Les critères de classification qualitative des champignons comestibles. 1945. Supplément à la Revue de Mycologie. Tome X (1) : 1-9

Boa E. 2006. Produits forestiers non ligneux 17. Champignons comestibles sauvages. Vue d'ensemble sur leurs utilisations et leur importance pour les populations.

Buck B. 1994. Ubwoba: Les champignons comestibles à l'Ouest du Burundi. Administation générale e la cooperation au développement. Rue du Trone, 4-1050, Bruxelles. Publication Agricole N°34

Buyck, B., D. Thoen and R. Walting. 1996. Ectomycorrhizal fungi of the Guinea–Congo region. Proc. R. Soc. Edinb. 104: 313–333.

Buyck, B. 2008. The edible mushrooms of Madagascar: An evolving enigma. *Econ. Bot.* 62(3): 509-520.

Degreef J, Demuynck L, Mukandera A, Nyirandayambaje G. et Al. 2016. Wild edible mushrooms, a valuable resource for food security and rural development in Burundi and Rwanda. Biotechnologie, Agronomie, Société et Environnement/Biotechnology, Agronomy, Society and Environment. 1370-6233 1780-4507

Dijk HV, Onguene AN, Kuyper TH W 2003. Knowledge and utilization of edible mushrooms by local populations of the rain forest of South Cameroon. Ambio 32 (1): 15-23

Douanla-Meli Clovis. 2007. Fungi of Cameroon: Ecological diversity with emphasis on the taxonomy of Non-gilled Hymenomycetes from the Mbalmayo forest reserve. Bibliotheca Mycologica, Publisheb by Borntraeger Gebrueder 410 p

Ducousso M., Ba A.M. & Thoen D. (2003). Les champignons ectomycorhiziens des forêts naturelles et des plantations d'Afrique de l'Ouest: une source de champignons comestibles. *Bois et forêts des tropiques*, 275(1), 51–63.

Ebenye HMC, Adrien Taudière, Niang N, Ndiaye C, Sauve M, Onguene NA, et al. 2016. Ectomycorrhizal fungi are shared between seedlings and adults in a monodominant *Gilbertiodendron dewevrei* rain forest in Cameroon. Biotropica. DOI: 10.1111/btp.

Egbe EA, Tonjock RK, Ebai MT, Nji T, Afui MM. 2013. Diversity and distribution of macrofungi (mushrooms) in the Mount Cameroon region. J. Ecol. Nat.Environ 5(10): 318-334

Eyi Ndong, H. 2009. Etude des champignons de la forêt dense humide consommés par les populations du nord du Gabon. PhD thesis, Université Libre de Bruxelles: 271 pp.

Eyi Ndong, H. & Degreef J. 2010. Diversité des espèces de *Cantharellus*, *Lentinus* et *Termitomyces* consommées par les Pygmées du Nord du Gabon. *In*: van der Burgt, J., van der Maesen, J. & Onana, J.-M. (Eds). *Systématique et Conservation des Plantes africaines.* Kew, Royal Botanic Gardens: 133-141.

Eyi-Ndong H., Degreef J. & De Kesel A. 2011. *Champignons Comestible des Forêts denses d'Afrique centrale Taxonomie et Identification*. Abc Taxa, 10, 254pp.
FAO 2004 Non wood forest products. Wild edible fungi: a global overview of their use and importance . Boa ed. FAO publications, Rome, Italy
Franqueville A. 1973. Atlas regional sud-ouest .République Uie du Cameroun. ORSTOM, Yaoundé, Cameroun
Guissou K.M.L., Lykke A.M., Sankara P., Guinko S., 2008. Declining wild mushroom recognition and usage in Burkina Faso. Econ. Bot., **62**(3), 530-539.
Kouagou YR, Tsopmbeng GN, Njouonkou AL 2016. Diversité et ethnomycologie des champignons sauvages utilisés dans la préfecture de la Lobaye en République Centrafricaine. Bull. sci. environ. biodivers. 1: 30-38
Karun NC, Sridhar KR 2013. Occurrence and distribution of *Termitomyces* (Basidiomycota, *Agaricales*) in the Western Ghats and on the west coast of India. Czech Mycology 65(2): 233–254
Härkönen 1994 Härkönen, M., Saarimäki, T. & Mwasumbi, L. 1994. Edible and poisonous mushrooms of Tanzania. *Afr. J. Mycol. Biotech.* 2(2): 99-123.
Härkönen, M., Niemelä, T. & Mwasumbi, L. 2003. Tanzanian mushrooms - Edible, harmful and other fungi. *Norrlinia* 10: 1-200.
Heim, R. 1936. Aperçu sur les champignons toxiques et comestibles des colonies françaises. *In*: Curasson G. (Ed.) *Pathol. Exot. Vétérin. Comp.* 3: 1-31.
Heim, R. 1941. Etudes descriptives et expérimentales sur les agarics termitophiles d'Afrique tropicale. *Mém. Acad. Sc. Inst. Fr.* 64: 1-74.
Heim R .1942. Nouvelles études descriptives sur les Agarics termitophiles d'Afrique tropicale. Archives du Museum Naturel d'Histoire Naturelle. Série 6 (18): 107-166
Hennings, P. 1895. Fungi Camerunenses I. Bot. Jahrb. Syst. 22: 72-111.
Letouzey R. 1985. Notice de la carte phytogéographique du Cameroun au 1:500 000 . Institut de la carte internationale de la végétation, Toulouse, France
Letouzey, R. & R. Mouranche 1952. Ekop du Cameroun. Publ. #4. Centre Technique Forestier Tropical. Nogent S/Marne, France.
Malaisse, F. 1997. Se nourrir en forêt claire africaine. Approche écologique et nutritionnelle. Gembloux, Les presses agronomiques & Wageningen, CTA: 384 pp.
Malaisse, F., De Kesel, A., N'Gasse, G. & Lognay G. 2008. Diversité des champignons consommés par les pygmées Bofi de la Lobaye en République Centrafricaine. *Geo-Eco-Trop* 28: 1-11.
Martínez-Carrera D. 2001. Current development of mushroom biotechnology in latin americamicologia aplicada international, 14(2), 2002, pp. 61-74
Mossebo, D.C., Njouonkou, A.L., Piatek, M., Kengni Ayissi, B. & Djamndo Djase, M. 2009. *Termitomyces striatus* f. *pileatus* f. nov. and f. *brunneus* f. nov. from Cameroon with a key to Central African species. *Mycotaxon* 107: 315-329.
Mueller GM, Schmit JP, Leakock PR, Bucyk B et al. 2006. Global diversity and distribution of macrofungi. Biodivers Conserv (2007) 16:37–48 DOI 10.1007/s10531-006-9108-8
Oei, P. 1996. Mushroom Cultivation : with special emphasis on appropriate techniques for developing countries. Leiden Tool, The Netherlands.
Olivry J.C, 1986. Fleuves et rivières du Cameroun. Collection Monographes hydrologiques d'ORSTOM 9. Paris, France
Onguene, A.N. 2000. Diversity and Dynamics of mycorrhizal association in tropical rain forest with different disturbance regimes in South Cameroun . Ph.D Thesis Wageningen

University, Tropenbos. Cameroon series 3, Posen en Louijen, Wageningen, the Netherlands, NWO, ISBN 90-5808-293-8, 167p.
Onguene, N.A. and Kuyper, 2001. Diversity and abundance of mycorrhizal association in the rain forest of South Cameroon. Tropenbos Cameroon Programme. Forest Ecology Management. 140 : 277-287.
Oso, B.A. 1975. Mushrooms and the Yoruba people of Nigeria. *Mycologia* 67(2): 311-319.
Oso BA 1977. Mushrooms in Yoruba mythology and medicinal practices. Econ. Bot. 31: 367-371
Rammeloo J, Walleyn R. 1993. The edible fungi of Africa South of the Sahara. A literature survey. Scripta Botanica Belgica 5.1-62
Rouland-Lefevre C, Diouf MN, Brauman A, Neyra M. 2002. Phylogenetic relationships in *Termitomyces* (Family Agaricaceae) based on the nucleotide sequence of ITS: A first approach to elucidate the evolutionary history of the symbiosis between fungus growing termites and their fungi. *Molecular phylogenetics and evolution*. 22(3):423-429.
Tonjock RK, Ebai M, Tabi, AfuiM, Mih, Egbe AE, Njouonkou L, Nji TM. 2011. Ethnomycological studies of edible and medicinal mushrooms in the Mount Cameroon region (Cameroon, Africa). Int. J. Med. Mushrooms. 13(3):299-305
Uaciquete, A., Dai, M.d.L. & Motta, H. 1996. Distribução, valor economico e uso sustentavel do cogumelo comestível em Moçambique [Distribution, economic value and sustainable use of edible mushrooms in Mozambique]. Grupo de Trabalho Ambiental [Environmental Working Group]. Maputo, Mozambique.
Van Der Westhuizen, G.C.A; Eicker (1991). "The ‘omajowa’ or ‘termitenpilz’ termitomyces sp. (agaricales) of Namibia". South African Journal Of Botany 57 (1): 67–70
Walleyn, R. & Rammeloo, J. 1994. The poisonous and useful fungi of Africa south of the Sahara. *Scripta Bot. Belg.* 10: 1-56.
Yongabi K, Agbo M, Martines-Carrera M. 2004. Ethnomycological studies on wild mushrooms in Cameroon, Central Africa. Micologia Applicad International. 16(2): 34-36
Yorou N.S., De Kesel A., Sinsin B. & Codjia J.C. (2002). Diversité et productivité des champignons comestibles de la forêt classée de Wari-Maro (Bénin, Afrique de l’Ouest). *Systematic and Geographic of Plants*, 71, 613–625.
Wade MJ (2007) The co-evolutionary genetics of ecological communities. *Nature Reviews Genetics*, **8**, 185–195.

List of figures, tables and photographs

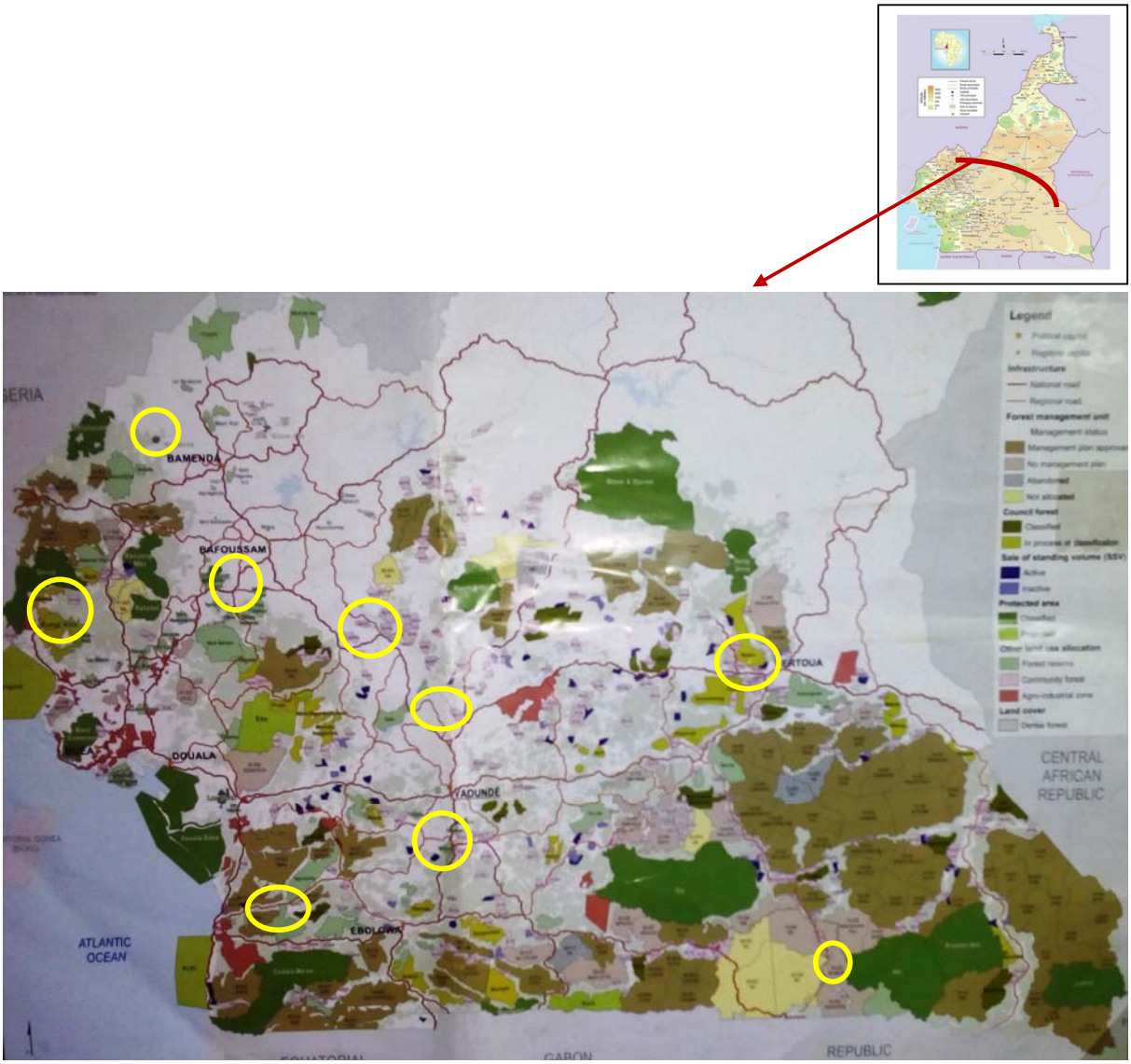

Figure 1: Map of localization sites of mushroom excursions in Grand-South Cameroon (Yellow circles)

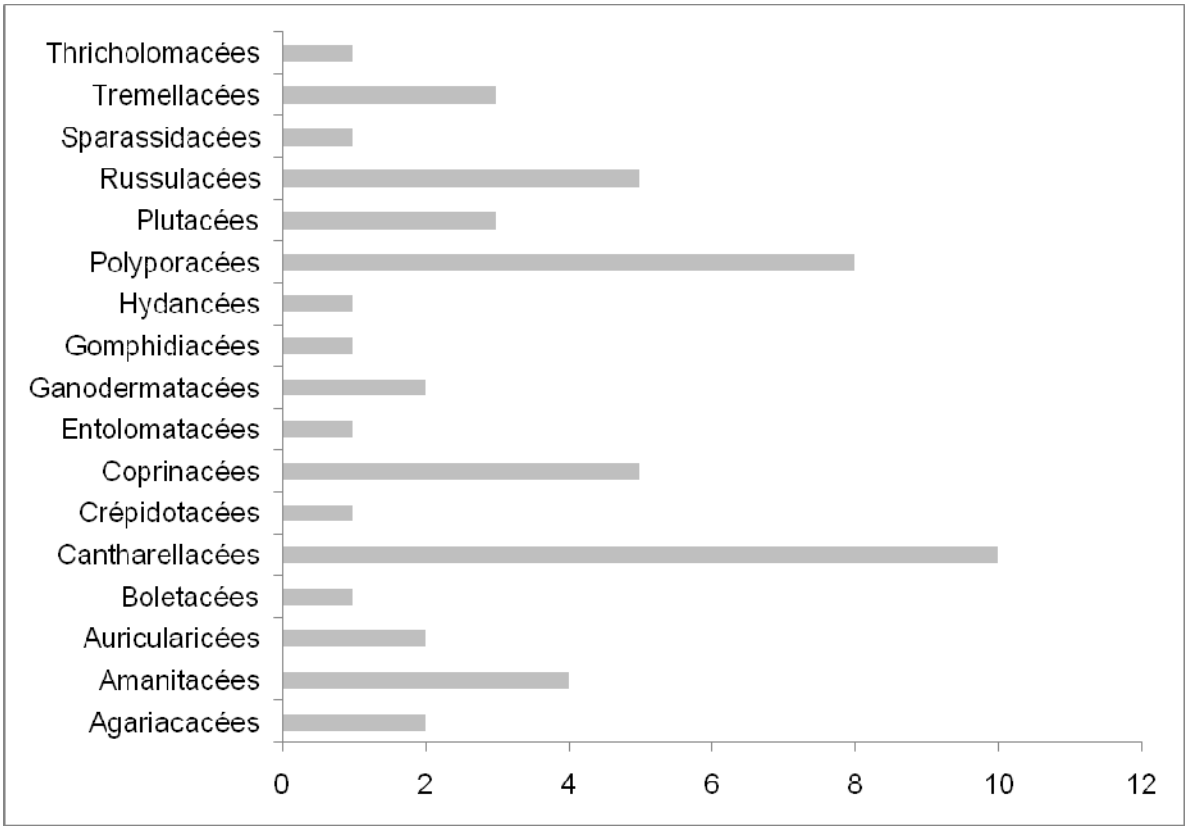

Figure 2: Relative abundance of species of wild edible mushrooms of humid forests of Cameroon

Table 1: Non-exhaustive checklist of wild edible mushrooms of humid forest of Grand-South Cameroon

63 saprophyte species *Agaricus goossesens ; A. silvatic (*Schaeff.*) ; Armillaria camerunensis* (Henn.*); Auricularia auricula-judae* (Bull.) J.Schröt.* *; Auricularia cornea* (Ehrenb) *; A. polytricha* (Mont.) Sacc. * *; Chlorophyllum molybdites* (G. Mey.) Massee ** *; Collybia cf. allegretti; Cookeina sulpices* (Berk.) Kuntze *; C. tricholoma* (Berk.) Kuntze *; C. occidentalis*; C. brunneofibrollus; Coprinus comatus; Cyathus striatus* (Huds.) Willd. *; Dacryopinax spathularia* (Schwein.) G.W.Martin*; Daldinia concentric* (Bolton) Cesati & de Notaris *; Dictyotophora spp. Flammulina velutipes* (Curtis) Singer*; Flavolus sp 1*, F. brasiliensis* (Fr.) Fr*; Lepiota clypeolaria* (Pers.) Gray *; Ganoderma applanatum* (Pers.) Pat. * *; G. lucidum* (Curtis ex Fr.) P.Karst. *; Gerronema hungo* (Henn.) Degreef&Eyi; *Grifola frondosa* (Dicks.) Gray *; Gymnocarpus aureobrunneus ; G. zenkeri* (Henn.) Singer ; *Laetiporus sulphureus* (Bull) Murril*; Lentinus brunneofloccosus* Pegler*; L. polychrous* (Lév.) Singer*; L. sajor-caju* (Fr.) Fr*; L. tigrinus* (Bull.) Fr.*; Lepiota sp 1; L. cristata* (Bolton) P. Kumm. *; L. disciples; Macrolepiota procera* (Scop) Singer*; Marasmius katangensis* Singer *; M. hungo; Mycena aschi; Mycena bipindensis; Psathyrella arrombonatus ; P. candolle* (Fr.) Maire *; P. cystidiosus ; P.citrinopileatus* Singer *; P. flabellatus* (Berk. & Broome) Sacc.*; P. ostreatus* (Fr.) P. Kumm.*; P.* cf. *ovaticystis; P. pulmonarius* (Fr.) Quél.*; P. tuber-regium** (Fr.) Fr*; P. squarrosolus* 'Mont.) Singer*; Pluteus cf.griseoroseus* Beeli*; Sarcosoma globosum* (Schmidel) Rehm*; Schyzophyllum commune* Fr.,*; Sparassis crispa* (Wulfen) Fr.,*; Stereum hirsutum* (Willd.) Pers. *; Trametes spp ; Tremella fuciformis* Berk.**; T. mesenterica* Retz. **; T. versicolor* Berk.**; Volvariella caesiotincta* P.D. Orton,*; V. esculenta* (Massee) Singer*; V. gloiocephala* (DC.) Vizzini, Contu & Justo*; V. volvacea* (Bull) Singer
22 Termitomyces species*** *Termitomyces. aurantiacus* (R. Heim) R. Heim*; T. clypeatus* R.Heim*; T. filiginosus* Heim *; T. entomoloïdes* Heim; *T. globullus* (Heim & Br.) Heim*; T. heimii* Natarajan*; T. lanatum ; T. Le Testui* (Pat.) R.Heim*; T. mammiformis* Heim*; T. mboudaeina; T. microcarpus* (Berk & Br.) Heim*; T. pantherina (*Nov*); T. reticulates* Van der Wedth & Ecker; *T. robustus* (Beeli) Heim*; T. schimperi* (Pat.) R.Heim*; T. striatus f. grisumboïdes* (Beeli) Heim*; T. striatus f. bibasidiatus* Mossebo; *T. subclypeatus* Mossebo; *T.tylerianus Otieno; T. Titanicus* (Pegler & Pierce); *T.subunkwonni* Mossebo
32 ectomycorrhizal species *Amanita vaginata* (Bull.) Lam.*; A. rubescens* (Pers.: Fr.) Gray.*; Cantharellus camerunensis ; C. cibarius var roseocarius ; C. congolensis* Beeli*; C. dichrous; C. miniatescens* Heinem*; C. densifolius* Heinem*; C. floridulis; C. isabellinus* Heinem*; C. luteopunctatus* (Beeli) Heinem. *; C. miniatescens* Heinem*; Cantharellus microcibarius; C. platyphyllus; C. pseudocibarius ; C. luteopuctatus* (Belli) Heinem*; C. rufopunctatus* (Beeli) Heinem*; Craterellus cornucopioïdes* (L.) Pers.*; C. crispus* (Bull.) Berk.*; Gomphus brunneus* (Heinem.) *; Lactarius gymnocarpus* Heim*; L. longipes* Verbeken*; L. rubroviolascens* R.Heim*; Lactifluus gymnocarpoides* (Verbeken) Verbeken*; L. piperatus* (L.) Roussel; *Phlebobus sudanicus; Russula cellulata*; R. meleagris* Buyck **; R. pseudocarmina* Buyck ; *R. striatoviridis *; Suillous granalatus* (L.) Roussel*; Strobilomyces strobilaceous* (Scop.) Berk.

NB: * Species with medicinal potentials, based on local populations and autochthonous people. **This species was cited as a tasty edible mushroom in Ngoumou, near Yaoundé but Bakweri populations in Mount Cameroon deny its appetence because it causes hallucinations

and deteriorations and is used by traditional healers for incantations. ***Some Termitomyces species, with the exception of *T. microcarpus*, are used to drive away bad spirits, to heal rheumatisms and paralysis, and as love charms. ****The sclerotium of *Pleurotus tuber-regium* is used as a love charms, antipoison and chest pain.

Table 2: Some wild edible mushrooms with medicinal properties according to local populations

Species of wild edible mushrooms involved	Types of treatments in traditional medicine	Other usages
Auricularia auricular-judae	Reinforce immune system	Aphrodisiac
Chlorobium molybdites		Causes deteriorations and provokes hallucinations and is used for mystic incantations by Nigerian traditional healers
Cookeina sulpices	Treat ear inflammation and mumps	
C. tricholoma		
Coprinus spp	treat woman infertility	
Daldinia concentrica	Heals skin diseases and scars	Used for dyes and decoration
*Dyctophora indusiata*Vent.	Causes whitfow	Apparently toxic and aphrodisiac Not edible
Flavolus spp		Provokes hallucinations and used for mystic incantations
Ganoderma spp	Treats cancer and heart problems as tea	Used for dyes and decoration
Lentinus squarrosolus	Heals baby navel	
Lepiota cristata	Heals convulsions in young children	
Pleurotus tuber-regium	Improve lactation of breastfeeding women ; the sclerotium heals heart palpitations Heals paralysis	Love charm with sclerotium ; talisman made by Nigerian traditional healers
Russula spp	Heals hemorroids and children rib pains	
Termitomyces sp	Treat ear inflammation and rheumatism pains	Chase bad spirits
Trametes versicolor	Treat internal growth and baby navel	

Photo n°1: Photograph of some wild edible of humid forest of Cameroon

<table>
<tr><td colspan="4">Wild edible mushrooms of humid forest of Cameroon by trophic group
From top to bottom: Saprophytes, Termitomyces and Ectomycorrhizae</td></tr>
<tr><td> 
Armillaria camerunensis</td><td> 
Sarcosoma globosum</td><td> 
Ganoderma applanum</td><td> 
Volvariella volvacea</td></tr>
<tr><td> 
Termitomyces schimperi</td><td> 
Termitomyces striatus</td><td> 
Termitomyces robustus</td><td> 
Termitomyces microcarpus</td></tr>
<tr><td> 
Cantharellus rufopunctatus</td><td> 
Suillus granalutus,</td><td> 
Lactarius gymnocarpus</td><td> 
Cantharellus miniatescens</td></tr>
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