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Edible mushrooms of the Zambezian woodland area A nutritional and ecological approach

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The present study was conducted near Lubumbashi (Congo Dem. Rep., formarly Zaire) which is situated in the Zambezian region. Harvesting of sporophores and conducting inquiries amongst the villagers allowed to record 39 taxa of edible mushrooms. For each specimen, vernacular names are noted and ecological data are presented. The phenological sequence for 26 of these fungi is also proposed for this region. Lastly, the food value of 9 commonly consumed species is evaluated on the basis of their amino acids and mineral compositions.
Keywords. Edible fungi, amino acids, mineral composition, Katanga, Congo (Zaire), Zambezian Region.

Champignons comestibles de l'aire des forêts claires zambéziennes : approche nutritionnelle et écologique. Cette étude fut menée dans les environs de Lubumbashi (Rép. dém. Congo, ex Zaïre), ville située en Région zambézienne. Les récoltes de sporophores et les enquêtes menées auprès des villageois ont permis de recenser 39 taxons de champignons comestibles. Pour chaque specimen, les noms vernaculaires sont cités et des données écologiques sont présentées. La séquence phénologique de 26 de ces champignons est également proposée pour cette région. Enfin, la valeur alimentaire de 9 espèces communément consommées est évaluée sur base de leur composition en acides aminés et en minéraux.
Mots-clés. Champignon comestible, acide aminé, composition minérale, Katanga, Congo (Zaïre), Région zambézienne.

INTRODUCTION

As stated in a recent literature survey about the use of macromycetes in the diet of local populations in Africa (Rammeloo, Walleyn, 1993), fungi are used throughout the whole of tropical Africa. Cultivation of macromycetes in Africa is negligible for the moment and the sporophores are simply picked in nature. With the increase of the population the culture could become important, especially for the food supply of very densely populated areas (Rammeloo, Walleyn, 1993). The African situation evolves to the situation of some Asian countries, as described by Gilbert and Robinson (1957): "The greatest need for added protein or fat, or food generally, is in the overpopulated lands of the Orient where the diet is limited to certain foodstuffs by religion or compelling tradition. Efforts to improve diets of such peoples by the introduction of novel foods have met with great resistance from these needy populations. Almost invariably they refuse to eat other foods or change their food habits". The present study describes the existing situation putting emphasis on the importance of the mushrooms collected in the wild, and more particularly the nutritional and ecological aspects of this harvest.

Ethnomycological studies show inevitably differences between populations primarily due to cultural traditions. Mushrooms are much more used by some tribes than others; even within a "mushroom eating" tribe, personal differences exist (Parent, Thoen, 1977). Some differences are linked to religious belief, others to the surrounding dominant vegetation type or to the combination of several factors.

Scientific literature about fungal species eaten by local populations is not abundant. Data for tropical Africa have been brought together by Rammeloo and Walleyn (1993). From this list, it is obvious that the information has to be considered with a lot of criticism. As already pointed out this is mainly due to the lack of knowledge of tropical fungi in general, and African fungi especially, to the very high species number involved (4.5 to 10 times more fungi than spermatophytes, the proportion of macro- and micromycetes being strongly different from a region to another), to the lack of mycologists working on tropical floras, and to the mycophobia of a vast number of European immigrants in Africa ! The best known regions are the former French colonies, notably Madagascar, Central African Republic, Gabon, Guinea and Côte d'Ivoire mainly explored by Heim (1936, 1938, 1955, 1964), the former Belgian colony (Zaire) and protectorates (Rwanda and Burundi) covered by the "Flore illustrée des champignons d'Afrique centrale", Malawi and Zambia where scientists with ethnomycological interests were active (Williamson, 1973, 1975; Morris, 1984, 1987, 1990; Piearce, 1981a, 1981b, 1987; Pegler, Piearce, 1980). The Zambezian woodland is extremely rich in mycorrhiza-forming species which are consumed in very high quantities (Parent, Thoen, 1977). The most comprehensive information for Africa comes from the Zambezian Region.

Publications on this topic mostly concern very incomplete inventories. Only in a few occasions the food value has been studied in more or less detail.

In this introductory study the species eaten have been catalogued, their vernacular and scientific names have been noted and a special emphasis has been put on ecology and phenology. The nutritional value of the most important species consumed has been determined by chemical analyses.

The region studied

The whole of the Zambezian Region belongs to Walter's tropical summer-rainfall zone. The macroclimate is essentially characterized by a wet season (from 3 to 6 months) alternating with a dry season (from 5 to 8 months). The mean annual precipitation varies between 540 and 1810 mm, with a mean value of about 1100 mm. The mean annual temperature varies from 17.2 to 26.4°C, the average being about 22°C. The temperature is the lowest at the beginning of the dry season; in the southern part of the Zambezian Region, diurnal minima of 0°C occur periodically.

In the Lubumbashi region, where our observations were made, the wet season occurs in the period from November till March and the dry season from May till September. October and April are both transition months. The climate belongs to Köppen's Cw type, characterized by a dry season lasting 186 days a year on average. The mean annual precipitation is about 1,270 mm but is very variable from year to year, varying from 716 to 1,758 mm. On average 118 rainy days occur yearly. About 50% of the daily precipitation is less than 5 mm, representing together less than 10% of the total rainfall. Daily rainfall exceeding 50 mm represents 24% of the total amount, occurring during 4.3 days a year on average. The mean temperature is about 20°C. The lowest temperatures occur from mid-May till mid-July ; the hottest month is October, sometimes November, with a daily maximum of 31-33°C. The daily thermal range is small during the wet season, more important during the dry season. The air moisture, linked to the rainfall, is minimal in October and maximal in February.

Following the Sahara, the Zambezian Region is the largest major phytochorion in Africa, covering some 3,770,000 km^2. It extends from the Atlantic to almost the Indian Ocean from a latitude of 3°S to 26°S. According to White (1983), it probably has the richest and most diversified flora in Africa, certainly having the widest range of vegetation types. Eight vegetation types and twenty mapping units were distinguished by White (1983) in the Zambezian area of the UNESCO-AETFAT-UNSO African vegetation map. Woodland is predominant, covering 2,864,650 km^2, corresponding to 9.1% of the whole of Africa. It occurs in eight countries (Congo Dem. Rep., Burundi, Tanzania, Angola, Zambia, Zimbabwe, Malawi and Mozambique). In the Zambezian Region four main types of woodland are recognized, namely:

	area (km^2)	% of the Zambezian Region
Wetter Zambezian miombo woodland	1,239,975	33.35
Drier Zambezian miombo woodland	730,875	19.66
Colophospermum mopane woodland	354,900	9.54
Undifferentiated woodland	538,900	14.49

Most of these woodlands are dominated by tree species belonging to the *Caesalpiniaceae*. A very remarkable characteristic of the African trees of this family is their ectomycorrhizal associates, first noted by Peyronel and Fassi (1957), later by Redhead (1968), Högberg and Nylund (1981), Alexander (1985), Högberg and Piearce (1986) and Thoen and Ba (1987), without confirmation however that the host plants were really infested. This is in strong contrast with the generally accepted idea that tropical forests are poor in ectomycorrhizal associates ! Some observations on rain forests indicate however that ectomycorrhizal associates could be more important than thought up to now. Some representatives of genera which are obligatory ectomycorrhizal in temperate regions seem to behave differently in the tropics (Rammeloo, pers. obs.).

Collection and conservation of specimens

Sporophores have been collected by one of us (Degreef) during a three month-stay, from the beginning of February till the beginning of May, in the Lubumbashi region (Congo) (11.29 °S, 27.36 °E). Most of the collections were made around the Luiswishi river. This spot is excellently situated permitting the study of the three most important vegetation formations in the region : the muhulu dense forest, the miombo woodland and the savanna. The carpophores picked up by the author were complemented by gatherings made by villagers who served as guides on the field. Furthermore part of material was bought from roadside stalls. Inquiries amongst the inhabitants permitted to complete the ecological data, mainly about the distribution of the species in different habitats and the data concerning the phenology.

Macroscopical descriptions and colour slides of the collections were realized. Then the material was dried and packed. Naming occurred later on in the National Botanic Garden of Belgium (Meise) after microscopical study of the exsiccatae. Two types of collections were made: "bulk collections" of some species permitting chemical analysis and collections of a restricted number of carpophores permitting the completion of the floristic list. Voucher specimens were deposited in the herbarium of the "Jardin Botanique National de Belgique - Nationale Plantentuin van België", Meise.

Chemical analysis

Preparation of the samples. Fresh carpophores are brushed and the stipe bases thoroughly cleaned. After weighing they are dried at a temperature of about 50°C, using an electrical heating apparatus. They are then packed for shipping. Some field dried specimens are completely dried by freeze-drying too, weighed and finally pulverized.

Dry weight. It is evaluated on field dried samples and on freeze-dried samples. In each case, an oven drying at 103 °C during 24 hours is practised.

Total protein content. The estimate of the total protein content is based on the classical Kjeldahl technique which consists in a mineralization followed by the titration of the nitrogen content. The nitrogen content is expressed in relation to the dry weight.

Quantitative analysis of the total amino acids. The analysis is based on the separation of the various amino acids obtained by hydrolysis of the sample with HCl 6N. The reaction product is then passed through an ion exchange column and disclosed by a ninhydrin reaction. This technique, which had been developed by Spackman, Stein and Moore (1958), is automatized using the LKB 4400 analyser. A spectrophotometer measures the optical absorption of the reaction products with the ninhydrin. The results are registered as a continuous curve; the amino acids are identified through the position of the peaks. Quantitative estimates are made through surface calculations.

Mineral composition. Samples are reduced to ashes through calcination in platinum pots. Ca, Mg, Na and K quantities are determined on the basis of the emittance of a beam after atomizing the elements in a flame, being subjected to a monochromatic radiation. This technique is automatized in the Perkin Elmer 372 automatic absorption spectrophotometer.

RESULTS AND DISCUSSION

Floristics of edible macromycetes

We recorded 39 edible taxa for the studied region (**Table 1**). In the same region, Parent and Thoen (1977) noted 16 edible species and a number of collections which however have only been named up to the genus. Vernacular names belonging to 11 dialects have been noted and transcribed. These names seem to be of very local importance. As noted by Morris (1984), Williamson stated for Malawi that each district seems to have its own set of names. It is not clear whether these observations refer only to different districts but also to different dialects. Parent and Thoen (1977), working in the same region, noted vernacular names in Kibemba, Kilamba and Kisanga. We compared our list with theirs for these three dialects. The fact that the same names are used 15 years later, for the same species, proves that the mycophagic knowledge orally transmitted from generation to generation is stable.

From the biological point of view, it is highly remarkable that 26 of the taxa of our list are ectomycorrhizal, only eight are saprophytes and five have a special status, being associated with termite nests. This clearly emphasizes the extreme richness of ectomycorrhizal associates existing in the Zambezian

Table 1. Ecology and vernacular names of the 39 edible fungal taxa of the Zambezian Region — *Écologie et noms vernaculaires de 39 taxons de champignons comestibles de la région zambézienne.*

	Species	Voucher specimen	Vernacular names	Habitat (a)			
				D.e.f.	M.w.	Sav.	Term.
1	*Agaricus volvatulus* Heinem. & Goos.	90 DEG 110			+		
2	*Amanita* aff. *aurea* (Beeli) Gilbert	T 5714	Kiloma		*		
3	*Amanita loosii* Beeli	90 DEG 216	Ntelia (2), Tintin (2), Nangnang (6),		*		
4	*Amanita* cf. *robusta* Beeli	T 5694	Ndelema (2), Mufuti (2), Futi (5), Ntundu (11)		*		
5	*Auricularia tenuis* Lév.	90 DEG 201	Kalulu (2), Mpundubowa (9)	+	+		
6	*Cantharellus cibarius* Fries	90 DEG 43	Bwitondwe (2)	++	++	+	+
7	*Cantharellus cibarius* var. *defibulatus* Heinem.	90 DEG 11	Bwitondwe (2), Kasuta (3),	++	++	+	+
8	*Cantharellus cibarius* var. *latifolius* Heinem.	T 5721	Bumpukutu (2, 5, 7)		*		
9	*Cantharellus congolensis* Beeli	90 DEG 199	Bwitondwe (2), Fumbo (2)	++			+
10	*Cantharellus densifolius* Heinem.	Sch.-L.36			*		
11	*Cantharellus incarnatus* (Beeli) Heinem.	De Loose B 36	Kamingombe (2)				
12	*Cantharellus luteopunctatus* (Beeli) Heinem.	T 5697	Kasununu (2, 5), Udjuu (10)		*		*
13	*Cantharellus miniatescens* Heinem.	90 DEG 13	Bwitondwe (2), Mutondobowa (5, 7), Lutondo (8)	++	++		+
14	*Cantharellus platyphyllus* Heinem.	T 5705	Bwitondwe (2, 7), Kitondo (2), Kapofu (5)		*		
15	*Cantharellus ruber* Heinem.	T 5696	Katiletile (2, 5), Kaleleka (2), Kaduu (10),		*		
16	*Cantharellus rufopunctatus* (Beeli) Heinem. var. *ochraceus* Heinem.	Sch.-L. 39			*		
17	*Cantharellus symoensii* Heinem.	90 DEG 21	Bwitondwe (2)	++	++		
18	*Clavaria albiramea* Corner	90 DEG 189	Vuyakanunu (2)	+	++		+
19	*Cotylidia* cf. *aurantiaca* (Pers.) Welden	90 DEG 25		++	+		+
20	*Craterellus cornucopioides* (L.) Pers. var. *cornucopioides*	Sch.-L. 45			*		
21	*Cymatoderma elegans* Jungh. ssp. *infundibuliforme* Boid.	90 DEG 188	Kondjata (2)		+		
22	*Lactarius* cf. *edulis* Verbeken & Buyck	90 DEG 192	Nime (2)		++		
23	*Lactarius* cf. *inversus* Goos. & Heim	T 5742	Numbululu (2)		*		
24	*Lactarius kabansus* Pegler & Piearce	90 DEG 20	Kabansa (2), Manza manza (2)		++		
25	*Lactarius* cf. *latifolius* Goos. & Heim	T 5698	Kisububya (2), Maya mori (11)		*		
26	*Lactarius* aff. *pseudovolemus* Heim	90 DEG 27	Musefwe (2)		++		
27	*Macrolepiota gracilenta* (Krombh.) S. Wasser var. *goossensiae* (Beeli) Heinem.	90 DEG 40	Mbundelema (2)		+		
28	*Macrolepiota procera* (Scop. ex Fr.) Sing.	90 DEG 172			++		
29	*Psanthyrella spadicea* (Schaeff. ex Fr.) Sing.	90 DEG 42			+		
30	*Pseudocraterellus laeticolor* Heinem.	90 DEG 187	Kisajipena (2)		+		
31	*Russula* cf. *cellulata* Buyck	90 DEG 195			+		

(**a**) D.e.f. = dry evergreen forest; M.w. = miombo woodland; Sav. = savanna; Term. = high termitaria.
+ : present; ++ : abundant; * : noted by other authors
Dialects: (1): Bangu Bangu; (2): Kibemba; (3): Kikongo; (4): Kikula; (5): Kilamba; (6): Kimputu; (7): Kisanga; (8): Kitabwa: (9): Lulua; (11): Tshiluba.

	Species	Voucher specimen	Vernacular names	Habitat (a)			
				D.e.f.	M.w.	Sav.	Term.
32	*Russula* cf. *diffusa* Buyck var. *diffusa*	90 DEG 157		++			
33	*Russula hiemisilvae* Buyck	90 DEG 9		++			
34	*Schizophyllum commune* Fr. ex Fr.	90 DEG 45	Busepa (2, 7), Sepa (2), Tukuni (4)		+		
35	*Termitomyces letestui* (Pat.) Heim	T 5544	Katoto (2, 5, 7), Mpundululu (4, 11), Bonkwom (6)		++		++
36	*Termitomyces microcarpus* (Berk. & Br.) Heim	90 DEG 180	Avava (1), Kasangwa (2), Soba (2), Tande (2), Kansanki (4), Musangwa (5) (7), Belbel (6), Wiskansik (10),		++		++
37	*Termitomyces schimperi* (Pat.) Heim	T 5598	Kinkungwa (2) (3) (7), Mpundululu (4) (11), Ntum (6), Ubemb (10), Ututa (11)		++		++
38	*Termitomyces striatus* (Beeli) Heim	90 DEG 197	Katondolo (2)		++		++
39	*Termitomyces striatus* (Beeli) Heim var. *aurantiacus* Heim	T 5543	Kamenankela (2), Musempila (3), Kamenamakanka (5), Bonsicy (6), Ulang (10), Kinsusa (11)		++		++

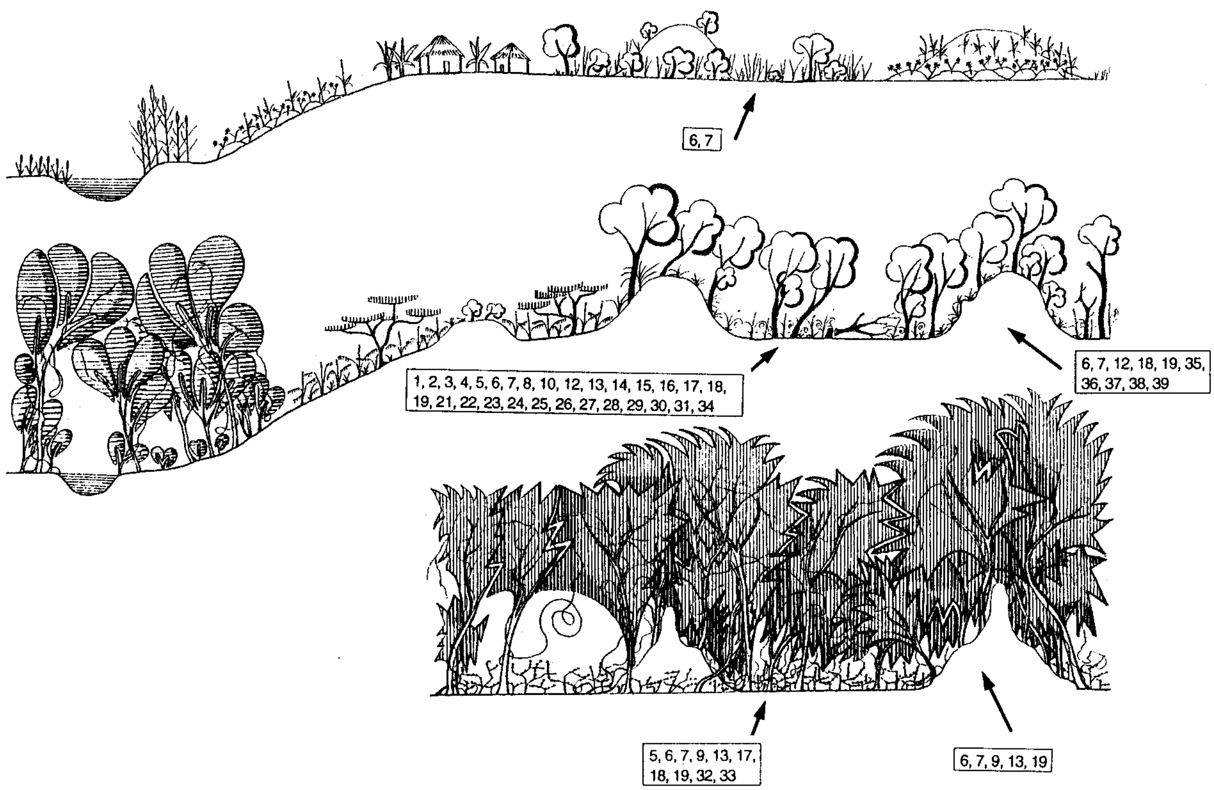


Figure 1. Ecology of the edible fungi in the Zambezian region — *Habitats des champignons comestibles de la région zambézienne.*

woodlands. The richness in ectomycorrhizal associates in the miombo woodland was already noted in the miombo of southern Burundi by Rammeloo (pers. obs.) and described by Högberg and Piearce (1986) for the Zambian miombo. These authors noted *Amanita*, *Cantharellus*, *Lactarius* and *Russula* as the most important ectomycorrhizal genera, whereas an extreme richness in boletes and *Inocybe* was noted too (Rammeloo, pers. obs.). As the representatives of these last mentioned groups are not eaten in the studied region, they have no place in our study.

Considering the quantities of the harvested edible taxa, the preeminence of ectomycorrhizal species become even more obvious. It clearly stresses the economic importance of conservation of these biomes for the local populations. The role of the woodland will even increase as already noted by Lawton (1978): "With the inevitable reduction in the area of the miombo woodlands which accompanies the changes in the agricultural system, their natural resources are becoming scarcer. Their importance in the economy is not appreciated by the people until there is a local shortage". In the same article this author notes that *Cantharellus* species could be a good subject of trade in Europe, being available during European winter. This can be true from a pure economic point of view, but has to be considered with much criticism, the mushrooms being a non-neglectable protein source for the local populations at a crucial period of the year. Considering that for the last decade there has been consistent change in the staple diet from the relatively protein rich finger millet to the protein poor but carbohydrate rich maize diet, which has to be considered as a deterioration of the diet, the addition of fungal protein gained even more interest.

The termitaria form a very special habitat for fungi, not only by the presence of the edible Termitomyces species (Otieno, 1966, 1969) but also by the presence of a number of other species which, however, are not edible (Heim, 1938; Alasoadura, 1966).

In the studied region the most representative "edible genera" are *Cantharellus* and *Amanita*, followed by *Termitomyces* and *Lactarius*. Local populations have a definite preference for certain taxa. It has not been possible to establish it fully. Species as *Schizophyllum commune* and *Lentinus* species for example are only consumed in periods when other species are lacking (Rammeloo, Walleyn, 1993). Thus it is not astonishing that no one *Lentinus* species has been noted during our stay in the rainy season, the moment of abundance of fleshy carpophores. In his flora of fungi, Morris (1987) however noted the consumption of *Lentinus squarrosulus* in Malawi, stipulating that it was commonly used in spite of its tough structure, but did not specify at which period of the year it was collected.

The lack of representatives of the genus *Agaricus* and of boletes on our list confirms the general observation (Rammeloo, Walleyn, 1993) that the representatives of these genera are not appreciated at all by the indigenous populations, although sometimes being the only mushrooms eaten by Europeans living in Africa.

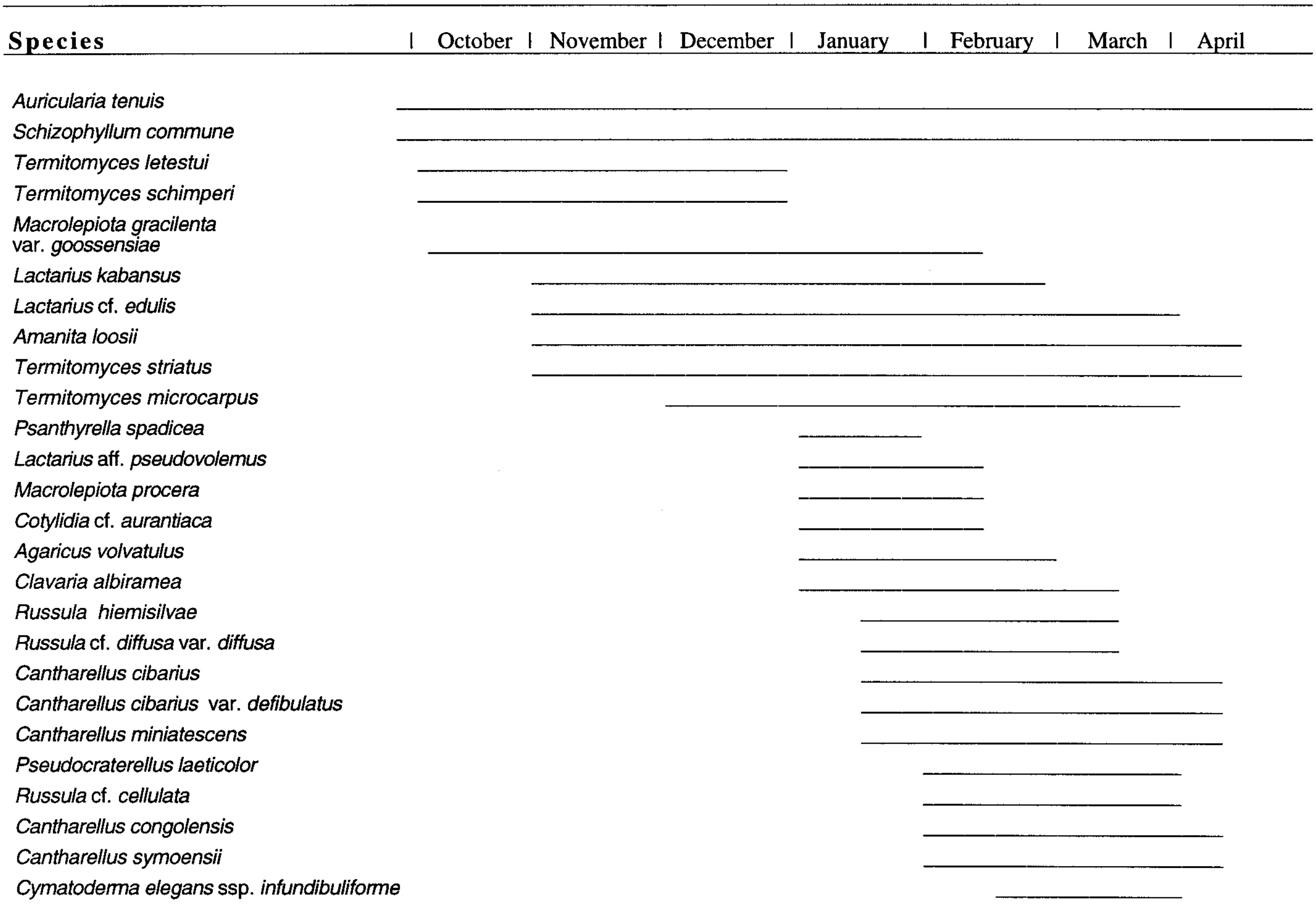
Our list does not cover the whole set of edible species for the region, but certainly refers to the most important ones. Other essential floristic data concerning edible species from the Zambezian Region were presented by Williamson (1973, 1975) for Malawi, by Parent and Thoen (1977) for the Shaba province of Zaïre, by Piearce (1981a, 1981b), Pegler and Piearce (1980) and Härkönen *et al.* (1993) for Zambia and by Morris (1984, 1987, 1990) for Malawi. Morris (1984) noted over 60 edible species for Malawi; Pegler and Piearce noted between 15 and 25 edible species for Zambia. More important however is the floristic composition of the lists. Comparison makes it clear that they all contain a very consistent common nucleus of species which are consumed everywhere in the Zambezian Region and composed mainly by *Cantharellus* spp., *Amanita* spp., *Termitomycetes* spp. followed by *Lactarius* spp. and *Russula* spp. This does not mean that women in the different countries of the Zambezian Region know all these species... As noted by Morris (1984), most women do not recognize more than 20 edible species.

Phenology

During the rainy season the observed edible species vary according to their own phenological behaviour. On basis of our observations and complemented with data available in the herbarium of the National Botanic Garden of Belgium (BR), we established a phenological calender of edible species for the Zambezian Region. This was only possible for 26 of the observed taxa because of the lack of reliable data for the 13 other taxa. Some fluctuations of course occur in the appearance of the carpophores in a given region which are mainly due to differences in quantity and date of rainfall from year to year. However the sequence of appearance of the different species is rather constant, as already noted by Rammeloo in the miombo woodlands of southern Burundi (pers. obs.).

Even seen on the very large "Zambezian scale", this sequence may be synthesized as shown in **table 2**. This has been documented best for *Termitomyces* species, but the data of the literature have never been

Table 2. Phenology of 26 edible fungal taxa in the Zambezian region — *Phénologie de 26 espèces de champignons comestibles de la région zambézienne.*



brought together. This phenological sequence could be explained by the reaction of the mycelia to the moistening of the soil. Soil moisture of the Luiswishi area along the year shows important differences from one type of vegetation to another (Malaisse, Kapinga, 1987). Some of the species appear immediately after the first rains, announcing the beginning of the rainy season, others fruit some weeks later. Much more studies, over longer periods, are necessary to establish definitely the sequence of appearance of these fungi. Fine ecological observations are necessary to elucidate the factors inducing mycelia to produce fruit bodies.

Chemical composition and food value

Till now, relatively few studies were realized in Africa concerning the chemical composition and the food value of fungi. The first known chemical analysis made on African wild mushrooms was realized by Vujicic and Vujicic (1971) using Zambian species. Antony (1973) made a dissertation at Chancellor College about the protein content of some mushrooms growing in Malawi. Parent and Thoen (1977) discussed the food value of edible mushrooms from the Upper-Shaba region of Zaire. Parent and Skelton (1977) analysed also the content of *Termitomyces microcarpus* as to the amount of a proteolytic enzyme. Alian and Musenge (1978) analysed seven Zambian collections. Other analyses were realized by Wehmeyer *et al.* (1981) on *Macrolepiota zeyheri* and *Agaricus brunnescens* and by Ogundana and Fagade (1981, 1982) who determine the nutritional value of some Nigerian edible mushrooms. Piearce and Francis (1982) made a detailed analysis of *Suillus granulatus* from Zambia, an introduced mycorrhizal species which is not yet completely accepted by local populations as a valuable food.

It appears very difficult to compare the results in all respects, due to the lack of data concerning some chemical characters. They however have some basic data as dry weight and crude protein in common, but even then, care has to be taken as to the real significance of these figures. It is obvious that in some of these studies no attention was paid to the nitrogen of the chitin. Furthermore, the so important amino acid equilibrium for estimating food value was always ignored except in the study of Piearce and Francis (1982) who analyzed the amino acid content of *Suillus granulatus*.

The dry weight mostly averages about 10 % of the fresh weight. This value is in accordance with the figures of Vuijcic and Vujicic (1971), Parent and Thoen (1977), Alian and Musenge (1978) and Piearce and Francis (1982). *Schizophyllum commune* is an exception having a dry weight of 65 % of the fresh weight. This value is in accordance with the figures of Parent and Thoen (1977). This particularity is due to the reviviscent habit of this fungus which has a very tough consistence. It is obvious that the ratio of fresh weight to dry weight is strongly influenced by the climatic conditions for a given species even at the same spot as noted by Fraiture for Belgian mushrooms (pers. comm.). This should also be true for tropical samples.

We observed that the total protein content is not quite variable, ranging from 22 to 28% of the dry weight. However, extreme registered values are : 6.87% for *Auricularia tenuis* followed by *Schizophyllum commune* which has a very low content of 14%. *Termitomyces microcarpus* is characterized by a very high content of 48%. The variability in the figures from Parent and Thoen (1977) is even larger, varying between 8.4 and 34%, with a mean value of 22% if *Termitomyces* and *Schizophyllum* were excluded, which corresponds to the observations of Chinn (1945), Adriaens (1953) and Piearce and Francis (1982).

For *Termitomyces microcarpus*, Parent and Thoen (1977) determined a crude protein content of 33%. The proteic richness of *Termitomyces* species is a general feature for the genus. The analyses of Parent and Thoen (1977) for four species of this genus show values from 33 till 45%. The same values were published by Parent and Skelton (1977) when analysing the content of proteolytic enzyme in *Termitomyces microcarpus*.

The total protein content is based on the determination of nitrogen content by semi-micro Kjeldahl. It has to be considered that the wall of the fungi is partly built of chitin, a nitrogen containing molecule which cannot be considered as a food source. Generally, at least when working with higher plants, the ratio nitrogen / dry weight is multiplied by a factor 6.25 to obtain the total protein content. In order to overcome the error introduced by the chitin nitrogen, we adopted the factor 4.38 in the case of fungi (Delmas, 1989). In **tables 3** and **4**, we produced the figures with both factors, permitting an easy comparison with the older literature which did not take into account the error introduced by the chitin nitrogen and with the more recent publications.

In the future it will be necessary to determine the real amount of chitin-nitrogen in different species of fungi in order to obtain a stable basis for further studies of their nutritional value. However, it is probable that the proportion of chitin-nitrogen versus food exploitable nitrogen must be different for an *Amanita* species compared to a *Schizophyllum* for instance. Regarding **table 4**, it should be noted that cystine is in fact a complex of two cysteins partially destroyed by the analysis method used. Furthermore tryptophane was totally destroyed according to the acid hydrolysis. Finally no difference was performed regarding L and D forms during the amino acids determination.

The total protein content does not give sufficient information to determine the nutritive value of food. An important criterion is the way this protein amount is available in food. Human beings need in their alimentation eight "essential" amino acids for maintenance of nitrogen equilibrium. If all of these amino acids are provided, the human body can form the remaining amino acids necessary for the composition of its synthesis. A qualitatively good food must show the right equilibrium between the eight essential amino acids. It has to be noted, however, that the analytical techniques currently used destroy one of these amino acids, tryptophan, therefore its amount could not be determined. The other amino acids are generally well represented in the different species. It has to be mentioned however that conversion of these great nitrogen rates into proteins does not represent the real food value: total amount of amino acids is clearly lower than protein content. In fact, chitin but also great amount of ammonia, and undetermined peaks, probably corresponding to free aminoacids and glucosamin, are observed.

From the analyses of the mineral content, it is obvious that cantharellus are very alike, exhibiting rather low Na and Ca contents compared to other species. It would be hazardous to conclude about the mineral content of Zambezian fungi only on the basis of our observations. Actually, there is a lack of sufficient comparable literature data, especially concerning tropical macromycetes collected in the wild.

Table 3. Dry weight (DW) and protein contents in per cent on fresh weight (FW) of nine edible fungal species — *Poids sec et teneurs en protéines de neuf espèces de champignons comestibles.*

	Amanita loosii	*Auricularia tenuis*	*Cantharellus cibarius* var. *defibulatus*	*Cantharellus congolensis*	*Cantharellus miniatescens*	*Cantharellus symoensii*	*Clavaria albiramea*	*Schizophyllum commune*	*Termitomyces microcarpus*
% DW	11.20	55.30	11.80	8.10	9.50	9.20	62.10	65.20	8.50
% N/FW	0.50	0.61	0.42	0.36	0.43	0.33	2.36	1.46	0.65
% prot./FW (factor 6.25)	3.15	3.79	2.66	2.28	2.72	2.28	14.77	9.13	4.08
% prot./FW (factor 4.38)	2.19	2.67	1.84	1.57	1.88	1.57	10.33	6.39	2.84

Table 4. Amino acids composition of nine edible fungal species, expressed in per cent on dry weight — *Teneur en acides aminés de neuf espèces de champignons comestibles.*

	Amanita loosii	*Auricularia tenuis*	*Cantharellus cibarius* var. *defibulatus*	*Cantharellus congolensis*	*Cantharellus miniatescens*	*Cantharellus symoensii*	*Clavaria albiramea*	*Schizophyllum commune*	*Termitomyces microcarpus*
% N/DW	4.51	1.10	3.60	4.51	4.59	3.96	3.81	2.24	7.69
% prot./DW (factor 6.25)	28.18	6.87	22.52	28.17	28.69	24.78	23.79	14.01	48.04
% prot./DW (factor 4.38)	19.75	4.81	15.76	19.75	20.10	17.34	16.68	9.81	33.68
Amino acids (g/100g DW)									
Alanine	1.24	0.40	1.07	0.78	1.14	1.16	0.95	0.72	2.13
Amino butyric acid	traces	traces	traces	0.11	traces	traces	0.48	traces	0.58
Arginine	1.19	0.28	1.11	1.00	1.72	1.13	0.90	0.65	1.51
Aspartic acid (1)	2.39	0.57	1.79	1.29	1.94	2.32	1.82	1.21	3.25
Cystine	0.14	-	-	-	-	-	-	-	-
Glucosamine	3.29	1.15	3.86	3.07	1.96	2.20	2.17	1.12	2.07
Glutamic acid (2)	3.50	0.63	2.43	1.87	3.59	2.41	2.36	1.44	4.81
Glycine	1.02	0.28	0.88	0.69	0.91	0.92	0.91	0.57	1.83
Histidine	0.63	0.13	0.41	0.44	0.50	0.49	0.34	0.26	1.22
Isoleucine	0.96	0.21	0.68	0.54	0.86	0.86	0.61	0.42	1.03
Leucine	1.65	0.40	1.29	1.03	1.43	1.51	1.14	0.76	2.02
Lysine	1.38	0.34	0.99	0.97	1.37	1.18	0.90	0.83	2.02
Methionine	0.40	0.07	0.17	0.15	0.20	0.20	0.17	0.16	0.42
Phenylalanine	0.92	0.24	0.80	0.65	0.95	0.89	0.82	0.43	1.40
Proline	1.08	0.26	0.88	0.72	0.95	0.84	0.86	0.45	1.07
Serine	1.29	0.31	1.00	0.77	1.07	1.19	1.09	0.63	1.87
Threonine	1.18	0.31	0.98	0.77	1.06	1.37	0.99	0.59	1.73
Tyrosine	0.73	0.13	0.56	0.55	0.88	0.76	1.71	0.33	1.24
Valine	1.00	0.27	0.79	0.57	0.79	0.92	0.87	0.50	1.45
Total amino acids	**23.99**	**5.98**	**19.69**	**15.97**	**21.32**	**20.35**	**19.09**	**11.07**	**31.65**

(1) including asparagine ; (2) including glutamine.

Table 5. Mineral composition of nine edible fungal species (analyses on DW) — *Composition minérale de neuf espèces de champignons comestibles.*

	Amanita loosii	*Auricularia tenuis*	*Cantharellus cibarius* var. *defibulatus*	*Cantharellus congolensis*	*Cantharellus miniatescens*	*Cantharellus symoensii*	*Clavaria albiramea*	*Schizophyllum commune*	*Termitomyces microcarpus*
Na (%)	0.0255	0.0231	0.0138	0.0111	0.0127	0.0125	0.075	0.0562	0.0362
K (%)	7.40	1.72	6.53	7.05	6.83	6.68	4.88	1.16	4.23
Ca (%)	0.054	0.032	0.027	0.022	0.014	0.016	0.042	0.119	0.174
Mg (%)	0.188	0.132	0.149	0.158	0.161	0.150	0.146	0.156	0.262

It is known that the caloric value of mushrooms is rather low (Delmas, 1989) but such a determination was not realized in our study.

Importance of the fungi consumption

No figures were registered about the quantities of fungi consumed in the Zambezian Region. Nevertheless Parent and Thoen (1977) estimated the quantities yearly harvested in the neighbourhood of Lubumbashi in Congo Dem. Rep. (formarly Zaire) to be about 20 tons, a really not negligible amount !

CONCLUSIONS

Fungi are very important in the Zambezian eco-systems, not only because of their very high number of ectomycorrhizal associates but also as a food source for local populations. From the caloric point of view, they only play a very limited role but in the region, the alimentary problem is primarily a diet deficient in proteins (Degreef, 1992). As the consumption of mushrooms is estimated at about 30 kg a year per inhabitant (Parent, Thoen, 1977), and considering the proteinic content of the carpophores, mushrooms only play a secondary role in the diet of indigenous populations. However, the input in minerals, vitamins and essential amino acids must be considered with regard to the period of the year they become available. Actually, the period of collecting corresponds to the possible starvation months and just precedes the collection period of edible fruits (Malaisse, Parent, 1985), another source of food supply for local populations in this region.

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