



Indigenous knowledge and utilization of wild Mushrooms in communities around Kibira and Bururi mountain forests in Burundi

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Abstract

Wild mushrooms are of paramount importance to human beings as a source of food, income and medicinal applications. However, the ethnomycological knowledge has not been well documented in Burundi and the potential benefits of this knowledge in medicine and sociocultural fields have not been explored. This study explored and documented the indigenous knowledge of wild edible mushrooms from the communities living around the Kibira and Bururi mountain forests in Burundi for the first time. Field surveys were conducted in the communities living around the Kibira National Park and the Bururi Forest Nature Reserve to document the local knowledge and the use of wild mushrooms. The interviews involved randomly picked 160 respondents of which, 99.4% of interviewees affirmed knowing mushrooms and 97.5% already utilized mushrooms. Among these, 69.4% utilized them as food. They recognize mushrooms as an alternative source of income (21.9%) and their medicinal applications (6.2%). The knowledge of mushroom edibility is transferred from parents to children by oral inheritance. That method has a negative impact on the traditional dissemination of this knowledge in the future due to some beliefs and conservative eating habits that induce a certain fear of mushrooms known as mycophobia, leading to the rejection of several mushroom species despite belonging to recognized edible taxa. A traditional method referred to as "Gusabura" was reported for eliminating toxic compounds in mildly toxic mushrooms prior to their consumption. The ethnomycological knowledge in Burundi is at risk of disappearing. Hence, there is a need to preserve this valuable indigenous knowledge by properly documenting it and introducing it in the lower level of the education system.

Keywords – “Gusabura” – Local mushroom knowledge – Mycophobia – Wild mushrooms’ utilization

Introduction

In most developing countries, rural people rely on wild edible mushrooms for their livelihood. They are considered as a relatively low-cost alternative to animal proteins and a source of food, income and raw material in local traditional medicine practice (Osarenkhoe et al. 2014). The appearance of the majority of edible mushrooms in the tropical region is restricted to the rainy

season, corresponding to the period of food shortage. Mushrooms are then an important option for people's survival during this food shortage period (Boa 2004).

The study of how people of a particular location and culture utilize mushrooms is named "ethnomycology" or "mushroom ethnostudy". Even though the interaction between humans and mushrooms dates back many millennia, the written evidence of ethnomycological knowledge is a recent conception (Miriam et al. 2006). Wild edible mushrooms are not well documented in many countries (Tibuhwa 2013). The First International Meeting on the Conservation and Utilization of Genetic Resources of Mushrooms for Food and Agriculture held in March 1998 in Bordeaux (France) recommended documenting, collecting and conserving wild edible and other useful mushroom germplasms in developing countries, tapping their indigenous knowledge as much as possible (Muruke et al. 2002). Nowadays, ethnomycology is gaining a growing interest in mycological scientific communities (Okigbo et al. 2012). Studying the local mycological knowledge consists of documenting the use of mushrooms as food, their medicinal application, their use as recreational objects, the beliefs and myths considerations and the income they generate for the households (Buyck & Nzigidahera 1995). The documentation of locally consumed mushrooms is very important as it helps to know the consumed species in a region and to avoid consuming toxic mushrooms and related harms. Moreover, several researchers (Buyck 1994, Buyck & Nzigidahera 1995, Eyi Ndong et al. 2011, De Kesel et al. 2017) suggest consuming only mushroom specimens that local people have experienced. Indeed, even if the knowledge of the scientific name of a particular mushroom is an indication of its edibility, the only reliable guide on the edibility of a mushroom specimen is to know someone who ate it and survived (Boa 2004). This highlights the importance of both local preferences and practices regarding mushrooms, as well as the importance of correct identification and naming. Failure to do so results in conflicting reports in field guides about mushroom edibility: some recommend eating a species, while others reject it as poisonous (Boa 2004). Most cases of mushroom poisoning are due to misidentification or confusion between two species looking morphologically similar. For instance, Boa (2004) reported a case of Mexicans living in California who ate *Amanita phalloides*, a poisonous species not known in their origin country, because they confused it with the deliciously edible *Volvariella volvacea*. Tibuhwa (2012) also reported this confusion in Tanzania. Härkönen et al. (2003) reported a high possibility of confusing *Amanita phalloides* with the edible *Amanita loosii*. Likewise, Milenge Kamalebo et al. (2018) suggested carrying out an ethnomycological survey to document locally used mushroom species prior to their domestication, while Yorou et al. (2014) suggested studying the various uses of wild mushrooms by local communities in order to valorise the services that they provide.

In Burundi, several studies have been carried out on wild edible mushrooms (Buyck 1994, Buyck & Nzigidahera 1995, Nzigidahera 2007, Degreef et al. 2016, Nteziryayo et al. 2019) but only two studies have focused on the knowledge and utilization of local mushrooms. Buyck (1994) studied the edible mushrooms from the Bujumbura - Rumonge region (Western Burundi), whereas Buyck & Nzigidahera (1995) documented the general attitude, perception, identification and preparation of edible fungi in the same area, while other regions of Burundi are still not studied on this aspect. However, several studies noted that local mushroom knowledge and utilization vary with people's cultures and beliefs and can differ from one region to another within the same country (Garibay-Orijel et al. 2007, Tibuhwa 2012, Tibuhwa 2013, Härkönen et al. 2015, Hussein et al. 2018). On the other hand, within local communities, the traditional knowledge is transmitted orally from one generation to another, and it seems to be the only effective way of preserving information concerning traditional useful mushrooms (Garibay-Orijel et al. 2007, Tibuhwa 2012, Härkönen et al. 2015). In most regions of Burundi, these traditions are at risk of disappearing due to habitat destruction and the youth migration from rural to towns. Therefore, an ethnomycological survey was carried out on the communities living around the Kibira National Park and the Natural Forest Reserve of Bururi in order to document the indigenous knowledge and the use of different mushroom species and their related beliefs and myths.

Table 1 List of questions extracted from the survey questionnaire and response options.

Nr	Question	Response option
1	Do you know what mushrooms are?	Yes/No
2	Have you ever used mushrooms?	Yes/No
3	For what purpose do you use mushrooms?	- Food - Medicinal purpose - For sale Others (explain)
4	If you eat mushrooms, are they from the wild or cultivated?	Wild/Cultivated
5	If you use mushroom for food, how are they cooked?	.....
6	If you use mushrooms for medicinal purpose, explain.	.....
7	If you sell mushrooms, where do you sell them?	- Local markets - Supermarkets - Restaurants - Hotels - Along roadsides
8	If you sell mushrooms, what measurement unit do you use and at what price?	- Unit : Kg, individual, pile. - Price (BIF)
9	Which species/variety do you use mostly? (vernacular names)	.....
10	In which form do you prefer mushrooms mostly?	- Fresh - Sundried - Salted - Smoked
11	In which periods of the year do you collect mushrooms?	.....
12	How do you differentiate between edible and poisonous mushrooms?	.....
13	Give the names of some non-edible mushrooms you know.	.....
14	Have you seen or heard any reported case of disease or death due to mushroom consumption?	Yes/No
15	If yes, state the number.	.....
16	How do you process mushrooms after collection from the field?	.....
17	Have you ever grown mushrooms?	Yes /No
18	If you grow mushrooms, what type? Cite the local/scientific names	.....
19	If you do not cultivate mushrooms, why?	.....
20	Given an opportunity, would you be interested to learn how to cultivate mushrooms?	Yes/ No
21	What socio-cultural beliefs about mushrooms in your community do you know?	.....

Results

Demographic features of the informants

In total, 160 individuals were interviewed during the survey, and their demographic features are presented in Table 2.

Knowledge and utilization of wild mushrooms in KNP and BFNR

The results on knowledge and utilization of wild mushrooms in the KNP and the BFNR are presented in Table 3 and Fig. 2 for the questions with suggested response options. For questions with no suggested response options, the responses collected from the respondents are summarized in the texts of the subsections below.

Table 2 Demographic features of the informants (n = 160).

Features	Frequency	(%)
*Gender		
Male	72	45
Female	88	55
*Age		
Less than 20 year	15	9.3
20-40 years	75	46.7
41 years and above	70	44
*Level of formal education		
No formal education	56	35
Primary education	77	48
Secondary education	27	17
University education	0	0
*Profession		
Farmer/pastoralist	122	76.3
Government employees	12	7.6
Others (traders and other jobs)	26	16.1

Table 3 Knowledge and utilization of wild mushrooms in the KNP and the BFNR.

Questions	Response options	Number of respondents	%
Do you know what mushrooms are?	Yes	159	99,4
	No	1	0,6
Have you ever used mushrooms?	Yes	156	97,5
	No	4	2,5
For which purpose do you use mushrooms?	Food	111	69,4
	Food and Medicinal purpose	10	6,2
	Food and Sale	35	21,9
	Other: no use	4	2,5
If you eat mushrooms, are they from the wild or cultivated?	From the wild	128	80,0
	Cultivated	28	17,5
	No use	4	2,5
If you use mushrooms for sale, where do you sell them?	Local markets	128	80,0
	Supermarkets	0	0,0
	Restaurants and Hotels	2	1,2
	Other: Along road sides	30	18,8
If you sell mushrooms, what measurement unit do you use?	kg	0	0,0
	Piece	49	30,6
	pile (heap)	111	69,4
In which form do you prefer mushrooms mostly?	Fresh	145	90,6
	dried	15	9,4
	salted	0	0,0
	Smoked	0	0,0
Have you heard any reported case of disease or death due to mushroom consumption?	Yes	4	2,5
	No	156	97,5
Have you ever grown mushrooms?	Yes	0	
	No	160	100,0
Given an opportunity, would you be interested to learn how to cultivate mushrooms?	Yes	160	100,0
	No	0	0,0

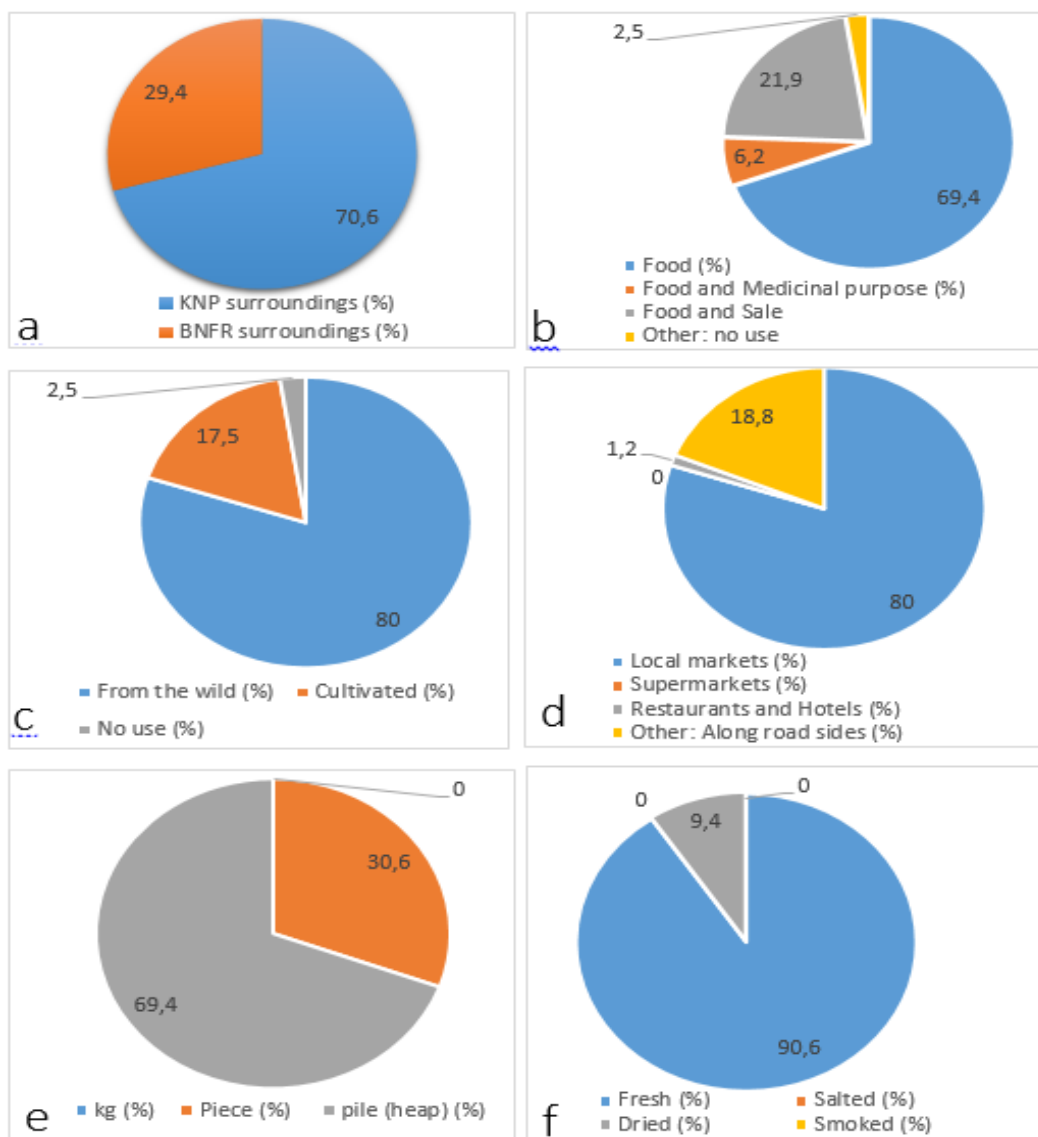


Fig. 2 – Repartition of surveyed people in KNP and BNFR and illustration of some aspects of the knowledge and utilization of wild mushrooms. a Surveyed people from KNP and BNFR surroundings. b Purpose for which mushrooms are used. c Origin of consumed mushrooms. d Places where mushrooms are sold. e The used measurement unit. f The form in which mushrooms are mostly preferred.

Medicinal applications of mushrooms

The medicinal applications they cited include the treatment of stomach pain, hearing impairment and vomiting problems occurring, especially for children whose mothers had consumed mushrooms during pregnancy.

Mushroom preparation

When asked about how they prepare mushrooms, the respondents claimed that the common methods employed are cooking and smoking. For mushroom cooking, the preparation consists of removing dust, separating the cap and the stipe, and cooking in water with salt and oil. Others stated that after removing dust and separating the cap and the stipe, they chop the mushrooms into small pieces, fry them in oil with onion and salt, and then with the addition of some water to increase the amount of sauce. For mushroom smoking, they remove the dust and the mushrooms are put above the fire flame on the mesh where they are imparted by the smoke from the fire. This is also used as a preservative method, as mushrooms stored after this treatment are not destroyed at

all. Depending on the wealth of the household, other people can add some ingredients to improve the mushroom taste. These include some vegetables, groundnut flour, tomatoes, small fish (*Stolothrissa tanganyicae*, *Limnothrissa miodon*), meat and chilli.

Mushroom market and prices

Regarding markets and prices, the informants declared to sell wild mushrooms on local markets (80% of the respondents), along roadsides (18.8 %) and in restaurants and hotels (1.2%) whereby mushrooms are sold by piece (individual) for big mushrooms, and by pile for small mushrooms. The price per pile (about 400 grams) or per mushroom individual (about 150 grams) varies between 500 BIF (0.2 \$) and 1500 BIF (0.6 \$). Mushroom hunters claimed that their activity is important because they earn money easily without much investment.

Mushroom processing and preservation

This study revealed that mushrooms are preferred in fresh conditions (90.6% of the respondents), and 9.4% prefer preserved mushrooms. The preservation methods include sun drying, smoking and semi-cooking in water (parboiling), followed by drying. No respondents declared to sell preserved mushrooms. However, some collectors declared that when they obtain a large number of mushrooms, some methods could be used to preserve them for a certain time for household consumption but not for sale. Among these methods, sun drying was reported to be the most used compared to other preservation methods. In the studied area, the practice named “Gusabura” (in the local language) was reported to be used in preparing mildly toxic mushrooms to alleviate or eliminate bad taste (bitter, sharp, hot) and the toxic compounds they contain prior to their consumption. The method involves parboiling the mushrooms in water for about 20 minutes and discarding the water used to boil them. Thereafter, the mushrooms can be cooked in fresh water with other ingredients and eaten. The involved species, among others, are *Lentinus squarrosulus* (slightly hot taste), *Neonothopanus hygrophanus* (bitter taste), and *Hypholoma subviride* (bitter taste). *Amanita* sp. (Urwerakare) was also reported among species that must undergo the above pre-treatment, not for its questionable taste but because it makes people drunk when eaten without pre-treatment. In addition, even if pre-treated, one has to eat a small amount to avoid drunkenness. Other species, such as *Suilus granulatus*, *Auricularia cornea*, and *Auricularia delicata* also have to undergo such pre-treatment to eliminate their slimy or viscid character on touch /sight. It was reported that the “Gusabura” technique is also used for mushroom preservation because after parboiling them and discarding the boiling water, they can be dried and kept in a preserving pot for about one month.

Learning about edible and toxic mushrooms

The interviewees reported that the main way of learning the edibility or non-edibility of mushrooms is by oral inheritance, a tradition where children know the edible mushrooms through information from their parents (especially mothers) or their guardians. There is a saying “*Kwihenda ntibishoboka kuko Ibiribwa nsanzwe ndabizi Ico ntazi sindagisoroma*”, translated into English as “There is no possibility of mistake; I know already the edible mushrooms. In case I do not know the specimen, I don’t pick it”. This ethnomycological knowledge transfer is given when the child accompanies the mother/grandmother for mushroom collecting from the wild. However, at a certain age (10-13 years), when the mother estimates that the child has enough skills in mushroom hunting, she can let him/her go alone to gather mushrooms in the wild for a feast, but she will have to check whether there are any suspected poisonous mushrooms that the child could have harvested by mistake. In this case, the non-edible ones are removed before cooking.

Interest to learn the technique of mushroom farming

When asked whether they have ever grown mushrooms, 100% of the respondents claimed that they have never grown mushrooms. Many of the respondents claimed to have heard that mushrooms could be cultivated but they have not practised such an activity themselves; some of

them agreed that they have eaten cultivated mushrooms, while others were even surprised to hear that mushrooms can be cultivated. All of the respondents (100%) declared to be interested to learn the technique of mushroom farming and get access to the spawn.

Some socio-cultural beliefs related to wild mushrooms

In this study, it was found that some people do not eat mushrooms because they fear that their cattle herd could disappear (1.6%). Others think that their consumption may lead to the lack of milk in lactating cattle (1.9%). This fear is found in communities having cattle herds and refers to the information obtained from their parents or other relatives. Another belief is that when a pregnant woman eats mushrooms, she has to give liquid from a cooked mushroom to her new-born or else the child will have some health problems, such as ear disease (hearing impairments), stomach pain or problem of vomiting when they are feeding him/her (11%). Another disseminated belief is related to some mushrooms called “INTUMO” (literally “dusty”) belonging to the group of Gastromycetes, genus *Scleroderma* (puffballs): people never touch them because they consider them as the excrements from ancient people (22.7% of the respondents).

Phenology

Regarding the mushroom appearance (phenology), all the informants declared that fruiting bodies appear during the rainy season. However, not all the species appear at the same time. Some appear just at the beginning of the rainy season, while others appear later. Some can be found for a long time, while others appear for a short time. The mushroom harvesters know very well at which period a certain type of mushroom appears in a particular place and manage to keep it a secret to avoid competition with other harvesters. Therefore, they will go to the same place on the same date of the following year to check whether mushrooms have been fruited. This is the case for *Termitomyces robustus* (ikizinu), *T. microcarpus* (ubumegeri) and *T. titanicus* (igihefu).

Mushrooms reported by the informants and harvested specimens

Table 4 and Fig. 3 show the consumed mushroom species reported by the informants and the specimens harvested during the survey period. The harvested mushroom specimens were presented to some of the harvesters and the forest guardians to link them with their vernacular names. This additional information significantly facilitated their scientific taxonomic identification. Table 5 and Fig. 4 show the non-consumed species from the KNP left aside by mushroom hunters during the sampling period. For each harvested sample, specimens were deposited in the herbarium of FABI/OBPE for future reference.

Table 4. Consumed species reported by interviewees and samples harvested from the KNP: vernacular names and their meanings, scientific names, families and reference specimens

Local name (In Kirundi*)			Scientific name	Family	Reference specimen from literature	FABI/OBPE herbarium voucher
Reported by interviewees	Meaning	Harvested: Yes/No				
Ubuzirantete	Not found	Yes	<i>Pleurotus citrinopileatus</i>	Pleurotaceae	NV-11 Nteziryayo et al. (2019)	NV_19
Nkundamazi	Liking water	Yes	<i>Trametes polyzona</i>	Polyporaceae	#4588(TN) Härkönen et al. (2003)	NV_18
Ikizinu	Visiting the termite hills	Yes	<i>Termitomyces robustus</i>	Lyophyllaceae	NV_15, NV_17, PSM_15, ADK_4198 (www.efta-online.org)	NV_20
Uburyabahigi	Eaten by hunters	Yes	<i>Lentinus squarrosulus</i>	Polyporaceae	RJH_264 (www.efta-online.org)	NV_21

Table 4. Continued.

Local name (In Kirundi*)		Harvested: Yes/No	Scientific name	Family	Reference specimen from literature	FABI/OBPE herbarium voucher
Reported by interviewees	Meaning					
Ubumegeri	Resembling to the ants	Yes	<i>Termitomyces microcarpus</i>	Lyophyllaceae	RHJ_70, JD_1042 (www.efta-online.org)	NV_22
Ikigogo	Very tall	Yes	<i>Macrolepiota dolichaula</i>	Agaricaceae	RJH_114, JD_1260, ADK_2900 (www.efta-online.org)	NV_23
Ubushekeshoke/jirote	Small and in tufts	Yes	<i>Collybia aurea</i>	Tricholomataceae	(Buyck 1994) (p52)	NV_24
Binwavyimpfizi	Mouth of the bull	Yes	<i>Echinochaete brachypora</i>	Polyporaceae	JD_1046 (www.efta-online.org)	NV_25
Binwavyimpfizi	Mouth of the bull	Yes	<i>Polyporus squamosus</i>	Polyporaceae	FPL 6846 Krueger (2002)	NV_26
Ikigote /Ikigotozi	Not found	Yes	<i>Polyporus moluccensis</i>	Polyporaceae	#5158 (TN) Härkönen et al. (2003) P24 &164	NV_27
Isepe	Not found	Yes	<i>Suilus granulatus</i>	Polyporaceae	AM_27 (www.efta-online.org); #659(TN) (Härkönen et al. (2003) P119	NV_28
Ubugume/Ubuguguna	Hard/tough	Yes	<i>Schizophyllum commune</i>	Schizophyllaceae	ADK_5289, JD_924 (www.efta-online.org)	NV_28
Ubunyagashiru	Not found	Yes	<i>Hypholoma subviride</i>	Marasmiaceae	JD_1254, JD_1443, RJH_310 (www.efta-online.org)	NV_29
Ibinyamatwi	Looking like ears	Yes	<i>Pleurotus</i> sp.	Pleurotaceae	-	NV_30
Not reported	-	Yes	<i>Trogia infundibuliformis</i>	Marasmiaceae	JD_997, RHJ_255 (www.efta-online.org)	NV_31
Matwiyigiti	Ears of the tree	Yes	<i>Auricularia cornea</i>	Auriculariaceae	RHJ_102, RHJ_284 JD_1209 (www.efta-online.org)	NV_32
Matwiyigiti	Ears of the tree	Yes	<i>Auricularia delicata</i>	Auriculariaceae	RHJ_14, RHJ_122 (www.efta-online.org)	NV_33
Urwerakare	That matures soon	Yes	<i>Amanita</i> sp.	Amanitaceae	No reference specimen	NV_34
Ibihefu	The biggest known	No	<i>Termitomyces titanicus</i>	Lyophyllaceae	JD_1015 De Kesel et al. (2017) (p232) ; (Buyck 1994) (p44-46)	-
Ubucabire/Ibit yabire	Not found	No	<i>Termitomyces</i> sp.1	Lyophyllaceae	-	-
Ubuzerumpu	Not found	No	<i>Termitomyces</i> sp.2	Lyophyllaceae	-	-
Ubuturi	Which makes ears explode	No	<i>Termitomyces striatus</i>	Lyophyllaceae	Tibuhwa 2020 Fig 61	-
Ubunyangombe	Not found	No	<i>Termitomyces mammiformis</i>	Lyophyllaceae	-	-

*Kirundi is the language spoken in Burundi, one of the countries forming the East African Community.



Fig. 3 – Consumed mushrooms harvested from KNP, Scientific names and pictures.
 a *Trametes polyzona*. b *Pleurotus citrinopileatus*. c *Macrolepiota daulichaula*. d *Lentinus squarrosulus*. e *Collibia aurea*. f *Auricularia cornea*. g *Schizophyllum commune*. h *Poylporus squamosus*. i *Trogia infundibuliformis*. j *Neonothopanus hygrophanus*. k *Termitomyces robustus*. l *Termitomyces microcarpus*. m *Hypholoma subviride*. n *Auricularia delicata*. o *Echinochaete brachypora*. p *Polyporus moluccensis*. q *Pleurotus* sp. r *Suilus granulatus*. s. *Amanita* sp.



Fig 4 – Non-consumed mushrooms harvested in KNP, Scientific names and pictures.
a Amanita muscaria. *b Marasmius sp.* *c Favolaschia calocera.* *d Favolaschia tonkinensis.*
e Auricularia sp. *f Macrolepiota sp.* *g Agaricus sp.* *h Marasmius sp.* *i Marasmius sp.*
j Marasmius sp. *k Not identified.* *l Dacryopinax spathularia.* *m Abortiporus roseus.*
n Armillaria sp. *o Not identified.* *p Marasmius bekolacongoli.* *q Lentinula sp.* *r Agaricus*
goossensiae. *s Macrolepiota Africana.* *t Not identified.* *u Lentinula sp.* *v Marasmius sp.*

Table 5. Non-consumed species from the KNP that are rejected by mushroom hunters and samples harvested: scientific names, families and reference specimens

Scientific name	Family	Reference specimen from literature	FABI/OBPE herbarium specimen
<i>Amanita muscaria</i>	Amanitaceae	1546 (TN) (Härkönen et al. 2003)	NV_35
<i>Marasmius</i> sp.	Marasmiaceae	-	NV_36
<i>Favolaschia calocera</i>	Polyporaceae	RHJ_119(www.efta-online.org)	NV_20
<i>Favolaschia tonkinensis</i>	Polyporaceae	JD_sn_1(www.efta-online.org)	NV_37
<i>Auricularia</i> sp.	Auriculariaceae	-	NV_38
<i>Macrolepiota</i> sp.	Agaricaceae	-	NV_39
<i>Agaricus</i> sp.	Agaricaceae	-	NV_40
<i>Marasmius</i> sp.	Marasmiaceae	-	NV_41
<i>Marasmius</i> sp.	Marasmiaceae	-	NV_42
<i>Marasmius</i> sp.	Marasmiaceae	-	NV_43
Not identified	Polyporaceae	-	NV_44
<i>Dacryopinax spathularia</i>	Dacrymycetaceae	ADK_2214(www.efta-online.org)	NV_45
<i>Abortiporus roseus</i>	Polyporaceae	5313(TN) (Härkönen et al. 2003)	NV_46
<i>Armillaria</i> sp.	Physalacriaceae	-	NV_47
Not identified	-	-	NV_48
<i>Marasmius bekolacongoli</i>	Marasmiaceae	RHJ_8 (www.efta-online.org)	NV_49
<i>Lentinula</i> sp.	Omphalotaceae	-	NV_50
<i>Agaricus goossensiae</i>	Amanitaceae	RHJ_251, (www.efta-online.org)	NV_51
<i>Macrolepiota africana</i>	Agaricaceae	RHJ_278 (www.efta-online.org)	NV_52
Not identified	-	-	-
<i>Lentinula</i> sp.	Omphalotaceae	-	NV_53
<i>Marasmius</i> sp.	Marasmiaceae	-	NV_54

Discussion

Results from this study show that females participated largely in the interview (55%) than males (45%) (Table 2). The high level of female participation in the survey was because females are mostly met in households or farms during the survey, while males are generally in bars or city centres for business deals. In addition, we noticed that men who met during the survey had very fair knowledge compared to women. Similar results from several studies show that women and children have greater knowledge on wild mushrooms than men (Garibay-Orijel et al. 2012, Tibuhwa 2013, Osarenkhoe et al. 2014, Okigbo & Nwatu 2015). Among them, 70.6% of the interviewees were from the KNP surroundings whereas 29.4% were from the NFRB surroundings. This larger number of interviewees from KNP surroundings than those from NFRB surroundings was because the NFRB is smaller than the KNP. Indeed, the KNP has an area of 40800 ha and stretches over four provinces, i.e., Muramvya, Kayanza, Cibitoke, and Bubanza, while the Bururi forest is located entirely in the Bururi commune, near the city centre of Bururi Province with an area of 3300 ha. Concerning the formal education level, most interviewees were those with primary education, followed by the illiterate and those with a secondary education level. This may be due to the free

primary education proclaimed since 2005 in Burundi. After primary education, a large number of students drop out and start farming activities or other small jobs to make a living. The study published by UNICEF (2018) reported that the average dropout rate in primary schools in Burundi was 8.6%. Regarding the profession, the interviewees were mainly farmers. The group of traders plus other jobs and the government employees occupied the second and the third position, respectively. This was because very few government employees were found in the households during the survey period. Generally, government employees are still few compared to the total population of Burundi. In 2016, agriculture accounted for 86.3% of total employment. The service sector accounted for 6.4 % of employment, while the combined trade and industry sectors accounted for 7.3 % (Banque Mondiale 2016). Where they exist, government employees are generally retained at work during working hours. The only government employees that were easily found in households and/or farms during the survey were the agronomists, while the group of small traders was also easily found operating on local markets. This is because the major part of the population of Burundi (more than 85%) depends on agriculture for its livelihood in rural areas. The tertiary sector represents less than 10% of the population (World Bank 2015). Moreover, most young students who drop out from their studies after primary or secondary school or the non-employed after their studies join their parents in farming activities.

In the study area, almost all interviewees affirmed knowing mushrooms, and most of them already utilized mushrooms for different purposes (Table 3, Fig. 2). Mushrooms play an important role in people's daily life. They are presented by the local population as an important source of food and income, especially during the first months of the rainy season, which is a difficult period corresponding to the food shortage when other crops have not yet been fruited. For this, they consider mushrooms as "a kind of meat, cheaper and easy to obtain without a loss of blood (without killing an animal)". This corroborates the observation by Härkönen (2002), who found that fungi in Africa are generally highly appreciated as foodstuffs and considered similar to meat. They appear at the beginning of the rainy season when the crops from the previous season are almost finished and the new crops have just been planted. Few people (6.2%) declared to use mushrooms for food and medicinal purposes. This observation is in line with the findings of Osarenkhoe et al. (2014), who found that 2% of the respondents who participated in his survey in Nigeria have used mushrooms as medicine to treat some diseases. Similarly, Härkönen et al. (2003), Tibuhwa (2012) and Hussein & Tibuhwa (2020) found several uses of mushrooms for medicinal applications in Tanzania. The majority of the informants declared to have eaten wild mushrooms (69.4%), and a few claimed to have eaten cultivated mushrooms. This highlights that the majority of Burundians do not have access to cultivated mushrooms and then rely on wild mushrooms. This can also be seen through the responses given by some informants when they were asked if they have already cultivated mushrooms or if they want to cultivate them when an opportunity was presented. No one among the interviewees declared to have cultivated them but some have seen where mushrooms are cultivated, whereas some of them were even surprised to hear that mushrooms could be cultivated. However, the technique of mushroom farming has been disseminated by some non-governmental organizations (NGO) such as COPED, World Vision and Care-Burundi in some provinces of the country, but it is still less known in the country. In the same line, a high percentage of the informants expressed their wish to learn the technology of mushroom farming. They declared that mushroom hunting is hard work associated with some risks, including wild animals (snakes, mosquitoes and tsetse flies, etc.), spines and prickles of wild plants, etc. In addition, mushroom cultivation can help them to produce them throughout the year around without consideration of seasons.

Through our observation, it was noticed that the activity was practised mainly by disadvantaged groups of rural communities. These findings are in line with those of other researchers. Tibuhwa (2013) reported that the only capital investment involved in wild mushroom harvesting in Tanzania is the energy spent by the mushroom hunter and small buckets or sacs used for carrying the harvested mushrooms. In addition, she found that many disadvantaged groups in rural areas, especially old people, women and children consider mushroom hunting as a source of

quick money. Ruán-Soto et al. (2006) reported that mushrooms were perceived as one of the "ranch foods", where "ranch" is a generic term used by people to designate every rural area in contact with wild nature.

This study revealed that mushrooms are mainly sold on local markets in fresh conditions because Burundian people like to use them fresh. This is in line with the findings from previous studies (Härkönen 2002, Härkönen et al. 2003, Tibuhwa 2012). When a large amount of mushrooms is harvested, sun drying is mainly used to preserve them for a certain period for household consumption but not for sale. Sun drying appears to be the cheapest method of mushroom preservation during sunlight weather. This corroborates the findings of Okigbo & Nwatu (2015), who found that 90.91% of the respondents in Onitsha South (Nigeria) use sun drying for preserving mushrooms. Tibuhwa (2013) reported several methods used by different communities in Tanzania for both short and long-term preservation while both fresh and dry mushrooms were sold in local open markets. Although her study reports in addition that the dry mushrooms were more expensive than the fresh ones, this is not the case in our studied areas, where it was found that mushrooms are preferred fresh. Another way of mushroom preservation is the practice of "Gusabura" which was reported to be used in preparing mildly toxic mushrooms to alleviate or eliminate the toxic compounds they contain prior to their consumption. This precautionary treatment shows that people from the study areas are aware that the toxicity of some mushrooms can be eliminated by heat. Involved species are *Lentinus squarrosulus* because of its slightly hot taste; *Neonothopanus hygrophanus* and *Hypholoma subviride* because of their bitter taste; *Amanita* sp. because it provokes drunkenness when eaten without pre-treatment. *Suilus granulatus*, *Auricularia cornea* and *Auricularia delicata* have to undergo the pre-treatment because of their slimy or viscid character on touch or sight. Here, the "gusabura" method is used not for eliminating toxic compounds but the slimy substance, which is considered to give a bad appearance (look) and taste to the mushrooms. Indeed, Burundian people, in general, do not like everything (including food) looking like mucus. In Tanzania, Härkönen et al. (2003) reported a similar practice used for eliminating the sharp taste of *Lactarius* species.

Regarding mushroom consumption or rejection, the reported main way of checking the edibility of a particular mushroom species is the oral tradition, where children know the edible mushrooms through the information got from their parents (especially mothers). In western Burundi (Rumonge zone) people reported that in case of confusion between an edible and a non-edible mushroom, they check the odor and taste of a small piece of it. In case the odor is different and/or the taste is hot, bitter or sharp, they conclude that it is not edible (Nteziryayo 2012). How people know that a particular species is edible depends on the family tradition and may vary a lot from one family to another and certainly from one region to another (Buyck 1994, Härkönen 2002, Osarenkhoe et al. 2014). Furthermore, Buyck (1994) reported that monkeys and other small wild animals play an important role in helping mushroom hunters to know whether a particular mushroom is edible or not in the Bujumbura-Rumonge region. Indeed, "if a monkey is observed to eat a certain mushroom species, people are likely to try it also". This is not the case for the communities living around the Kibira and Bururi mountain forests where the oral tradition is highlighted to be the only way to recognize whether a particular mushroom can be consumed or not. In this respect, several species are rejected despite belonging to recognized edible taxa. These include *Favolaschia calocera*, *Favolaschia tonkinensis*, *Dacryopinax spathularia*, *Abortiporus roseus*, *Marasmius bekolacongoli*, *Agaricus goossensiae* and *Macrolepiota Africana* (Table 5, fig. 4). For these species and others not consumed, no vernacular names were found (Table 5). This corroborates the reports by other researchers who noted that when a species got one or more vernacular names, it is a proof of its local importance (Härkönen et al. 2003, Eyi Ndong et al. 2011, De Kesel et al. 2017). In contrast, inedible or useless species in Africa do not attract the attention of local people to identify them and then no vernacular names are given to them. They just pick the traditionally consumed mushrooms and reject all others (Härkönen et al. 2003). In the study area, all unconsumed or useless species are grouped under the name "Nsubizahunkuye", which means literally "put me back in my place". Among these, *Amanita muscaria* was the most recognized

deadly toxic species. This also justifies why the number of intoxication or death cases reported in this study is very low, compared to the study conducted by Nteziryayo (2012) in the Rumonge region. This observation was also noted by other researchers, such as Buyck (1994) and Härkönen et al. (2003), who reported mushroom poisonings as rare in mountain areas where people consume very few species of mushrooms compared to the miombo areas where a high number of species are used for food. Therefore, mycophobia appears to be the safest and best attitude of people to avoid or prevent intoxication accidents. *Collybia aurea* and *Suilus granulatus* are not liked by many people. The few mushroom hunters especially in Batwa communities and forest guardians started trying them after seeing that expatriates like to purchase them under the french names “Girolles” (meaning *Cantharellus* species) and “cèpes” (meaning ceps or *Boletus* species), respectively. This justifies why their local names (“Jirore” and “Isepe”) are derivated from these french names. Buyck (1994) noted the consumption of *Collybia aurea* in Burundi and reported that it was the first record of consumption of this species in Africa.

Regarding socio-cultural beliefs, this study revealed that some people reject mushrooms because their parents told them that mushroom consumption could lead to the disappearance of their cattle herd or the lack of milk in lactating cattle. This belief resembles another one in Burundi about termite consumption. According to that, cattle farmers never eat termites (“iswa”) because they think that their livestock should either disappear or milk will be lacking for lactating cattle or the termite consumer will find the termites’ feet in the milk when he wants to drink it. Another belief is that when a pregnant woman eats mushrooms, she will have to give liquid from a cooked mushroom to her newborn otherwise, the child will have some health problems, such as ear disease (hearing impairment), stomach pain or vomiting whenever they are fed. This means that the Burundian tradition recognizes the medicinal application of mushrooms. Some mushrooms called “INTUMO” are never touched because they are considered the excrement from ancient people. The “INTUMO” (literally “dusty”) belongs to the sub-kingdom of the Gastromycetes. Referring to the morphological characters described by the respondents and the literature, the involved genus is probably *Scleroderma* (puffball). They are said “dusty” because the basidia and basidiospores formed throughout the fertile area of the basidiocarp and are called the gleba, a powdery mass of basidiospores. At maturity, the peridium, a part of the basidiocarp that encloses the gleba, will puff out and release the spores in a powdery mass, giving the impression of dust. This belief was also noted by other researchers in Rumonge region (Buyck 1994, Buyck & Nzigidahera 1995). These socio-cultural beliefs and myths associated with the lack of knowledge about the taxonomy, the nutritional and medicinal properties of mushrooms and the conservative eating habits of some Burundian people play an important role in creating a certain mycophobia (fear of mushrooms) in the study areas. People collect only the mushroom specimen that they know. The strong migration towards urban centres and the destruction of the natural environment in most parts of Burundi could also explain mycophobia. This mycophobia is expressed by the name “NSUBIZAHUNKUYE” given to all unconsumed mushrooms. It means “put me back in my place”. This name translates as the belief that an inedible mushroom once picked, must be put back in its place to avoid disasters. Buyck (1994) and Buyck & Nzigidahera (1995) reported fear regarding the consumption of some mushrooms in the Rumonge-Bujumbura region, which was expressed by the name “IBISAZI”, meaning “crazy mushrooms”. As people in Burundi are afraid of crazy people, they also fear the inedible mushroom in the same way. This expresses that people may not pick the mushrooms, otherwise they will see bad consequences if they eat them. Other cases of mycophobia or non-mycophily were so far reported in other countries (Oso 1975, Prance 1984, Härkönen et al. 2003, Ruán-Soto et al. 2006, Tibuhwa 2012). For instance, Härkönen et al. (2003) reported a fear regarding many types of mushrooms in Tanzania and concluded that many African families pick only mushrooms traditionally known as edible and reject all others. This fear seems to be normal because mushrooms are much less known than higher plants in Africa (Buyck 1994).

Concerning mushroom phenology, the study revealed that the mushroom sporophores appear during the rainy season and various species appear at different times. This mushroom phenology is

well known by the mushroom harvesters. This corroborates the observations by several researchers (Buyck 1994, Härkönen 2002, Dijk et al. 2003), who noted that the appearance of most edible mushroom species is highly predictable in time and such patterns are well known by local people in Africa. The respondents mentioned 22 different species of mushrooms consumed in the study areas (Table 4, Fig. 3). Table 4 and Fig. 3 show that some of the wild edible mushrooms reported by the informants were not identified. This was because their specimens were not found in the forest during the sampling time. These include Ibinankoba, ubwoba, ubundotwe, ubunyankerera (Nyenterere) igikongoro, ibinanzovu, ubuzeri, and ibijeri. Without a reference specimen (sample) collected, it is not easy to identify species referring only to the local names (in Kirundi) and descriptions given by informants. However, some termitophilic mushrooms (*Termitomyces titanicus*, *Termitomyces striatus*, *Termitomyces mammiformis*, *Termitomyces* sp.1, *Termitomyces* sp.2) were identified without collected specimens because both their local and scientific names were published by other researchers (Buyck 1994, Buyck & Nzigidahera 1995, Nzigidahera 2007). In contrast, some specimens of wild edible mushrooms that have not been reported by the informants were harvested and identified (Table 4 and Fig. 3). The unavailability of some mushroom specimens during the study could be explained by the seasonality of their growth in the forest and their presence in limited places. Despite living around the high mountainous forests where saprotrophic mushrooms are more abundant, many people cited the termitophilic mushrooms (*Termitomyces robustus* and *T. microcarpus*) as the most consumed species while the saprotrophic mushrooms were reported by a few respondents. This may be due to the National Parks access restriction instituted to people in 2013, thus causing people to rely on mushrooms found outside the protected areas only. The only interviewees who seemed to know the saprotrophic mushrooms were the guardians of the protected areas and some respondents who know to hide or to run faster when a guardian shows up in the park. However, most of the old respondents highlighted that some of the edible mushrooms they were used to harvesting and consuming in the last years are no longer found in the wild due to the increase of urbanization and deforestation. They requested urgent actions for preserving existing mushrooms from extinction. Mushrooms are just fruiting bodies of certain fungi, harvesting them does not affect the fungi organism. It is thus important to enlighten the National Park guardian and the responsible authorities to kindly allow mushroom gatherers to harvest mushrooms since the practices hardly affect the abundance and diversity of the collected fungal organisms.

This study revealed that some children are very active in mushroom hunting. Some children who were doing their primary studies revealed that they sell the collected mushrooms to earn money that can help them to purchase clothes and some school materials. They affirmed to be proud in this activity because they do not like to depend always on their parents for all their basic needs. This observation is in line with the findings of Osarenkhoe et al. (2014) who reported that children use the money they make from the sale of edible mushrooms to pay their school fees.

It was observed in this study that elder respondents (above 50 years old) gave more information on the use of mushrooms for medicinal applications. These include the treatment of stomach pain, hearing impairment and vomiting problems. Most of the young respondents were ignoring such applications. So, this study suggests documenting properly this indigenous knowledge and including ethnomycological lessons in the lower level of the education system of Burundi to avoid the loss of this valuable knowledge at risk of disappearing.

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