DETAILED FINAL REPORT

Documenting the diversity of macrofungi and local knowledge for sustainable conservation of fragmented swamp forest of Lokoli in southern Benin

Introduction

In contrast to other organisms like plants and animals, knowledge on fungal diversity and conservation is lagging behind although fungi are the second most diverse group of organisms (Purvis and Hector 2000). They are ubiquitous and play key roles in ecosystems (Mueller and Schmit 2007). They can directly improve livelihoods through economic, nutritional and medicinal contributions. In Benin, the diversity of fungi is roughly estimated at 16,842 species; to date, only 432 species i.e. 2,6% are known (Piepenbring et al. 2020). Based on a report on the alarming rate at which the tropical forest is disappearing (Myers1980), there is evidence that many tropical fungi will disappear without been discovered and identified (Lindenmayer et al., 2013). Likewise, we then could gain no information on the species' function in the ecosystem and for the population, since many studies have highlighted how community dependence on forest resources has high implications for long-term management and sustainability of forests (Saha and Sundriyal 2011). To be able to save known and unknown fungal taxa (species) and their habitats from extinction, unique and never explored habitats need to be surveyed. At the same time, local communities need to be informed and reoriented towards new income-generating activities which do not require the destruction or conversion of pristine land. To make it feasible reorientation of income-generating activities should not require relocation nor significant financial investments. We think mushroom cultivation is one of such options fitting these requirements. In Benin, the Lokoli swamp forest is a unique type of habitat in West Africa (Sinsin and Assogbadjo 2002), currently fragmented and never surveyed for fungi. To save the biodiversity, directly or indirectly threatened by the pressure of the local population, we feel that raising awareness and training local communities in mushroom cultivation will be the most effective conservation actions. Thus, this project aims in the first step to document the diversity of macro fungi in Lokoli swamp forest through a series of mycological surveys. In a second step, the local knowledge on the use of mushrooms will be documented through

an ethnomycological survey. In the third step, we will initiate and train local population into mushroom cultivation of two most sought-after and consumed species. Finally, the importance of mushroom conservation as well as that of the Lokoli swamp forest will be communicated to the local community through environmental education and community outreach.

Data analysis

All statistical analyses were performed using R 4.1.2 (R Core Team, 2021) in the RStudio integrated development environment (RStudio Team, 2021). The citation frequencies of the species were calculated. The influence of occupation on the number of known species was assessed by comparing the median number of species cited between occupational groups using the Kruskal-Walis rank test followed by the multiple kruskal comparison test under the agricolae package (de Mendiburu 2021). A graphical representation of this result was made through scatter boxes under the ggpubr package (Kassambara 2020). Finally, the relationship between the frequency of consumption of mushrooms and their availability and appreciation was highlighted through an ordinal logistic regression under the MASS package (Venables and Ripley., 2009) and then the result was graphically presented using the ggplot2 package (Wickham H. 2016).

Results

1. **Documenting the diversity of macro fungi in Lokoli swamp forest**

Five plots of 30 m x 30 m were established within each habitat (typical dense forest, moderately degraded dense forest, highly degraded dense forest). Using a GPS, the exact coordinates of these different plots were recorded. The survey within each plot consisted of systematically sweeping each plot in parallel strips 2m wide and before collecting each specimen, the fruiting bodies were photographed in their natural environment. Thereafter, the occurrences, the

number of fruit bodies, and the fresh biomass of each specimen were recorded. Fresh fruit bodies were identified whenever possible in the field; those that could not be identified in the field were collected, labelled, and air- or oven-dried at 40–50 °C. The dried fruit bodies were then preserved together with their labels in plastic bags with silica gel for macro- and micro-morphological examinations. Dried specimens were deposited at the mycological herbarium of the University of Parakou (UNIPAR; Thiers 2019). Mycological surveys within the plots yielded 148 specimens of which only 50 specimens representing 28 species were identified (some photos in annex). However, Chao's diversity index indicates that the macrofungi richness of this ecosystem could potentially reach roughly 102 species. Shannon's diversity index coupled with Piélou's J-equitability reveals that the number of fruiting bodies is equal between species, suggesting a high specific diversity (Table 1).

Table 1: Specific diversity index of Lokoli macrofungi

Richness	Chao	Shannon	Jevenness
28	101.94444	3.051303	0.91570099

2. Documenting the local knowledge on the use of mushrooms in Lokoli swamp forest

The surveys were conducted through administering structured questionnaire by interviewing 200 local residents in each target village (Lokoli, Koussoukpa and Dèmè). The respondents are farmers, traditional healers, traders, and forest owners. The questionnaire is designed by considering socio-economic variables and some questions, such as gender, age, level of education, distance of mushroom collecting from the respondents' home area, different uses of the species harvested and various threats to the species. The questionnaire also took into account other aspects such as the level of domestication of the different species and the motivation for their conservation, the local and national market demand for edible mushrooms.

2.1. Frequency of citation of species

A total of 8 names in the Fongbé language corresponding to species were cited by local people as species they consume. The highest frequency of citation was recorded for *Candolleomyces tuberculatus* called Dékpohounto (dead foot mushroom of *Elaeis guineensis*) followed by Termitomyces sp2 called Lisso (Table 2).

Table 2. Frequency of citation of edible species

Local names	Scientific names	n	Freq (%)
Aho/Agboto	*Lentinus squarosulus*	336	13.598
Attinhounto		165	6.677
Dekpohounto	*Candolleomyces tuberculatus*	505	20.437
Fofoé		67	2.711
Houinkpahounto	*Volvarielle volvacea*	261	10.563
Kohlè	*Termitomyces sp1*	312	12.626
Lisso	*Termitomyces sp2*	483	19.547
Tchinkin		342	13.841

2.2. Impact of the profession on the number of known species

The number of known species differed significantly by occupation in general ($p < 0.0001$). However, multiple comparisons revealed no significant difference in the number of species between certain professions. Thus, between farmers and traditional healers the number of mushroom species cited did not differ significantly. The same is true between teachers and other civil servants (public and private) as well as between learners, craftsmen and traders. But these three groups of ethnomycological knowledge level differ from each other (Figure 1).

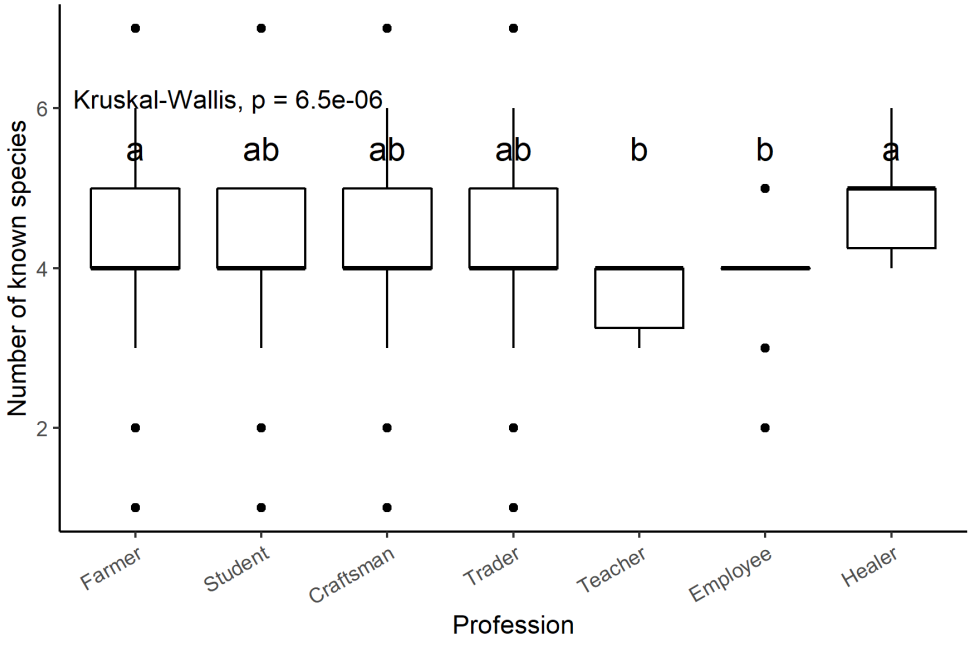

Figure 1: Comparison of the number of known species between professions

2.3. The relationship between the frequency of consumption of mushrooms and their availability and the level of appreciation by consumers

The ordinal logistic model type II analysis of variance indicates that the frequency of consumption of mushrooms is significantly influenced by the availability of these resources, the accessibility of carpophores collection sites and the degree of appreciation of the species by the consumers (Table 3). Indeed, all other things being equal, the probability that a species will be consumed at a certain frequency (low, medium, high) differs significantly according to the degree of abundance. The more abundant a species is, the more likely it is to be consumed more frequently (Figure 2a). Furthermore, the probability of a species being consumed at a certain frequency (low, medium, high) differs significantly depending on whether its collection sites are easily accessible or not. The ease of access to collection sites increases the probability that the species will be consumed more frequently (Figure 2b). On the other hand, the more popular a species is, the less likely it is to be consumed frequently (Figure 2c).

Table 3: Type II analysis of variance of the effect of accessibility, availability and degree of appreciation of species on their frequency of consumption by local populations

	LR Chisq	Df	Pr(>Chisq)	
accessibilty	14.7408	1	0.0001233	***
Availability	25.2705	2	3.255e-06	***
Appreciation	9.1266	1	0.0025192	**

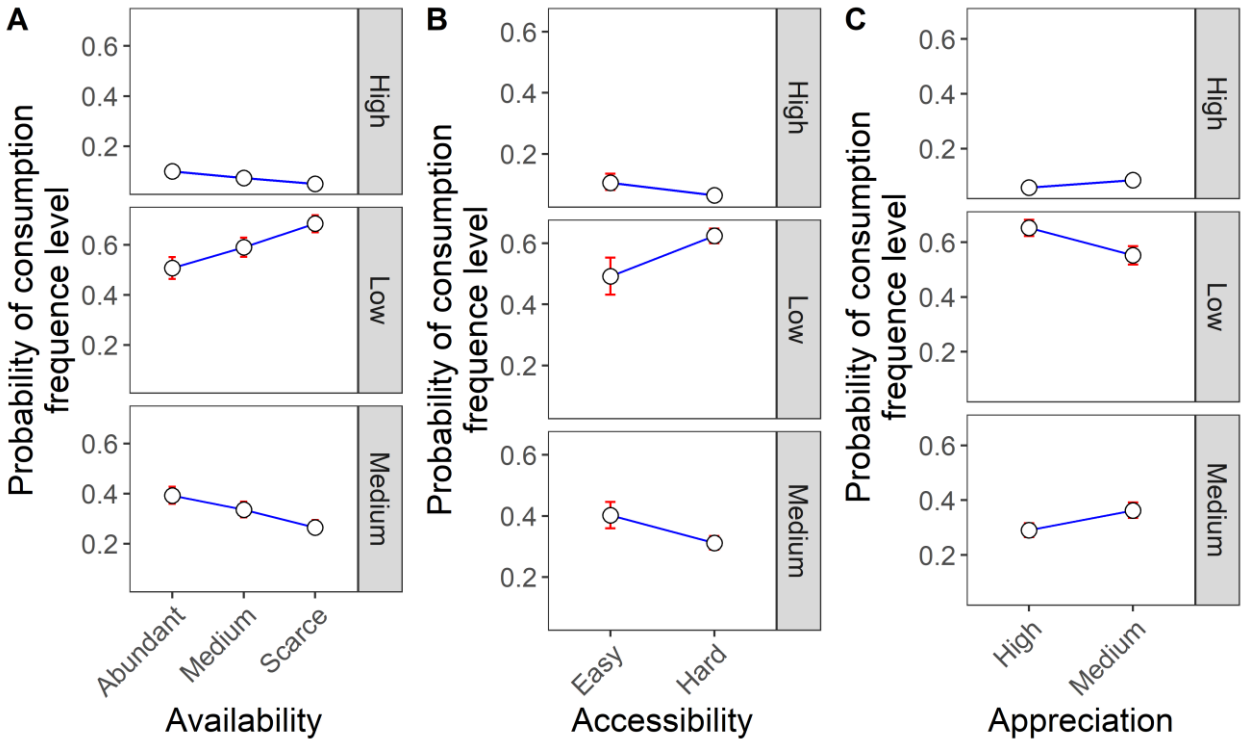

Figure 2: Effect of species availability and consumer appreciation on consumption frequency.

3. Training of rural households in the mushroom cultivation and community outreach

A total of 25 people were trained for this activity. The theoretical training was conducted in the local language to enable the participants to better understand the basic operations and concepts of mushroom cultivation. Firstly,

each participant was provided with a nose mask to ensure strict compliance with the protection conditions against Covid 19. Then, the posters containing the necessary information were displayed and the well-illustrated leaflets (see annex) containing the same information were distributed to each participant. The trainers then unfolded the content of the posters, making sure that each concept was understood. Among other information and topics explained, we have: What is a mushroom? How to produce or cultivate a mushroom? Substrate and how to treat a substrate (sorting, heat treatment, packaging)? how to seed, incubate and harvest. This session ended with questions of understanding and answers to questions. Finally, a snack to refresh the participants was made (see annex) and a group photo was taken (see annex).

The practical training took place on the following days with the collection of the lignocellulosic substrate (sawdust). It was also, under the participation of local people, chosen a space for the incubation of the crops. Thus, a space (see annex) was quickly set up respecting the minimal rule for a mushroom farm (minimum luminosity, shade, not too high temperature). The collected substrate was then soaked and mixed with water for the formulation of the substrate bags for cultivation. After the formulation of the substrate bags, the demonstration on pasteurisation was done (see annex). After the pasteurisation was completed, the participants were shown the strategy for checking the moisture content of the substrate before seeding. The pasteurised substrate was cooled down before seeding. Participants were then trained on the seeding technique (see annex). All seeded substrates were placed in incubation. Finally, we demonstrated to the participants the monitoring technique (watering, control of substrate colonisation).

Flyers and posters were used to communicate the importance of saving the swamp forest of Lokoli, and show to the population how their pressure on this forest affects the fungal diversity. The group of 25 volunteers in mushroom cultivation

training were used as our focal point in each village to mobilize population during the awareness campaigns.

Discussion

From this study 148 specimens were collected and only 50 specimens identified which yielded 28 species of fungi. The data analysis showed that the diversity of fungi in the Lokoli forest is still incomplete and many species are still to be discovered. Thus, future studies to complete our sampling effort will increase our insight of the mycodiversity of Lokoli. The result of this study clearly explains the determinism of choice of mushroom species by the local populations of the Lokoli swamp forest and shows that the consumption of species is guided less by the appreciation of the species but mainly by the abundance of the species in the environment and also by the consumer's ability to go easily to the fruiting places to collect it. On the other hand, despite a good appreciation of a species, it may not be consumed more frequently. This could be due to difficulties in accessing the fruiting sites or to the scarcity of these species due to the pressure of use they had undergone. This result corroborates perfectly with the ethnobotanical hypothesis of availability, which states that local populations tend to exploit more abundant and accessible species in their environment (Gaoué 2017, Gonçalves et al. 2016, de Oliveira Trindade et al. 2015, Albuquerque 2006, Voeks 2004). However, Gonçalves et al. (2016) finds that depending on the use category, availability does not always determine the species use of a plant species. Thus, availability does not explain the use of plants for medicinal or technological purposes. for example, contradicts the work of (Albuquerque 2006, de Oliveira Trindade et al. 2015) which indicates that in traditional medicine, people prefer indigenous plant species even if they are less abundant and less accessible.

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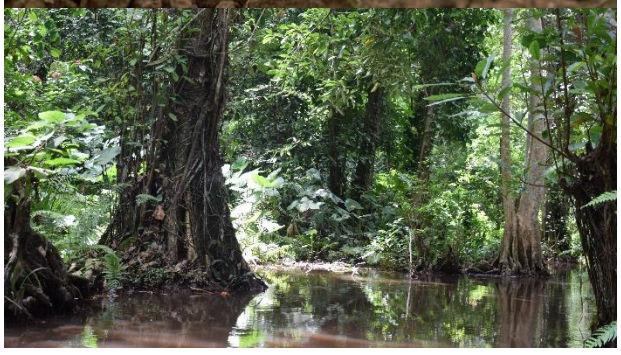
Annex

Photos from series of mycological surveys














Some photos from mushroom cultivation training and public awareness









Initiation à la culture des champignons à Lokoli :
Itinéraires de production
Quelques souche cultivables
Matériel nécessaires
Etapes de production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