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Tropical Mycology and Plant Soil Fungi Interactions

Circle of Action for the Protection of the Environment and Biodiversity

**Diversity, conservation status and promotion of the genus
Cantharellus in Benin (West Africa)**

Midterm-Report

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Introduction

Species of *Cantharellus* (chanterelles), like many other wild mushrooms, play a crucial role in the lives of local populations in Tropical Africa and are among the best-known and most appreciated mushroom species (Eyssartier, 2003). They are probably the most diverse of the macromycetes (Parent & Thoen, 1977), several chanterelles are good edible mushrooms that are traded and thus generate income for local populations (Tibuhwa et al., 2012). Ecologically, species of *Cantharellus* that are highly selective in terms of habitats and tree partners, are confined to very specific habitats in West Africa (Yorou et al., 2014).

In Benin, current scientific knowledge on these species is limited only to the gallery forests of Kota and Bassila (De Kesel et al., 2011; Yorou & De Kesel, 2011, De Kesel et al., 2016). As a result, this resource remains lost to local mycophagous populations and known habitats, resulting in anthropogenic pressures leading to threats to these species. Currently four of the eight species of *Cantharellus* known from Benin are red listed (Yorou & De Kesel, 2011). In order to document the diversity of *Cantharellus* species and to propose sustainable conservation while promoting their value, this project was financed by the Rufford Foundation. This mid-term report describes the activities carried out so far within the framework of this project.

1 Methodology

1.1 Study area

The study was carried out in five (05) forest reserves (Figure 1, Table 1) in the Sudano-Guinean region of Benin (Figure 1). This is the region conducive to the fructification of ectomycorrhizal fungi in general (Yorou, 2010). Of the five forests selected in this region, two (02), namely Bassila and Kota, have already been identified as a mushroom sanctuary in Benin sheltering a particular mycoflora including chanterelles (Yorou & De Kesel, 2011). The three (03) other forests, including Mont Kouffé, which received few attentions from mycologist, and those of Ouénou-Bénou and Trois rivières that have never been investigated in Benin, have been chosen to explore in order to identify new habitats for chanterelles in Benin.

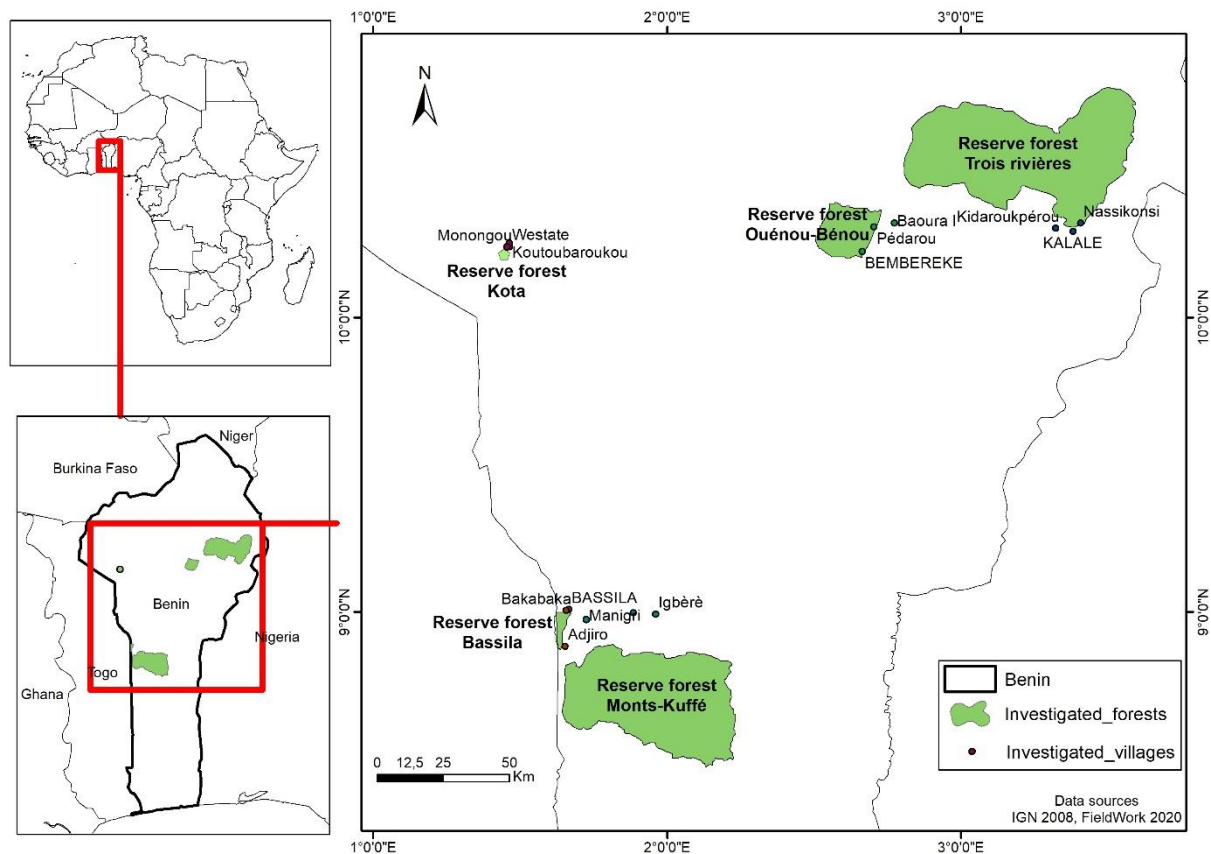


Figure 1: Presentation of the study environment

1.2 Data collection and analysis

Two types of data were collected in the field: ethnomycological and mycosociological. Ethnomycological data was collected in 15 villages, three (03) villages around each target forest (Table 1). A total of 450 people (farmers, housewives and forest rangers) were surveyed, i.e. 30 people per village. We used Survey sheets and the Kobocollect software to administer the questionnaire to informants on: the local nomenclature of chanterelles, uses, socio-cultural importance, and threats. Based on previous studies namely Yorou and De Kesel (2011), De Kesel et al (2011, 2016) and many others unpublished data, a picture album of chanterelle from Benin was developed to facilitate the surveys.

Table 1: Geolocation of the forests and villages investigated

Forest	Rental (Degree decimal)	Rainfall	Type of plant formation and woody species EcM dominant	Villages investigated	Spoken languages
Bassila	8.871857 - 9.003009 1.615169- 1.673367	1200 mm	Gallery forest of <i>Berlinia grandiflora</i>	Bassila	Anii
				Adjiro	Lokpa
				Bakabaka	Anii
Trois rivière	10.312001 - 10.688385 2.822108 - 3.566224	1100 mm	Clear forest with <i>Isoberlinia doka</i> and <i>Isoberlinia tomentosa</i>	Kidaroukperou	Bô
				Kalale	Bô
				Nassikonsi	Bô
Mont kouffè	8.478385 - 8.880038 1.651341 - 2.230978	1100 mm	Clear forest with <i>Isoberlinia doka</i> and <i>Isoberlinia tomentosa</i>	Igbèrè	Nagot
				Manigri	Nagot
				Mondogui	Nagot
Kota	10.213056 1.445	1 300 mm	Forest gallery with <i>Berlinia grandiflora</i> and <i>Uapaca guineensis</i>	Koutoubaroukou	Wama
				Monongou	Wama
				Westate	Wama
Ouénou Bénou	10.201179 - 10.390622 2.503000 - 2.728333	1100 mm	Clear forest with <i>Isoberlinia doka</i> and <i>Isoberlinia tomentosa</i>	Baoura	Bariba
				Bembèrèkè	Bariba
				Pedarou	Bariba

To make the mycosociological surveys, transects of variable lengths (0.5 - 1Km) were prospected from June to September 2020. Chanterelle were systematically collected and conditioned for conservation at the herbarium of the University of Parakou. For each sample, environmental factors and the anthropogenic disturbances were recorded. Each sample was examined on microscope for taxonomic identification of species.

For statistical analysis, we performed both descriptive and inferential statistics (Cramer's test and Correspondence Analysis) using R 3.6.3 software (R Core Team, 2020). Diversity index and conservation priority index (Martinez et al., 2006) were also computed. Using the wallace platform (Kass et al. 2018), the distribution of this genus was modelled. 48 occurrences, of which 36 were recorded from June to September 2020 and 12 from MyTIPS database (Research Unit of Tropical Mycology and Plants Soil Fungi Interaction) were used for this purpose. 19 bioclimatic variables were acquired from the worldclim website (<http://www.worldclim.org>) to explain the distribution of this genus using the maxent algorithm incorporated in this platform.

2 Results

2.1 Diversity of chanterelles in Benin

A total of six (06) species belonging the genus *Cantharellus* were observed in the field (Figure 2). Considering the collections recorded by MyTIPS, three (03) species were not observed in the field this year. Thus, for Benin nine (09) species of chanterelles are listed in Table 2 with their abundance.

Table 2: Abundance of different species of chanterelles in Benin

Cash	Forest	Abundance	Observation type
<i>C. addaensis</i>	All investigated forests	Very abundant	Direct observation
<i>C. solidus</i>	FG Bassila	Very abundant	Direct observation
<i>C. guineensis</i>	FG Bassila	Rare	Direct observation
<i>C. platyphyllus</i>	FG Kota	Abundant	Direct observation
<i>C. congolensis</i>	FG Kota	Rare	Direct observation
<i>C. sp</i> (Probably a new species)	FG Kota, FG Bassila	Moderately abundant	Direct observation
<i>C. rufhopunctatus</i>	FG Bassila	Rare	MyTIPS record
<i>C. Isabelinus</i>	FG Kota	-	MyTIPS record
<i>C. conspicuus</i>	FG Bassila	-	MyTIPS record

Among the five (05) forests surveyed, the richest chanterelle are the forests of Bassila and Kota with respectively six (06) and five (05) species. The other three (03) forests have only one (01) species (Table 3).

Due to small variations in spore size and shape as well as hyphal endings in the pileipellis of these species, the identification of eight well-known species is confirmed under the microscope. For the species that is not identified at the specific level (*Cantharellus sp*), molecular analyzes will be carried out in the Tropical Mycology and interactions of fungal soil plant laboratory in order to complete its identification.

Table 3: Diversity of chanterelles by investigated site

Forest	Richness	Shannon	Jevenness
Bassila	6	1.724	1
Kota	5	1.609	1
Mont Kouffè	1	0.000	-
Trois rivières	1	0.000	-
Ouénou Bénou	1	0.000	-
Pooled_sites	9	1,839	0.8845



Figure 2-a: *Cantharellus congolensis*, **b:** *Cantharellus guineensis*, **c:** *Cantharellus solidus*, **d:** *Cantharellus* sp, **e:** *Cantharellus platyphyllus*, **f:** *Cantharellus addaensis*.

2.2 Ecology of chanterelles in Benin

The species collected were all identified under almost identical macroecological conditions except of *Cantharellus addaensis*. These species were collected very close to the watercourse in gallery forests and in areas that are temporarily flooded, indicating the need for high humidity for their biological cycles. *Cantharellus addaensis*, which is an exception, is a species that is found in both gallery and open forest. Three ectomycorrhizial trees, *Berlinia grandiflora*, *Isoberlinia doka* and *Uapaca guineensis*, are identified around the fruiting bodies of the species encountered. Cramer's test revealed an affinity of chanterelles to their symbiotic partner trees with a very significant probability at the threshold of 5% ($p = 5.555e-10$ ***) and an association coefficient $V = 59.81\%$. The results of the correspondence analysis which completes this test illustrate a grouping of all species around *Berlinia grandiflora* according to dimension 1 (Dim 1 = 97.53%) with the exception of *Cantharellus addaensis* which groups together with *Isoberlinia doka* (Figure 3). Thus, for the conservation of chanterelles via their partners trees, *Berlinia grandiflora* and *Isoberlinia doka* will be promoted in the next step of this project.

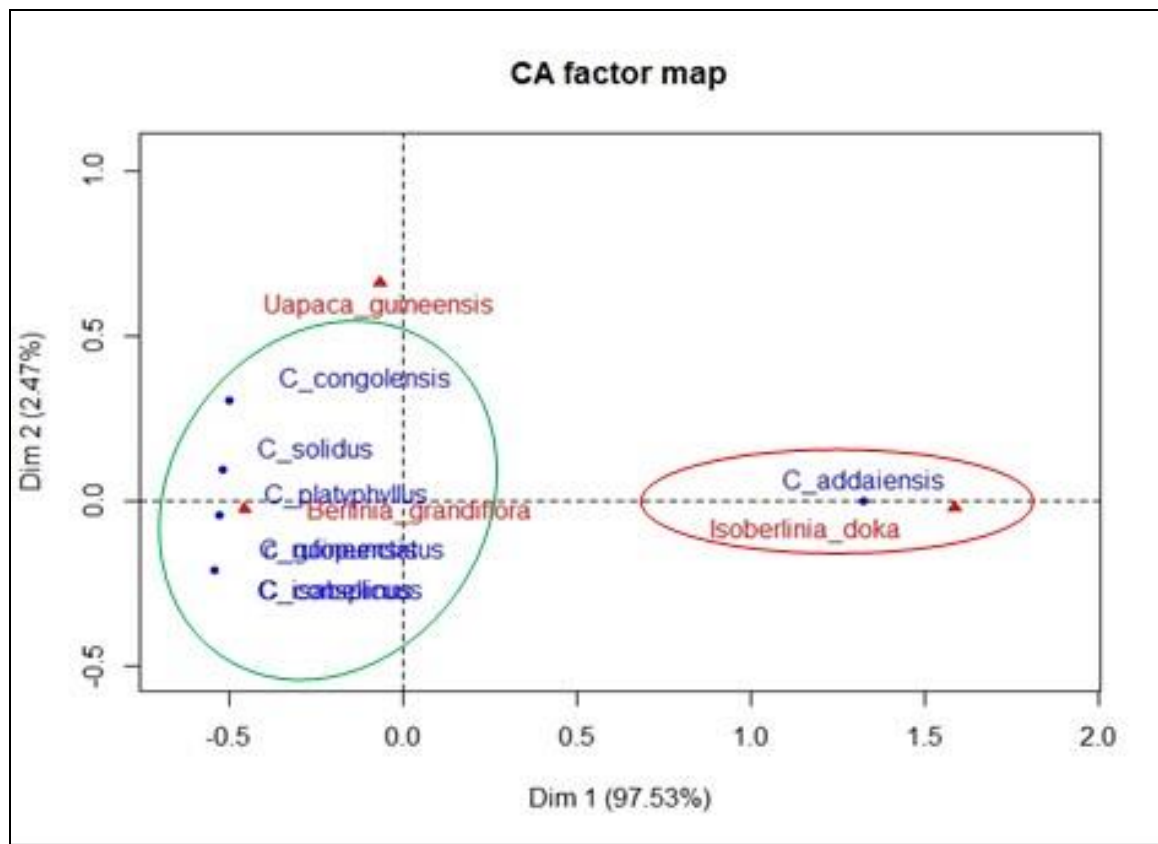


Figure 3: Grouping of chanterelles with probable symbiotic partners

2.3 Inter-ethnic variability in the recognize and the assessing of mushrooms

Ethno-mycological investigations reveal that seven (07) chanterelles of the nine (09) compiled for Benin, are known by the local populations. They are used only in food. Table 4 shows the list of chanterelles with their local names by ethnicity and their appreciation.

Table 4: Ethno mycological knowledge of chanterelles in Benin

Scientific names	Local names + appreciation					
	Anii	Bariba	Bô	Lokpa	Nagot	Wama
<i>Cantharellus addaensis</i>	Gatchitchrifoï quigniné +	-	-	-	Ossousou koukpanti +	-
<i>Cantharellus solidus</i>	Gnoncra sangato +++	-	-	-	-	-
<i>Cantharellus guineensis</i>	Anako ++	-	-	Tèr'n kèkpèka ++	-	-
<i>Cantharellus platyphyllus</i>	-	-	-	-	-	Kwanataihu +++
<i>Cantharellus congolensis</i>	-	-	-	-	-	-
<i>Cantharellus sp</i>	Gnoncra N ' Fonnon +++	-	-	-	-	Yagapemna ++
<i>Cantharellus rufopunctatus</i>	-	-	-	-	-	Mamyaga ++
<i>Cantharellus Isabelinus</i>	-	-	-	-	-	-
<i>Cantharellus conspicuus</i>	-	-	-	-	-	-

Legend: + + +: much appreciated, + +: appreciated, +: less appreciated, - : knowledge unavailable on the edibility

Essentially, Anii and Wama ethnic groups close respectively to the Bassila and Kota forests that are home to the largest number of chanterelles have a good knowledge on these species. The species recognized and cited by the populations are only used for food. No trade activity is associated with these species except for *C. solidus* which is sold in piles of 50 XOF in Bassila when harvests are abundant. The collections made are only for self-consumption.

From this investigation, it was noted that there is a confusion of chanterelles, especially those of yellow orange color like *Lactarius* species. *Cantharellus congolensis*, on the other hand, is rejected by several respondents as being toxic because of its strangely grey color.

2.4 Distribution of chanterelles in Benin

The model has an AUC of 0.91 revealing an excellent prediction quality for the distribution of ecological niche of chanterelles in Benin. The prediction map shows a localized distribution of the chanterelle ecological niche (Figure 3) in the Sudano-Guinean and Sudanian part of Benin. The major part of this niche, located in the western part of this zone, occupies the Bassila phytogeographic zone, the western part of the North Borgou phytogeographic zone, and the southwestern part of the Atacora chain. The predicted eastern niche occupies the northeastern part of the South Borgou phytogeographic zone. More precisely, the very favourable areas predicted for chanterelles are in the reserve forests of Bassila, Pénésoulou and Belefoungou, and the forest reserve of the natural monument of Kota (Probability of occurrence > 0.7). Also, the model predicts mean probabilities of chanterelle occurrence in the classified forests of Tanekas, Birni and Kouandé, ($0.7 > \text{Probability of occurrence} > 0.4$) where no chanterelle occurrence has yet been recorded.

The model response shows a positive correlation with the variables Bio_13 (Precipitation of the wettest month), Bio_14 (Precipitation of the driest month), Bio_17 (Precipitation of the driest quarter) and Bio_8 (mean temperature of the wettest month), expressing high probabilities of occurrence indicates that chanterelles are sensitive to humidity and precipitation. Also, the positive correlation with Bio_6 (minimum temperature of the coldest month) also indicates that low temperatures influence the distribution of chanterelles.

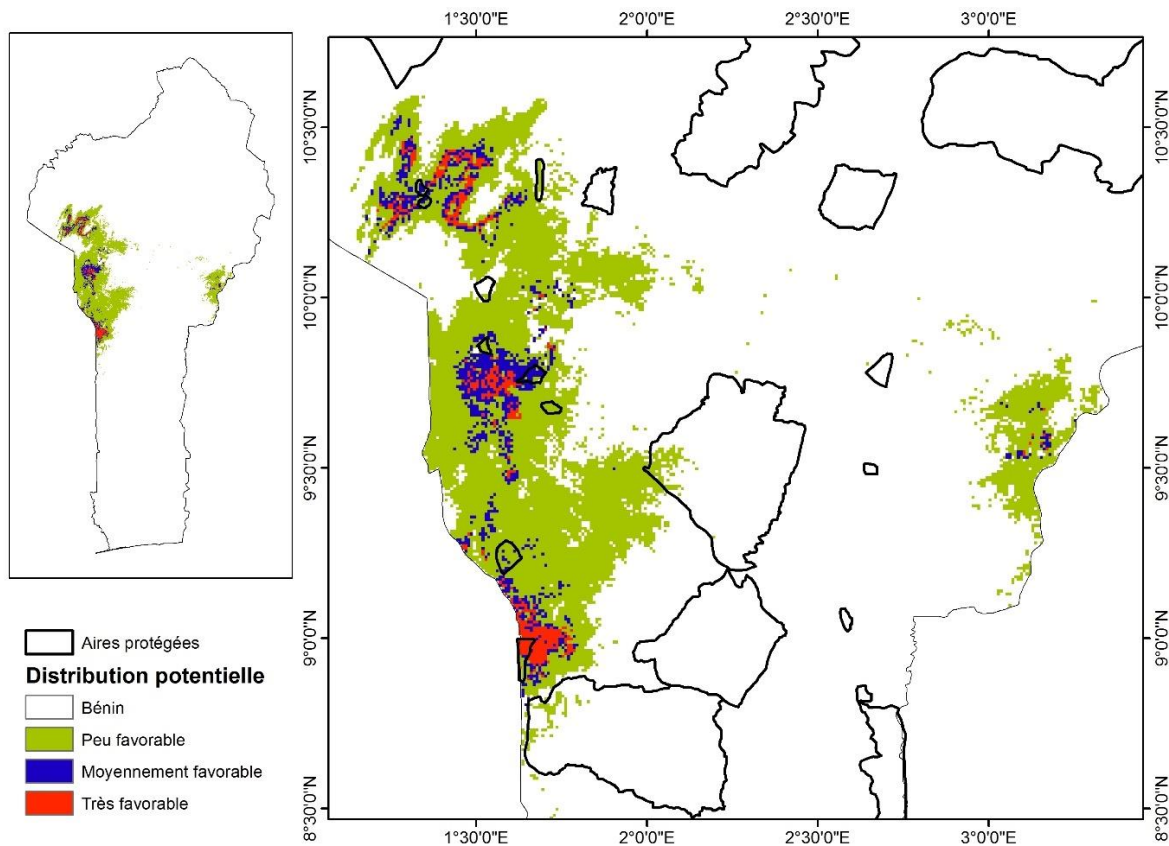


Figure 3: Potential distribution of the ecological niche of chanterelles in Benin

2.5 Evolution of natural production, threats and conservation priorities of chanterelles

According to the ethno mycological data, the natural production of chanterelles is declining in Benin. This is due to several threats to their habitat. We observed several threats to the habitat of these species in the field. This is:

- Deforestation by selective cutting of ectomycorrhizal trees, in particular *Berlinia grandiflora*, *Isoberlinia doka*, *Isoberlinia tomentosa* ;
- Production of charcoal on the fruiting sites of chanterelle;
- Agricultural production in protected areas destroying the fruiting sites of chanterelles;
- Standing cutting of shrubs for firewood;
- Overgrazing on fruiting sites by transhumant.

Beyond these threats, which make all these species of *Cantharellus* in Benin vulnerable due to the small extent of their ecological niches, the Conservation Priority Index of Martinez et al. (2006) indicates three (03) species to be prioritized in conservation actions: *C. guineensis*, *C. sp*, *C. congolensis* (Table 5).

Table 5: Conservation Priority Index (CPI) of chanterelles in Benin.

Species	ROA	RD	RPV	CPI
<i>Cantharellus solidus</i>	4	2.73	1.40	9.48
<i>Cantharellus guineensis</i>	4	3.00	5.00	37.16
<i>Cantharellus sp</i>	4	3.19	3.00	23.70
<i>Cantharellus platyphyllus</i>	4	3.00	1.00	7.43
<i>Cantharellus congolensis</i>	4	2.98	2.60	19.20
<i>Cantharellus addaensis</i>	4	2.14	0.57	3.03

ROA = Range of Origin for the Area, RCD = Range of Demand, RPV = Range of Perceived Vulnerability.

Although this index is relatively low for *C. solidus* and *C. platyphyllus*. Nevertheless, these species remain endangered in the face of threats due to the fact that they are confined to very small niches and threatened mainly by human activities. Of the four species listed by Yorou and De Kesel (2011) as Critically Endangered in Benin, only *C. platyphyllus*, *C. congolensis* were observed in the field. Due to the interannual variability in the fruiting bodies of many macromycetes, further work is needed to update the conservation status of the other two (*C. rufopunctatus*, *C. conspicuus*) that were not observed in the field this year. Thus, we establish this categorization for the chanterelles of Benin (Table 6).

Table 6: Conservation status of chanterelles from Benin

Conservation status of chanterelles from Benin		
<i>Cantharellus ruphopunctatus</i>	Critical Endangered	Yorou and De Kesel (2011)
<i>Cantharellus conspicuus</i>	Critical Endangered	Yorou and De Kesel (2011)
<i>Cantharellus platyphyllus</i>	Critical Endangered	Yorou and De Kesel (2011) + Field data 2020
<i>Cantharellus congolensis</i>	Critical Endangered	Yorou and De Kesel (2011) + Field data 2020
<i>Cantharellus solidus</i>	Vulnerable	Field data 2020
<i>Cantharellus guineensis</i>	Vulnerable	Field data 2020
<i>Cantharellus sp</i>	Data deficient	Field data 2020
<i>Cantharellus Isabelinus</i>	Data deficient	Field data 2020
<i>Cantharellus addaensis</i>	Least Concern	Field data 2020

Conclusion

This project, which is the first investigation on chanterelles in Benin, has allowed us to have a first database on the mycosociological and ethno-mycological level on these species. Only the abundant species (*C. solidus*, *C. platyphyllus*, *C. sp*) are well known by the populations and frequently collected for self-consumption. It is also a first step in the knowledge of the distribution of this genus in Benin which is typically inferred from the plant formations of the Bassila phytodistrict and the Atacora chain. Essentially threatened by anthropic activities, two new species are identified as vulnerable (*C. solidus* and *C. sp*) and thus extend the list of four species of the genus *Cantharellus* (*C. congolensis*, *C. guineensis*, *C. platyphyllus* and *C. conspicuus*) already included in the Red List of Macromycetes of Benin.

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Annex



a-b: Illegal login of ectomycorrhizal trees (*Isoberlinia doka*), **c:** Cutting of standing shrubs for firewood needs, **d:** Coal production, **e:** Yam's farm in survey plot in Mont kouffè forest, **f:** Grazing.



g: Ethno mycological survey

h: Microscopical analysis of specimens

i: Fieldwork with local mycophagous women of Kota