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Inventory and distribution of higher fungi (macrofungi) at the bog Ain Khiar (El Kala National Park, north east of Algeria)

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ABSTRACT

The macro-ecology of higher fungi in peatlands of the National Park of El Kala is unknown. This research aims to identify environmental factors that explain the distribution of fungi and subsequently contribute to the knowledge of the composition mycofloristique these particular settings. For this, we selected a protected site in the El Kala National Park and RAMSAR listed since 2002: "The Bog Khiar Ain. The fruiting bodies of fungi have been exhaustively identified during visits monthly from November 2003 until May 2008, and several environmental factors that determine the distribution of species were recorded: altitude, soil acidity, degree of humification Peat, floristic composition of vegetation. Thus, 21 species have been recorded on this site, including 06 species (25%) are specific to this station. A differentiated analysis by functional groups of macrofungi shows that saprotrophic species numbering 15, are determined by several factors of similar importance ectomycorrhizal species are mainly determined by the dominant tree species. A more meaningful analysis of the ecology of fungal communities is obtained by distinguishing functional groups, their composition being determined byenvironmentalfactors.

Keywords: Macromycetes - Inventory - Bog Ain Khiar - trophic status - distribution.

INTRODUCTION

The macro-ecological study of fungi has been initiated by the published works MAYOR (1907) which were mainly carried out in the forests of Baïnem (Algiers). At the National Park of El Kala, no study has been published inventory until today, as well as for mycological inventories on peatlands.
More generally, with the exception of the most characteristic species or the most iconic, precise information on the ecology and biogeographic distribution of macrofungi associated with peat bogs are very rare. The only basic bibliographic reference for knowledge and the ecology of fungi in North Africa (Algeria, Tunisia and Morocco) is the herbarium developed by G. MALENCON and R. Bertault (1970, 1975), preserved at the Museum of Natural History in Montpellier, but unfortunately it does not provide any quantitative indication on the spectra of ecological species.

Our study, fungal communities devoted to the bog Khiar Ain (National Park of El Kala), classified wetland RAMSAR site since 2002 (A. and A. Boumezbeur Bouteldja, 2002), is divided into two complementary parts. The first part consists of a macroscopic and microscopic species recorded at the site selected, while the second part aims to better describe the ecology of these fungi by analyzing both the distribution of species depending on environmental conditions (synecology) and fungal communities as descriptors of these conditions (myco-coenologie).

MATERIALS AND METHODS

2.1. *Site Selection*
A peat site was chosen at the El Kala National Park as representative of northern peatlands in eastern Algeria: the bog Khiar Ain. The Bog Ain Khiar or also known as the alder Ain Khiar is a wetland RAMSAR site ranked "1" since 2002 with the Black Lake (PNEK). Located in the commune of Ain Khiar, Daira El Tarf, El Tarf Wilaya (Fig. 1.), The site is at an altitude of 0 to 3m (36 ° 40'N latitude, longitude 8 ° 20'E), its area is by 180 hectares

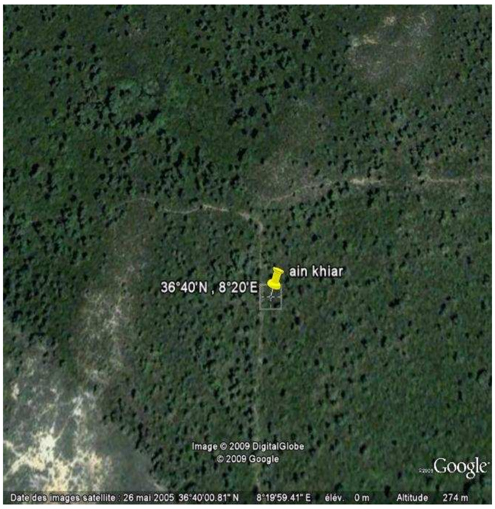


Fig. 1. : Location of alder Ain Khiar compared to PNEK

Description: characteristic of El Kala National Park, extremely rare elsewhere in Algeria, the alder riparian forest, is characterized by floristic composition based on Alnus glutinosa, Fraxinus sp. Populus sp. Salix sp. and demanding canopy moisture. Fen Khiar Ain is located between the coastal dunes and the agricultural plain of El Tarf (Fig. 1). Receiving, winter flood waters of the Oued El Kebir, which drains the entire region, it becomes a swamp. This small ecosystem has a biological value and scientific appreciable in the Maghreb. It is an environment of extremely rare natural wetlands of the Mediterranean region which can be considered as a site of international importance. Also the fact that it is also a bog, not studied, increases the intrinsic value indisputable site (Boumezbeur A. and A. Bouteldja, 2002).

Physical:

Geology and geomorphology: The territory is located in Ain alder Khiar is characterized by a relief and a fairly complex geology. In general, be distinguished as an imaginary line north-south major geomorphological units, training low hill 30 to 310m, as El Jebel Kors with an average of 100m high. Hydrology: the alder Khiar Ain is part of the plain of El Tarf near the Oued El Kebir and Watershed Dam Mexna. It is powered by Khelidjes and Chaabet (small streams and creeks) of Boukchrida, El Aloui and Tchaouf and receives winter flooding of the Oued El Kebir. As part of the lowlands, it is sometimes flooded even in summer, especially when late rains fall in April-May

Climate: This particular ecosystem benefits from special conditions or microclimate in which it does not ring contours. In general, according to the classification of Emberger, the area lies in the subhumid bioclimatic characterized by cold winters and wet and hot, dry summer. The rainfall varies from 717.2 mm to 944mm per year, with January being the wettest month. This vast amount is due to the absence of topographic barriers and the proximity to the sea and lakes surrounding the wetland complex in the region of El Kala. The temperature variations show that the month of August is the warmest month, the minimum average temperatures are 8 ° C and maximum 29.7 ° C.

Soil Type: This is the soils of wetlands based stringers, largely developed in the lowland flooded across the impermeability of the subsoil is linked to the expansion of the clays of Numidia.

Ecological features:
The alder Ain Khiar's plant represented by vegetation characterized by the presence of Fraxinus sp. Alnus glutinosa, Populis sp. Salix sp., A canopy whose main character is its moisture requirements. The trees are basically calling the alder leaf deciduous, with a height of up to 20m on average. Their recovery in the soil, very important, can reach 100% in some places, with an average of 80%. The presence of old trees and / or standing dead trees and bryophytes promote the installation of a specific mycflore of great ecological interest (Boumezbeur A. and A. Bouteldja, 2002).

2.2. Sampling Method:
The site of Ain Khiar, is considered environmentally homogeneous according to the physiognomy of vegetation. Given the large area of the site and its homogeneity we studied a plot with an area of 1000m2, following the stratified sampling method suggested by RODWELL et al. (1991) for the study of vegetation in the middle peat. This corresponds to estimates of sampling minimum area for higher fungi (between 500 and 1000 m2) calculated by ARNOLDS (1992).

The sampling method chosen, which seemed to best meet our goals is the method of "random transects" FAVRE (1948) for a fairly complete census of species on this site.
2.3. SAMPLING AND DETERMINATION conks

The fruiting bodies were counted exhaustively on the site (plots chosen randomly) in monthly statements from November 2003 until May 2008. The number of fruiting bodies per unit area (1000 m2) was converted into an index of abundance: 1 = a single fruiting body per plot, 2 = 0.04-0.50 (2-5) conks / 1000 m2, 3 = 0.51-1.0 (6-10) conks / 1000 m2, 4 = 1.1-2.0 (11-20) conks / 1000 m2, 5 = 2.1 (> 20) conks / 1000 m2.

The identification of fruiting bodies was confirmed as often as necessary by microscopic examination and consultation of specialized literature. Specimens of most of those species are preserved in the herbarium exsiccata R. DJELLOUL and sent to the laboratory Cryptogamie, Faculty of Pharmacy, University Henry Poincaré-Nancy 1-for identification.

2.4. Records of environmental factors
The elevation of the site has been derived from topographic maps. The measure of soil acidity and pH of the water of expression of the peat was measured by pH meter electronics 15 ° C, four samples, distinguishing two horizons: 0-10 cm and 10-20 cm. The degree of humification (determination of carbon) of peat has been evaluated by the method WALKLEY-BLACK changed for two horizons above (SIDAR M. et al., 2008).
The floristic composition of vegetation phaenogamic and bryophytes was found (H. Friberg et al., 2009)

2.5. Analysis of data
The relationship between environmental factors identified in the plot identified and the abundance of fruiting bodies have been analyzed. The maximum index of abundance of each species (observed in the monthly statements) has been used as the measure of its abundance in the plot in question. This index is a variable-ordinal, its association with environmental factors

was analyzed by correlation tests K Pearson (Chi-square tests). According to these tests, the hypothesis H0 representing the abundance of fruiting bodies of the species tested independent factor is rejected for P <0.05.

Significant correlations (P <0.01) for quantitative environmental variables (pH and high) and the degree of humification were divided into positive and negative correlations, depending on whether the species is associated with high or low values of the variable environmental analysis. Relations with the recovery of plant species were analyzed by species. To determine the relative influence of different environmental factors on fungal populations differs among functional groups of fungi, four organic statutes have been distinguished: ectomycorrhizal, saprotrophic humicolous, saprotrophic not humicolous (graminicola, wood fungus, gnats, we added parasites this group) and bryotrophes.

RESULTS AND DISCUSSION

3.1. General distribution of fungal species

A total of 21 species was determined (Table 1) On the site of Ain Khiar. Among these 21 species, 06 species are site-specific (not harvested in other sites of El Kala National Park studied).

Species in bold in the table, are species that were collected at other sites in high altitudes (> 500m).

Table 1. : List of species recorded, indicating trophic status and the index of abundance.
Species Trophic Status Index of abundance

Espèces	**Statut trophique**	**Indice d'abondance**
Crepidotus variabilis (Pers.: Fr.) Kumm.	saprotrophe lignicole (Salix)	2
**Tubaria furfuracea* ((Maire ex Kühn.)	Saprotrophe humicole	1
***Sarcoscypha coccinea* (Scop. : Fr.) Lambotte	Saprotrophe lignicole	1
Hygrocybe reae (Maire) Lange	saprotrophe humicole	3
***Schizophyllum commun* Fr. : Fr.	saprotrophe lignicole	4
Geoglossum coockeianum Nannf.	saprotrophe humicole	1
Clitocybe candicans (Pers. : Fr.) Kummer	saprotrophe humicole	2
Marasmius littoralis	Saprotrophe humicole	2
Clitocybe decembris Singer	saprotrophe humicole	2
**Pluteus sp.*	saprotrophe lignicole	1
Auricularia auricular-judae (Bull.: Fr.) Wettst	saprotrophe lignicole (Aulne)	1
Coprinus micaceus (Bull. : Fr.) Fr.	saprotrophe lignicole (Salix)	3
Coprinus disseminatus (Pers. : Fr.) Gray	saprotrophe lignicole (Aulne)	5
Hypholoma fasciculare : (Hudson : Fr.) Kummer	saprotrophe lignicole	4
**Typhula quisquiliaris* (Fr. :Fr.) P. Hennings	saprotrophe (fougères)	3
**Galerina sp.*	Bryotrophe	1
**Alnicola bohemica* (Vel.) Kühner & R. MAIRE	Mycorhizique (Aulne)	3
***Hebeloma mesophaeum* (Pers.) Quelet	Mycorhizique (Aulne ?)	2
**Cortinarius sp.*	Mycorhizique	1
Amanita rubescens Pers. : Fr.	Mycorhizique	2
Armillaria mellea (Vahl: Fr.) Kummer	parasite nécrotrophe (Aulne)	1

(*) Species-specific study site
(**) Species harvested in high altitude> 500m at other sites

3.2. Correlations between the variables and environmental

Mycoflor

The altitude of the plot varies from 0 to 3m. Of the 21 species recorded and analyzed, 18 are correlated with altitude (they are common species in low altitude). These species are specific to the relatively low altitude environments which 6 are specific to peatlands (Table 2).. Only three species are ubiquitous, can drive both high altitude than low altitude.

Table 2. : Number of fungal species associated with altitude, for all species and for the four functional groups.

Statut trophique	Basse altitude <500m	Haute altitude >500m
Espèces ectomycorhizique	4	1
Espèces saprotrophes humicoles	6	0
Espèces saprotrophes non humicoles	10	2
Bryotrophes	1	0
Toutes espèces confondues	**21**	**3**

As a result, the average fungal diversity at this site (middle peat in low altitude) is higher altitude environments, with 18 species growing within 500 m and 3 species growing to over 500 meters.

Soil acidity (pH of the water of expression of peat) ranges from 6 to 6.8. Most species whose abundance is related to the pH of the surface horizon (0-10 cm) also correlate to the pH of the deepest layer (10-20 cm), some species, however, are correlated at pH superficial (Tab. 3.). Only two species ectomycorrhiza (Hebeloma mesophaeum and Cortinarius sp.) Humicolous saprotrophic species and associated with deep peat (Clitocybe December) is only correlated to measurements of 10-20 cm horizon, suggesting a breakdown of mycelium deeper than in other species tested.

Table 3. : Number of fungal species associated with soil acidity in the surface horizon (0-10 cm) and lower horizon (10-20 cm) for all species and the 4 functional groups.

Statut trophique	Horizon superficiel	Horizon inférieur
Espèces ectomycorhizique	2	4
Espèces saprotrophes humicoles	5	6
Espèces saprotrophes non humicoles	4	2
Bryotrophes	1	1
Toutes espèces confondues	**10**	**13**

The rate of total organic carbon in the bog Ain Khiar is quite large, according to the analysis of Walkley-Black modified, 60% organic matter was determined. Only 10 species were significantly influenced by the degree of humification (Table 4.), Whose four ectomycorrhizal species are associated with a high rate of decomposition and saprotrophic species humicolous. The species bryotrophe is influenced by the rate of humification important to the surface horizon.

Table 4 : Number of fungal species associated influenced by the rate of humification in the surface horizon (0-10 cm) and lower horizon (10-20 cm) for all species and all four functional groups:

Statut trophique	Horizon superficiel	Horizon inférieur
Espèces ectomycorhizique	4	4
Espèces saprotrophes humicoles	5	6
Espèces saprotrophes non humicoles	0	0
Bryotrophes	1	0
Toutes espèces confondues	**10**	**10**

All species correlated with the degree of humification of the lower horizon are also correlated with that of the surface horizon, the bryotrophes to mycelium in direct contact with live moss, are correlated to the humification of surface layer.

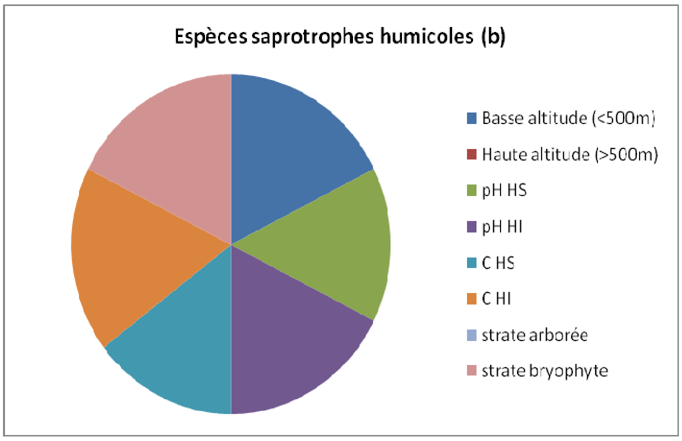
The fungal species whose wood fungus mycelium is in contact with the stem (branches of trees) are not significantly correlated with the rate of total soil carbon. The recovery of woody species in the canopy is an important factor for the distribution of more than half the species studied (Table 5).. The analysis reveals a strong influence on the composition of Alnus ectomycorrhiza of fungal species diversity and the general. It is the same for Salix, each with a procession ectomycorrhiza specific but not very diversified. The bryophytes are strongly correlated to the composition of the medium studied mycofloristique. These correlations affect both fungal species directly associated with mosses (Galerina sp.) Humicolous saprotrophic and species associated with organic matter.

Table 5 : Number of fungal species associated with the recovery of plant species and the fourfunctional groups :

	Tous	EM	SH	SnH	B
(a) Strate arborée					
Alnus glutinosaSalix sp.	10	04	00	06	00
Fraxinus sp.	03	00	00	03	00
	01	00	00	01	00
(b) Strate muscinale					
	07	00	06	00	01
Toutes espèces confondues	**21**	**04**	**06**	**10**	**01**

- *EM, ectomycorrhizal species, HS, species saprotrophic humicolous; SnH, species not saprotrophic humicolous; B bryotrophes species.*

Ectomycorrhizal species (Fig. 2a) depends primarily on the nature of tree cover and degree of humification of soil, with nearly equal proportions (20%) significant correlations. Saprotrophic species not humicolous (Fig.2c), mostly associated with dead wood and wood debris, mainly depend on the nature of the wood substrate (60%). In contrast, saprotrophic humicolous (Fig.2b) are determined by various other factors of equal importance, namely, the acidity (Hinf. 18%, HSUPA. 21%). Species bryotrophes (Fig.2d) are mainly determined by the composition of the moss layer (25%), but also by the degree of humification of soil (25% correlation) and the degree of soil acidity. Other factors have only marginal significance, indicating a resemblance mycocoenoses bryotrophes for the same type of plant association in equivalent altitude.



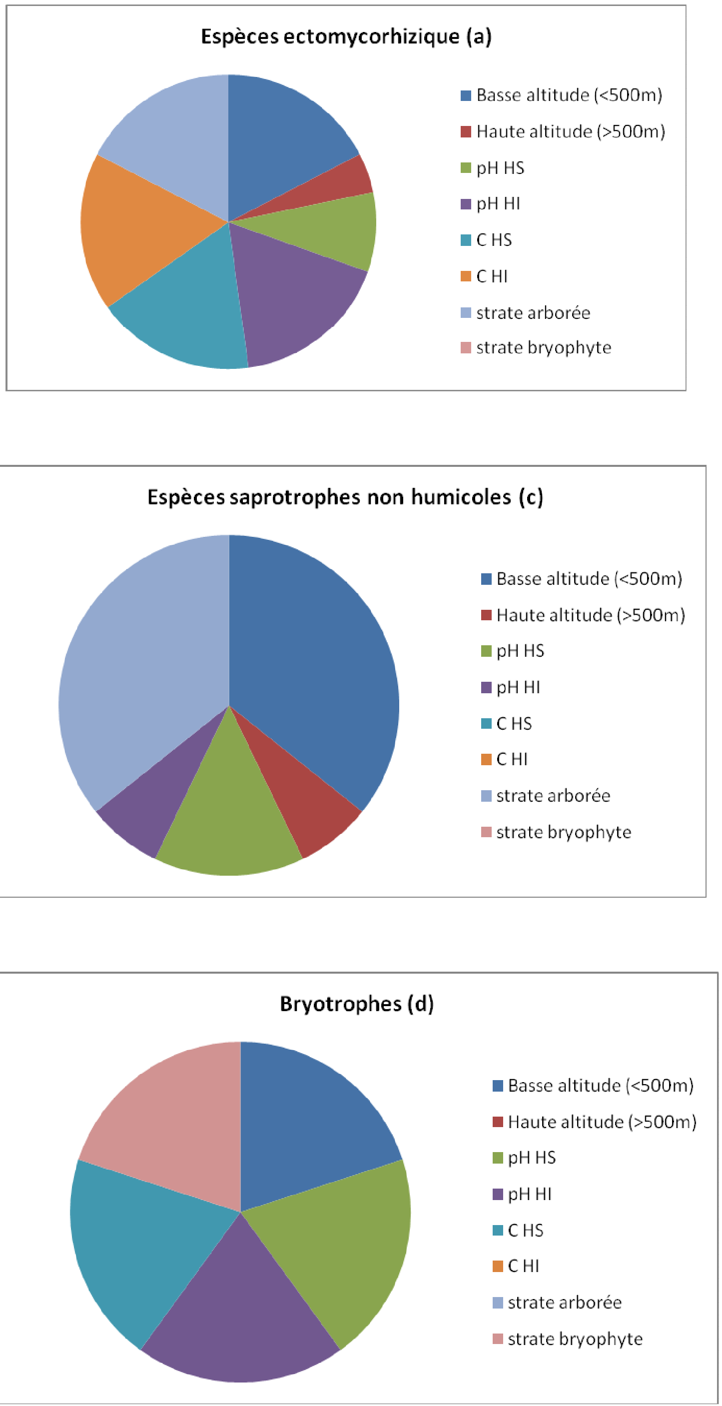


Figure 2. : The relative influence of different environmental factors studied on the species composition of fungal communities, given separately for the four functional groups of basidiomycetes. (A, b, c, d)

We can thus summarize the data collected in Table 6:

Table 6. List of fungal species identified, and environmental variables which its abundance was correlated. Codes of environmental variables bold denote significant correlations at P <0.01, the other significant correlations at P <0.05 (Pearson K-test).
Name Var. abiotic Stratum Stratum tree moss

Name	Var. abiotiques	Strate arborée	Strate muscinale
Crepidotus variabilis (Pers.: Fr.) Kumm.	**Alt+, pH+**	Sal	
**Tubaria furfuracea* ((Maire ex Kühn.)	**Alt+, pH+, CT+**		+
Sarcoscypha coccinea (Scop. : Fr.) Lambotte	Alt-, pH-	Aln	
Hygrocybe reae (Maire) Lange	**Alt+, pH+, CT+**		+
Schizophyllum commun Fr. : Fr.	Alt-, pH-, CT-		
Geoglossum coockeianum Nannf.	**Alt+, pH+, CT+**		+
Clitocybe candicans (Pers. : Fr.) Kummer	**Alt+, pH+, CT+**		+
Marasmius littoralis	**Alt+, pH+, CT+**		+
Clitocybe decembris Singer	**Alt+, pH+, CT+**		+
**Pluteus sp.*	**Alt+**, pH-, CT-	Aln	
Auricularia auricular-judae (Bull.: Fr.) Wettst	**Alt+, pH+,** CT-	Aln	
Coprinus micaceus (Bull. : Fr.) Fr.	**Alt+, pH+,** CT-	Sal	
Coprinus disseminatus (Pers. : Fr.) Gray	**Alt+**, pH-, CT-	Aln	
Hypholoma fasciculare : (Hudson : Fr.) Kummer	**Alt+, pH+,** CT-	Aln	
**Typhula quisquiliaris* (Fr. :Fr.) P. Hennings	**Alt+, pH+,** CT-		
**Galerina sp.*	**Alt+, pH+, CT+**		+
**Alnicola bohemica* (Vel.) Kühner & R. MAIRE	**Alt+, pH+, CT+**	Aln	
Hebeloma mesophaeum (Pers.) Quelet	Alt-, **pH+, CT+**	Aln	
**Cortinarius sp.*	**Alt+, pH+, CT+**	Aln	
Amanita rubescens Pers. : Fr.	**Alt+, pH+, CT+**	Aln	
Armillaria mellea (Vahl: Fr.) Kummer	**Alt+, pH+,** CT-	Aln	

(*) Species-specific study site

DISCUSSION

With this inventory, comprehensive, managers will have an assessment of the dream of that remarkable bog. This must be complemented by work repeated in future. These tests showed significantly different influence of environmental factors on the respective composition of the different fungal communities (ectomycorrhizal species, and saprotrophic bryotrophes, see Fig. 2). From these comparisons out in particular the preponderant influence of tree cover on the composition ectomycorrhiza, and the nature of the moss layer, and the altitude (highly significant on the various study sites throughout the search), the composition bryotrophe: this suggests a degree of predictability procession fungal dominant to peaty formations and ectomycorrhizal communities bryotrophes, knowing the nature of vegetation and elevation.

In contrast, the populations appear saprotrophic determined by a combination of factors co-dominant (species composition, acidity, altitude, humidity) that do not, according to this analysis, to predict the composition of saprotrophic communities of a given . The reasons may be an ecological versatility of all dominant species, or more likely a need to distinguish different categories saprotrophic (eg. Depending on the substrate), according to a typology embryonic (MOREAU PA, 2002).

If correlations between fungal species and environmental factors or plant species have been described in this work, no functional relationship has been proposed here, and such relations should be established at other levels of study, the determination of a relationship ECM is carried out either by direct observation of fruiting bodies (J. Favre, 1948), or by identification of mycorrhizae (GUARDS M., 1990).

Similarly, the correlations between the herbaceous plants and fungi (non-operating results given the correlations are not significant) describe only ecological convergence, since no functional relationship between plants and fungi studied was demonstrated. We note in particular that Salix sp., Which accompanies the afforestation of peatlands is linked to the presence of ectomycorrhizal fungi of neighboring trees.

The correlations presented here concern only 21% of the total fungal diversity among these species we find species not reported by MALENCON & Bertault (1970, 1975), (Crepidotus variabilis Geoglossum coockeianum, Typhula quisquiliaris) It is therefore describe the main features of the environment, which simply define the ecological spectrum of the most representative species. The study of fungal associations (or "mycocoenologie"), using multivariate statistical analysis, allows to take into account the rarest species on these two or three plots in comparison with species that are better represented and whose ecology is better defined, and these results will be published later. These two complementary aspects of the ecology of fruit bodies, if they do not directly interpretable information on the biology of species, however are applied very direct approaches to inventory and bioassessment fungal communities (ARNOLD , 1988; COURTECUISSE R. et al. 2000; GULDEN G., 1992)

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