

## Original Research Article

### Diversity of Basidiomycetous Macrofungi from Mpanga Forest in Mpigi District, Central Uganda

#### ABSTRACT

The present study was conducted at Mpanga Research Forest located in Mpigi District, Uganda, during the months of March, April, May and June 2020 (for the first rainy season) then in September, October, November, and December 2020 (for the second rainy season) to determine the diversity and distribution of macrofungi as well as their influence by seasonality, and physicochemical properties of the soil. An inventory was carried out through plot sampling and survey which consists of installing three permanent plots of 30 m x 30 m in each of the four selected sites, the soil was also measured in the sample plots. To measure distribution and diversity, abundance, species richness, density, and Simpson's and Shannon's indices were calculated. SPSS version 20 software was used for the significance tests of the diversity parameters between the two rainy seasons and for those of the correlation between the soil factors and the abundance of macrofungi species. A total of 120 species of basidiomycetous macrofungi distributed in 53 genera and 22 families were recorded. The dominant genus was *Psathyrella* followed by *Marasmius* belonging to the most dominant families (Coprinaceae and Marasmiaceae), and the most dominant orders (Agaricales and Tricholomatales). During the two rainy seasons, the majority of the species that have been collected belong to the group of saprophytes. Macrofungi species collected during the second rainy season were more abundant and diverse than those collected during the first rainy season. Among the physicochemical properties of the soil, pH, calcium, potassium, nitrogen, organic carbon, phosphorus, clay, sand and organic matter were significantly correlated with the abundance of macrofungi species. The results of this study provided basic information on the diversity of macrofungi in Mpanga forest, it can be a point of reference for further research to study the evolution of macrofungal biodiversity in this forest.

**Keywords:** Macrofungi, Diversity, rainy season, soil factors, Mpanga forest.

## INTRODUCTION

Fungi are one of the four classifications of the living kingdom, alongside animals, plants, and bacteria. Formerly classified as plants, they now form a separate kingdom within the eukaryotic group, called Mycota or Fungi [1]. The reign of Mycota is not limited to large mushrooms whose appearance in the forest and sales in the markets are familiar to us; it also includes mold that attacks our food, parasitizes our skin or gives the cheese a special taste.

These molds are called microfungi because they are invisible to the naked eye. The term macrofungi (mushrooms) or macromycetes has been defined by several authors who all agree on the production of fruiting bodies visible to the naked eye [2, 3, 4, 5]. Most macrofungi are members of Basidiomycota, but some belong to Ascomycota. These two divisions are distinguished by their sexual reproduction spores which are internal, contained in asci for Ascomycota and external, carried by sterigmata at the top of the basidia for Basidiomycota. Macrofungi, in particular basidiomycetous, which appear mainly during the rainy season in forests, are less known than higher plants because of their ephemeral appearance. Despite their short lifespan, basidiomycetous macrofungi play an important role for the local communities of tropical Africa as sources of food, medicines and substantial income [6,7,8]. Over two-thirds of these communities depend on forest products, either for subsistence or as cash income derived from a wide range of non-timber forest products (NTFPs), including basidiomycetous macrofungi [9].

Apart from the nutritional and medicinal aspects, basidiomycetous macrofungi play also an important role in ecosystem functioning [10] by allowing nutrient recycling, growth, and seedling establishment in forest soil [11]. Thus, they are very good indicators of the health or age of an ecosystem [12]. In Africa, the work of [13], [14], and [15] conducted in West Africa has shown this fundamental role played by basidiomycetous macrofungi in the functioning and regeneration of natural forest ecosystems in tropical Africa. In addition to their ecological importance, basidiomycetous macrofungi constitute an important heritage among the world's biological resources, on the one hand through their usefulness and on the other hand through their diversity [16,17,18,19,20].

The fungal kingdom is currently one of the most diverse systematic groups in the biosphere after insects [21], the number of species is estimated at 2.2 to 3.8 million worldwide [22], but macrofungi are less represented with an estimate of 140,000 species [23]. Within the group of macrofungi, the basidiomycetous are the most diversified and studied with 22,000 species described worldwide [24]. However, despite being an important heritage among the world's biological resources, the documentation on their diversity is still insufficient in sub-Saharan

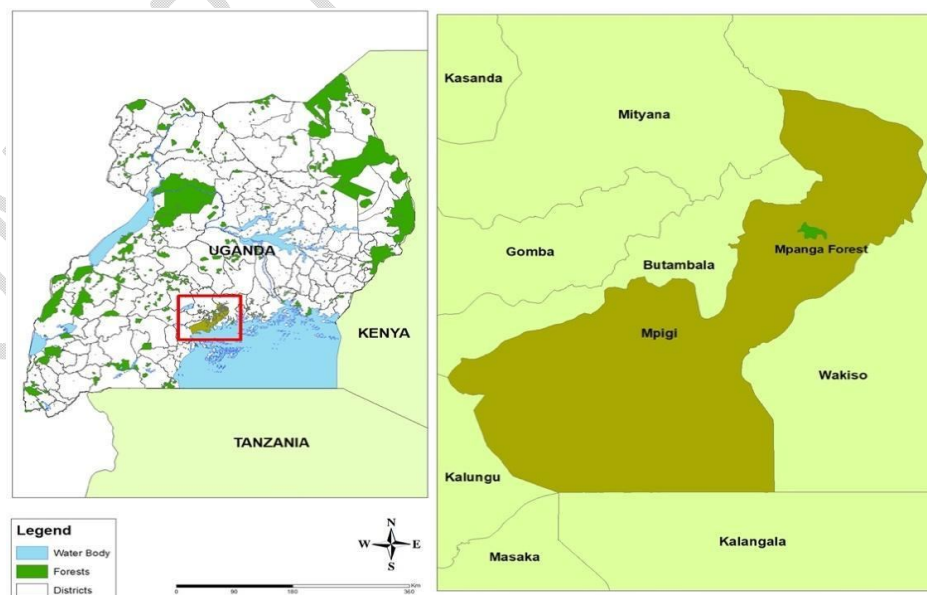
Africa. This insufficiency is more marked in West Africa because no flora has yet been available and the recent studies were carried out by [25,26],[10],[27],[28] and [29]. In South Africa, [30] recently published the first macrofungi checklist for South Africa. The most in-depth work has been carried out in Central and East Africa with the existence of three flora: “the iconographic flora of the mushrooms of Congo” [31], “the illustrated flora of the mushrooms of Central Africa” [32], and “a preliminary agaric flora of East Africa” [33] but the recent studies were carried out by [34,35,36]. In East Africa, diversity has been widely documented in older publications but recent ones have been done by [37], [38] and [39]. In Uganda, apart from the very old publications of [33],[40],[41], studies conducted by [42] and [43] summarize the literature on the diversity of basidiomycetous macrofungi. The studies conducted by [42] and [43] recorded respectively 10 species of basidiomycetous macrofungi belonging to 5 genera and 173 species of basidiomycetous macrofungi belonging to 62 genera. However, the study conducted by [43] focused exclusively on one subclass of basidiomycetes called Aphyllophoromycetidae.

The equatorial natural forest of Mpanga with its 500 species of trees and shrubs, 300 species of birds, 97 butterflies, and 112 moths [44], has been the subject of many studies on animal and plant biodiversity [45, 46, 47, 48, 49, 50]. It has also been the subject of a study on the Saprophytic Ascomycetous and Fungi Imperfectione dead and decomposing branches, logs, and stumps [51], but no studies focusing exclusively on Basidiomycetous macrofungi have ever been carried out, hence the need to study them because of their risk of extinction due to anthropogenic activities to which the forest is exposed. Despite the Ugandan government's commitment to promoting the conservation, management, and sustainable use of its biological resources by 2025 [52], the lack of data on the diversity of such an important resource in Uganda, which is the wettest country in the sub-region with its 4.9 million hectares of natural forests [53] conducive for the development of macrofungi, constitutes a failure in the sustainable management of this forest resource. That's why this present study aims mainly to contribute to the knowledge of the diversity of Basidiomycetous macrofungi in Mpanga forest for good sustainable management, knowing that the protection of biodiversity has become a major issue of forest policy. Specifically, it consists in determining the diversity and distribution of macrofungi as well as their influence by seasonality and physicochemical properties of the soil.

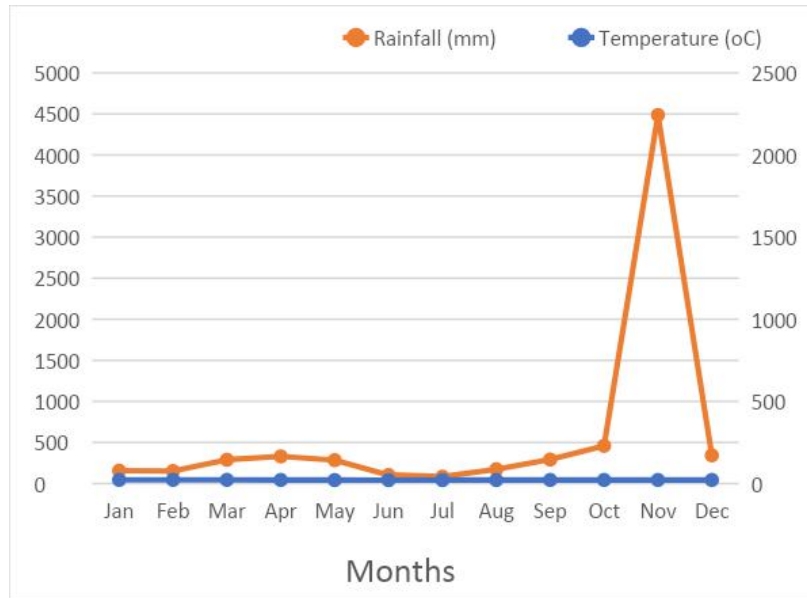
## **MATERIALS AND METHODS**

### **Study area**

The study was conducted at Mpanga Research Forest located in Mpigi District, Uganda (Figure 1). Mpanga Forest Reserve (0 ° 127 'N, 32 ° 175' E) is an area of moist semi-deciduous tropical forest with *Celtis* that lies between 1140 and 1200 m altitude in Mawokota County, south of Mengo, 3 km southwest of Mpigi town, 36 km west of Kampala and 25 km north-west Entebbe, only about 20 km from the shores of Lake Victoria [48]. It is also located in the climatic zone of Lake Victoria [54], characterized by a bimodal distribution of precipitation, with the wettest periods from March to June and from September to December as shown by the ombrothermic diagram of Mpigi district (Figure 2). The mean annual precipitation and the minimum and maximum temperatures are estimated at 1168 mm, 17.2°C, and 26.1°C, respectively with a relative humidity of 90% according to [49]. Soils in the region are generally red and yellow latosols on the peaks and crests, sandy-gray loams on the lower slopes of the hills, and gray-blue clays and silts on the lower slopes and valleys [55 and 56]. Mpanga is a small expanse of natural equatorial forest of 453 hectares [57] which supports an impressive plant biodiversity composed of 500 species of trees and shrubs [58], dominated by Cannabaceae followed by Moraceae and Euphorbiaceae [59]. Some of the floristic elements are *Beilschmiedia ugandensis*, *Euphorbia hirta*, *Euphorbia heterophylla*, *Lovoa trichillioides*, *Budongo Mahogany*, *Euntumia Africana*, *Morus nigra*, *Trichilla emetica*, *Celtis mildbraedii*, *Pseudospondias macrocarpa*, *Celtis durandii*, *Albizia coliria*, *Albizia glaberrima*, *Albizia zygia*, *Celtis zenkeri*, *Antiaris toxicaria*, *Entandrophragma spp.*, *Funtumia spp.*, *Antiaris toxicaria*, *Ficus exasperata*, *Ficus mucoso*.



**Figure 1:** Study area (Mpanga forest) in Mpigi district, Uganda



**Figure 2:** Ombrothermic diagram of Mpigi district (2020)

### Survey

Surveys were carried out in the forest of Mpanga, during the months of March, April, May and June 2020 (for the first rainy season) then of September, October, November and December 2020 (for the second rainy season) since macrofungi can't be observed all year round [60] for most of the time. Macrofungi are not distributed at random; several factors condition their growth. They exhibit a pattern of diversity that is related to largely to substratum and host availability [61]. This host, which is related to vegetation, is obviously of capital importance for the success of the macrofungi harvesting campaign because many ectomycorrhizal species (for example in the genera *Cantharellus*, *Lactarius*, *Russula*, and most Boletales) are associated with certain forest species [62]. Apart from vegetation, ecological factors such as precipitation and physicochemical properties of the soil are also to be considered. Thus, a preliminary study was carried out at the beginning of February 2020 to confirm the choice of sites which should house the plots. This study was guided by an experienced forest agent who has a good knowledge of the different types of forest vegetation in Mpanga. At the end of this preliminary study, 4 sites were selected:

**Sites 1 and 3:** are the clear part of the forest rich in Cannabaceae, dominated by the *Celtis* (a and c).

**Sites 2 and 4:** characterized by a vegetation rich in Euphorbiaceae and Moraceae (b and d).



**Photo1.** The vegetation of the 4 prospected sites: **(a and c)**- Vegetation rich in Cannabaceae, dominated by *Celtis*; **(b and d)**- Vegetation rich in Euphorbiaceae and Moraceae

### Sampling

The survey method that was used is plot and survey sampling recommended by [63]. Three permanent plots of 30m x 30m have been installed in each of the 4 sites (**Figure 3**). The location of the plots was chosen at random within the sites. The distance between the plots (taken two by two) of the same site is at least 100m. In order to facilitate the location of the plots, trees along the boundaries of the plots have been tied with a ribbon and the geographic coordinates of the plots and of each species of macrofungi harvested have been recorded using a GPS. The geographical coordinates of the plots are as follows:

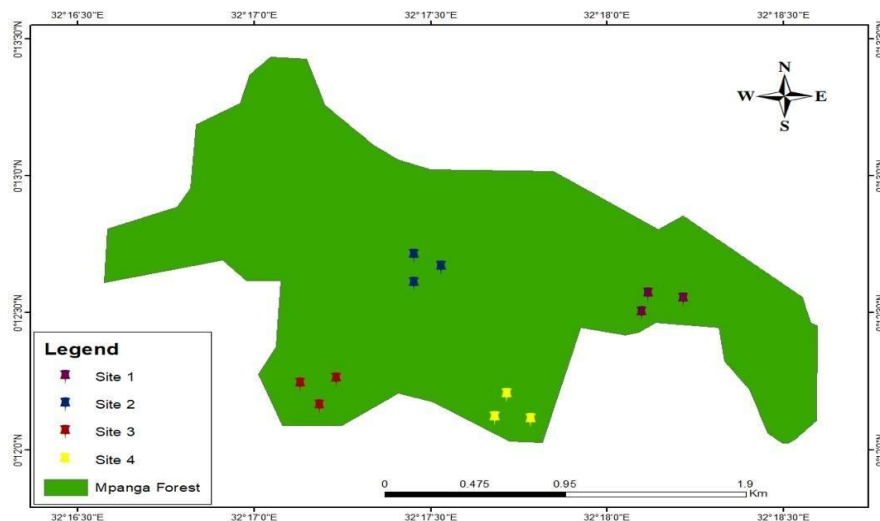
**Site1/ Plot1** (0°12'33"N - 32°18'9"E); **Plot2** (0°12'33"N - 32°18'12"E); **Plot3** (0°12'29"N - 32°18'6"E).

**Site2/ Plot4** (0°12'42"N - 32°17'27"E); **Plot5** (0°12'36"N - 32°17'27"E); **Plot6** (0°12'39"N - 32°17'31"E).

**Site3/ Plot7** (0°12'14"N - 32°17'7"E); **Plot8** (0°12'9"N - 32°17'11"E); **Plot9** (0°12'15"N - 32°17'13"E).

**Site4/ Plot10** (0°12'11"N - 32°17'42"E); **Plot11** (0°12'9"N - 32°17'4"E); **Plot12** (0°12'6"N - 32°17'46"E).

To measure the soil, 1-kilogram soil samples were taken at a depth of 0 to 15 cm + the humus layer in each of the four sites in duplicate. The samples were air-dried at about 25 °C for 5 days to eliminate the moisture. They were then ground using a porcelain pestle and mortar and then sieved through a 2-millimeter sieve to remove debris and other non-soil materials including stones and roots. These sieved soil samples were repackaged, clearly labeled to be analyzed from the Soil, Plant, and Water analytical Laboratory at the Department of Agricultural and Environmental Sciences of Makerere University. On the sieved soil samples, a broad spectrum of agronomy related soil properties was analyzed and these included; soil pH, soil organic matter and carbon, total nitrogen, available phosphorus; exchangeable Calcium ( $\text{Ca}^{2+}$ ), Magnesium ( $\text{Mg}^{2+}$ ), Sodium ( $\text{Na}^+$ ), Potassium ( $\text{K}^+$ ), and soil texture (the percentage proportions of sand, clay, and silt).



**Figure 3:** Location of sites in Mpanga Forest

### Data collection

Each week, a site was visited, and always on the same day of the week. Since we have 4 sites in which 3 plots were placed, every month, all the plots were revisited during the first rainy season and second rainy season of the year 2020. Thus, in one month, 4 surveys (periods) were carried out in all the sites, which corresponds to 16 surveys for the first rainy season and 16 surveys for the second rainy season. A total of 32 surveys were taken throughout the harvesting season. The survey technique consists of sweeping the entire plot in 2m parallel strips to avoid omissions [64]. During the survey, all visible macrofungi were systematically collected and sorted by species, the number of individuals of each species was also counted.

This technique was supplemented by opportunistic sampling to consider the random distribution of fruiting bodies and species observed outside the plots [64].

For in situ photography of collected samples, a digital camera was used to photograph each taxon encountered in order to materialize the morphological characters. The following parameters were taken into account and noted for each sample collected: the type of substrate on which the macrofungus grows (on bare soil, on litter, on a living or senescent tree trunk or other); the degree of cover (a wooded area or not) and the humidity of the environment (very humid, humid, dry or very dry soil). The characteristics of each species of macrofungi harvested are noted, including the size and color of each part, the presence or absence of a ring, the shape of the ring, and the presence of pores or blades [28]. The collected samples are put in a basket and transported to the Laboratory of the Faculty of Agriculture of Uganda Martyrs University.

### **Identification**

The identification of the samples collected was based on the description of the morphological, organoleptic and ecological characteristics of the specimens. The description of the macro-morphological characteristics require a rigorous and detailed visual examination of the macrofungus in all its contours. The description of four samples was carried out based on the recommendations of [65] concerning the agricoloid (lamellate) and boletoid species and of [66] for the description of the porous and rough structure species (polypores). These recommendations consist in describing the different parts of the sporophore (**cap**, **hymenophore**, and **foot** or **stipe**) as well as the **flesh** of each sample.

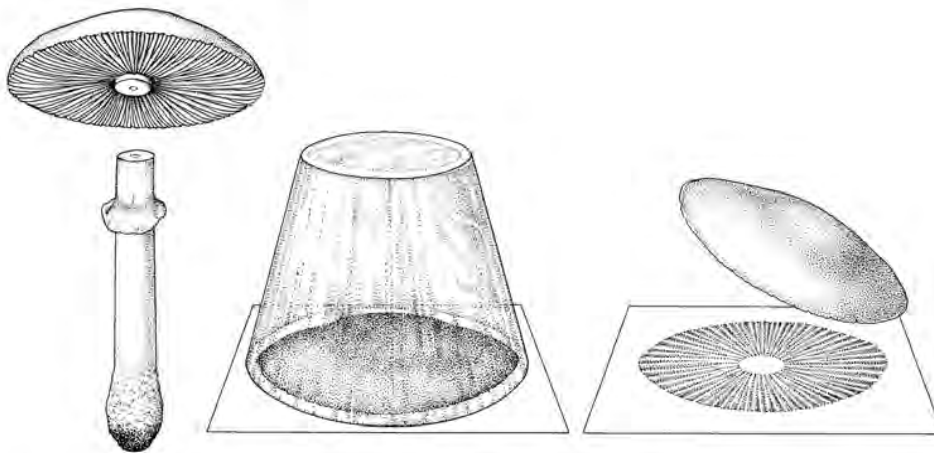
The description of the **cap** focused on the main identification characteristics such as the shape, the coating, margin, color, and diameter. That of the **hymenophore** focused on its color, shape, and insertion as well as the organization of its lamellae. Concerning the **foot** or **stipe**, the description also covered the color, shape, length, insertion, and ornamentation. The general veil and the partial veil or ring are also described if they exist. Consistency, color, smell and flavor are the characteristics that have been described for the **flesh**.

The organoleptic characteristics that have been described are smell and taste. These are important characters but very difficult to categorize. Nevertheless, certain smells like bleach, radish, corpse, lighting gas, old camembert, etc. [67] can be distinguished. The smell can sometimes be surprising: garlic, citrus, almond, anise, cinnamon, chlorine, maple, flour, fetid, etc. [68, 69, 62].

The parameters which have been taken into account to describe the ecological characteristics are the texture of the soil, the type of substrate on which the macrofungus grows (on bare

soil, on litter, on the trunk of a living or senescent tree or other); the degree of cover (a wooded area or not) and the humidity of the environment (very wet, wet, dry or very dry soil).

Other characteristics like latex and spore color are also described. Some basidiomycetous macrofungi such as species belonging to the genus *Lactarius*, present milk after their cutting or crumbling. The color, the taste, the viscosity and abundance of this milk are important characteristics for determining a species [68, 62]. To reveal the color of the spores, the classic technique (Fig. 4) inspired by [62] was performed. It consists in cutting the foot of the fresh specimen and placing the cap, hymenium downwards, on a white paper. Then cover the hat with glass to prevent it from drying out and maintain a humid confined atmosphere. A few hours are needed so that the hymenium releases enough spores and that their color can be judged by mass. Spore color is one of the most important characters for species identification [68, 62].



**Fig 4:** Classic method of obtaining a spore [62]

The identification of a macrofungus based on the description of the morphological characteristics is a tedious task that systematically appeals to all the senses and requires a very observant mind, but is essential to obtain a reference specimen of scientific value [62, 28]. The study of these characteristics, part of which was carried out in the field, was completed in the laboratory of the Faculty of Agriculture of Uganda Martyrs University.

By comparing the morphological and ecological characteristics previously described with those described in the identification manuals, the confirmation of the identification of our samples was carried out. The manuals which were used to confirm the identification are: "Iconographic flora of the mushrooms of the Congo" [70], "Illustrated flora of the mushrooms of Central Africa" [71], "Taxonomic and identification of edible mushrooms dense forests from central Africa" [62], and "A preliminary Agaric Flora of East Africa" [33]. The

lastoneisareviewofthefungioftropicalAfrica withafocus on East Africa. For the update and the nomenclature of macrofungi, the exhaustive synonym update list available at <http://www.indexfungorum.org/names/Names.asp> was consulted.

### **Classification**

The systematic classification of macrofungi is based and established on morphological characteristics. To classify a macrofungus, it must first be identified. This identification was based on the observation of morphological, organoleptic, and ecological characteristics. The systematic classification method that was used is largely inspired by that of [72], [65], and [67]. The use of keys for determination of [73] concerning the characteristics observed, allowed, by a succession of choices and proposals, to move forward in the determination. However, all characteristics allowing the identification of macrofungi are not taken into consideration to classify them [74].

### **Preservation**

The most practical and common method of preservation in mycology consists of simply drying the specimens [62]. Thus, samples were dried using a drying oven at a temperature of 50 to 65 ° C in order to preserve the DNA and allow its subsequent analysis. The drying time was 2 hours for non-fleshy specimens and 4 hours for fleshy or waterlogged specimens. After drying and in order to avoid any rehydration, the still hot specimens were packaged with their number in hermetic plastic bags of the "Minigrip" type which were immediately sealed. Before final conservation in the herbarium, labelling was carried out. On the label, the name of the collector and the unique number associated with the specimen, the date, and place of harvest, the geographical coordinates, the altitude as well as any vegetation and ecological data [62] have been included.

### **Data analysis**

#### **Diversity analysis**

The different orders and families of macrofungi were plotted against the total number of individual isolates (species) per given order and family. Species richness was calculated as the total number of species per 30 X 30 m plot. The density of species was determined by the following formula [11].

$$\text{Density of macrofungi sp. (\%)} = \frac{\text{Total no. of individuals of a particular species}}{\text{Total no. of species}} \times 100$$

Diversity indices, widely used to measure biological diversity [75] such as Shannon, and Simpson diversity indices noted below were used.

$$\text{Shannon Index } (H) = - \sum_{i=1}^s p_i \ln p_i$$

$$\text{Simpson Index } (1 - D) = 1 - 1 / \sum_{i=1}^s p_i^2$$

$p$  is the proportion ( $n/N$ ) of individuals of one particular species found ( $n$ ) divided by the total number of individuals found ( $N$ ),  $\ln$  is the natural log,  $\Sigma$  is the sum of the calculations, and  $s$  is the number of species.

Pair T-test ANOVA at a 95% confidence level between means using SPSS version 20 software was performed for species richness, density, Simpson and Shannon diversity indices to find out if there is a significant effect of seasonality on macrofungi species.

### Soil analysis

Each soil property was specifically analyzed by particular analytical methods and procedures.

**Calcium and Magnesium** were analyzed using the atomic absorption spectrophotometer (AAS)

on methanol extracts. **Potassium and Sodium** were analyzed using the Flame

photometer on the same methanol extract, **Available phosphorus** content was determined

using a spectrophotometer at 882 nm wavelength after the methanol extracts reaction with ammonium molybdate in the presence of ascorbic acid [76]. **Soil pH** was measured in a soil-

water solution at a ratio of 1:2.5 by the help of a pH meter; **Total Nitrogen (N)** was determined

calorimetrically at a wave length of 655 nm on the complexed digestion mixtures using  $N^1$  and  $N^2$  reagents. (Reagents in  $N^1$  include; sodium salicylate, sodium

citrate, sodium tartrate and sodium nitroprusside,  $N^2$  reagents include; sodium hydroxide and sodium hypochlorite (JIK) mixed in the stipulated proportions by [77]. **Organic matter**

**(O.M)** was determined using the Walkley and Black method following wet oxidation using

concentrated Sulphuric acid and Potassium Dichromate. **Soil texture** was analysed using the

hydrometer method (Bouyoucos method). All analyzes were performed using routine

procedures described by [77] and other internationally recommended standard operating

procedures (SOPs). To assess the correlation between the physicochemical properties of the

soilandtheabundanceofmacrofungispecies,correlationanalysis by using SPSS software was done. The abundance of species was determined by the following formulas [78].

$$\text{Abund. of macrofungi sp. (\%)} = \frac{\text{Number of individuals of the species in the site}}{\text{Total number of individuals of all species in the site}} \times 100$$

## **Results**

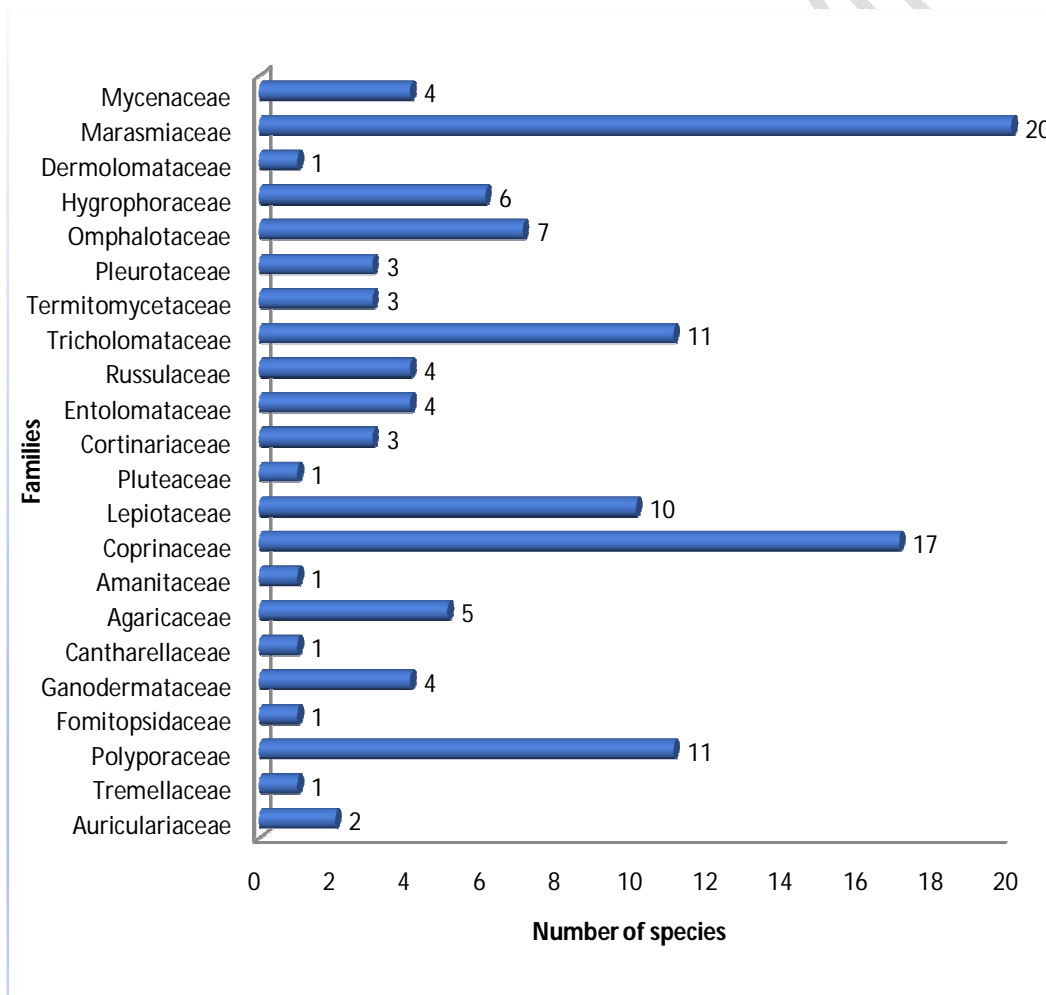
### **Diversity of the macrofungal community within Mpanga forest**

A total of 120 species of basidiomycetous macrofungi distributed in 53 genera were recorded.

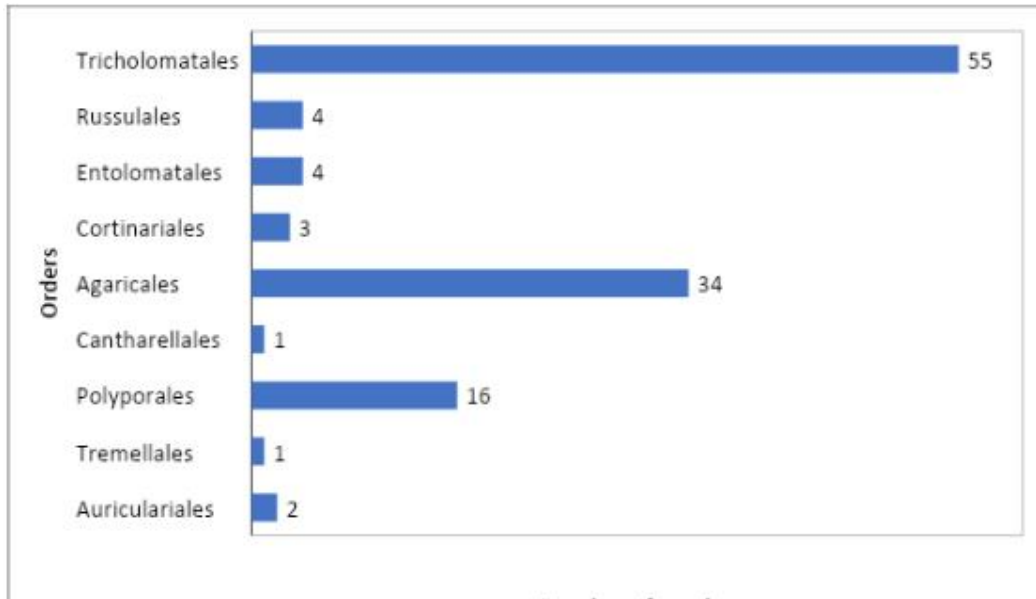
Among these genera, the most dominant are *Psathyrella* and *Marasmius* respectively

represented by 1 and 9 species while those like *Tremella*, *Neofavolus*, *Daedaleopsis*, *Trametes*, *Hexagonia*, *Oligoporus*, *Ganoderma*, *Cantharellus*, *Hymenagaricus*, *Micropsalliota*, *Amanita*, *Parasola*, *Cystolepiota*, *Volvariella*, *Cortinarius*, *Claudopus*, *Rhodocybe*, *Panus*, *Pleurotus*, *Neonothopanus*, *Cuphophyllus*, *Cystoderma*, *Lentinula*, *Lactocollybia*, *Oudemansiella* are all represented by 1 species (**Appendix.1**).

The 53 genera of macrofungi belong to 22 families and 9 orders. The majority of identified species belong to Marasmiaceae (20 species) followed by Coprinaceae (17 species) while Dermolomataceae, Pluteaceae, Amanitaceae, Cantharellaceae, Fomitopsidaceae and Auriculariaceae are represented by a single species (**Fig.5**). Among the 9 orders, the most abundant was that of Tricholomatales (55 species) followed by Agaricales and Polyporales represented by 34 and 16 species respectively (**Fig.6**).



**Fig 5:** Families and ampleness of macrofungi species in Mpanga forest



**Fig6:** Orders and amplessness of macrofungi species in Mpanga Forest



**Photo2:** The 22 families of macrofungi listed represented by one species: 1. *Cantharellus* sp. (Cantharellaceae); 2. *Oligoporus ptychogaster* (Fomitopsidaceae); 3. *Panus fulvus*

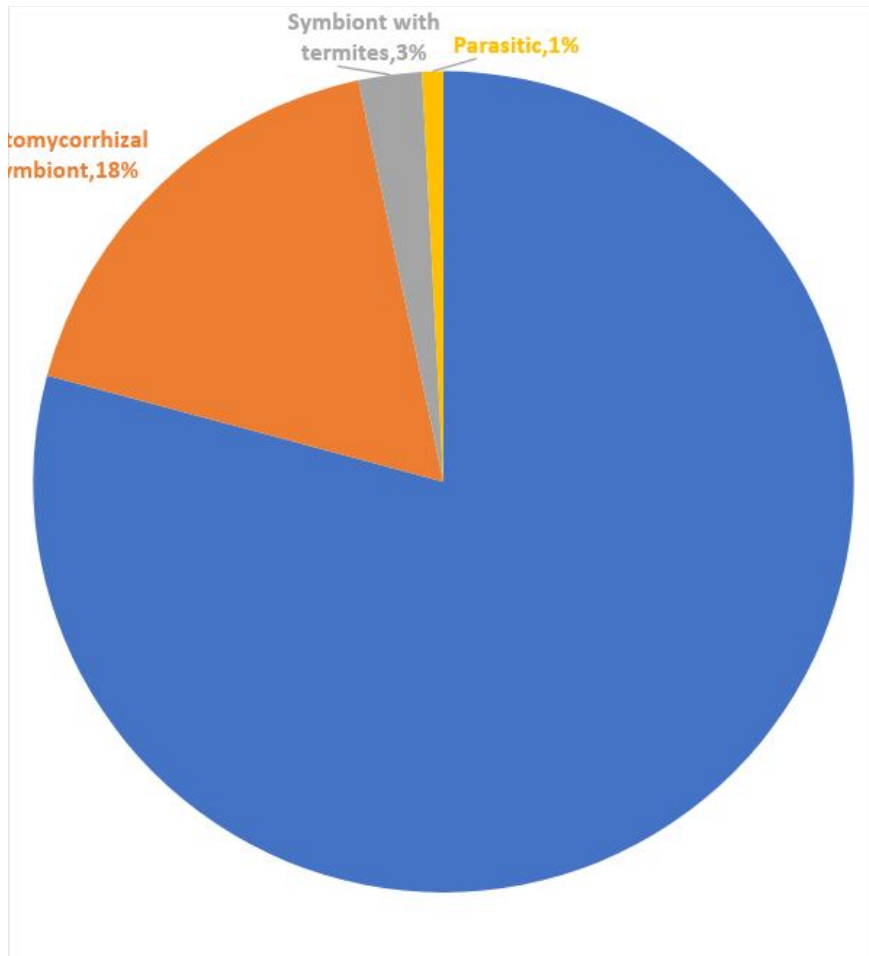
(Tricholomataceae); 4. *Auricularia delicata* (Auriculariaceae); 5. *Agaricus arvensis* (Agaricaceae); 6. *Marasmius rotula* (Marasmiaceae); 7. *Cortinarius humicola* (Cortinariaceae); 8. *Tremellafuciformis* (Tremellaceae); 9. *Volvariella volvacea* (Pluteaceae); 10. *Polyporustenuiculus* (Polyporaceae); 11. *Coprinellus* sp. (Coprinaceae); 12. *Ganoderma applanatum* (Ganodermataceae); 13. *Amanita sinicoflava* (Amanitaceae); 14. *Entoloma conferendum* (Entolomataceae); 15. *Pleurotus ostreatus* (Pleurotaceae); 16. *Gymnopus ocior* (Omphalotaceae); 17. *Hygrocybe colemanniana* (Hygrophoraceae); 18. *Macrolepiota africana* (Lepiotaceae); 19. *Termitomyces robustus* (Termitomycetaceae); 20. *Mycena rapiolens* (Mycenaceae); 21. *Cystoderma amianthinum* (Dermolomataceae); 22. *Russula virescens* (Russulaceae).

### **Ecological distribution of macrofungi**

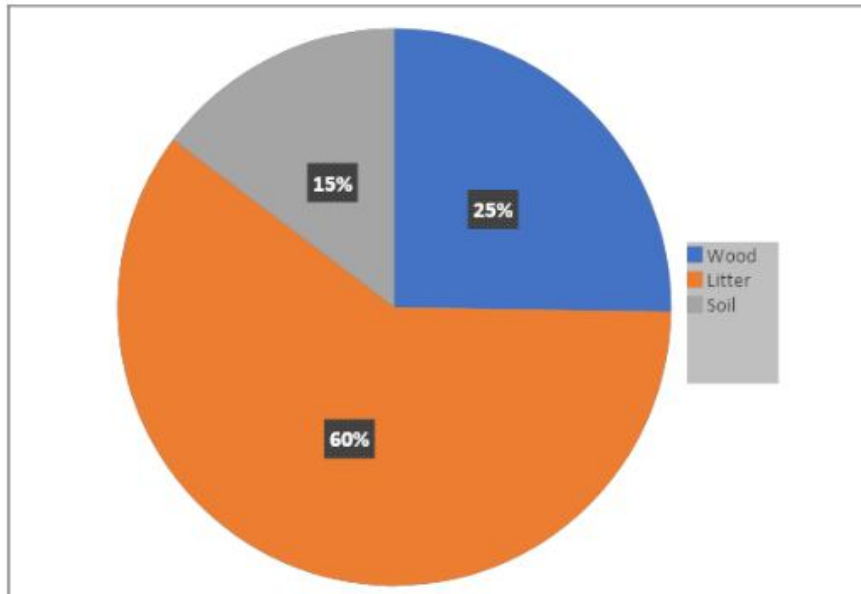
The results of this preliminary study on the diversity of basidiomycetous macrofungi showed that the Mpanga forest abounds in considerable macrofungal biodiversity with 120 species harvested in just two rainy seasons. During these two rainy seasons, the majority of macrofungi collected belonged to the group of saprophytes. Macrofungal species collected during the second rainy season were more abundant and diverse than those collected during the first rainy season.

From the collected macrofungi species, the saprophyte group largely dominates with 79% followed by the ectomycorrhizal symbiont group, while the symbiont group with termites and the parasitic group are poorly represented with 3% and 1% respectively (**Fig.7**). Depending on the substrate they decompose, the group of saprophytes is dominated by humicolous species which decompose soil organic matter (60%), followed respectively by saprophytic species of litter which decompose dead leaves, twigs, and other plant debris (25%) and lignicolous species which decompose dead wood's organic matter (15%) (**Fig.8**).

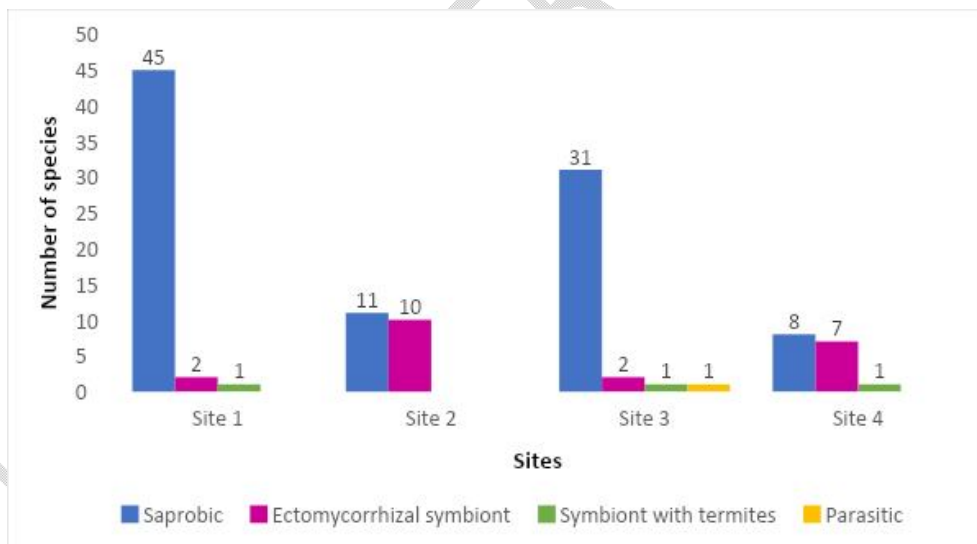
By considering the ecological distribution of macrofungi in the 4 prospected sites, **Fig.9** shows that the saprophyte group still remains dominant in all sites, but this dominance is more pronounced in sites 1 and 3 with 45 and 31 species respectively. These sites (Sites 1 and 3) are however very poor in ectomycorrhizal symbiont species with 2 species in each, while Site 2 harbors the largest number of ectomycorrhizal symbiont species (10 species) followed by Site 4 (7 species). As for species symbionts with termites, they are represented by a single species in sites 1, 3 and 4, and absent in site 2 while the only parasitic species collected was found in site 3.



**Fig 7:** Ecological distribution of Macrofungi in Mpanga Forest



**Fig 8:** Distribution of saprophytic macrofungi according to their substrate



**Fig9:** Ecological distribution of macrofungi within the four prospected sites

### **Influence of seasonality on the diversity**

The harvest of macrofungi was more fruitful during the second rainy season with 101 species against 69 species during the first rainy season. Fifty species were present in the second rainy season only and 18 species were present in the first rainy season only, while 51 species were present both in the first and second rainy seasons (**Appendix.2**). Moreover, by comparing the values of the diversity indices of Simpson and Shannon during the first rainy season (0.97 &

3.94) and those during the second rainy season (0.99 & 4.44), the values of the latter are significantly higher ( $P < 0.05$ ). Macrofungi density and species richness were also significantly ( $P < 0.05$ ) higher during the second rainy season than during the first one (**Table.1**).

**Table 1:** Statistical test of significance on species richness, density, and diversity indices during the two rainy seasons

Parameters	Seasons	Measured values $\pm$ SD	t value	df	Pvalue
Species richness (m)	First season	5.75 $\pm$ 2.094	- 4.392	11	0.001*
	Second season	8.42 $\pm$ 3.528			
Density (m <sup>2</sup> )	First season	17.71 $\pm$ 15.255	- 3.690	68	0.000*
	Second season	30.06 $\pm$ 21.640			
Simpson diversity	First season	0.97 $\pm$ 10.526	8,564	897,36	0.000*
	Second season	0.99 $\pm$ 20.223			
Shannon diversity	First season	3.94 $\pm$ 10.526	- 17. 613	1090.9	0.000*
	Second season	4.44 $\pm$ 20.223			

\*Significant difference ( $P < 0.05$ )

#### Relationship between the physicochemical properties of the soil and the abundance of macrofungi species

The correlation between the physicochemical properties of the soil and the abundance of macrofungi species only concerned species having the soil as direct substrate (37 species) in order to obtain convincing results.

Generally, the physicochemical properties of the soil of Mpanga forest vary from one site to another, except for silt, the percentage of which is constant at 12% in each of the 4 prospected sites. Apart from the silt, the result of the correlation between the other soil factors and the abundance of the 37 species of macrofungi showed that 16 species were significantly correlated with certain soil factors (**Appendix.3**). Among these factors, sodium (Na) was significantly correlated with the most species such as *Macrolepiotadolicaula* (-0.951), *Arrhenia obscurata* (-0.995), *Lentinus* sp. (0.986), *Lactarius indigo* (0.988), *Termitomyces microcarpus* (0.965) and *Hygrocybe colemanniana* (0.975). As for calcium (Ca), it was significantly correlated with 3 species which are *Cuphophyllus virgineus* (-0.998), *Tetrapyrgos nigripes* (-0.962) and *Clitocybe fragrans* (-0.983) while clay was significantly correlated with two species which are *Termitomyces clypeatus* (-0.986) and *Clitocybe phaeophthalma* (-0.986). The other parameters were each significantly correlated with a single

species of macrofungi. This is the case of potassium (K) with *Inocybes indonia* (0.953), nitrogen (N) with *Arrhenia velutipes* (0.994), organic carbon (OC) with *Arrhenia velutipes* (0.986), organic matter (OM) with *Arrhenia velutipes* (0.986), phosphorus (P) with *Rhodocybe* sp. (0.976), pH with *Russula aurea* (-0.953) and sand with *Termitomyces clypeatus* (0.986).

## DISCUSSION

A similar study conducted in Bwindi Impenetrable and Kibale National Parks, Albertine Rift, Western Uganda reported 173 species [43] while that conducted in Southwestern region of Uganda, specifically in Malabigambo and Namalala Forest Reserves reported only 10 species [42]. The latter was carried out in an area similar to ours despite the low number of species recorded. This difference is explained by the many forest gaps caused by the encroachment and overexploitation of timber in the forest reserves of Malabigambo and Namalala [42] while Mpanga forest is one of the few well-managed government reserves in Mpigi district [48], although there are still gaps in cooperation between the community and the forest management staff. In other tropical African countries, similar studies have also been carried out, but in larger forest areas than ours. This is the case of Cameroon where [79] recorded 177 species in the Mount Cameroon region and that of Kenya where [38] recorded 224 species in the Kereita and Kikuyu Escarpment forests. These results show that in forest areas that have not undergone excessive deforestation, the larger the area, the more fruitful the harvesting of macrofungi.

The dominance of macrofungi species belonging to the *Marasmius* and *Psathyrella* genera is consistent with the nature of the study site which is a tropical moist semi-deciduous forest with *Celtis* whose fall of its dead leaves constitutes a moist litter enriching the soil with black humus, conducive to the development of macrofungi belonging to the genera *Psathyrella* and *Marasmius*. Moreover, since the greatest number of macrofungi species was collected in the middle of the rainy seasons, the dominance of species belonging to the Coprinaceae family is normal because they need heavy rains to appear and develop [67].

The majority of macrofungal species collected belonged to the saprophyte group. This could be attributed to the ability of saprophytic macrofungi to degrade many types of substrates present in the forest [80].

These results are consistent with the dominance of species belonging to the Marasmiaceae and Coprinaceae families, which are saprophytic species decomposing mainly litter-based substrates. They are mainly favored by the presence of dead twigs and leaf substrates while others occur on cow dung [38]. Similar results have been found by several authors who noted that saprophytic macrofungi were the dominant macrofungal group in tropical forests [78, 81, 82, 83]. By comparing the ecological distribution of macrofungi in the 4 prospected sites, the dominance of the group of saprophytes is confirmed especially in sites 1 and 3 rich in Cannabaceae, in particular, the genus *Celtis* while in sites 2 and 4, a single species differentiated the saprophytic groups from those of the ectomycorrhizal symbionts. Our results corroborate those of several studies which have shown that species belonging to the genus *Celtis* are part of the forest species that allow tropical forests to produce a great diversity of wood and leaves resulting in a multitude of substrates favorable to the development of saprophytic macrofungi [83, 84, 85]. As for the difference observed in sites 2 and 4, it can be explained by the fact that these sites are characterized by vegetation rich in Euphorbiaceae which is a family strongly involved in symbiotic associations with macrofungi [86]. The low representation of ectomycorrhizal macrofungi species observed during the entire collection could be linked to the tropical nature of Mpanga because, in China, studies have shown that ectomycorrhizal macrofungi were more diversified in temperate forests than in tropical forests [82, 78].

The difference in diversity observed during the two rainy seasons could be explained by the fact that there is enough humidity available during the second rainy season which is the rainiest since humidity is one of the main factors influencing fruiting of macrofungi. This corresponds with the conclusions of [79] in the Mount Cameroon region, [87], in the southern part of Cameroon, [88] in southern Ghana, [89] and [90] who worked on the diversity of macrofungi in semi-evergreen humid deciduous forest in Shimoga-Ksrnatak district, India. It was also found that some species of macrofungi were present in both rainy seasons, while others were only present in the first or second rainy season. These results could be due to differences in the time between the appearance of favorable fruiting conditions and the production of fruit bodies between the different species of macrofungi studied, as noted by [79]. This agrees with the findings of [91], who studied substrate specificity and community phenology of macrofungi in Tanzania. During the collection period, it was noted that generally small, delicate and fragile species with small thread-like stipules of litter-dwelling genera such as

*Coprinus*, *Marasmius* and *Mycena*, fruited following heavy rains. These species came and went very quickly while the all fruiting bodies fructified after a continuous period of rains lasting several days. The same observation was made by [67] and [79], and similar results were also found by [92], who noted that most macrofungi require a period of vegetative growth prior to fruiting during which mycelia accumulate before being triggered to fruit.

The results also showed that fleshy macrofungi were dominant during the second rainy season while during the first rainy season, non-fleshy macrofungi (polypores) were dominant (**Appendix 2**). Since the second rainy season is rainier than the first, the dominance of fleshy macrofungi could be explained by the fact that this period is favorable for their production. During this period, adequate humidity, favorable temperature, relative humidity and sunshine help macrofungi to decompose dead organic matter [93]. As for the dominance of polypores during the first rainy season, it could be due to the decrease in precipitation and relative humidity, the increase in temperature and sunshine which most of the fleshy macrofungi cannot withstand [79]. It was also noted that species like *Volvariella volvacea* among other species (**Appendix 2**) showed no seasonal variation but were present in both seasons. Similar results were also recorded by [87].

The correlation results between the physicochemical properties and the abundance of the species obtained during this study are similar to those recorded by [42] on the study of the ecology of edible indigenous macrofungi from Lake Victoria Basin, Uganda. Other authors such as [94], [95] and [96], have also demonstrated the existence of an edaphic preference of many macrofungi in tropical forests. [97] and [98] noted that sandy loam texture, low soil bulk density, high organic matter and pH were properties that stimulated the development of macrofungi. The importance of organic matter is due to its water holding capacity and nutrient availability [99]. [97] and [99] also noted that acid soils combined with a high content of organic matter stimulate the decay function of macrofungi compared to other microorganisms such as bacteria and actinomycetes. The soils of our study site were generally acidic, which is consistent with the findings of [100] and [101] in their studies conducted in tropical regions.

## **CONCLUSION**

The results of this preliminary study on the diversity of basidiomycetous macrofungi showed that the Mpanga forest abounds in considerable macrofungal biodiversity with 120 species harvested just in two rainy seasons. During these seasons, the majority of the species that have been collected belong to the group of saprophytes. Macrofungi species collected during

thesecondrainyseasonweremoreabundantanddiverse than those collected during the first rainyseason.Amongthephysicochemicalpropertiesofthesoil,pH,calcium, potassium, nitrogen,organiccarbon,phosphorus,clay,sandandorganicmatterwere significantly correlated with the abundance of macrofungal species.**Thisstudyprovided basic information on the diversity of macrofungi in Mpanga forest, it can beapointofreference for further research to study the evolution of macrofungal biodiversity inthisforest.**

Moreover,the importance of macrofungi not only in the dynamics of forest ecosystemsbutalsoinhumannutritionandhealthincreases the need for conservation of this resource of non-timber forest products. Conservation canalso beachievedthroughtheir cultivationandthereductionof illegal logging hence the need to include macrofungal biodiversity conservation in forest management policies in Uganda.

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**Appendix1.** Systematic classification of identified species with an indication of their harvest date and geographic coordinates

Division	Class	Subclass	Order	Family	Genus	Species	Sample number	Harvest date	Geographic coordinates
Basidiomycota	Phragmobasidiomycetes		Auriculariales	Auriculariaceae	<i>Auricularia</i>	<i>Auricularia delicata</i>	KN 110 MF	07 / 05/ 20	0°12'31"N 32°18'6"E
						<i>Auricularia auricula-judae</i>	KN 065 MF	23/ 11/20	0°12'19"N 32°17'54"E
			Tremellales	Tremellaceae	<i>Tremalla</i>	<i>Tremalla fuciformis</i>	KN 131 MF	14/ 05/ 20	0°12'29"N 32°18'11"E
	Homobasidiomycetes	Aphylophoromycetideae	Polyporales	Polyporaceae	<i>Polyporus</i>	<i>Polyporus grammocephalus</i>	KN 032 MF	19/ 10/ 20	0°12'25"N 32°18'5"E
						<i>Polyporus badius</i>	KN 021 MF	19/ 10/ 20	0°12'31"N 32°18'5"E
						<i>Polyporus tenuiculus</i>	KN 183 MF	27/ 05/ 20	0°12'32"N 32°18'7"E
						<i>Polyporus varius</i>	KN 193 MF	07/ 06/20	0°12'25"N 32°18'12"E
					<i>Neofavolus</i>	<i>Neofavolus alveolaris</i>	KN 001 MF	05/ 10/ 20	0°12'23"N 32°18'11"E
					<i>Daedaleopsis</i>	<i>Daedaleopsis confragosa</i>	KN 089 MF	14/ 12/ 20	0°12'2"N 32°18'40"E
					<i>Trametes</i>	<i>Trametes gibbosa</i>	KN 009 MF	05/ 10/ 20	0°12'24"N 32°18'11"E
					<i>Microporus</i>	<i>Microporus xanthopus</i>	KN 055 MF	09/ 11/20	0°12'22"N 32°17'58"E
						<i>Microporus affinis</i>	KN 192 MF	07/ 06/ 20	0°12'26"N 32°18'11"E
						<i>Microporus vernicipes</i>	KN 204 MF	07/ 06/ 20	0°12'35"N 32°18'8"E
					<i>Hexagonia</i>	<i>Hexagonia tenuis</i>	KN 187 MF	27/ 05/20	0°12'33"N

									32°18'6"E		
				Fomitopsidaceae	<i>Oligoporus</i>	<i>Oligoporus ptychogaster</i>	KN 200 MF	07/ 06/ 20	0°12'35"N 32°18'9"E		
				Ganodermataceae	<i>Ganoderma</i>	<i>Ganoderma applanatum</i>	KN 066 MF	23/11/20	0°12'19"N 32°17'53"E		
					<i>Amauroderma</i>	<i>Amauroderma rude</i>	KN 189 MF	27/ 05/20	0°12'2"N 32°17'52"E		
						<i>Amauroderma</i> sp.	KN 082 MF	07/12/20	0°12'30"N 32°18'11"E		
					<i>Amauroderma rugosum</i>	KN 195 MF	07/ 06/20	0°12'29"N 32°18'10"E			
			Cantharellales	Cantharellaceae	<i>Cantharellus</i>	<i>Cantharellus</i> sp.	KN 198 MF	07/ 06/20	0°12'34"N 32°18'10"E		
		Agarico mycetideae	Agaricales	Agaricaceae	<i>Agaricus</i>	<i>Agaricus arvensis</i>	KN 011 MF	05/ 10/20	0°12'25"N 32°18'11"E		
								<i>Agaricus diminutivus</i>	KN 074 MF	30/11/20	0°12'25"N 32°18'14"E
								<i>Agaricus moelleri</i>	KN 150 MF	21/ 05/20	0°12'10"N 32°17'42"E
						<i>Hymenagaricus</i>	<i>Hymenagaricus</i> sp.	KN 062 MF	23/11/20	0°12'20"N 32°17'54"E	
						<i>Micropsalliota</i>	<i>Micropsalliota</i> sp.	KN 035 MF	19/10/20	0°12'26"N 32°18'5"E	
						Amanitaceae	<i>Amanita</i>	<i>Amanita sinicoflava</i>	KN 072 MF	30/11/20	0°12'23"N 32°18'11"E
						Coprinnaceae	<i>Coprinellus</i>	<i>Coprinellus disseminatus</i>	KN 053 MF	09/11/20	0°12'19"N 32°17'54"E
								<i>Coprinellus</i> sp.	KN 185 MF	27/05/ 20	0°12'32"N 32°18'5"E
							<i>Coprinopsis</i>	<i>Coprinopsis lagopus</i>	KN 088 FM	07/12/ 20	0°12'40"N 32°18'44"E

					<i>Coprinopsis domesticus</i>	KN 141 MF	14/05/20	0°12'27"N 32°18'9"E	
					<i>Coprinopsis cinerea</i>	KN 197 MF	07/ 06/ 20	0°12'32"N 32°18'5"E	
				<i>Parasola</i>	<i>Parasola auricoma</i>	KN 201 FM	07/ 06/ 20	0°12'35"N 32°18'9"E	
				<i>Psathyrella</i>	<i>Psathyrella tephrophylla</i>	KN 086 MF	07/12/20	0°12'28"N 32°18'37"E	
					<i>Psathyrella leucotephra</i>	KN 015 MF	12/ 10/20	0°12'1"N 32°17'8"E	
					<i>Psathyrella candolleana</i>	KN 045 MF	02/ 11/ 20	0°12'2"N 32°17'41"E	
					<i>Psathyrella spadiceogrisea</i>	KN 054 NF	09/11/20	0°12'19"N 32°17'54"E	
					<i>Psathyrella clivensis</i>	KN 106 MF	07/ 05/ 20	0°12'34"N 32°18'6"E	
					<i>Psathyrella inflatocystis</i>	KN 128 MF	14/ 05/ 20	0°12'30"N 32°18'12"E	
					<i>Psathyrella conferta</i>	KN 042 MF	26/ 10/ 20	0°12'31"N 32°18'11"E	
					<i>Psathyrella pennata</i>	KN 159 MF	21/ 05/ 20	0°12'10"N 32°17'42"E	
					<i>Psathyrella conopilus</i>	KN 136 MF	14/ 05/ 20	0°12'30"N 32°18'11"E	
					<i>Psathyrella olympiana</i>	KN 026 MF	19/ 10/ 20	0°12'32"N 32°18'5"E	
					<i>Psathyrella sp.</i>	KN 181 MF	27/ 05/ 20	0°12'11"N 32°17'28"E	
			Lepiotaceae		<i>Lepiota</i>	<i>Lepiota cristata</i>	KN 061 MF	23/ 11/ 20	0°12'17"N 32°17'54"E
						<i>Lepiota felina</i>	KN 057 MF	23/ 11/ 20	0°12'22"N

									32°17'57"E	
				<i>Macrolepiota</i>	<i>Macrolepiota africana</i>	KN 030 MF	19/ 10/ 20	0°12'24"N 32°18'7"E		
					<i>Macrolepiota procera</i>	KN 126 MF	14/05/ 20	0°12'32"N 32°18'12"E		
					<i>Macrolepiota dolichaula</i>	KN 076 MF	30/ 11/ 20	0°12'30"N 32°18'9"E		
					<i>Cystolepiota</i>	<i>Cystolepiota pulverulenta</i>	KN 024 MF	19/ 10/ 20	0°12'5"N 32°18'56"E	
					<i>Leucoagaricus</i>	<i>Leucoagaricus rubrotinctus</i>	KN 014 MF	12/ 10/ 20	0°12'25"N 32°18'5"E	
						<i>Leucoagaricus croceovelutinus</i>	KN 182 MF	27/ 05/ 20	0°12'13"N 32°17'25"E	
					<i>Leucocoprinus</i>	<i>Leucocoprinus scissus</i>	KN 018 MF	12/ 10/ 20	0°12'6"N 32°17'40"E	
						<i>Leucocoprinus brebissoni</i>	KN 104 MF	07/ 05/ 20	0°12'34"N 32°18'7"E	
				Pluteaceae	<i>Volvariella</i>	<i>Volvariella volvacea</i>	KN 155 MF	21/ 05/ 20	0°12'11"N 32°18'42"E	
			Cortinariales	Cortinariaceae	<i>Cortinarius</i>	<i>Cortinarius humicola</i>	KN 137 MF	14/ 05/ 20	0°12'29"N 32°17'11"E	
					<i>Inocybe</i>	<i>Inocybe sindonia</i>	KN 095 MF	14/12 /20	0°12'2"N 32°17'40"E	
						<i>Inocybe rimosa</i>	KN 203 MF	07/ 06/ 20	0°12'36"N 32°18'9"E	
			Entolomatales	Entolomataceae	<i>Entoloma</i>	<i>Entoloma conferendum</i>	KN 083 MF	07/ 12/ 20	0°12'40"N 32°18'34"E	
						<i>Entoloma</i> sp.	KN 036 MF	26/ 10/ 20	0°12'28"N 32°18'10"E	
					<i>Claudopus</i>	<i>Claudopus variabilis</i>	KN 081 MF	07/ 12/ 20	0°12'33"N 32°18'12"E	

				<i>Rhodocybe</i>	<i>Rhodocybe</i> sp.	KN 135 MF	14/ 05/ 20	0°12'29"N 32°18'11"E	
			Russulales	Russulaceae	<i>Russula</i>	<i>Russula aurea</i>	KN 013 MF	05 / 10/ 20	0°12'24"N 32°18'11"E
							<i>Russula virescens</i>	KN 138 MF	14/ 05/ 20
					<i>Lactarius</i>	<i>Lactarius chrysorrheus</i>	KN 144 MF	14/ 05/ 20	0°12'26"N 32°18'9"E
						<i>Lactarius indigo</i>	KN 151 MF	21/ 05/20	0°12'12"N 32°17'43"E
			Tricholomatales	Tricholomataceae	<i>Tricholoma</i>	<i>Tricholoma stiparophyllum</i>	KN 068 MF	20/ 11/ 20	0°12'25"N 32°18'5"E
						<i>Tricholoma</i> sp. 1	KN 070 MF	20/ 11/ 20	0°12'24"N 32°18'5"E
						<i>Tricholoma</i> sp. 2	KN 171 MF	24/ 05/ 20	0°12'22"N 32°17'55"E
					<i>Arrhenia</i>	<i>Arrhenia velutipes</i>	KN 040 MF	26/ 10/ 20	0°12'32"N 32°18'12"E
						<i>Arrhenia epichysium</i>	KN 134 MF	14/05/ 20	0°12'29"N 32°18'41"E
						<i>Arrhenia obscurata</i>	KN 168 MF	24/ 05/ 20	0°12'14"N 32°17'53"E
					<i>Clitocybe</i>	<i>Clitocybe phaeophthalma</i>	KN 116 MF	07/ 05/ 20	0°12'30"N 32°18'6"E
						<i>Clitocybe fragrans</i>	KN 107 MF	07/ 05/ 20	0°12'34"N 32°18'6"E
						<i>Clitocybe</i> sp. 1	KN 037 MF	26/ 10/ 20	0°12'32"N 32°18'11"E
						<i>Clitocybe</i> sp. 2	KN 102 MF	07/ 05/ 20	0°12'34"N 32°18'7"E
				<i>Panus</i>	<i>Panus fulvus</i>	KN 084 MF	07/12/ 20	0°12'31"N	

								32°18'15"E
			Termitomycetaceae	<i>Termitomyces</i>	<i>Termitomyces robustus</i>	KN 031 MF	19/ 10/ 20	0°12'26"N 32°18'7"E
					<i>Termitomyces microcarpus</i>	KN 148 MF	14/ 05/ 20	0°12'5"N 32°18'10"E
					<i>Termitomyces clypeatus</i>	KN 060 MF	23/ 11/ 20	0°12'23"N 32°17'56"E
			Pleurotaceae	<i>Pleurotus</i>	<i>Pleurotus ostreatus</i>	KN 052 MF	09/11/ 20	0°12'21"N 32°17'55"E
				<i>Lentinus</i>	<i>Lentinus tigrinus</i>	KN 165 MF	24/ 05/ 20	0°12'22"N 32°18'5"E
					<i>Lentinus</i> sp.	KN 049 MF	02/ 11/ 20	0°12'10"N 32°17'40"E
			Omphalotaceae	<i>Neonothopanus</i>	<i>Neonothopanus hygrophanus</i>	KN 153 MF	21/ 05/ 20	0°12'31"N 32°18'42"E
				<i>Gymnopus</i>	<i>Gymnopus dryophilus</i>	KN 145 MF	14/ 05/ 20	0°12'26"N 32°18'9"E
					<i>Gymnopus luxurians</i>	KN 103 MF	07/ 05/ 20	0°12'34"N 32°18'7"E
					<i>Gymnopus ocior</i>	KN 114 MF	07/ 05/20	0°12'30"N 32°18'6"E
					<i>Gymnopus biformis</i>	KN 092 MF	14/ 12/ 20	0°12'2"N 32°17'40"E
					<i>Gymnopus confluens</i>	KN 034 MF	19/ 10/ 20	0°12'24"N 32°18'5"E
					<i>Gymnopus foetidus</i>	KN 033 MF	19/ 10/ 20	0°12'27"N 32°18'5"E
			Hygrophoraceae	<i>Hygrocybe</i>	<i>Hygrocybe colemanniana</i>	KN 023 MF	19/ 10/ 20	0°12'31"N 32°18'7"E
					<i>Hygrocybe radiata</i>	KN 127 MF	14/ 05/ 20	0°12'30"N 32°18'11"E

					<i>Hygrocybe</i> sp.	KN 058 MF	23/ 11/ 20	0°12'22"N 32°17'57"E	
					<i>Lichenomphalia</i>	<i>Lichenomphalia umbellifera</i>	KN 038 MF	26/ 10/ 20	0°12'32"N 32°18'11"E
						<i>Lichenomphalia velutina</i>	KN 080 MF	07/12/ 20	0°12'33"N 32°18'12"E
					<i>Cuphophyllus</i>	<i>Cuphophyllus virgineus</i>	KN 117 MF	07/ 05/ 20	0°12'26"N 32°18'6"E
			Dermolomataceae	<i>Cystoderma</i>	<i>Cystoderma amianthinum</i>	KN 016 MF	12/10/ 20	0°12'1"N 32°17'41"E	
			Marasmiaceae	<i>Marasmius</i>	<i>Marasmius bekolacongoli</i>	KN 004 MF	05/ 10/ 20	0°12'23"N 32°18'11"E	
					<i>Marasmius fulvoferrugineus</i>	KN 140 MF	14/ 05/20	0°12'26"N 32°18'9"E	
					<i>Marasmius tageticolor</i>	KN 170 MF	24/ 05/ 20	0°12'18"N 32°17'56"E	
					<i>Marasmius spissus</i>	KN 129 MF	14/ 05/ 20	0°12'29"N 32°18'11"E	
					<i>Marasmius siccus</i>	KN 112 MF	07/ 05/ 20	0°12'31"N 32°18'6"E	
					<i>Marasmius rotula</i>	KN 118 MF	07/ 05/ 20	0°12'26"N 32°18'6"E	
					<i>Marasmius wynneae</i>	KN 007 MF	05/10/ 20	0°12'25"N 32°18'10"E	
					<i>Marasmius arborescens</i>	KN 079 MF	07/ 12/ 20	0°12'33"N 32°18'11"E	
					<i>Marasmius</i> sp.	KN 194 MF	07/ 06/ 20	0°12'27"N 32°18'10"E	
					<i>Lentinula</i>	<i>Lentinula edodes</i>	KN 139 MF	14/ 05/ 20	0°12'27"N 32°18'9"E

					<i>Collybia</i>	<i>Collybia alboflavoda</i>	KN 028 MF	19/ 10/20	0°12'25"N 32°18'5"E
						<i>Collybia subpruinosa</i>	KN 158 MF	21/ 05/ 20	0°12'11"N 32°17'42"E
						<i>Collybia cookei</i>	KN 162 MF	21/ 05/20	0°12'4"N 32°17'41"E
						<i>Collybia dryophila</i>	KN 047 MF	02/11/ 20	0°12'5"N 32°17'40"E
						<i>Collybia aurea</i>	KN 078 MF	07/12/ 20	0°12'31"N 32°18'6"E
						<i>Collybia</i> sp.	KN 048 MF	02/11/20	0°12'6"N 32°17'40"E
					<i>Lactocollybia</i>	<i>Lactocollybia</i> sp.	KN 142 MF	14/ 05/ 20	0°12'27"N 32°18'9"E
					<i>Tetrapyrgos</i>	<i>Tetrapyrgos nigripes</i>	KN 071 MF	30/11/ 20	0°12'26"N 32°18'5"E
						<i>Tetrapyrgos</i> sp.	KN 059 MF	23/11/ 20	0°12'22"N 32°17'57"E
					<i>Oudemansiella</i>	<i>Oudemansiella canarii</i>	KN 063 MF	23/11/ 20	0°12'19"N 32°17'54"E
				Mycenaceae	<i>Mycena</i>	<i>Mycena rapiolens</i>	KN 025 MF	19/ 10/20	0°12'31"N 32°18'5"E
						<i>Mycena cinerella</i>	KN 115 MF	07/ 05/ 20	0°12'30"N 32°18'6"E
						<i>Mycena vulgaris</i>	KN 019 MF	12/ 10/ 20	0°12'27"N 32°18'5"E
						<i>Mycena leptcephala</i>	KN 123 MF	14/ 05/ 20	0°12'32"N 32°18'11"E
<b>1 Division</b>	<b>2 Classes</b>	<b>2 subclasses</b>	<b>9 orders</b>	<b>22 families</b>	<b>53 Genera</b>	<b>120 Species</b>			

KN = Khady Ngom; MF = Mpanga Forest

**Appendix2.** Checklist of macrofungi species with an indication of their ecology, substrate, and seasonality

Species	Ecology	Substrate	First season	Second season
<i>Auricularia delicata</i> (Mont. ex Fr.) Henn	Saprobic	Wood	-	+
<i>Auricularia auricula-judae</i> (Bull.) Qué1	Saprobic	Wood	-	+
<i>Tremalla fuciformis</i> Berk	Saprobic	Wood	+	-
<i>Polyporus grammocephalus</i> Berk	Saprobic	Wood	+	-
<i>Polyporus badius</i> (Pers.) Schwein	Saprobic	Wood	+	-
<i>Polyporus tenuiculus</i> (P. Beauv.) Fr	Saprobic	Wood	+	-
<i>Polyporus varius</i> (Pers.) Fr	Saprobic	Wood	+	-
<i>Neofavolus alveolaris</i> (DC.) Sotome &T. Hatt	Saprobic	Wood	+	-
<i>Daedaleopsis confragosa</i> (Bolton) J. Schröt	Saprobic	Wood	+	+
<i>Trametes gibbosa</i> (Pers.) Fr	Saprobic	Wood	+	-
<i>Microporus xanthopus</i> (Fr.) Kuntze	Saprobic	Wood	+	-
<i>Microporus affinis</i> (Blume &T. Nees) Kuntze	Saprobic	Wood	+	+
<i>Microporus vernicipes</i> (Berk.) Kuntze	Saprobic	Wood	+	-
<i>Hexagonia tenius</i> (P. Beauv.) Fr	Saprobic	Wood	+	-
<i>Oligoporus ptychogaster</i> (F. Ludw.) Falck & O. Falck	Saprobic	Wood	+	+
<i>Ganoderma applanatum</i> (Pers.) Pat	Parasitic	Tree trunk	+	+
<i>Amauroderma rude</i> (Berk.)Torrend	Saprobic	Soil	+	-
<i>Amauroderma</i> sp.	Saprobic	Soil	+	-
<i>Amauroderma rugosum</i> (Blume &T. Nees)Torrend	Saprobic	Soil	+	-
<i>Cantharellus</i> sp.	Ectomycorrhizal symbiont	Rotten wood	+	-
<i>Agaricus arvensis</i> Schaeff	Saprobic	Soil	-	+
<i>Agaricus diminutivus</i> Peck	Saprobic	Litter	-	+
<i>Agaricus moelleri</i> Wasser	Saprobic	Litter	+	+

<i>Hymenagaricus</i> sp.	Saprobic	Litter	-	+
<i>Micropsalliota</i> sp.	Saprobic	Litter	-	+
<i>Amanita sinicoflava</i> Tulloss	Ectomycorrhizal symbiont	Soil	-	+
<i>Coprinellus disseminatus</i> (Pers.) J.E. Lange	Saprobic	Litter	-	-
<i>Coprinellus</i> sp.	Saprobic	Litter	+	-
<i>Coprinopsis lagopus</i> (Fr.) Redhead	Saprobic	Litter	-	+
<i>Coprinopsis domesticus</i> (Bolton) Gray	Saprobic	Litter	+	-
<i>Coprinopsis cinerea</i> (Schaeff.) Redhead, Vilgalys & Moncalvo	Saprobic	Soil	+	+
<i>Parasola auricoma</i> (Pat.) Redhead, Vilgalys & Hopple	Saprobic	Litter	-	+
<i>Psathyrella tephrophylla</i> (Romagn.) M.M. Moser	Saprobic	Litter	-	+
<i>Psathyrella leucotephra</i> (Berk. & Broome) P.D. Orton	Saprobic	Litter	-	+
<i>Psathyrella candolleana</i> (Fr.) Maire	Saprobic	Litter	+	+
<i>Psathyrella spadiceogrisea</i> (Schaeff.) Maire	Saprobic	Litter	-	+
<i>Psathyrella clivensis</i> (Berk. & Broome) Rezende-Pinto	Saprobic	Litter	+	-
<i>Psathyrella inflatocystis</i> A.H. Sm	Saprobic	Litter	+	-
<i>Psathyrella conferta</i> Eyssart. & Chiaffi	Saprobic	Litter	-	+
<i>Psathyrella pennata</i> (Fr.) A. Pearson & Dennis	Saprobic	Litter	-	+
<i>Psathyrella conopilus</i> (Fr.) A. Pearson & Dennis	Saprobic	Litter	+	-
<i>Psathyrella olympiana</i> A.H. Sm	Saprobic	Litter	-	+
<i>Psathyrella</i> sp.	Saprobic	Litter	+	-
<i>Lepiota cristata</i> (Bolton) P. Kumm	Saprobic	Litter	-	+
<i>Lepiota felina</i> (Pers.) P. Karst	Saprobic	Litter	-	+
<i>Macrolepiota africana</i> (R. Heim) Heinem	Saprobic	Litter	-	+
<i>Macrolepiota procera</i> (Scop.) Singer	Saprobic	Litter	-	+
<i>Macrolepiota dolichaula</i> (Berk. & Broome) Pegler & R.W. Rayner	Saprobic	Soil	-	+
<i>Cystolepiota pulverulenta</i> (Huijsman) Vellinga	Saprobic	Litter	-	+
<i>Leucoagaricus rubrotinctus</i> (Peck) Singer	Saprobic	Soil	-	+
<i>Leucoagaricus croceovelutinus</i> (Bon & Boiffard) Bon	Saprobic	Litter	+	-
<i>Leucocoprinus scissus</i> Justo, Bizzi & Angelini	Saprobic	Litter	-	+
<i>Leucocoprinus brebissoni</i> (Godey) Locquin	Saprobic	Litter	+	+

<i>Volvariella volvacea</i> (Bull.) Singer	Saprobic	Wood	+	+
<i>Cortinarius humicola</i> (Quél.) Maire	Ectomycorrhizal symbiont	Soil	+	+
<i>Inocybe sindonia</i> (Fr.) P. Karst	Ectomycorrhizal symbiont	Soil	-	+
<i>Inocybe rimosa</i> (Bull.) P. Kumm	Ectomycorrhizal symbiont	Soil	+	+
<i>Entoloma conferendum</i> (Britzelm.) Noordel	Saprobic	Litter	-	+
<i>Entoloma</i> sp.	Saprobic	Litter	-	+
<i>Claudopus variabilis</i> (Pers.) Gillet	Saprobic	Wood	-	+
<i>Rhodocybe</i> sp.	Ectomycorrhizal symbiont	Soil	-	+
<i>Russula aurea</i> Pers	Ectomycorrhizal symbiont	Soil	-	+
<i>Russula virescens</i> (Schaeff.) Fr.	Ectomycorrhizal symbiont	Soil	+	+
<i>Lactarius chrysorrheus</i> Fr.	Ectomycorrhizal symbiont	Soil	-	-
<i>Lactarius indigo</i> (Schwein.) Fr.	Ectomycorrhizal symbiont	Soil	+	+
<i>Tricholoma stiparophyllum</i> (N. Lund) P. Karst	Ectomycorrhizal symbiont	Soil	-	+
<i>Tricholoma</i> sp. 1	Ectomycorrhizal symbiont	Soil	-	+
<i>Tricholoma</i> sp. 2	Ectomycorrhizal symbiont	Soil	+	+
<i>Arrhenia velutipes</i> (P.D. Orton) Redhead, Lutzoni, Moncalvo & Vilgalys	Saprobic	Soil	-	+
<i>Arrhenia epichysium</i> (Pers.) Redhead, Lutzoni, Moncalvo & Vilgalys	Saprobic	Wood	+	+
<i>Arrhenia obscurata</i> (D.A. Reid) Redhead, Lutzoni, Moncalvo & Vilgalys	Saprobic	Soil	-	+
<i>Clitocybe phaeophthalma</i> (Pers.) Kuyper	Ectomycorrhizal symbiont	Soil	+	+
<i>Clitocybe fragrans</i> (With.) P. Kumm	Ectomycorrhizal symbiont	Soil	+	+
<i>Clitocybe</i> sp. 1	Ectomycorrhizal symbiont	Soil	-	+
<i>Clitocybe</i> sp. 2	Ectomycorrhizal symbiont	Soil	+	+
<i>Panus fulvus</i> (Berk.) Pegler & R.W. Rayner	Saprobic	Wood	-	+
<i>Termitomyces robustus</i> (Beeli) R. Heim	Symbiont with termites	Termite mound	-	+
<i>Termitomyces microcarpus</i> (Berk. & Broome) R. Heim	Symbiont with termites	Termite mound	+	+
<i>Termitomyces clypeatus</i> R. Heim	Symbiont with termites	Termite mound	+	+
<i>Pleurotus ostreatus</i> (Jacq.) P. Kumm	Saprobic	Litter	+	+
<i>Lentinus tigrinus</i> (Bull.) Fr	Saprobic	Soil	+	+
<i>Lentinus</i> sp.	Saprobic	Soil	-	+
<i>Neonothopanus hygrophanus</i> (Mont.) De Kesel & Degree	Saprobic	Wood	+	+

<i>Gymnopus dryophilus</i> (Bull.) Murrill	Saprobic	Litter	+	+
<i>Gymnopus luxurians</i> (Peck) Murrill	Saprobic	Litter	+	+
<i>Gymnopus ocior</i> (Pers.)Antonín & Noordel	Saprobic	Litter	+	+
<i>Gymnopus biformis</i> (Peck) Halling	Saprobic	Litter	-	+
<i>Gymnopus confluens</i> (Pers.)Antonín, Halling & Noordel	Saprobic	Litter	+	+
<i>Gymnopus foetidus</i> (Sowerby) J.L. Mata & R.H. Petersen	Saprobic	Wood	-	+
<i>Hygrocybe colemanniana</i> (A. Bloxam) P.D. Orton & Watling	Ectomycorrhizal symbiont	Soil	+	+
<i>Hygrocybe radiata</i> Arnolds	Ectomycorrhizal symbiont	Soil	+	+
<i>Hygrocybe</i> sp.	Ectomycorrhizal symbiont	Soil	+	+
<i>Lichenomphalia umbellifera</i> (L.) Redhead, Lutzoni, Moncalvo & Vilgalys	Saprobic	Litter	-	+
<i>Lichenomphalia velutina</i> (Quél.) Redhead, Lutzoni, Moncalvo & Vilgalys	Saprobic	Litter	+	+
<i>Cuphophyllus virgineus</i> (Wulfen) Kovalenko	Saprobic	Soil	-	+
<i>Cystoderma amianthinum</i> (Scop.) Fayod	Ectomycorrhizal symbiont	Soil	+	+
<i>Marasmius bekolacongoli</i> Beeli	Saprobic	Litter	+	+
<i>Marasmius fulvoferrugineus</i> Gilliam	Saprobic	Litter	-	+
<i>Marasmius tageticolor</i> Berk	Saprobic	Litter	+	+
<i>Marasmius spissus</i> Gilliam	Saprobic	Litter	+	+
<i>Marasmius siccus</i> (Schwein.) Fr.	Saprobic	Litter	-	+
<i>Marasmius rotula</i> (Scop.) Fr.	Saprobic	Litter	+	+
<i>Marasmius wynneae</i> Berk. & Broome	Saprobic	Litter	+	+
<i>Marasmius arborescens</i> (Henn.) Beeli	Saprobic	Litter	-	+
<i>Marasmius</i> sp.	Saprobic	Litter	+	+
<i>Lentinula edodes</i> (Berk.) Pegler	Saprobic	Soil	+	+
<i>Collybia alboflavoda</i> (Peck) Kauffman	Saprobic	Litter	-	+
<i>Collybia subpruinosa</i> (Murrill) Dennis	Saprobic	Litter	-	+
<i>Collybia cookei</i> (Bres.) J.D. Arnold	Saprobic	Wood	+	+
<i>Collybia dryophila</i> (Bull.) P. Kumm	Saprobic	Litter	+	+
<i>Collybia aurea</i> (Beeli) Pegler	Saprobic	Litter	-	+
<i>Collybia</i> sp.	Saprobic	Litter	+	+
<i>Lactocollybia</i> sp.	Saprobic	Litter	+	+

<i>Tetrapyrgos nigripes</i> (Fr.) E. Horak	Saprobic	Soil	+	+
<i>Tetrapyrgos</i> sp.	Saprobic	Litter	-	+
<i>Oudemansiella canarii</i> (Jungh.) Höhn	Saprobic	Wood	-	+
<i>Mycena rapiolens</i> J. Favre	Saprobic	Wood	+	+
<i>Mycena cinerella</i> (P. Karst.) P. Karst	Saprobic	Litter	+	+
<i>Mycena vulgaris</i> (Pers.) P. Kumm	Saprobic	Litter	+	+
<i>Mycena leptcephala</i> (Pers.) Gillet	Saprobic	Litter	+	+

UNDER PEER REVIEW

**Appendix3.** Correlation between the physical properties of the soil and the abundance of macrofungi species

		Ca	<i>Cuphophyllus virgineus</i>
Ca	Pearson Correlation	1	-0.998**
	Sig. (2-tailed)		0,002
	N	4	4
<i>Cuphophyllus virgineus</i>	Pearson Correlation	-0.998**	1
	Sig. (2-tailed)	0,002	
	N	4	4
**Correlation is significant at the 0.01 level (2-tailed), N = Number of sites			
		Ca	<i>Tetrapyrgos nigripes</i>
Ca	Pearson Correlation	1	-0.962*
	Sig. (2-tailed)		0,038
	N	4	4
<i>Tetrapyrgos nigripes</i>	Pearson Correlation	-0.962*	1
	Sig. (2-tailed)	0,038	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed)			
		Ca	
Ca	Pearson Correlation	1	-0.983*
	Sig. (2-tailed)		0,017
	N	4	4
<i>Clitocybe fragrans</i>	Pearson Correlation	-0.983*	1
	Sig. (2-tailed)	0,017	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Clay	<i>Termitomyces clypeatus</i>
Clay	Pearson Correlation	1	-0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Termitomyces clypeatus</i>	Pearson Correlation	-0.986*	1
	Sig. (2-tailed)	0,014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Clay	<i>Clitocybe phaeophthalma</i>
Clay	Pearson Correlation	1	-0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Clitocybe phaeophthalma</i>	Pearson Correlation	-0.986*	1
	Sig. (2-tailed)	0,014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		K	<i>Inocybe sindonia</i>
K	Pearson Correlation	1	0.953*
	Sig. (2-tailed)		0,047
	N	4	4
<i>Inocybe sindonia</i>	Pearson Correlation	0.953*	1
	Sig. (2-tailed)	0,047	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed) N = Number of sites,			
		N	<i>Arrhenia velutipes</i>
N	Pearson Correlation	1	0.994**
	Sig. (2-tailed)		0,006
	N	4	4
<i>Arrhenia velutipes</i>	Pearson Correlation	0.994**	1
	Sig. (2-tailed)	0,006	

N		4	4
**Correlation is significant at the 0.01 level (2-tailed), N = Number of sites			
		Na	<i>Macrolepiota dolichaula</i>
Na	Pearson Correlation	1	-0.951*
	Sig. (2-tailed)		0,049
	N	4	4
<i>Macrolepiota dolichaula</i>	Pearson Correlation	-0.951*	1
	Sig. (2-tailed)	0,049	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Na	<i>Arrhenia obscurata</i>
Na	Pearson Correlation	1	-0.995**
	Sig. (2-tailed)		0,005
	N	4	4
<i>Arrhenia obscurata</i>	Pearson Correlation	-0.995**	1
	Sig. (2-tailed)	0,005	
	N	4	4
**Correlation is significant at the 0.01 level (2-tailed), N = Number of sites			
		Na	<i>Lentinus sp.</i>
Na	Pearson Correlation	1	0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Lentinus sp.</i>	Pearson Correlation	0.986*	1
	Sig. (2-tailed)	0,014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Na	<i>Lactarius indigo</i>
Na	Pearson Correlation	1	0.988*
	Sig. (2-tailed)		0,012
	N	4	4
<i>Lactarius indigo</i>	Pearson Correlation	0.988*	1
	Sig. (2-tailed)	0,012	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Na	<i>Termitomyces microcarpus</i>
Na	Pearson Correlation	1	0.965*
	Sig. (2-tailed)		0,035
	N	4	4
<i>Termitomyces microcarpus</i>	Pearson Correlation	0.965*	1
	Sig. (2-tailed)	0,035	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		Na	<i>Hygrocybe colemanniana</i>
Na	Pearson Correlation	1	0.975*
	Sig. (2-tailed)		0,025
	N	4	4
<i>Hygrocybe colemanniana</i>	Pearson Correlation	0.975*	1
	Sig. (2-tailed)	0,025	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		OC	<i>Arrhenia velutipes</i>
OC	Pearson Correlation	1	0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Arrhenia velutipes</i>	Pearson Correlation	0.986*	1
	Sig. (2-tailed)	0,014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		OM	<i>Arrhenia velutipes</i>

OM	Pearson Correlation	1	0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Arrhenia velutipes</i>	Pearson Correlation	0.986*	1
	Sig. (2-tailed)	0.014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
		P	<i>Rhodocybe</i> sp.
P	Pearson Correlation	1	0.976*
	Sig. (2-tailed)		0,024
	N	4	4
<i>Rhodocybe</i> sp.	Pearson Correlation	0.976*	1
	Sig. (2-tailed)	0.024	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
pH	Pearson Correlation	1	-0.953*
	Sig. (2-tailed)		0,047
	N	4	4
<i>Russula aurea</i>	Pearson Correlation	-0.953*	1
	Sig. (2-tailed)	0.047	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			
			<i>Termitomyces clypeatus</i>
Sand	Pearson Correlation	1	0.986*
	Sig. (2-tailed)		0,014
	N	4	4
<i>Termitomyces clypeatus</i>	Pearson Correlation	0.986*	1
	Sig. (2-tailed)	0.014	
	N	4	4
*Correlation is significant at the 0.05 level (2-tailed), N = Number of sites			