UNIVERSITY OF RWANDA

Diversity and Ecology of Wild Mushrooms of Riparian Zone of Lake Kivu, Rwanda

By

Emmanuel MUNYANEZA

College of Sciences and Technology

School of Science

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Diversity and Ecology of Wild Mushrooms of Riparian Zone of Lake Kivu, Rwanda

Thesis submitted in partial fulfillment of the award of MSc degree in Biodiversity Conservation and Natural Resources Management

By

Emmanuel MUNYANEZA
Reg.N° 215043178
In the College of Science and Technology

Supervisors: **Prof. Elias BIZURU**,University of Rwanda
Dr. Jérôme DEGREEF, Fédération Wallonie-Bruxelles & Botanic Garden Meise (Belgium)

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DECLARATION

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for award of other degree. Except for quotations and summaries which have been acknowledged, the work presented is entirely my own.

Emmanuel MUNYANEZA

Reg.N^{o} 215043178

Signed

Date: 25/05/2018

Certification

This is to certify that the Project Work entitled "**Diversity and Ecology of Wild Mushrooms of Riparian Zone of Lake Kivu, Rwanda"** is a record of the original bonafide work done by:

MUNYANEZA Emmanuel (REG.NO: 215043178)

in partial fulfilment of the requirement for the Degree of MASTER OF SCIENCE IN BIODIVERSITY CONSERVATION AND NATURAL RESOURCES MANAGEMENT in

College of Science and Technology, University of Rwanda during the Academic Year 2017-2018.

……..	……..
Prof. Elias BIZURU	Dr MUTANGANA Dieudonné
Supervisor	Head of Department of Biology

ABSTRACT

Fungi are among the most diverse group of living organisms on earth, though inadequately studied worldwide and especially in Rwanda. The main objective of this study was to assess the diversity and describe the ecology of mushrooms species in Rwanda in order to develop a baseline that can help for further studies on fungi in the country.

The Macromycetes diversity and distribution of the riparian zone of Lake Kivu were studied by plot-based mushroom surveys at 3 study sites (Mariri, Mpangara and Nyakarwa) and simple random searches in the garden of the Museum of Environment, from September 2016 to June 2017. More than 64 mushroom species were recorded, collected, dried and their specimens are conserved in the Museum of Environment of Karongi, Rwanda. A total of 64 species were collected, belonging to 8 orders, 26 families and 40 genera. It was revealed that the riparian zone of Lake Kivu is dominated by Agaricales, an order represented by 52 species, 81% of all species collected. The total order/family ratio of 0.31, family/genus ratio of 0.65 and genus/species ratio of 0.63 is an indicator of high family and generic diversity in the collections. Families highly represented in collections with the most number of species are Agaricaceae with 18 species, Tricholomataceae with 10 species and Psathyrellaceae with 5 species. In this study, *Termitomyces medius* was collected and recorded for the first time in Rwanda. This study has provided 14 new records on the list of mushroom species in Rwanda. Moreover, the study has also provided other 43 potential new records which were identified to genus level. More number of mushrooms species was recorded in Nyakarwa Forest and Sorenson similarity matrix calculated showed dissimilarity richness and distribution of mushrooms species among 4 sites surveyed during this study. During the study period, the number of species present increased with rainfall. The most species were recorded and collected in December and decreased to 0 in the June dry season.

KEY WORDS

Mushrooms, diversity, ecology, Lake Kivu, riparian zone.

LIST OF SYMBOLS AND ACRONYMS

INMR:	Institute of National Museums of Rwanda
ITCZ:	Intertropical Convergence Zone
MINIRENA:	Ministry of Natural Resources
MINITERE:	Ministère des Terres, de 'Environnement, des Forets, de l'eau et des Ressources Naturelles
REMA:	Rwanda Environment Management Authority
USAID:	United States Agency for International Development

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1. Introduction

The biological diversity of Rwanda is well conserved and protected within protected ecosystems (REMA, 2014b; USAID, 2014) while no or less consideration is given to non-protected ecosystems. However, as it was mentioned by some authors, conserving the national or regional biodiversity only in protected areas and National Parks, is a strategy unlikely to succeed, because they don't cover all proportional type of habitat of national or regional biodiversity (Hayes & Ostrom 2005;Cai et al. 2009; Cox & Underwood 2011).

Various scientific and government reports on national biodiversity have revealed that Rwanda hosts natural ecosystems with large biological diversity (Stuart et al. 1990; Plumptre et al. 2003; MINIRENA 2011; REMA 2014b). The diversity of natural ecosystems found in Rwanda include Afromontane forests, savannas, gallery forests, riparian zones, wetlands and lakes (REMA, 2010, 2014b). As it has been reported in the Fifth National Report to the Convention of Biological Diversity (REMA, 2014b) the status and trend of biological diversity in Rwanda vary from one ecosystem to another and the human-induced landscape changes are pressing more on non-protected areas than on National Park and other protected areas. However, some research done in various remnant natural ecosystems in Rwanda have already revealed that some interesting and rare species are persisting in small remnant natural habitats separated by intensive agricultural and urban areas (Kanyamibwa 1997; Nsabagasani et al. 2008; Bizuru et al. 2011; Fischer 2011; REMA 2014a). During the biodiversity survey done in Lake Kivu islands (REMA, 2014a), it was revealed also that this area constitutes a refugia area of damaged zones of the main land and are home to different plants and animals species which some of them having a particular status of being endemic or endangered, like *Atilax palutinosus* and water bird species. Although the survey did not consider riparian zone of Lake Kivu, the vegetation structure and vegetation composition of Lake Kivu islands and riparian zones are very similar and they could have similar biological diversity. The riparian zone should have another ecological advantage as it is connected to adjacent upland and plays the role of corridor and refuge for all surrounding biodiversity (Goforth *et al.*, 2002).

Like many other research and biodiversity surveys done in Rwanda, in the survey done by REMA (REMA, 2011, 2014a) mushroom species were ignored and not considered among biodiversity living organisms to be surveyed. According to Egbe Enow et al. (2013), mushrooms are not taken into consideration in many research works due to their largely

hidden nature and frequently sporadic and short-lived sporocarps. Despite this kind of ignorance by research, mushrooms constitute a significant part of terrestrial ecosystems, forming a large share of the world biodiversity richness and are key-players in ecosystem processes (Molina 1994; Halme 2012). In general, Fungi is one of largest group of organisms on the Earth with an estimated number of 1.5 million species (Hawksworth, 2001; Osemwegie, Okhuoya and Dania Akande, 2014) and it occupies the second place after insect with about 8 million of species (Hawksworth, 2002). It is also estimated that only about 8-10% of the 1.5 million species have been described and most of them, are in temperate regions; the tropical region which is undoubtedly hosting the highest fungi diversity has been inadequately sampled and scarcely documented (Hawksworth 2001; 2002). Moreover, mushrooms are also currently highly threatened by habitat loss, pollution, over-exploitation and climate change (Osarenkhoe et al. 2014; Degreef et al. 2016).

Although the taxonomic knowledge of fungi is very incomplete and their ecology has not yet been studied, some preliminary observations on the taxonomic diversity and ecology have shown that the African tropical region should be a hotspot of endemic species (Verbeken and Buyck, 2002). Central and East African regions, which are known to be a hotspot of biological diversity, host a big number of mushrooms species (Buyck, 1994; Chelela, Chacha and Matemu, 2015; Degreef *et al.*, 2016). Despite that mycological richness of Africa, till now only one research study has been done on diversity and ecology of mushrooms in Rwanda (Degreef et al. 2016). This study only focused on edible species and was restricted to montane forest ecosystems. However, as it has been found in previous research works that the distribution of many African fungi are linked to the contrast between open woodlands and dense forests (Buyck 1994; Verbeken & Buyck 2002; Djelloul & Samraoui 2011). Based on habitat structure of riparian zone of Kivu Lake, riparian forest of evergreen forest densely populated by native tree species, woodland and herbaceous layer of grass savannah; those different vegetation types should host different mushroom species associated with different habitat structure and linked to ecological requirement of each species.

Riparian zones and islands of Kivu Lake, are ones of remnant natural habitats which are not yet included in biodiversity conservation policy in Rwanda while its species richness is high and specific (REMA, 2011, 2014a). High biodiversity of riparian zones is due to the fact that they encompass sharp environmental gradients and diverse ecological processes (Goforth et al. 2002; Olson et al. 2007; Henson et al. 2010). Therefore, riparian zones and islands should be potential habitats for sustaining a significant portion of national biodiversity in Rwanda

based on consideration of Gregory et al. (1991) underlining that riparian zones act as biodiversity refugia while the disturbance and fragmentation of adjacent upland are intensified.

Despite high biological richness of the country, all research works have focused only on plants and animals. Fungi have always been forgotten or ignored and are not included in any scientific report on biological diversity of Rwanda or of Albertine Rift Region. Existing information on fungal diversity and composition in the country is very poor. Thus, it is highly imperative to assess fungal diversity and species composition of different habitats and ecosystems. Therefore, this study was designed with the aim of addressing general lack of information pertaining to mushroom diversity with a view to attract attention of policy makers to integrate riparian zones and mushroom species in biodiversity conservation strategies and to increase the knowledge of edible and medicinal mushroom resources of the country.

The general objective of this study is to assess mushroom species found in the riparian zones of Lake Kivu and to identify ecological factors that influence mushroom distribution in different habitat types within this zone. The specific objectives of this study are (1) to contribute to the inventory of mushrooms species of Rwanda; (2) to identify ecological factors related to mushroom species distribution in study sites; (3) to collect and preserve mushrooms specimens from the study area and finally (4) to compile data on traditional uses in the region (neighbouring countries) of mushrooms species identified.

To achieve the mentioned objectives, the following research questions were formulated: What are mushroom species that are correlated with different habitat types and the ecological condition of the riparian zone of Kivu Lake? Is there any similarity of species distribution across different habitat types? What are the potential uses of mushroom species occurring in this region? The central hypothesis of the study was that the riparian zone of Lake Kivu hosts specific mushroom species. We expected that the mushrooms species found in this region have multiple uses that we have to document, popularize and include in potential ecosystem services of this zone.

2. Materials and Methods

2.1. Description of study sites

The riparian zone of Lake Kivu constitute one of natural habitats of the Albertine Rift region, in western province of Rwanda and this region is an area of high endemism and threatened species (Plumptre *et al.*, 2003). Lake Kivu is located at the topographic high point of the western branch of the African Great Rift Valley, at 1463 m above mean sea level (Wood, 2014). The riparian zones and surrounding areas of Lake Kivu, like all other ecological zones of the country, benefit from a continental tropical humid climate with alternating dry and rain seasons. This alternation is due to a bimodal rainfall pattern that Rwanda experience, driven by the progression of the Inter-Tropical Convergence Zone (ITCZ) (McSweeney, 2011). Therefore, Rwanda is characterized by 4 seasons: short dry season in January to February, long rains season occurring over March- May, long dry season from June to August and short rains season in October to December (McSweeney, 2011). Riparian zones of Kivu Lake, where the study sites are located, receive annual rainfall from 1100-1200 mm with mean annual temperature ranging between 18 and 20^{o}C (MINITERE, 2007).

The study sites included, the garden of Museum of Environment in Karongi, Mariri Peninsulas, Mpangara Island and the Nyakarwa Forest. Mpangara Island and Mariri Peninsula were chosen for their topography which facilitates accessibility for most vegetation types. Since 2015 the two sites are managed as protected forests (Official Gazette n^{0} 27 of 06/07/2015 on Ministerial Order No 006/Minirena/2015 of 18/06/2015 determining the management of protected state forests not governed by special laws). The status of protected forest is a good factor for research site allowing continuous research activities. Nyakarwa Forest was chosen due to its vegetation structure which is special and unique on the mainland adjacent to Lake Kivu riparian zone with a mixture of local and exotic tree species, large amounts of litter, and biodegradable organic matter.

Photo a: Nyakarwa Forest

Photo b: Mariri Woodland

Photo c. Mpangara Island

Mpangara Island is an island of 2.57 ha, located in Karongi District. The vegetation type of this island is composed of riparian woodland layer of indigenous plant species (*Ficus ingens, Rhus natalensis, Carissa edulis, Carissa spinarum*) and some exotic plant species (*Eucalyptus ssp. and Grevillea robusta*). The island also has a shrub layer dominated by *Lantana camara*, an exotic plant species, some local species including *Lantana trifolia*, *Rhus natalensis*, and savannah grassland.

Mariri Peninsula is located in Bwishyura Sector, Karongi District. It is a peninsula of 3.12 ha characterized by a woodland layer on the shores of Lake Kivu and woodland savannah and grassland layer upward. The riparian woodland is dominated by indigenous plant species including *Ficus ingens, Acacia hockii, Phoenix reclinata* and *Euphorbia candelabrum. Lantana camara* tend also to invade this natural habitat.

Nyakarwa Forest is about 4 ha and is known as "Agashyamba ka Nyakarwa" by local residents which means forest located on island. The vegetation of that forest is dominated by many indigenous plant species (*Euphorbia candelabrum, Harungana madagascariensis, Dodonea viscosa, Phoenix reclinata, Ochna holstii* etc) with a canopy of exotic species (*Casuarina equisetifolia, Eucalyptus ssp.* and *Jacaranda mimosifolia*). The forest also shelters important indigenous herbaceous and bryophytes species.

The garden of the Museum of Environment is located in Karongi District at the shores of Lake Kivu. This garden is covering an area of about 0,5 ha and the whole area is almost covered by *Paspalum notatum*. In the Paspalum's gazon some exotic and local ornamental trees, shrubs and herbs are planted to embellishing the garden.

2.2. Data collection and analysis

A reconnaissance survey was conducted during April-May 2016 to get an insight of the vegetation pattern and topography in order to locate sampling plots. A total of 18 plots (10m x10m), six from each site (Mariri, Mpangara and Nyakarwa), were established and sampled. Because the museum garden is small and very easy to survey all its corners, fruiting bodies were collected randomly all over in the garden during study period. Plots were established randomly in each vegetation structure according to the accessibility of site. This is the best method recommended in the areas with stratified vegetation structure and allows the collection of data on diversity and comparison of abundance and diversity between habitat structures (Kenkel et al. 1989; Hill et al. 2005; Moore et al. 2011).

All mushroom species found in plots and garden were recorded, photographed and collected. All ecological data of each species found were also recorded. Ecological data includes habitat, substrates (i.e. dead wood, standing trees, termite mount, soil and litter). The plots were surveyed using presence-absence for fruit bodies of mushroom in systematic placement for the coverage of plots as it is recommended by Lodge et al. (2004); Hill et al.(2005) and Halme (2012) , twice a month from September 2016 to June 2017. Fruit bodies were collected, and each specimen was described when fresh (size, shape, colour, hymenium or details of the spore bearing surface) and all specimens were separated into species and/or genus by identifying their characters according to the keys and reference guides (Buyck 1994; Eyi Ndong et al. 2011; De Kesel et al. 2017; Degreef and De Kesel, 2017) . Specimens collected were dried and preserved using standard methods (Eyi Ndong et al. 2011) and constitute the basic data of museum herbarium and the duplicates will be sent to the Herbarium of Botanic Garden Meise in Belgium.

The frequency of species, represented by the number of plots in which a species was recorded was computed for each site. Species similarity between sites was determined using the Sorenson's coefficients and Chao 2 estimator was used for estimating omitted species (Hill *et al.*, 2005; Marcon, 2006). The relative dominance and relative density was calculated by the following formula(Cottam & Curtis 1956).

$$\text{Relative frequency} = \frac{\text{Number of plots containing species}_x \text{ in Site}_n}{\text{Total number of plots in site}_n} \times 100$$

$$\text{Relative density} = \frac{\text{Number of species of family}_x \text{ in site}_n}{\text{Number of species of all families in Site}_n} \times 100$$

The following frequency classes were used to designate the frequency status of each species in different study sites and in the whole region covered by this study. The species frequency indicates the number (%) of plots in which the species has been recorded

Table 1. Scales used in rating mushrooms species frequency

Scale	Rating	Description
1	Rare	Species with relative frequency < 20%
2	Occasional	Species with relative frequency between 21% and 49 %
3	Frequent	Species with relative frequency between 50% and 74%
4	Abundant	Species with relative frequency > 75%

Ethnomycological data had been gathered through survey and literature review. The information on edibility of some recorded species is mostly obtained from the population surrounding the study areas including people that we met in bushes and forest collecting firewood and a group of population that have been expropriated from some Kivu islands. The uses of different species in other communities and countries have been gathered from available literature.

3. Results

3.1. Species richness within Macrofungi

The riparian zones of Kivu Lake are dominated by Agaricales, an order represented by 52 species among 64 species which means 81% of all species collected. Agaricales are followed by Boletales with 4 species (6%), Geastrales and Polyporales with 2 species for each (3%) while other orders are represented by one species.

A total of 64 species collected from all four study sites, Mariri, Mpangara, Nyakarwa and INMR garden belong to 8 orders, 26 families and 40 genera. The total order/family ratio of 0.31, family/genus ratio of 0.65 and genus/species ratio of 0.63 indicates the total high family and generic diversity in the collections. The families highly represented in collections with the most number of species are Agaricaceae with 18 species, Tricholomataceae with 10 species, Psathyrellaceae with 5 species and Strophariaceae with 4 species. Those 4 families account for more than 50% of collected species whereas Lyophyllaceae is represented by 3 species, Boletinellaceae, Geastraceae and Marasmiaceae are each represented by 2 species. Other 18 families are each represented by only one species. Table 2, shows the total number of families, genera, species and relative density of species collected in this study. The full list of species collected and identified in this study is presented in Appendix 1 while appendix 4 shows their photos. Appendix 3 shows the provisional list of mushrooms species recorded in Rwanda.

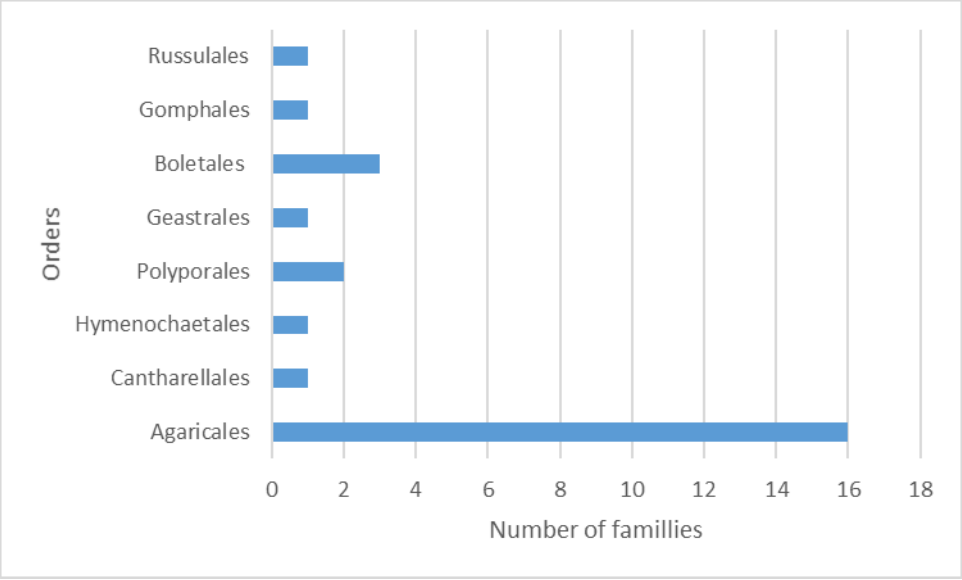

Figure. 1. Orders and ampleness of mushrooms families in riparian zones of Lake Kivu.

Table 2. Total number of families, genera, species and relative density of species collected in this study.

No.	Family name	Number of Genera	Number of Species	Relative density %
1	Agaricaceae	7	18	28.13
2	Amanitaceae	1	1	1.56
3	Bolbitiaceae	1	1	1.56
4	Boletinellaceae	2	2	3.13
5	Cantharellaceae	1	1	1.56
6	Entolomataceae	1	1	1.56
7	Ganodermataceae	1	1	1.56
8	Geastraceae	2	2	3.13
9	Gomphaceae	1	1	1.56
10	Hygrophoraceae	1	1	1.56
11	Hygrophoropsidaceae	1	1	1.56
12	Inocybaceae	1	1	1.56
13	Lyophyllaceae	1	3	4.69
14	Marasmiaceae	1	2	3.13
15	Mycenaceae	1	1	1.56
16	Nidulariaceae	1	1	1.56
17	Pleurotaceae	1	1	1.56
18	Pluteaceae	1	1	1.56
19	Polyporaceae	1	1	1.56
20	Psathyrellaceae	2	5	7.81
21	Repetobasidiaceae	1	1	1.56
22	Russulaceae	1	1	1.56
23	Schizophyllaceae	1	1	1.56
24	Sclerodermataceae	1	1	1.56
25	Strophariaceae	2	4	6.25
26	Tricholomataceae	5	10	15.63

Among all mushroom species recorded and collected during this study in riparian zones of Lake Kivu, a high number of species was recorded from Nyakarwa Forest with 40 species (16 families and 6 orders). (Figure 2).

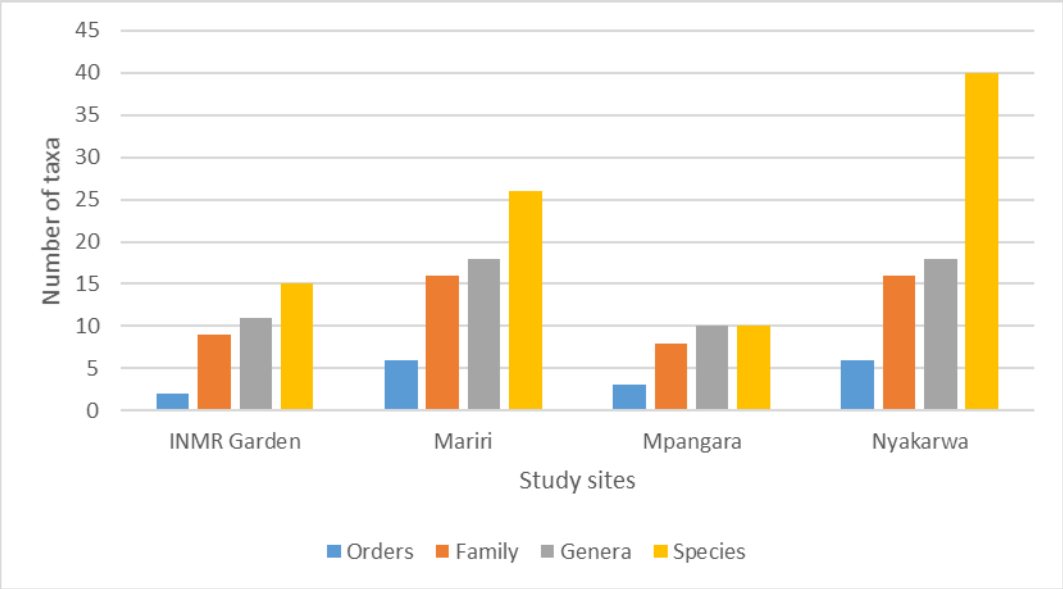

Figure 2. Richness of species, genera, families and orders in study sites

3.2. Species distribution and ecology

The frequency of occurrence of species recorded during this study in each study site is presented in Figure 3 and Figure 4 show the overall frequency of occurrence of species if we consider the whole region covered by our study which means all sites together including museum garden.

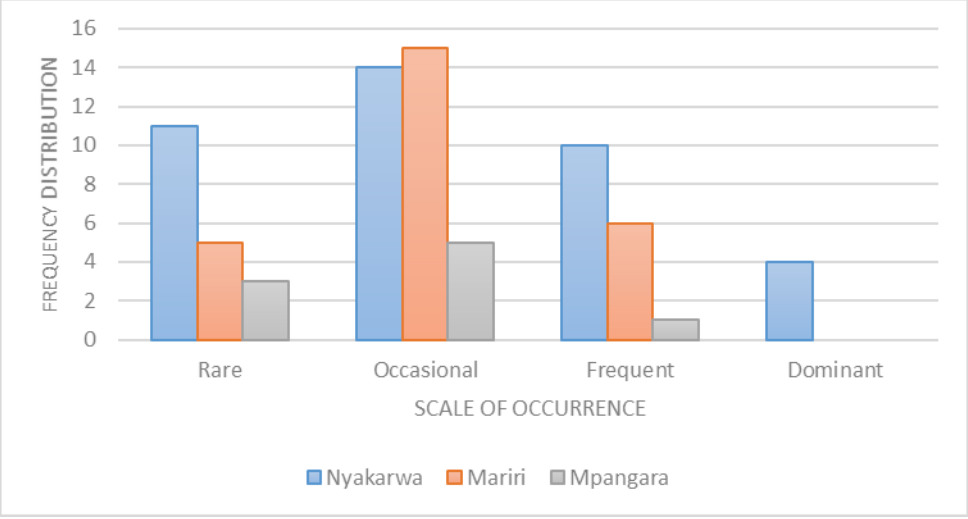

Figure 3. Frequency distribution of species in study sites

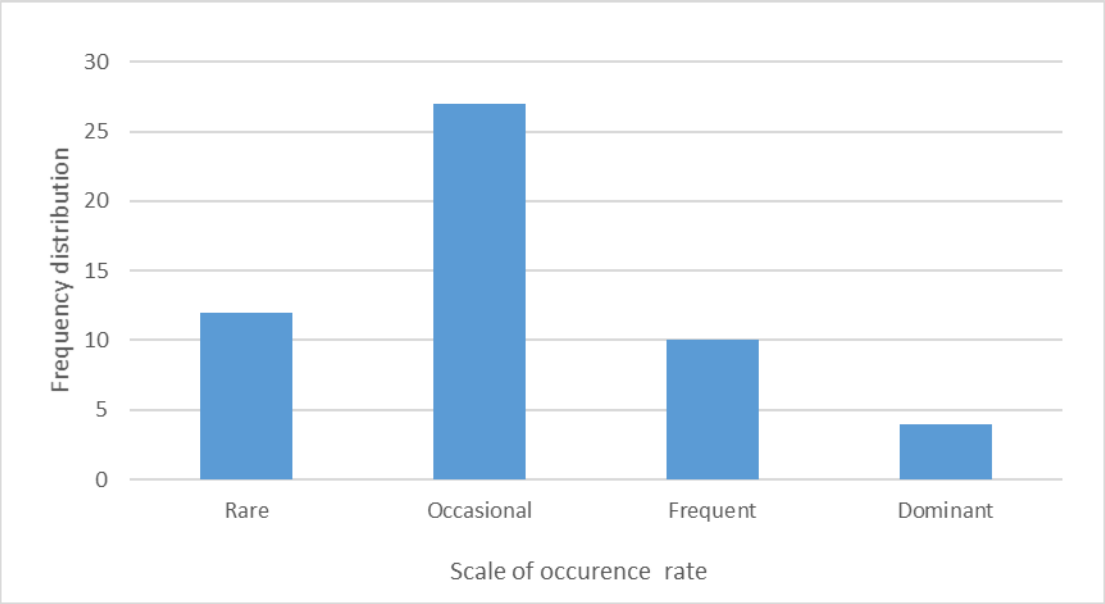

Figure 4. Frequency distribution of mushrooms species in whole study region

The similarity of species distribution in study sites was calculated using Sorenson's similarity matrices and the results are shown in the Table 3.

Table 3. Sorenson's similarity matrices for species distribution in study sites

	Nyakarwa	Mariri	Mpangara	INMR Garden
Nyakarwa	1			
Mariri	0.39	1		
Mpangara	0.36	0.11	1	
INMR Garden	0.36	0.24	0.16	1

The number of species recorded during study period varied according to rainfall received in the region. The number of species seems clearly correlated with the rainy season. The most species were recorded and collected in December and decreased to 0 in dry season from June (Figure 5).

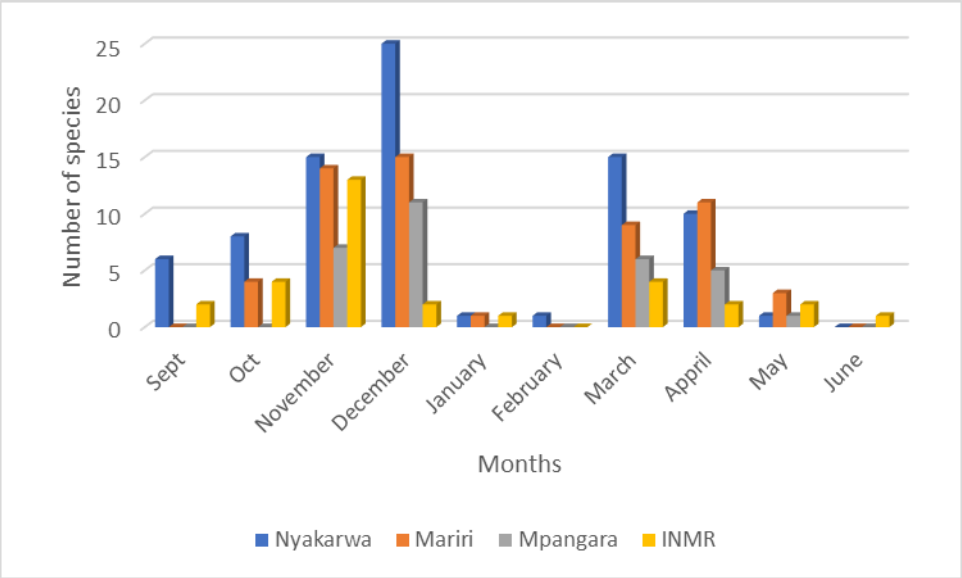

Figure 5. Monthly recorded species numbers in different study sites

Vegetation structure play a big role on mushroom distribution, most species have been recorded and collected in forest, followed by woodland, garden and grassland (Figure 6).

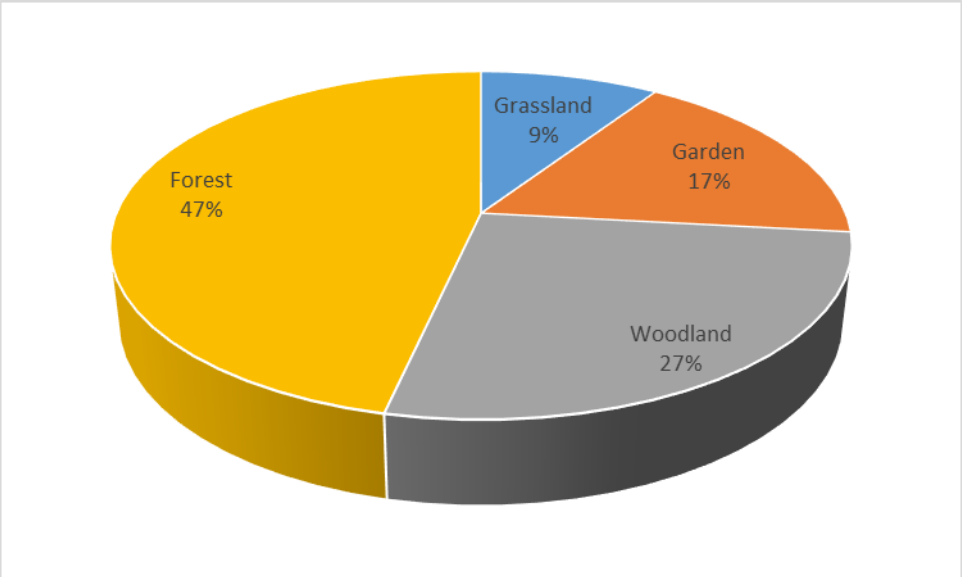

Figure 6. Distribution of mushroom species in different habitat types.

3.3. Potential use of recorded mushrooms species

Information from field survey on uses of wild mushrooms in Karongi region has revealed that only 3 species of mushrooms are known and used as edible mushrooms. These species belong to Termitomyces genera and are *Termitomyces medius*, *Termitomyces microcarpus*, and *Termitomyces robustus*. All others species are considered as toxic and poisonous. However, among species recorded in study area about 14 species are known to be edible in other countries and 3 species are used in traditional medicine (Table 4).

Table 4: List of species with their potential uses

Species	Uses	Country	References
Agaricus crocopeplus	Edible	Tanzania	Tibuhwa, 2012
Collybia piperata	Edible	D R Congo	Eyi Ndong et al. 2011
Cotylidia aurantiaca	Edible	Burundi,D R Congo , Rwanda	Degreef et al. 1997; Degreef et al. 2016
Gymnopilus zenkeri	Edible	Cameroun, Gabon, Malawi, Ouganda	Eyi Ndong et al. 2011
Lentinus brunneofloccosus	Edible	R of Centrafrique, D R Congo, Gabon, Ghana	Eyi Ndong et al. 2011
Macrolepiota africana	Edible	Cameroun, R of Centrafrique, D R Congo, Gabon, Kenya, Rwanda	Degreef et al. 1997; Degreef et al. 2016; Eyi Ndong et al. 2011
Macrolepiota procera	Edible	Gabon, D R Congo, Nigeria, Tanzanie	Degreef et al. 1997; Eyi Ndong et al. 2011; Hussein et al. 2015; Okoro & Achuba 2012
	Medicine (Wound, Antimicrobial)	Tanzania	Hussein et al. 2015; Tibuhwa 2012
Marasmius arborescens	Edible	Angola, Burundi, D R Congo, Rwanda	Degreef et al. 2016; Eyi Ndong et al. 2011
Schizophyllum commune	Edible	Gabon, D R Congo, Nigeria, Tanzania,	Degreef et al. 1997; Eyi Ndong et al. 2011; Eyi Ndong et al. 2014
	Medicine (Diabete)	Nigeria	Oyetayo 2011
Suillus granulatus	Edible	Rwanda	Degreef et al. 2016
Termitomyces medius	Edible	Rwanda	Present study

Species	Uses	Country	References
Termitomyces microcarpus	Edible	Burundi, Gabon, D R Congo, Cameroun, Uganda, Tanzania, Rwanda	Buyck 1994; Chelela et al. 2015; Degreef et al. 1997; Degreef et al. 2016; Opige, M., Kateyo, E., Kabasa, J. D., Olila 2006
	Medicine (Gonorrhea)	Nigeria, Tanzania	Oyetayo 2011
	Medicine (Lactogen)	Tanzania	Tibuhwa 2012
Termitomyces robustus	Edible	Burundi, Nigeria, DR Congo, Cameroun, Uganda, Gabon, Rwanda	Buyck 1994; Eyi Ndong et al. 2014; Eyi Ndong et al. 2011; Degreef et al. 2016
Volvariella volvacea	Edible	Gabon, Nigeria	Eyi Ndong et al. 2011; Eyi Ndong et al. 2014; Okoro & Achuba 2012
	Medicine	Nigeria (Antibiotic)	Oyetayo 2011

4. Discussion

The results of this study are the first for such systematic survey and inventory of wild macromycetes diversity in Rwanda. Among study sites surveyed, significant high number of species was collected in Nyakarwa Forest during the study period, where 40 species belonging to 18 genera in 16 families were recorded. Nyakarwa forest is followed by Mariri in species richness with 26 species belonging to 18 genera and 16 families (Figure.3).

The high level of Nyakarwa fungal diversity may be attributed to a closed canopy of its vegetation and biodegrading ability of many recalcitrant substrates found in that forest. This result is in agreement with Verbeken & Buyck (2002), Gómez-Hernández & Williams-Linera (2011), and Sandhya et al. (2017) ,that have highlighted the correlation of these ecological features with mushrooms abundance in their study sites. The biggest number of mushroom species of Mariri was also recorded in riparian woodland and was collected on organic materials, decomposing plant litter and decaying shrubs. Only 7 species were collected in the grassland habitat, *Cotylidia aurantiaca*, *Gymnopilus zenkeri*, *Parasola plicatilis*, *Phlebopus*

sudanicus, Pholiota sp., Schizophyllum commune and *Suillus granulatus*. The lowest species richness of Mpangara Island could be due to its location of being isolated from mainland.

The high frequency of Agaricaceae family in study sites is attributed to adaptability of the species of this family in tropical areas and this is in agreement with the results obtained from other studies in tropical areas (Kebede, 2017; Megersa *et al.*, 2017; Sandhya, Surendra and Kumar, 2017). The dominance of species of this family is due to their efficient dispersal mechanisms and adaptation to ecological conditions (Hawksworth, 2001; Kebede, 2017). Tibuhwa (2012) underlined that species of Agaricaceae were also the most common species and were used by communities around Ngorongoro and Serengeti National Park in Tanzania. Apart the explanation given by these authors mentioned above, there is no other convincing reason to explain the high abundance of Agaricaceae family in this region in comparison to other fungi families. As they are well distributed in all habitat types it is an indicator that it must be a special link between ecological requirements of species members of this family and ecological features of this region. Therefore, a further study is needed to evaluate the correlation of the presence of Agaricaceae in this region and its ecological features.

The distribution of mushroom species in four study sites (Museum garden, Mariri, Mpangara and Nyakarwa) are relatively less similar, Sorenson's similarity index $\leq 0,39$. The mushroom species collected in Nyakarwa Forest are distributed in other three study sites with Sorenson's similarity index of 0,36 and 0,39. The similarity of Nyakarwa and other sites should be attributed to the fact that this site represent all ecological features of Kivu riparian zone and most species distributed in different sites of this zone are present in Nyakarwa Forest. The sites which are very dissimilar are Mpangara and Mariri, with a similarity index of 0,11 (Table 3).

The difference in species richness between Mpangara Island and the Mariri Peninsula is somewhat surprising because the structure of the natural vegetation of these two habitats is very similar. The dissimilarity in species richness may be caused by their location: the isolation from mainland of Mpangara as it is an island while Mariri is a peninsula. This assumption is supported by previous results showing the effect of isolation on the distribution and abundance of species. Peay et al. (2007), Henson et al. (2010) and Jones et al. (2016) have highlighted that isolation decreases species richness by reducing the number of potential colonists dispersing into an area and as consequence many islands lack species common on

the mainland while they can support other species in great abundance, or harbour species largely restricted to islands given their land area.

During the study period, the frequency occurrence of species in each habitat was found to be different. In all study sites, occasional species made most of the collection and the distribution of dominant species were very low (Figure 4 and Figure 5). The fact that most species recorded are ranged from rare and occasional species indicates that species distribution varies with vegetation structure. More species were collected in plots located in forest (Figure 8). On the other hand, the methodology used, surveying twice a month, may lead to the missing of some records as the fructification of most mushroom species occur at different times, although the value of the Chao2 estimator calculated (64 $\pm$ 3.6) was moderate.

Most of the species were recorded in forest habitat, followed by woodland, garden and finally grassland. Most species recorded are saprotrophic and were recorded in plots with dead organic materials, decomposing plant litter and decaying wood.

Due to ephemeral fruiting bodies that can be observed only for few days, phenological data is difficult and time consuming to obtain results with high exactitude level. However, in this study, a large number of records were correlated with precipitation. The most species were recorded and collected in November and December in the first rainy season (Agricultural season A) and in April and May in the second rainy season (Agricultural season B) (Figure 6 and Figure7). Comparing two rainy seasons, most mushroom collections were observed in November-December than in March-May. This difference can be due to many factors including phenological period of species occurring in this region and variation of rainfall received in each season. A further study extending over long study period and taking into account the rainfall variation may provide more information about fruiting period of each species and assess whether there is any correlation between species abundance and seasons.

Among 64 species recorded in this study, only 3 species of *Termitomyces* have been reported to be edible by local community. Those species are *Termitomyces medius, Termitomyces microcarpus and Termitomyces robustus.* The population of Karongi don't consider mushrooms as a principal source of food; they use them occasionally if they found them in their field. However, among species collected, there are about 14 species known to be edible in other countries including neighbouring countries, Burundi, Tanzania, Uganda and Democratic Republic of Congo (Table 4). To differentiate edible mushrooms to non-edibles

ones, the local population use a common name of " Ibihegehege" for non-edible mushroom while each edible species has a specific vernacular name. Indenganzira is the vernacular name of *Termitomyces medius*, Imegeri is the vernacular name of *Termotomyces microcarpus* and Igihumyo or Icyobo are the vernaculars names of *Termitomyces robustus*. *Termitomyces medius* was collected once in November and has been recorded and reported by an ethno mycological study for the first time as edible mushroom in Rwanda during this study.

As saprophytic mushrooms are found growing on rotten logs of woody tree trunks, decaying or dead organic matter, and dump soil rich in organic substances, some wild species are subject of research work for growing them on artificial medium. Among saprophytic edible species, *Volvariella volvacea* and other two species belonging to Coprinus and Pleurotus genera (Coprinus cinereus, Pleurotus flabellatus) have been grown on agricultural and agro-industrial residues as substrate by different scientists and the results were interesting (Apetorgbor et al. 2005; Mshandete & Cuff, 2008) . Therefore, some species recorded in this zone including *Volvariella volvacea, Coprinus sp.* and *Pleurotus sp.* can also be subject of research work focusing to grow them on artificial medium in order to improve their production and generating a great socio-economic impact in human welfare on local level.

5. Conclusion and recommendations

The present study is an attempt to provide a preliminary picture of mushroom diversity in Rwanda, especially of riparian zones of Kivu Lake, and occurring in diverse natural habitat including woodland, grassland savannah and riparian forest. The list of mushrooms species collected and recorded in this study provides a baseline of information for further assessment on macrofungal diversity of the country. On the list of 37 species recorded by Degreef et al. (2016) in Rwanda, this study has provided additional records, 14 records identified to species level and 43 potential records identified to genus level (worth identification to species level) (Appendix 3). Record of the rare *Termitomyces medius* only known from Zambia and DR Congo is also an additional record among edible mushroom of Rwanda reported by an ethnomycological study.

The distribution of species in study sites surveyed, has led to think about several viewpoints to consider as main causes of unequal distribution and dissimilarity in species richness between sites. The diversity of habitat structure is believed to have the strongest impact on mushrooms species richness and distribution in surveyed sites. The habitat structure influences the quality of substratum then the mushroom diversity according to species ecology.

Though the full spectrum of mushroom diversity of the country is still far from being described and documented, these results on mushrooms occurrence in riparian zone of Lake Kivu, provide opportunities to forward conservation plan involving mushrooms as other living organisms that need a special consideration in biodiversity conservation program. Thus, it is highly recommended for further insight into mushrooms species composition and distribution in different ecological zones and habitat types of Rwanda with more in-depth studies namely on ecological aspects (host-plants for ectomycorrhizal species, substrate for saprotrophic species and soil type as an ecological correlate for species presence). The assessment survey should be combined with ethnomycological studies to highlight species with special cultural and economic values for community. The survey and research should also focus on species with potential ability to be grown on an artificial medium. As mushrooms cultivation does not require big space and good soil, cultivation of local species should generate income for many smallholder farmers in Rwanda and improve food security and quality in the country.

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Emmanuel MUNYANEZA

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Appendix 1. **List of species collected and identified in riparian zone of Kivu Lake**

Specimen number	Species	Family	Nyakarwa	Mariri	Mpangara	Garden
EM 15	*Agaricus crocopeplus*	Agaricaceae				x
EM76	*Agaricus sp. 1*	Agaricaceae	x			
EM 23	*Agaricus sp. 2*	Agaricaceae	x			
EM67	*Agaricus sp. 3*	Agaricaceae		x		
EM 38	*Agaricus sp. 4*	Agaricaceae				x
EM 110	*Amanita sp.*	Amanitaceae		x		
EM 11	Cantharellus sp.	Cantharellaceae	x			
EM 6	*Chlorophyllum hortense*	Agaricaceae	x			
EM 28	*Clitocybe sp. 1*	Tricholomataceae	x			
EM 85& 57	*Clitocybe sp. 2*	Tricholomataceae	x			
EM 59 &77	*Clitocybe sp. 3*	Tricholomataceae	x			
EM 1	*Collybia piperata*	Tricholomataceae	x	x	x	
EM93	*Collybia sp.*	Tricholomataceae	x			
EM 21	*Coprinus sp. 2*	Agaricaceae	x	x	x	
EM 12	*Coprinus sp.1*	Agaricaceae	x	x		
EM 33	Cotylidia aurantiaca	Repetobasidiaceae		x		
EM 51	*Cyathus stercoreus*	Nidulariaceae	x	x		
EM 96	*Entoloma sp.*	Entolomataceae	x			
EM 31	Ganoderma sp.	Ganodermataceae	x	x		
EM 64	Geastrum sp 1	Geastraceae	x			
EM 68	Geastrum sp 2	Geastraceae	x			
EM 41	*Gymnopilus sp.*	Strophariaceae				x
EM70	*Gymnopilus sp.*	Strophariaceae	x			
EM 19	*Gymnopilus zenkeri*	Strophariaceae		x		x
EM 14	*Hygrocybe nigrescens*	Hygrophoraceae				x
EM 46	Hygrophoropsis sp	Hygrophoropsidaceae				x
EM101	*Inocybe sp.*	Inocybaceae		x		
EM 52	Lentinus brunneofloccosus	Polyporaceae	x			
EM30	*Lepiota sp. 1*	Agaricaceae	x			
EM56	*Lepiota sp. 2*	Agaricaceae	x			
EM63	*Lepiota sp. 3*	Agaricaceae	x			
EM94	*Lepiota sp. 4*	Agaricaceae		x		
EM 100	*Lepiota sp. 5*	Agaricaceae	x	x		
EM 40	*Lepista sordida*	Tricholomataceae			x	
EM 43	*Lepista sp.*	Tricholomataceae				x
EM83	*Lepista sp.*	Tricholomataceae	x			

Appendix 1(continued). **List of species collected and identified in riparian zone of Kivu Lake**

Specimen number	Species	Family	Nyakarwa	Mariri	Mpangara	Garden
EM 86	*Leucoagaricus sp*	Agaricaceae	x			
EM102	*Lycoperdon sp.*	Agaricaceae		x		
EM 53	*Macrolepiota africana*	Agaricaceae	x			
EM 27	*Macrolepiota procera*	Agaricaceae	x			
EM 10	*Macrolepiota sp*	Agaricaceae	x			
EM 92	*Marasmius arborescens*	Marasmiaceae	x			
EM24	*Marasmius sp*	Marasmiaceae	x	x	x	
EM 91	*Mycena sp*	Mycenaceae	x			
EM 4	*Panaeolus sp*	Bolbitiaceae	x	x	x	
EM 2	*Parasola plicatilis*	Psathyrellaceae	x	x	x	x
EM 109	Phlebopus sudanicus	Boletinellaceae		x		
EM 18	*Pholiota sp*	Strophariaceae		x	x	x
EM 73	Pisolithus tinctorius	Sclerodermataceae		x		
EM 45	*Pleurotus sp2*	Pleurotaceae				x
EM 36	*Psathyrella sp*	Psathyrellaceae	x	x	x	
EM 5	*Psathyrella sp*	Psathyrellaceae		x		
EM49	*Psathyrella sp.*	Psathyrellaceae	x	x		x
EM62	*Psathyrella sp.*	Psathyrellaceae	x			
EM 29	Ramaria sp.	Gomphaceae	x	x	x	
EM 99	Russula sp.	Russulaceae		x		
EM 32	*Schizophyllum commune*	Schizophyllaceae		x		
EM 37	Suillus granulatus	Boletinellaceae	x	x	x	
EM 44	*Termitomyces medius*	Lyophyllaceae				x
EM 3	*Termitomyces microcarpus*	Lyophyllaceae	x			x
EM 13 &17	*Termitomyces robustus*	Lyophyllaceae				x
EM25	*Tricholoma sp.*	Tricholomataceae	x			
EM54	*Tricholomopsis sp.*	Tricholomataceae	x			
EM 42	*Volvariella volvacea*	Pluteaceae				x

Appendix 2. Seasonal distribution of species recorded and collected during the study.

Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Agaricus crocopeplus		x								
Agaricus sp. 1			x							
Agaricus sp. 2			x							
Agaricus sp. 3				x						
Agaricus sp. 4					x					
Amanita sp.									x	
Cantharellus sp.		x								
Chlorophyllum hortense	x		x					x		
Clitocybe sp. 1			x	x						
Clitocybe sp. 2				x			x			
Clitocybe sp. 3				x						
Collybia piperata	x	x	x	x			x	x		
Collybia sp.							x			
Coprinus sp. 2		x	x	x			x	x	x	
Coprinus sp.1		x		x						
Cotylidia aurantiaca			x	x				x		
Cyathus stercoreus				x			x	x		
Entoloma sp.							x			
Ganoderma sp.		x	x	x						
Geastrum sp 1				x						
Geastrum sp 2				x						
Gymnopilus sp.			x							
Gymnopilus sp.				x						
Gymnopilus zenkeri			x	x			x	x	x	
Hygrocybe nigrescens		x								
Hygrophoropsis sp			x							
Inocybe sp.							x			
Lentinus brunneofloccosus				x						
Lepiota sp. 1			x	x						
Lepiota sp. 2				x						
Lepiota sp. 3				x						
Lepiota sp. 4							x			
Lepiota sp. 5				x			x			
Lepista sordida			x							
Lepista sp.1			x							
Lepista sp.2							x			
Leucoagaricus sp							x			
Lycoperdon sp.							x			
Macrolepiota africana				x						
Macrolepiota procera			x							
Macrolepiota sp		x								

Appendix 2. (continued**). Seasonal distribution of Species recorded and collected during the study.**

Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Marasmius arborescens							x			
Marasmius sp			x	x			x	x	x	
Mycena sp		x	x		x		x			
Panaeolus sp	x		x							
Parasola plicatilis	x	x	x	x		x	x	x		
Phlebopus sudanicus								x		
Pholiota sp		x	x	x			x	x		
Pisolithus tinctorius				x				x		
Pleurotus sp2			x							
Psathyrella sp. 1	x		x	x	x		x			
Psathyrella sp. 2			x	x				x	x	
Psathyrella sp. 3			x	x			x	x		
Psathyrella sp. 4				x						
Ramaria sp.			x	x						
Russula sp.							x			
Schizophyllum commune			x	x				x	x	
Suillus granulatus			x	x			x	x	x	
Termitomyces medius			x							
Termitomyces microcarpus	x	x		x				x		
Termitomyces robustus		x	x				x	x		x
Tricholoma sp.			x	x						
Tricholomopsis sp.				x						
Volvariella volvacea			x							

Appendix 3. Provisional list of mushroom species recorded in Rwanda.

Species	Family	Reference
Agaricus arvensis Schaeff	Agaricaceae	Degreef et.al. (2016)
Agaricus crocopeplus Berk. & Broome	Agaricaceae	Present study
Agaricus sp. 1	Agaricaceae	Present study
Agaricus sp. 2	Agaricaceae	Present study
Agaricus sp. 3	Agaricaceae	Present study
Agaricus sp. 4	Agaricaceae	Present study
Agaricus sylvicola (Vitt.) Lév.	Agaricaceae	Degreef et.al. (2016)
Amanita sp.	Amanitaceae	Present study
Armillaria borealis Marxmüller & Korhonen	Physalacriaceae	Degreef et.al. (2016)
*Armillaria cepistipes V*elen.	Physalacriaceae	Degreef et.al. (2016)
Armillaria heimii Pegler	Physalacriaceae	Degreef et.al. (2016)
Armillaria lutea Gillet	Physalacriaceae	Degreef et.al. (2016)
Armillaria ostoyae (Romagn.) Herink	Physalacriaceae	Degreef et.al. (2016)
Armillaria tabescens (Scop.) Emel	Physalacriaceae	Degreef et.al. (2016)
Auricularia auricula-judae (Bull.) Quél.	Auriculariaceae	Degreef et.al. (2016)
Auricularia cornea Ehrenb.	Auriculariaceae	Degreef et.al. (2016)
Auricularia delicata (Mont. ex Fr.) Henn.	Auriculariaceae	Degreef et.al. (2016)
Cantharellus sp.	Cantharellaceae	Present study
Chlorophyllum hortense (Murrill) Vellinga	Agaricaceae	Present study
Clitocybe sp. 1	Tricholomataceae	Present study
Clitocybe sp. 2	Tricholomataceae	Present study
Clitocybe sp. 3	Tricholomataceae	Present study
Collybia aurea (Beeli) Pegler	Tricholomataceae	Degreef et.al. (2016)
Collybia piperata (Beeli) Singer	Tricholomataceae	Present study
Collybia sp.	Tricholomataceae	Present study
Coprinus sp. 2	Agaricaceae	Present study
Coprinus sp.1	Agaricaceae	Present study
Cotylidia aurantiaca (Pat.) A.L. Welden	Repetobasidiaceae	Present study, Degreef et.al. (2016)
Cyathus stercoreus (Schwein.) De Toni	Nidulariaceae	Present study
Cystodermella elegans (Beeli) Harmaja	Agaricaceae	Degreef et.al. (2016)
Dacryopinax spathularia (Schwein.) G.W. Martin	Dacrymycetaceae	Degreef et.al. (2016)
Entoloma sp.	Entolomataceae	Present study
Ganoderma sp.	Ganodermataceae	Present study
Geastrum sp 1	Geastraceae	Present study
Geastrum sp 2	Geastraceae	Present study
Gymnopilus sp.1	Strophariaceae	Present study

Appendix 3 (continued**). Provisional list of mushroom species recorded in Rwanda**

Species	Family	Reference
Gymnopilus sp.2	Strophariaceae	Present study
Gymnopilus zenkeri (Henn.) Singer	Strophariaceae	Present study
Hygrocybe nigrescens (Quél.) Kühner	Hygrophoraceae	Present study
Hygrophoropsis sp.	Hygrophoropsidaceae	Present study
Hypholoma subviride (Berk. & M.A. Curtis) Dennis	Strophariaceae	Degreef et.al. (2016)
Inocybe sp.	Inocybaceae	Present study
Lentinus brunneofloccosus Pegler	Polyporaceae	Present study
Lentinus cladopus Lév.	Polyporaceae	Degreef et.al. (2016)
Lentinus retinervis Pegler	Polyporaceae	Degreef et.al. (2016)
Lentinus sajor-caju (Fr.) Fr.	Polyporaceae	Degreef et.al. (2016)
Lepiota sp. 1	Agaricaceae	Present study
Lepiota sp. 2	Agaricaceae	Present study
Lepiota sp. 3	Agaricaceae	Present study
Lepiota sp. 4	Agaricaceae	Present study
Lepiota sp. 5	Agaricaceae	Present study
Lepista sordida (Schumach.) Singer	Tricholomataceae	Present study, Degreef et.al. (2016)
Lepista sp.1	Tricholomataceae	Present study
Lepista sp.2	Tricholomataceae	Present study
Leucoagaricus sp.	Agaricaceae	Present study
Lycoperdon sp.	Agaricaceae	Present study
Macrolepiota africana (R.Heim) Heinem.	Agaricaceae	Present study, Degreef et.al. (2016)
Macrolepiota dolichaula (Berk. & Broome) Pegler & R.W. Rayner	Agaricaceae	Degreef et.al. (2016)
Macrolepiota procera (Scop.) Singer	Agaricaceae	Present study
Macrolepiota sp.	Agaricaceae	Present study
Marasmiellus inoderma (Berk.) Singer	Marasmiaceae	Degreef et.al. (2016)
Marasmius arborescens (Henn.) Beeli	Marasmiaceae	Present study, Degreef et.al. (2016)
Marasmius bekolacongoli Beeli	Marasmiaceae	Degreef et.al. (2016)
Marasmius sp.	Marasmiaceae	Present study
Mycena sp.	Mycenaceae	Present study
Panaeolus sp.	Bolbitiaceae	Present study
Parasola plicatilis (Curtis) Redhead et al	Psathyrellaceae	Present study
Paxillus brunneotomentosus Heinem. & Rammeloo	Paxillaceae	Degreef et.al. (2016)
Phlebopus sudanicus (Har. & Pat.) Heinem.	Boletinellaceae	Present study
Pholiota sp.	Strophariaceae	Present study
Pisolithus tinctorius Coker & Couch	Sclerodermataceae	Present study
Pleurotus cystidiosus O.K. Mill.	Pleurotaceae	Degreef et.al. (2016)

Appendix 3 (continued**). Provisional list of mushroom species recorded in Rwanda**

Species	Family	Reference
Pleurotus djamor (Rumph. ex Fr.) Boedijn	Pleurotaceae	Degreef et.al. (2016)
Pleurotus flabellatus Sacc.	Pleurotaceae	Degreef et.al. (2016)
Pleurotus sp.1	Pleurotaceae	Present study
Polyporus tenuiculus (P. Beauv.) Fr	Polyporaceae	Degreef et.al. (2016)
Psathyrella atroumbonata Pegler	Psathyrellaceae	Degreef et.al. (2016)
Psathyrella sp. 1	Psathyrellaceae	Present study
Psathyrella sp. 2	Psathyrellaceae	Present study
Psathyrella sp. 3	Psathyrellaceae	Present study
Psathyrella sp. 4	Psathyrellaceae	Present study
Psathyrella tuberculata (Path.) A.H. Sm.	Psathyrellaceae	Degreef et.al. (2016)
Ramaria sp.	Gomphaceae	Present study
Russula sp.	Russulaceae	Present study
Schizophyllum commune Fr.	Schizophyllaceae	Present study
Suillus granulatus (L.) Roussel	Boletinellaceae	Present study, Degreef et.al. (2016)
Termitomyces medius R. Heim & Grassé	Lyophyllaceae	Present study
Termitomyces microcarpus (Berk. & Broome) R. Heim	Lyophyllaceae	Present study, Degreef et.al. (2016)
Termitomyces robustus (Beeli) R. Heim	Lyophyllaceae	Present study, Degreef et.al. (2016)
Termitomyces schimperi (Pat.) R. Heim	Lyophyllaceae	Degreef et.al. (2016)
Termitomyces striatus (Beeli) R. Heim	Lyophyllaceae	Degreef et.al. (2016)
Tricholoma sp.	Tricholomataceae	Present study
Tricholomopsis sp.	Tricholomataceae	Present study
Volvariella volvacea (Bul.) Singer	Pluteaceae	Present study

Appendix 4. Photo of some species collected and identified.

1. Agaricus crocopeplus, 2. Agaricus sp., 3. Agaricus sp., 4. Amanita sp., 5. Cantharellus sp., 6. Chlorophyllum hortense, 7. Clitocybe sp., 8. Clitocybe sp., 9. Collybia piperata, 10. Coprinus sp., 11. Coprinus sp., 12. Cotylidia aurantiaca

Appendix 4 (continued). **Photos of some species collected and identified.**

13. *Cyathus stercoreus*, 14. *Entoloma sp.* , 15. *Ganoderma sp.*, 16. *Geastrum sp*.

17. *Geastrum sp.*, 18. *Gymnopilus sp.*, 19. *Gymnopilus zenkeri* 20. *Hygrocybe nigrescens*, 21. *Hygrophoropsis sp.*, 22. *Lentinus brunneofloccosus* 23. *Lepiota sp.*, 24. *Lepista sordida*

Appendix 4 (continued**). Photos of some species collected and identified.**

25. *Lepista sp*. 26. *Leucoagaricus sp*. 27. *Macrolepiota africana*, 28. *Macrolepiota procera*
29. *Marasmius arborescens* 30. *Mycena sp*. 31. *Panaeolus sp*. 32. *Parasola plicatilis*
33. *Phlebopus sudanicus* 34. *Pholiota sp.* 35. *Pisolithus tinctorius* 36. *Pleurotus sp*.

Appendix 4 (continued**). Photos of some species collected and identified.**

37. *Psathyrella sp*. 38. *Psathyrella sp* 2. 39. *Ramaria sp*. 40. *Russula sp*.
41. *Schizophyllum commune* 42. *Suillus granulatus* 43. *Termitomyces medius*
44. *Termitomyces microcarpus* 45. *Termitomyces robustus* 46. *Volavariella volvacea*

Appendix 5. Distribution of mushroom species in different habitat types

Species	Habitat types			
	Forest	Grassland	Woodland	Garden
Agaricus crocopeplus				x
Agaricus sp. 1	x			
Agaricus sp. 2	x			
Agaricus sp. 3			x	
Agaricus sp. 4				x
Amanita sp.			x	
Cantharellus sp.	x			
Chlorophyllum hortense	x			
Clitocybe sp. 1	x			
Clitocybe sp. 2	x			
Clitocybe sp. 3	x			
Collybia piperata	x		x	
Collybia sp.	x			
Coprinus sp. 2	x		x	
Coprinus sp.1	x		x	
Cotylidia aurantiaca		x		
Cyathus stercoreus	x		x	
Entoloma sp.	x			
Ganoderma sp.	x			
Geastrum sp. 1	x			
Geastrum sp. 2	x			
Gymnopilus sp. 1				x
Gymnopilus sp.2	x			
Gymnopilus zenkeri		x	x	x
Hygrocybe nigrescens				x
Hygrophoropsis sp.				x
Inocybe sp.			x	
Lentinus brunneofloccosus	x			
Lepiota sp. 1	x			
Lepiota sp. 2	x			
Lepiota sp. 3	x			
Lepiota sp. 4			x	
Lepiota sp. 5	x		x	
Lepista sordida		x		
Lepista sp. 1				x
Lepista sp. 2	x			
Leucoagaricus sp	x			
Lycoperdon sp.			x	
Macrolepiota africana	x			
Macrolepiota procera	x			
Macrolepiota sp.	x		x	

Appendix 5 (Continued). **Distribution of mushroom species in different habitat types**

Species	Habitat types			
	Forest	**Grassland**	**Woodland**	**Garden**
Marasmius arborescens	x			
Marasmius sp.	x			
Mycena sp.	x			
Panaeolus sp.	x		x	
Parasola plicatilis	x	x	x	x
Phlebopus sudanicus		x	x	
Pholiota sp.		x	x	x
Pisolithus tinctorius			x	
Pleurotus sp2				x
Psathyrella sp. 1	x		x	
Psathyrella sp. 2			x	
Psathyrella sp. 3	x		x	x
Psathyrella sp. 4	x			
Ramaria sp.	x		x	
Russula sp.			x	
Schizophyllum commune		x		
Suillus granulatus	x	x	x	
Termitomyces medius				x
Termitomyces microcarpus	x			x
Termitomyces robustus				x
Tricholoma sp.	x			
Tricholomopsis sp.	x			
Volvariella volvacea				x