This work studies the mushroom diversity relationship between a lowland forest and rubber plantations under similar climate conditions. A total of 93 species amounting to 425 fruit bodies, composed of 9% Ascomycetes and 91% Basidiomycetes were encountered over a total land spread of 3125 m2. Sixty four (64) species made up of 10.9% Ascomycetous and 89.1% Basidiomycetous macrofungi were identified. These are distributed into 4 Classes, 9 Orders and 28 Families including the Class Hymenomycetes (57%) and the Family Tricholomataceae (6 genera and 11 species) which recorded the highest number of taxa. Wood inhabiting fungi (dead and living wood types) also had the highest number of representative taxa (70%) with 19.36% of the encountered taxa observed to be non-substrate specific. They grow on different substrates e.g. Chlorophyllum sp. grows on top soil and decomposing litters while Coprinus atramentarius Ulje and Bas., grows on litters and dead decaying woods. Lowland old growth forest recorded the highest number of mushrooms (40) amounting to 90 fruit bodies out of which 22.5% were exclusive to the forest. The book promises values in ethnography and biodiversity.

Omorefosa Osemwegie

Dr. Osemwegie, O.O. in collaboration with Prof. J. Okhuoya have over 18 years experience in Mycology/Plant Pathology and Mushroom Biology in Nigeria. The authors have several publications and currently works in the university system where they have been involved in numerous mushroom related researches.

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DEDICATION

This Thesis is first dedicated to God almighty, the un-changeable, El-Shaddai for his mercies and divine grace upon my life, and that made the manifestation of this dream possible.

Secondly to the loving memories of my father Mr. Christopher Otasowie Osemwegie and my father-in-law Mr. Olusanya Ogundein for believing in me and teaching me that happiness is not measured by wealth but by infinite love to God and the people around you.

Thirdly, this thesis is dedicated to four ladies in my life Mrs Temitope Osemwegie (wife), Mrs. Anna Olabisi Osemwegie (mother), Osaruomame Oluwapamilerin and Osarenoma Boluwatiseleri (daughters) who encouraged and supported me through thick and thin.

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ABSTRACT

The survey of rubber plantations and a lowland forest in Iyanomo produced a galaxy of mushrooms which were identified and inventoried. The species diversity and richness per sampled plots were estimated while abundance per month and per plot was correlated with climatic and litter dynamics. A total of 93 species of mushrooms amounting to 425 fruit bodies, comprising 9% Ascomycetes and 91% Basidiomycetes, were encountered and inventoried during the period of study over a total land spread of 3125 m^2. Sixty four (64) species out of the total encountered, which was made up of 10.9% Ascomycetous and 89.1% Basidiomycetous macrofungi, were identified. These are distributed into 4 Classes, 9 Orders and 28 Families amongst which the Class Hymenomycetes (57%) and the Family Tricholomataceae (6 genera and 11 species) recorded the highest number of taxa. Wood inhabiting fungi (dead and living wood types) were the highest number of representative taxa (70%) while 19.36% of encountered taxa were observed to be non-substrate specific. They grow on different kinds of substrates, for example, *Chlorophyllum* sp. grows on top soil and decomposing litters, *Coprinus atramentarius* Ulje and Bas., grow on decomposing litters and dead decaying woods. Lowland or old growth forest recorded the highest number of mushrooms (40) amounting to 90 fruit bodies. 22.5% of these mushrooms were observed to grow only in this forest and were not observed in any of the plantations sampled.

The statistical estimation of 100 randomization of sample accumulation order showed a progressive increase in species richness indices (Mao Tau, Chao 1 and Jack 1) and species diversity indices such as Alpha, Shannon and Simpson from Plots A through to E. This suggests that Plot A recorded the least species richness and diversity values while Plot E had the highest species richness or richer species composition and diversity. The species-abundance accumulation curve is asymptotic and promises more hidden mushroom treasures that could be revealed through the extension of the period, area and frequency of survey. A range of species similarity indices such as Jaccard, Sorensen, Morisita-Horn and Bray-Curtis showed that Plots A and B were the most similar in terms of species composition and diversity with 0.575 (Jaccard), 0.73 (Sorensen), 0.826 (Morisita-Horn) and 0.702 (Bray-Curtis) respectively (the closer to 1 the more similar). Plots A and D, B and D were the most dissimilar in species diversity and composition.

Mushroom abundance per month and plot were observed to vary and correlate negatively with litter mass and litter nutrient contents (C, N and P). Statistically, there was a significant difference between litter mass per plot (P = 2.42) and per month (P = 1.73), and C-content (P = 11.0) but no significant difference between N and P contents per month (P = 0.568, 0.50) and plot (P = 0.10, 0.47). Mushroom abundance distribution per month was observed to be similar to the rainfall profile of the study area than other climatic parameters such as wind speed, temperature, relative humidity and evaporation rate.

CHAPTER ONE

1.0 INTRODUCTION

1.1 General

Mushrooms which in various works are also referred to as macrofungi, toadstools, macromycetes, basidioma (sexual fruit body of basidiomycetes) or ascoma (sexual fruit body of ascomycetes) represent a biological and taxonomically distinctive group that are defined diversely in literature as larger fungi or higher fungi of the Class; Basidiomycetes or Ascomycetes, non-lichenized fungi with large fruitification, fungi with typical stalk and cap configuration or fleshy fungi, fruiting body of a fungus plant which typically contains spores or spore-bearing structures visible to the naked eye (Redhead, 1997; Labarère and Menini, 2000; Kirk *et al.*, 2001; Miles and Chang, 2004; Wasser, 2007). The term mushroom is also used in a restrictive form for edible toadstool or basidiomycetes, polypore (non-gilled or non-lamellae mushroom), large fungus with medicinal values, toadstool which is inedible or poisonous, extension of a fungus mycelium; a mass of interwoven hyphae, agaric (fleshy mushroom), sporocarp of a fungus rather than the mycelium (Gray, 1967; Holden, 1970; Nicholson, 1989; Hí rkrmen *et al*., 1993a; Adewusi *et al*., 1993; Masuka and Ryvarden, 1993). Mushroom is described by Chang and Miles (1993) as a macrofungus with a distinctive fruit body which may be epigeous (above ground) or hypogeous (below ground) and is sufficiently large enough to be seen by the naked eye and picked up by hand. Mushrooms therefore need not be restricted to basidiomycetes or ascomycetes, fleshy or non-fleshy, edible or non-edible, medicinal or lethal, subterranean rather than epigeous or hypogeous and may grow on different substrates/substrata in diverse habitat (Bates, 2006). Mushrooms consequently include edible, ectomycorrhizae species associated with the roots of conifers and dicotyledonous trees or saprophytic species growing on plant tissues and plant wastes or poisonous species or opportunistic parasites of tree plants (Labarère and Menini, 2000). They are also reported in many literature to be of varying size, colours, shape (bracket, puffballs, truffles, cup, toothed, club etc.), and texture with a more recent observation that a few mushrooms are zygomycetes (O'Dell *et al*., 2004; Wasser, 2007). The growing global consciousness and knowledge of mushroom resources and products have given birth to a new

area of mycology referred to as mushroom biology. Chang and Miles (1993) described this discipline as a scientific study comprising diverse aspects that include mushroom cultivation and genetics; medicinal and nutritional mushrooms; pathology, physiology, taxonomy and toxicity of mushrooms etc.

Mushrooms are non-photosynthetic, achlorophyllous fungal organisms incapable of manufacturing their own food as do green plants. They produce a wide range of enzymes that can degrade a variety of complex substrates or organic matter and consequently have broad ecological distribution covering temperate, subtropical and tropical vegetations where they survive as saprophytes, parasites of trees or as symbionts with insects and roots of higher plants (i.e. mycorrhizae) (Zadrazil, 1980; Wood, 1984; Chang *et al*., 1993). They are also important in nature conservation and forest management because of their functional ecological roles relating to micro- and macrofauna, and mycorestoration process (Stamets, 1993; Avila *et al.*, 1999; Ohga *et al.*, 2000; Mshigeni, 2005; Stamets, 2005). In addition, they also play the role of spore dissemination which is a means of ensuring the establishment of new cryptic mycelia or perhaps strengthening genetic adaptation or even prevention of gene flow (Fries, 1981; Gregory, 1984). They are valuable to plants, humans, some animals and insects despite the fact that they are less studied relative to higher plants as good health food. The nutritional and the medicinal values of mushrooms are recognized in different parts of the globe with their nutrient contents and medicinal usage well reported in literature especially in Asia, Europe and America (Ogundana, 1975; Oso, 1977; Ogundana and Fagade, 1982; Rammeloo and Walleyn, 1983; Lelley, 1987; Arora, 1989; Masuka and Ryvarden, 1993; Quimio *et al*., 1990; Bhandary, 1991; Alofe *et al*., 1996; Kekawa, 2001; Akpaja *et al*., 2003; Osemwegie *et al*., 2006). The demand for mushrooms as food or and medicine especially in highly developed countries of the world has lead to extensive cultivation practice, exportation and rapid technological development in the production of various edible and medicinal mushrooms. The adopted cultivation technologies address the improvement of yield; reduce cropping period and genetic engineering of pest-pathogen resistant variety (Chang, 1980; Oei, 1991; Chang and Miles, 1993; Mshigeni *et al.*, 2003; Miles and Chang, 2004). Mushrooms are also still sourced from the wild rather than from cultivation cottages or markets in places such as Nigeria and other developing nations of the world due to lack of mushroom production know-how and insufficient commercial mushroom cultivation industries. This practice would logically predispose and expose mushroom pickers and hunters to unexpected dangers (perhaps life threatening) such as wild animal and insect

attack. It may also expose consumers to the risk of mycetisma or mushroom poisoning (Quimio *et al*., 1990; Oei, 1991; Akpaja *et al*., 2003; Osemwegie *et al*., 2006).

Alabi, (1991), Osemwegie *et al*. (2006) and Idu *et al*. (2007) reported low incidents of mushroom poisoning and death from consumption of mushrooms collected from the wild either for commerce or food subsistence in Nigeria. This they attributed to the cultural value attached to indigenous knowledge handed down generations. Although mushrooms are widely reported in scientific literature to be a good source of food, tonic and, in some cases medicine since prehistoric times, their nutritive nature was however more recent (Chang, 1980; Alofe, 1991; Chang and Miles, 1993; Miles and Chang, 1997; Stamets, 2000). Mushrooms contain 20-45% of protein (dry matter) which is rich in all essential amino acid and whose quality out rank plant proteins but comes close to animal proteins (Lelley, 1987). In addition, they also contain polymeric carbohydrate like chitin; various low molecular weight carbon compounds that include glucose, fructose, galactose and threalose; minerals notable amongst which are potassium, phosphorus and iron. They are also very rich in crude fibre and vitamins particularly thiamine (B1), riboflavin (B2), panthotenic acid (B3), ascorbic acid (C) and biotin (H) (Labarère and Menini, 2000).

In developing countries of the world however, mushrooms are a good replacement for meat in many local soups or used to supplement diets or eaten as dishes apart from other uses such as in mythism, fun-games, hair and cloth dying, health or folk medicine practice (Mshigeni, 2003; Mshigeni *et al*., 2003). The nutritive value of many edible mushrooms has been widely studied in different parts of the world including Ghana (Holden 1970), Tanzania (Härkönen, 1992; Härkönen *et al*., 1993b; Magingo *et al*., 2004), Zambia (Piearce and Francis, 1982), Zimbabwe (Masuka and Ryvarden, 1993) and some parts of Nigeria (Ogundana and Fagade, 1982; Alofe, 1985; Aletor and Alademiti 1989; Quimio *et al*., 1990; Aletor 1995; Adewusi *et al*., 1993; Osemwegie *et al*., 2006). Mushrooms are popular for their rich nutrient content and desirable food characteristics which include remarkable taste and flavour. They are also easily and readily processed, dried, pickled or canned for storage until ready for transport to end users/consumers. This popularity is reported in literature to enhance both foreign and local commerce of different magnitude; agriculture (e.g. animal husbandry, crop and tree farming for yield improvement, fertilization of agricultural soils and biological control of pathogens and pests); bioconversion of solid wastes of industrial, domestic and agricultural origin; biotechnology such as bioremediation or mycorestoration of arable lands

contaminated by either heavy metals or agrochemical products e.g. pesticides and herbicides or petroleum hydrocarbon and other effluents of diverse origins (Thorn and Barron, 1983; Kope, 1990; Morgan *et al*., 1991; Marx *et al*., 1993; Onianwa, 1995; Okeke *et al*., 1996; Ochiel *et al*., 1997; Isikhuemhen *et al*., 2003; Anoliefo *et al*., 2002; Wasser, 2007). Furthermore, the popularity of mushrooms is also recognized in industries as sources of amino acids, antibiotics, enzymes, organic acids, food, beverages, and natural products such as abscisic acid to zymosterol and as invaluable substitute for chemicals in biopulping, and there are reports that new mushroom products are still being explored in most parts of the world (Agu, *et al*., 1993; Kirk *et al*., 1993; Dreyfuss and Chapela, 1994; Bucher *et al*., 2004; Mshigeni, 2005). They are equally applied in folk medicine practice in Africa, Asia and South America even though there is relative paucity of documentation of the wealth of folk knowledge of medicinal mushrooms, local man-biodiversity interrelationships, mushroom genetic resource or biodiversity data, quantitative evaluation of species richness and rate of loss of species richness in Nigeria (Alabi, 1991; Ryvarden *et al*., 1994; Chang and Mshigeni, 2001; Akpaja *et al*., 2003; Osemwegie *et al*., 2006; Idu *et al*., 2007). Little is reported globally about mushroom biogeography with poor knowledge of aboriginal and introduced macrofungal species in different locations around the globe despite corroborative reports that they have the longest history of diversity studies than any other group of fungi (Miles and Chang, 1997; Mueller *et al*., 2006). Their ecological role in forest ecosystem stability, development and community function can not be over-emphasized (Gilbertson and Bigelow, 1998; Read and Perez-Moreno, 2003).

The growing popularity of mushrooms which perhaps derived from their edibility and diverse uses especially in meeting human needs has encouraged diverse global research interests in their cultivation, biodiversity, biogeography, ethnomycology, conservation and ecology (Jain, 2000; Labarère and Menini, 2000; Stamets, 2000; Kirk *et al*., 2001; Miles and Chang, 2004; Mshigeni, 2005). Therefore it has become necessary to join in the global initiatives at understanding our indigenous mushroom resource, threats to their diversity and ecological functions especially in Nigeria where there is a dearth of such research initiative.

1.2 Forest community and litterfall

The forest ecosystem is complex with many literature reports on forest community structure, function and composition especially in relation to animals, insects and leafy plants rather than macrofungi (Cole and Rapp, 1980; Waring and Schlesinger, 1985). Fungi and especially mushrooms have hitherto been recognised as an integral part of the forest community and perhaps plantations, farms, gardens and other place with high deposits of organic matter. Shigeki *et al*. (1994), Magan and Gadd (1997) and Takashi (2007) enunciated the role of fungi and mushrooms in woodland ecosystems or forestôs mineral cycles and the importance of lignin as a regulating factor in the decomposition of litter. Consequently, fungi and mushrooms are also affected by a huge range of interconnected ecosystem activities such as nutrient acquisition, competition for limited space, decomposition, litterfalls and biogeochemical cycles (Myers, 1988; Shigeki, 1994; Coûteaux *et al*., 1995; Sala *et al*., 2000; Kauserud *et al*., 2008).

According to Simmons (2003) litterfall is relevant to the movement of various organic and inorganic matter through ecosystems especially those characterised by expanse of tall, species rich and heterogeneous trees as well as the overall ecosystem functioning. Although, Proctor (1983), and Dantas and Phillipson (1989) observed that litterfall is important in the estimation of primary productivity, stand vitality, indices of seasonal phenomena related to plant phenology, energy and nutrient fluxes, and as indicators of ecosystem functioning. The word litter is reported by McIntosh (1964) in the concise oxford dictionary, and Eagle and Hawkins (1975) in the oxford illustrated dictionary of English to mean (i) rushes, straw and other materials used in making animal beddings; (ii) straw and dung for farmyard; (iii) state of untidiness or disorderly accumulation of papers or make place untidy, scatter or leave lying. Ecologically, litter referred to a layer of dead plant material or any material especially of organic origin lying on the surface of the soil such as dead plants, shed plant parts or organs (Proctor, 1983; Simmons, 2003). This material does not however include standing dead matter such as tree stumps, dead tree and felled tree trunk which render the aforementioned definitions unsatisfactory to an ecologist concerned with the functions of an ecosystem. Furthermore, Proctor (1983) defined litter as dead or decaying organic matter whose source may be from above ground plant parts or below ground plant parts while Maguire (1994) and Mudrick *et al.* (1994) remarked that it represents a major biological pathway for element transfer from vegetation to soil. Litterfall is consequently defined as the

organic debris or litter falling from the above ground parts of a plant onto the forest or plantation floor (Onyinbe, 1990). Proctor *et al.,* (1983) and Clark *et al*. (2001) on the other hand refer to litterfall as the pathway for the transfer of organic and chemical elements from vegetation to the soil surface in forest ecosystem. Simmons (2003) in another vein defined litterfall as the constant rain of organic debris on the forest floor while also describing it in a functional term as the transfer of organic matter (carbon, energy and nutrients) from the tree canopy to the forest floor. Therefore, the characteristic components of litterfall will include leaves, buds, twigs, flowers, fruits, seeds, glumes and coarse woods of not more than 2cm diameter of which only the leaf litter has been extensively studied with work on all other components dearth (Vitousek, 1984; Proctor, 1984; Dantas and Phillipson, 1989; Simmons, 2003).

Literature are equally numerous on litterfall estimates either relative to their rate of accumulation or disappearance or decomposition or nutrient content in various woodland stands across the world spreading through both temperate and tropical climates (Melillo *et al*., 1982; Aerts, 1997). Vitousek (1982), Simmons (2003) and Vallinga (2004) reported that the ratio of leaf fall to litter accumulation is higher in the tropics and low at higher latitudes recognizing the effect of climate and edaphic characteristics. Woodland litter have also been widely studied in relation to fauna and flora diversity, ecological performance and fidelity (Sydes and Grime, 1981; Melillo *et al*., 1982; Hamrick and Lee, 1987; Fowler, 1988; Dantas and Phillipson, 1989; Molofsky and Augspurger, 1992; Finotti *et al*., 2003). Reports are however scarce with little attention given to understanding the relationship between litterfall and mushroom diversity in various woodland stands in both temperate and tropical latitudes by mycologist.

Information and studies on the eco-diversity of mushrooms in Edo State and Nigeria as a whole is recent, scanty and fail to reflect the true nature of our mushroom heritage and resources. It is therefore important to join in the global initiative of mushroom research by channelling adequate research efforts at creating inventories and identifying our mushroom genetic resource so as to be able to (i) monitor the rate of depletion of mushroom diversity, (ii) identify endangered species and establish conservation strategies or basis for preserving pristine areas, (iii) create a global recognition for Edo State and Nigeria in projecting her numerous mushrooms resources, various uses and their heritable potentials, (iv) boost understanding of mushroom seasonality behaviour and investigate mushroom relationship

with the biotic and abiotic communities, (v) identify resident mushroom resources and immigrant species from other ecologically different areas and, (vi) promote mushrooms as a sensitive indicator of climatic change.

This study is therefore the first attempt made at documenting diverse mushrooms in a rubber plantation. It is also the first attempt made in Nigeria at comparing mushroom diversity and species richness of both monogenous and heterogenous tree stands. Shigeki (1994), Lodge and Cantrell (1995), Lindblad (2001), Dijk *et al*. (2003), Manoharachary *et al*., (2005), Cifuentes and Villarruel-Ordaz (2006), Gazis and Romina (2006) and Houseknecht and Weir (2006) are some of the mushroom diversity works carried out across the world more especially in the USA relating mushrooms to human disturbed and undisturbed vegetations, rainfall patterns, wood decay and stage of decay, tree diversity and canopy but little has been done on the relationship between mushrooms and litterfall mass or decomposition rate of litterfalls in different vegetations. This study is aimed at understanding the relationship (if any) between litter mass and mushroom diversity and species richness.

1.3 Scope of study

This study was carried out in partial fulfilment of a global consciousness at documenting the earthôs biota. Mushrooms are ecologically significant but poorly documented members of many woodland or forest ecosystems. From the literature survey thus far, it is apparent that information on the ecology of mushrooms with emphasis on their species diversity, synecology, phenology and climate effect on diversity, and litterfall in both heterogenous and homogenous forests in Nigeria is completely lacking and scanty in Sub-Saharan Africa. Consequently, this present study is undertaken with the following aims and objectives.

(i) Survey, collect, accurately (or near accurately) identify and inventory mushrooms present in rubber plantations and lowland forests in Nigeria using Iyanomo Rubber Research Institute as a study area. Collected and well preserved mushrooms are kept in the ómycoariumôof the Department of Botany, University of Benin as baseline reference.

(ii) To compare species composition and diversity of mushrooms in rubber plantations with a lowland forest in addition to providing information on species phenology (fruiting period) and substrate propensity (relationship).

(iii) To study the influence (if any) of physical factors such as rainfall, temperature, humidity and wind speed on mushroom diversity in both ecosystems (rubber plantation and an old-growth forest).

(iv) To study some mushroom community characteristics such as abundance, density, relative density, fidelity and gregariousness (sociability).

(v) To examine the influence of litterfalls on mushroom abundance in rubber plantations and a lowland forest.

(vi) To create baseline data for further studies on mushroom ecology and diversity.

CHAPTER TWO

LITERATURE REVIEW

2.1 Mushroom ecology and biodiversity

Mushroom ecology is a subset of fungi ecology which has hitherto received less attention and overlooked as integral part woodland (forest, plantation, vegetation) ecology (Brown and Lugo, 1990, Dix and Webster, 1995). Mushrooms or macrofungi or macromycetes as a subset of fungi community was reported by Christensen (1989), Dix and Webster (1995), Graham (1927), Wicklow and Carroll (1984) to exhibit like all other biotic community sociological characteristics. These are measurable by methods first sketched by Hueck (1953). This is reflected in the geographical distributions of constituent species, habitat specificity or affinity, species diversity and composition in the community, community structure, and mechanisms involved in species replacements. Behavioural characteristic relating to the ecological functions of mushrooms in the community and ecosystem at large is also inevitably a sociological attribute worthy of note. Based on this, mushroom ecology like fungi ecology is studied under three different overlapping topics which include synecology (community ecology), autecology (population ecology) and function in ecosystem (community function).

Mushrooms have a long history of existence which dates back to prehistoric times but remained cryptic until recognized by a French scientist, Antonio Micheliôs *Nova Plantarum Genera* and a *Swedish naturalist*; Corulus Linnaeus as plants. This laid the foundation for growing global scientific and mycological research interests in their diversity, taxonomy, ethnomycology and ecology. The first pieces of ecological work on mushrooms that were carried on by professional and leisure mycologists alike, focused on inventorying mushrooms in various communities and ecosystems rather than a scientific study of their function, interactive relationship with other biota and abiota, substrate-fungus relationship, tree and tree parts-fungus relationship, and woodland clearing, fragmentation, edge and human effects on mushroom species composition and rate of loss of mushroom resource as well as species

richness of any community and ecosystems (Burdsall and Volks, 1992; Labarère and Menini, 2000; Mueller *et al.*, 2004). This consequently improved mushroom knowledge, taxonomy and global data even though such studies were sectional or regional especially in Europe, America and Asia.

Arnold (1992) as well as Vogt *et al*. (1992) recognized that macromycetes studies solely depend on the sporadic occurrence of fruit bodies. These fruit bodies occur in scattered patches or sporadically and are used as indices over cryptic mycelia for many biodiversity studies (Arnolds, 1992; Vogt *et al*., 1992). This is because fruit bodies are immediately visible and attract more attention as a result of their ephemeral beauty than the mycelia. This is perhaps why Straatsma *et al.* (2001) proposed that mushroom fruit bodies rather than their mycelia are generally more important in the context of nature conservation and management. These fruit bodies are observed only for a few hours or days which makes phenological data collection difficult and laborious. Ecological studies based on long and short term surveys in various ecosystems in America and Europe are reflected in the work of Ohenoja (1984), Vogt *et al*. (1992), Egli *et al*. (1997), Johnson (1998), Straatsma *et al*. (2001), Straatsma and Krisai-Greilhuber (2003). Baxter (1947), Bisby and Ainsworth (1943), Fries (1825 and 1874), Patouillard (1900 and 1914), Shantz and Piemeisel (1917) and Singer (1962 and 1986) carried out studies aimed at defining the number of fungi in various ecosystems, naming, classifying and documenting mushroom taxa using morphological (macroscopic) characteristics. The use of morphological characteristics in mushroom identification is currently confounded by phylogenetic studies through molecular and genetic techniques (Moncalvo *et al.*, 1993; Binder *et al.*, 1997; Thorn *et al.*, 2000). This has increased the understanding of worldôs biodiversity, a term defined by Calow (1999) as the number and variety of taxa in an ecological system while creating the consciousness for improving the management of the natural resources of wild mushrooms, establishing a red list of endangered species and protecting the biodiversity (Hawksworth, 1991, 1998, 2001 and 2004; Dreyfuss and Chapela, 1994; Hyde *et al*., 1997; Nagaike, 2000).

Biodiversity is usually interpreted as species diversity though other taxa could be used and within-species genetic diversity could also be included. It is a contraction of biological diversity. Hawksworth (1991 and 2001) estimated the global fungal biodiversity conservatively at 1.5 million based on the extrapolation from the ratio of the number of native plant species to the number of described fungal species in the British Isles (1: 6). Several

other reports however differ in their views on global fungal diversity estimate (Manoharachary *et al*., 2005; Crous *et al*., 2006; Chaverri and Vilchez, 2006; Wasser, 2007). This recognizes the fact that fungi are poorly collected and studied in most countries, regions and habitats world wide (Crous *et al*., 2006). Mueller *et al*., (2006) estimated that macrofungi diversity in Africa is about 70% of 2,250 species recorded while compiling the number of taxon names from literature and unpublished data from contributing authors with the intent to estimate the ñ*actual*ò global macrofungi diversity based on the ratio of plant-fungus diversity and levels of endemism. In addition, Hammond (1992) argued that the estimate of overall fungal species richness would be tentative only in the absence of good data on tropical fungal communities, latitudinal and other gradient diversity, and on how rapidly the number of fungal species increase at greater spatial scale. He therefore hypothesized that the overall woodland architecture which is capable of providing more resource and surfaces is a better predictor of the number of fungi and small animals present in a given area than the plant species richness as reported by Christensen (1989), Shigeki *et al*. (1994) and Dix and Webster (1995), Arnold *et al*. (2000). In view of this, it is expected that global fungal biodiversity is to be more than what is estimated by Hawksworth (1991) and Wasser (2007). Consequently, Labarère and Menini (2000) concluded that the knowledge of wild mushroom species in the world over is poor and more studies need to be carried out on the biodiversity of fungi especially those that are macroscopic and less cryptic. This is to improve the existing record on the 7% (about 100,000) fungi and 10% (14,000) mushrooms estimated by Wasser (2007), as species already described globally. This is however one of the basis for undertaking this study.

2.2 Mushroom studies in Nigeria

In Africa most especially Nigeria, appropriate estimation of mycota species diversity is yet to be established and no fungal biodiversity data base or inventory of mushrooms currently exists despite few pace-setting research reports on mushroom diversity by Alasoadura (1967a and (1967b), Zoberi (1972 and 1973), Oso (1975 and 1977), Pegler (1977), Ogundana (1979) and Alabi (1991). Similar studies carried out across Africa include Pegler (1977) in Angola, Piening (1962) and Holden (1970) in Ghana, Dijk *et al*. (2003) in Cameroon, Masuka and Ryvarden (1993) and Morris (1987) in Malawi, Mshigeni (2003) in Namibia, Crous *et al*., (2006) in South Africa, Härkönen *et al*. (1993b) on Tanzania and Piearce (1981a and 1981b) in Zambia. Biodiversity works on Nigeria mycota were mostly

limited to epigeous species with scant knowledge of hypogeous types, scattered, regional, under-reported and under-represented relative to the verse array of animal and plant biota. This is exemplified by the works of Oso (1977) on the Yorubas in the western part of Nigeria, Nicholson (1989 and 2000) and Akpaja *et al*. (2003) on the Igbo people in south east Nigeria, Isikhuemhen (2000) and Osemwegie *et al*. (2006) on the Edo and Delta zones in the south south of the country. These reports focused on different lowland rain forest mushrooms around the country exempting other woodland stands such as plantations, savannah and mangroves. There is also no recorded data on myco-sociological studies of mushrooms despite Hueck (1953) remark that global interest on the knowledge of ecology and sociology of mushrooms is showing a definite rise. However, Mshigeni (2005) wrote and I quote ówhen we read publications on widelife in Africa, mushrooms are seldom mentioned. When we undertake literature surveys on Africaôs agricultural crops, mushrooms featured nowhere. When we thumb through the pages in documents presenting accounts on cultivated vegetables in Africa, mushrooms never appear in the table of contents. And when we read inventories of Africaôs medicinal biota, mushrooms are rarely listed in those publicationsô unquote. Therefore, the essence of this study is to provide a baseline record of mushroom diversity in rubber plantations while also comparing such diversity with those of a heterogeneous old-growth forest within the same ecoclimatic zone or ecozone in Edo state, Nigeria. In addition, this study is carried out against litter, climatic and seasonal gradients while focusing on the possibility of a relationship amongst these variables.

The source of mushrooms either for food, commerce or healing practices in Nigeria is still the wild such as lawn, parks, yards, farms, plantations and forests (Osemwegie *et al*., 2006). Collections of mushrooms that meet culinary and medicinal needs of any collector are hitherto known by undocumented instinct derived from bequeathed traditional knowledge through generations. It is therefore important to note if edible and medicinal mushrooms differ across various ethnic and cultural settings (Kekawa, 2001; Kayode, 2006; Idu *et al*., 2006). Though there is a long history of mushroom uses and mycophagy especially amongst rural people in various parts of Nigeria but little is documented in literature to be edible and medicinal (Akpaja *et al*., 2003; Osemwegie *et al*., 2006). Edible and medicinal mushrooms such as *Pleurotus tuberregium*, *P. squarrosullus*, *Lentinus subnudus*, *Volvariella volvaceae* (Syn. *esculenta*), *Termitomyces robustus*, *T. microcarpus* and *Tricholoma lobayensis* are some of the popularly cultivated species in Nigeria and Africa even though efforts are still ongoing to expand the number of cultivable specie (Ogundana, 1978; Fasidi and Kadiri,

1993; Isikhuemhen and Okhuoya, 1995; Fasidi, 1996; Chuwa *et al*., 1997; Osemwegie *et al*., 2002; Kadiri and Arzai, 2004; Magingo *et al*., 2004; Belewu and Belewu, 2005; Gbolagade, 2005; Okhuoya *et al*., 2005). This study intends to recognise mushroom species with documented edible and medicinal potency that are hitherto ignored and misconceived as unfit for consumption here in Edo State, Nigeria and dymestify them. Ethnomycological studies of mushrooms in Nigeria include Oso (1975) on the Yoruba people, Akpaja *et al*. (2003) on the Igbo people, Osagualekhor and Okhuoya (2005) on the Esan people and Osemwegie *et al*., (2006) on the Benin people.

Currently, population pressure, allowable logging which is a huge business venture and occupation in Nigeria, clearing of forests for various construction projects and farm lands coupled with indiscriminate practice of fire wood collection, mushroom exploitation, forest fragmentation, bush burning and increased harvesting of other non-wood products have long and short term negative effects on the composition of mycota in the country (Volk *et al*., 1994, Castellano, 1997, Shackleton, 2000, Chaverri and Vilchez, 2006). Therefore, lack of baseline records of extant macrofungal species of various woodland ecosystems across the country makes it difficult to identify species that are faced with the danger of extinction or otherwise extinct and evaluate the rate of species loss considering their significant roles in ecosystem function. Elsewhere outside Nigeria like USA, Europe, Asia and some parts of East/South Africa, there is a growing consciousness for the conservation of plant genetic resource as part of a global initiative created by F.A.O (Food and Agriculture Organisation) in 1963, the Consultation Group in International Agricultural Research (CGIAR) in 1974, International Board for Plant Genetic Resources (IBPGR) in 1983 and the United Nationôs (UN) conference on environment and development (UNCED) in June 1996, and the Society for Conservation Biology (2005) in a convention on Biological Diversity. This study is consequently inspired by the declaration of the 2002 World Summit on Sustainable Development (WSSD) as reported by UN (2002) and aims at contributing to global knowledge on mushroom diversity and conservation of mushroom resources especially in Edo State. In addition to these, the study also aims at providing information on edible and medicinal macrofungi, their relationship with humans, their phenology and distributions.

2.3 Litterfall studies

Litterfall studies the world over are related to above ground primary productivity, carbon and nutrient cycling of forests and other wood land ecosystems or vegetations (Proctor, 1983; Dantas and Phillipson, 1989). Furthermore, data on litterfall have variously been used as indices of seasonal phenomena related to plant phenology (Palmer, 1988; Molofsky and Augspurger, 1992). Litterfall study has a history as far back as 1876 when the first classical work was published on litterfall decomposition (Satchell, 1974). Several litterfall studies relating to ecosystem functioning are noted to be especially in the areas of ecosystem dynamics such as literfall rates, nutrient-use efficiency and economy, litterfall decomposition, net primary productivity which is reported by Clark *et al*. (2001) as the most important component of the above ground biomass, nutrient release mechanisms and above as well as below ground mineral nutrient flux in different vegetations and plantations around the globe (Bray and Gorham, 1964; Cole and Rapp, 1980; Abbot and Crossley, 1982; Berendse and Aerts, 1987; OôConnell, 1987; Dantas and Phillipson, 1989; Lockaby *et al*., 1995; Singh, 1992; Lisanework and Michelsen, 1994; Attignon *et al*., 2004). Studies quantifying litterfall input in different vegetation types are prolific (Dantas and Phillipson, 1989; Brouwer, 1996; Aerts, 1997; Singh, 2004). Litterfall is also used as major index in many scientific studies relating to estimation of forest susceptibility to fire, forest structure, tree species heterogeneity or composition, forest herbivory, physiology of woody plants, forest regeneration and forest agronomy in various woodland stands (Tanner, 1977a and b; Swift *et al*., 1981; Ewel, 1980; Seastedt *et al*., 1983; Proctor, 1984; Mattson and Swank, 1989; Molofsky and Augspurger, 1992; Reich *et al*., 1992; Fernandez *et al*., 1993; Arunachlam *et al*., 1998; Binkley, 1994; Edmonds, 2000; Jin *et al*., 2002). Heal *et al*. (1997) and Singh *et al*. 1999) observed that many studies are abound on litterfall studies in forest ecosystems which they estimated to be approximately 1000 papers since 1980. Lockaby *et al*. (1995) remarked that these studies represent the integrated effect of multiple plant species and vegetation strata growing together within a single system. In addition, Bell (1974), Brasell *et al*. (1980) and Vogt *et al*. (1986) while reviewing litterfall studies all reported that most of the investigations carried out on litterfall are for temperate forests meaning that there are only few reports of litterfall studies on tropical forests. In Nigeria however, some of the litterfall studies reported are old. They include Afolayan (1979), Egunjobi and Onweluzo (1979), Oguntala (1979), Swift *et al*., (1981), Nwoboshi (1980), Orimoyegun (1985), Okadeba and Aduayi (1985), Oyinbe (1990), Okeke and Omaliko (1991) and Muoghalu *et al*.

(1993a and b, 1994). There is also paucity of studies and literature on the relationship between litterfall and fungi especially mushroom diversity even though they are recognised as key part of woodland ecosystems with an essential role in plant nutrition. Suffice to say that they are involved in the release of elemental mineral nutrients trapped in various decaying organic matter (Grime, 1997). Furthermore, Lawton (1994) remarked that the importance of fungi in woodland ecosystems is underestimated because their mycelium is usually hidden mostly in soil and plant litters while Christensen (1989) linked saprophytic fungi both to elemental extraction from the forest floor and to accumulation and translocation.

A review of literature on the role of mushrooms or macrofungi in overall ecosystem functioning shows that most of the studies are on decomposition, symbiotic and biodegradative activities as exemplified by Harvey *et al*. (1980), Bernhard-Reversat (1982), Golley, (1983), Hedger (1990), Molina *et al*. (1992), Cornejo *et al*. (1994), Pietikainen and Fritze (1995) and Laclau *et al*. (2003) rather than on eco-sociological issues that affect their habitat, distribution pattern, biogeography, interactive propensity especially, in relation to other biota. Furthermore, the effects of tree behaviour and characteristics such as pattern of leaffall (litterfall), nutrient uptake, canopy cover and retranslocation of nutrients on the macrofungi diversity in a woodland ecosystem has gained very little local and global attention. Despite the fact that Shigeki *et al*. (1994) remarked that standing crops and diversity of woody plants as well as forest succession have a strong effect on fungal flora and their quantities through the development of a variety of niches. Cooke and Rayner (1984), and Rayner and Boddy (1988) remarked that the Basidiomycota and Ascomycota mostly in the orders Aphyllophorales, Agaricales and Sphaeriales are responsible for decomposition of a high proportion of the annual terrestrial production of 100 gigatonnes of lignocellulose-rich plant cell material, of which lignin alone accounts for 20 gigatones. In Nigeria however, there is dearth of literature on the synecology and autecology of macrofungi community in ecosystems. Globally, studies that are carried out on macrofungi community interrelationships and structure are also few and in dare need of attention as most of such studies are mainly on mycorrhiza fungi (Harley and Smith, 1983; Allen, 1993; Mudrick *et al*., 1994; O'Dell et al., 1999) and non-mycorrhiza fungi such as wood-rotting fungi (Siitonen *et al*.,2005).

Macrofungi are recognised by several authors in the decomposition of forest litters but it was not until Meentemeyerôs (1978) influential paper about the effect of climate and litter chemistry on litter decomposition that lignin or lignin to nutrient ratio, nitrogen (N) or carbon- nitrogen ratio (C/N) concentration was linked to macrofungi presence in litter decomposition activities. Lignin was also established in literature as a regulating factor in leaflitter decomposition in various woodland ecosystems (Vitousek *et al*., 1994; Aerts and De Caluwe, 1997; Evans and Hedger, 2001; Tan and Zou, 2001, Osono, 2007). Hedger (1985) described in details the stratification of Basidiomycetes decomposer communities in moist forest overstory in Ecuador while Osono (2007) recently carried out a novel study on the ecology of ligninolytic fungi inhabiting leaflitter and forest floor materials. This report focused on their taxonomic and functional diversity, relationship with other organisms, ligninolytic enzymes in soil environment, succession/substrate pattern, spatial and temporal abundance, and effects of physical factors on them. No work has however been carried out both in Nigeria and the Sub-Saharan Africa on the relationship between litterfall mass or quantity on species diversity of macrofungi which formed the basis of this study.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The study area

The study area, Rubber Research Institute of Nigeria (R.R.I.N.) is situated in Iyanomo, Okha Local government area, approximately about 29km from Benin City, Edo State. It lies between latitudes 5º and 6º, and longitudes 5º and 6º (Fig 1). It is an elevation of 300-250m a.s.l. and covers about 2078 hectares (20.78 sqkm) comprising secondary forests and plantations of which approximately 400 hectares (4 sqkm) is cultivated with various clones of *Hevea* trees.

The study area experiences two discernable seasons in a year which include the wet season influenced by the South-west trade wind spanning April to October and dry season brought about by the North ï East trade wind spanning November to March in addition to marked diurnal variations. The area lies within a heavy rainfall zone with an average annual rainfall of the area is 2,450mm and about seven months of rainfall which peaks at June and September. All meteorological information/data used for the study were collected from the meteorological unit of the Rubber Research Institute of Nigeria (Table 8). The relative humidity of the area is maximum in the mornings and evenings but minimum in mid-day. The atmospheric temperature data showed that the highest temperatures (29º -30º C) were recorded in the months of November to April and the lowest temperature (20º -21º C) in the month of January. The topography is slightly undulating and transversed by a valley of semi-permanently dried up stream with a typical lowland rain forest vegetation type. The soil in the study area is a sandy reddish ferralsol which contains very limited minerals as a result of its susceptibility to leaching while various geologic rocks comprising migmatite (gneisses complex), meta-igneous rocks, charnockitic rocks, older granites and un-metamorphosed dolerite dyke were recorded by Rahman (1976) and Onyinbe (1990) to be present in the study area.

3.2 Plantation and forest investigated

The study was carried out in selected plantations and a forest stand in the Rubber Research Institute of Nigeria. Two young plots (30-35 years old) marked A and B, and 2 old plots (45-55 years old) marked C and D respectively, characterised by mixed or multi-clone rubber trees not more than 5km from each other along the same stretch of road and each of which is about 1hectare (10,000 square meters) were selected as the study sites.

Plots A and B are characterised by a monoculture of almost equal height (6 ï 8 metres) rubber trees which were actively taped for latex and the plots weeded at least twice a year. Plots C and D on the other hand are abandoned plantations with taller trees of not less 7.5 metres and thick undergrowth. The old growth forest stand designated Plot E was characterised by diverse heterogeneous trees with thick undergrowths was also selected. The field layout of the rubber plantations and Forests in the Rubber Research Institute of Nigeria Iyanomo (RRIN) is presented in Fig. 2. Each site was mapped with coloured ribbon (red, yellow and blue) into plot of 50 x 50 m which is a distance of 5 m from the plantation or forest edge. The subplot in each study site are subdivided into mini square plots (25 x 25 m) and randomly surveyed for 3 hours twice a month for epigeous macrofungi using various foray materials such as hand trowel, pen knife, small paint brush for removing loose sand particles, cane basket for keeping collected specimens, a battery powered digital high resolution camera (Olympus 5.1 megapixel).

Collection and preservation of these macrofungi was carried out according to Lodge *et al*. (2004). Identification was by means of macroscopic features (no molecular identification was carried out) using a variety of field monographs of coloured mushroom and other books (Lange and Hora, 1972; Largent and Their, 1984; Arora, 1986; Largent, 1986; Arora, 1991; Mueller *et al*., 2004; Lincoff, 2005), and internet facilities and foreign assistance. Habit and habitat, colour, smell (if any), sociability and substrate were noted in the field. The survey and other ecological investigations were carried out for a period of 14 months particularly noting period of fruit body appearance for each observed mushroom (phenology), mushroom-substrate interaction and gregariousness (June 2006 to August 2007).

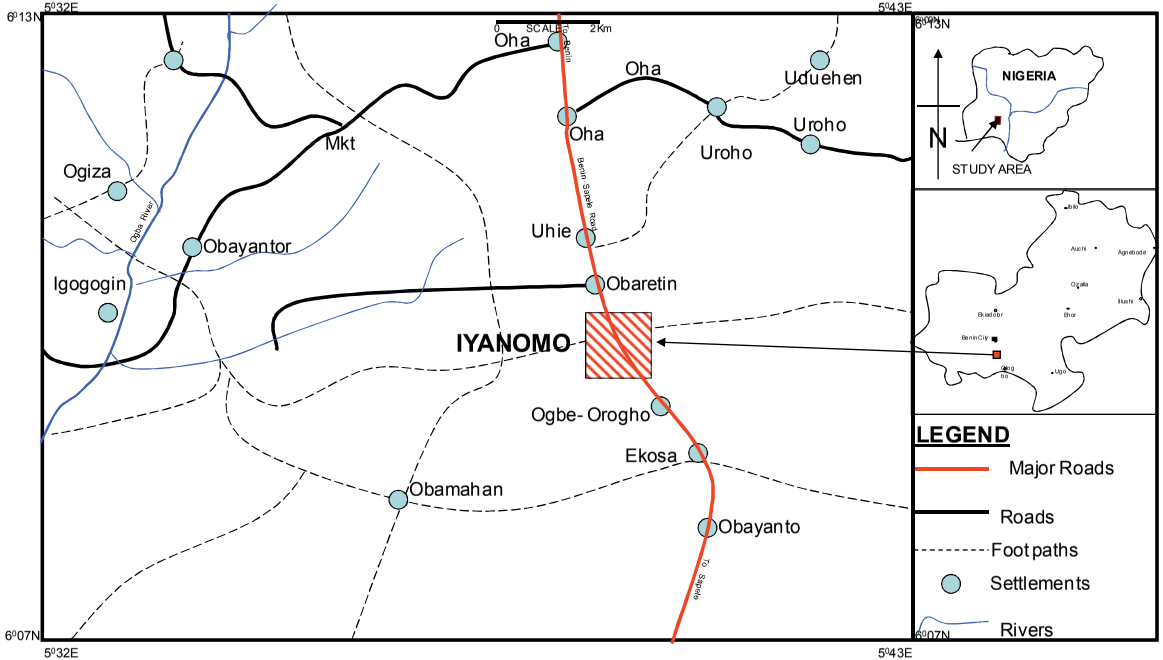


Fig. 1: Map of Iyanomo and environs showing the study area

3.3 Preparation of voucher specimens

Mushrooms collected from each plot in the 5 different locations mapped A, B, C, D and E were brought to the University of Benin laboratory and after identification, oven dried overnight at 80º C under continuous air circulation (Mueller *et al*., 2004; Lodge *et al*., 2004). Each dried mushroom specimen was bagged (Ziploc bags 16.5 x 14.9 cm) and dropped in the Departmental herbarium.

3.4 Determination of ecological parameters

After a complete check list of all the macrofungi growing in the rubber plantation had been made, each macrofungal taxon was graded for such analytical data as dominance, abundance and density.

3.4.1 Abundance (A)

This was determined counting the number of individuals of a species or the number of fruit bodies over mapped areas (Zak and Willig, 2004).

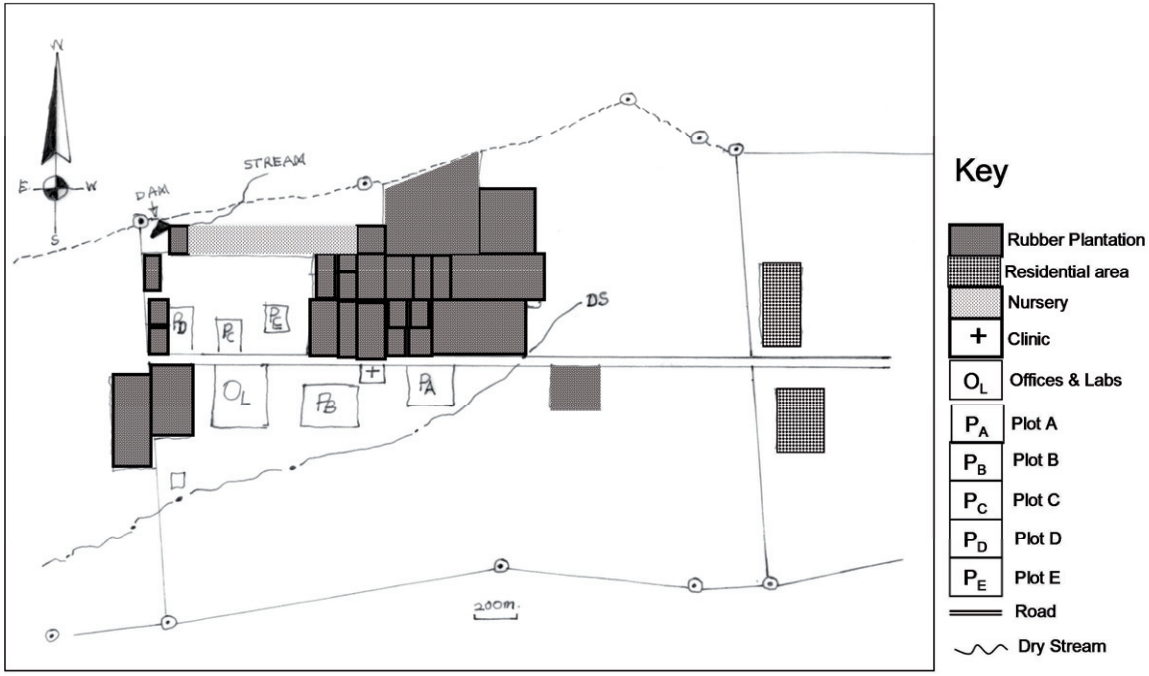


Fig. 2: Field layout of rubber plantation at Rubber Research Institute, Iyanomo showing sampling plots

3.4.2 Density (D)

Density (D) was determined by estimating the abundance (A) of individuals of a species in a unit subplot and dividing by the area (a) of sampled site (Misra, 1974; Shigeki *et al*., 1994).

D = A/a

3.4.3 Fidelity (F)

Fidelity refers to the faithfulness of a species (taxon) to a particular kind of community and the following classes established by Pandeya *et al*., (1968), Kershaw (1973) and Misra (1974) were adapted to mushrooms in the different woodland communities as follows:

Class 1: Exclusive (characteristic species) to one kind of community.

Class 2: Selective (characteristic species) - occurring mostly in one kind of community but rarely in another kind of community.

Class 3: Preferential (characteristic species) - occurring in several communities but abundant in some kind only.

Class 4: Indifferent (companion species) ï occurring uniformly in all types of communities.

Class 5: Strange/rare and accidental intruders in a community.

3.4.4 Relative Density (RD)

Relative density was determined by expressing the density of a species (Di) as a percentage of the proportion of the total density (DT) of all species present (Misra, 1974).

RD of any taxon = Di/DT x 100%

3.4.5 Gregariousness

Gregariousness or sociability of mushrooms were also determined according to Kershaw (1973) and Misra (1974) but modified for the purpose of this study into class 1 (mushrooms growing singly or as isolated individuals), class 2 (mushrooms growing in small

unjoined groups of < 3), Class 3 (mushrooms growing in small groups but co-joined of Ò3), class 4 (mushrooms growing in large co-joined groups of Ó5) Class 5 (mushrooms growing in large unjoined groups).

3.5 Litter trapping and nutrient analysis

Litterfall studies were carried out in all the mapped areas in the 5 study sites using wooden litter traps/trays (1m x 1m x 0.1m) floored with 0.5mm wire mesh. A total of 8 litter trays raised 15cm above ground level were placed randomly in each mapped plots not recognizing gaps created by felled trees especially in the old (45-55) rubber plantations and forests. The litterfall were collected according to Proctor *et al*. (1983), from the numerous litter trays in each of the various study sites monthly in labelled polyethylene bags (37 x 20 cm), brought to the laboratory, sorted out into four factions/components i.e. leaves, flowers and seeds, twigs and small wood (Ò2cm diameter; pieces larger than this were broken off and discarded; separate bark fragments were included if they were Ò 2cm along their longest dimension), weighed fresh using a top loading digital weighing balance (Mettler PM4800, Delta range) equipment, air dried for at least 6 hours after which they were oven dried for 12 hours at 100º C and the dry weight for each sample determined. Litters from fallen trays were not collected nor used for the study. For each month and for each litter component, composite (mixed) samples were analysed for N, P and C according to Okalebo *et al*. (2002). Organic carbon was determined by the sulphuric acid and aqueous potassium dichromate ($K_2Cr_2O_7$) mixture while total content of nitrogen and phosphorus was measured by treating samples with hydrogen peroxide + Sulpuric acid + selenium + salicylic acid.

3.6 Analysis of ecological parameters and litterfall

Data obtained during the study were analysed using the EstmateS 8.0 version (Colwell, 2005) for statistical estimation of species richness, similarity (shared species) index (Chao *et al*., 2005) and biodiversity indexes. The use of multiple species richness and biodiversity indexes stems from the difficulty associated with the general concept of diversity which as yet fails to be satisfactorily quantified by any single statistic or descriptor (Devries and Walla, 2001; Colwell, 2005). The species accumulation curve for the study area was plotted according to Colwell and Coddington (1994). The fine litter variables (litter mass, C-,

N- and P-contents) were analysed statistically using Spss 11 for correlation (Sabine and Everitt, 2004) and ANOVA.

CHAPTER FOUR

4.0 RESULTS

The results obtained from this research study are presented in three sections which comprise (i) enumeration and composition of mushroom taxa, (ii) interpretation of results from ecological investigations such as abundance, density, fidelity, relative density and gregariousness, and (iii) monthly dry weight (g/m^2/month)of litterfall and macro-element data comparison with results of ecological investigation.

4.1 Enumeration of mushroom taxa

The enumeration of the various mushroom floras was outlined in alphabetical order of Family under each arbitrary group. Morphological description, habitat, location and phenology are enumerated. I however wish to make it clear that microscopic examination and molecular identification of the mushrooms were not carried out. Photograph of mushrooms were provided in plates numbered 1- 93.

4.1.1 Gilled Mushrooms (Agarics or Fleshy Mushrooms)

4.1.1.1 AGARICACEAE

Plate 1: *Agaricus arvensis* Schaeff.
Ecological status: Rare
Location: Plot A
Substrate: Plantation floor
Morphodescription: Cap is fleshy, white, broadly parabolic to plane, dry and smooth. Gills are crowded, free and whitish. Stalk is central, thick, tapering down to a slight abrupt bulb.
Phenology: June.

Plate 2: *Chlorophyllum* species
Ecological status: rare

Location: Plot E

Substrate: Decomposing forest litter and soil

Morphodescription: Pileus is whitish, large, almost broadly convex, and dry with buff scales at the center and a smooth margin. Gills are free, white and crowded. Stipe is central, whitish from cap to annulus but whitish pink down wards, lacking volva, narrowly clavate, inserted with whitish pink to whitish brown annulus ring.

Phenology: July

Plate 1: ***Agaricus arvensis*** **(Scale bar = 2cm)**

Plate 2: *Chlorophyllum* species (Scale bar = 2.5cm)

Plate 3: *Lepiota* species
Ecological status: Rare
Location: Plot E
Substrate: Decomposing moist litterfall (kormobiont).
Morphovdescription: Cap is broadly convex with a slight umbo, white with chocolate brown squamules spreading from the umbo to the centre towards the margin. Stalk is slender, smooth, brown, annulated (white ring) and equal.
Phenology: August.

Plate 4: *Macrolepiota* species
Ecological status: Rare
Location: Plot E
Substrate: Decomposing moist litterfall (kormobiont).
Morphodescription: Cap is large, dry, and broadly convex with a slight umbo, cream to yellowish-grey in colour, warty to appressed-squamulose or scurfy especially spreading from

the umbo and loosing concentration towards the margin. Stalk is usually short, equal, central annulated and smooth. The gills are free, close and seceding.

Phenology: September.

Plate 3: *Lepiota* species (Scale bar = 1cm)

Plate 4: *Macrolepiota* species (Scale bar = 1cm)

4.1.1.2 AMANITACEAE

Amanita phylloides (Vail) Secretan.

Ecological status: Rare

Location: Plots D and E

Substrate: Dead logs

Morphodescription: Cap is wide, convex pale green to greenish-yellow with thin patches of universal veil tissue and margin not radially lined. Lamillae more or less free. Stipe is long, central bulbous with a volva and central.

Phenology: June ï August.

4.1.1.3 COPRINACEAE

Coprinus acuminatus (Romagn.) P.D.Orton

Ecological status: Common in plots A and B but occasional in plots C, D and E

Location: Plots A, B, C, D and E

Substrate: Decomposing forest/plantation litters

Morphodescription: Cap is bell shaped, pale brownish to grey in colour with scaly remnant of universal veil toward the center of the pileus. Pileus is plicate striate closer to the margin while the gills are free and deliquescent. Stipe is thin, frail without annulus and volva.

Phenology: July ï September in plots A and B. September in plots C, D and E.

Coprinus atramentarius Ulje and Bas.

Ecological status: Common in plots A and B

Location: Plots A and B

Substrate: Decomposing forest/plantation litters and decaying tree branches

Morphodescription: Cap is oval to bell shaped to convex, greyish brown with white partial veil that leaves an evanescent ring near the stalk base, margin pleated, gills are free and deliquescent. Stipe is thin, frail without annulus and volva.

Phenology: July ï September in plots A and B.

Plate 5: *Coprinus disseminatus* (Pers. ex Fr.) S.F.G.

Ecological status: Rare

Location: Plots A and B

Substrate: Decomposing plantation litters

Morphodescription: Cap is convex to broadly convex, greyish brown without any veil, almost pruinose and striated. Gills are dark greyish brown, crowded and free or adnex. Stipe is thin, fragile and not less than 4cm long.

Phenology: August

Plate 5: *Coprinus disseminatus* (Pers. ex Fr.) S.F.G (Scale bar = 1cm)

Plate 6: *Omphalina chrysophylla* (Fr.) Murrill

Ecological status: Rare

Location: Plots C and D

Substrate: Decaying logs

Morphodescription: Fruit body is tubaeform or trumpet-shaped with a typical central stipe and funnel-shaped cap. The pileus is gold to golden brown coloured, appearing striate when matured, centrally depressed with a smooth upper surface and rolled or incurved margin. The gills descend to the stipe or heavily decurrent, orange to golden coloured, distant and regular. Stipe is hard, equal, smooth, orange coloured, faintly gold and terminated in a basal disc.

Phenology: September

Plate 7: *Panaeolus foenisecii* (Pers.: Fr.) Kuhner.

Ecological status: Common

Location: Plots A and B

Substrate: Decaying litters

Morphodescription: Pileus is broadly conic, becoming broadly convex at maturity, smooth to faintly wrinkle with a dull brown colour which later fades to light greyish-brown from the centre of the pileus. Gills are attached light to dark brown in colour while the stipe is without veil or annulus, equal and central with brown surface.

Phenology: June to September

Plate 6: *Omphalina chrysophylla* (Scale bar = 1cm)

Plate 7: *Panaeolus foenisecii* (Pers.: Fr.) Kuhner (Scale bar = 1cm)

4.1.1.4 CREPIDOTACEAE

Plate 8: *Crepidotus mollis* (Bull.) Kummer

Ecological status: Rare

Location: Plots B and C

Substrate: Decaying forest twigs and coarse woods (Ó2cm in diameter)

Morphodescription: fruit body is bean shaped Ò 2.5cm in diameter, laterally attached, partially stipitate or sessile with a pallid to cream colouration.

Phenology: August and November.

4.1.1.5 HYGROPHORACEAE

Plate 9: *Hygrocybe* species

Ecological status: Rare

Location: Plot D

Substrate: Decomposing litterfall (kormobiont) and soil

Morphodescription: Cap is orbicular to spherical, orange red in colour and yellowish orange at the margin with a shallow or slight depression at the center. The gill is yellowish orange,

close, slightly decurrent or decending to the stipe. The margin is wavy while the stipe is yellowish orange, central, hollow and almost flattened to spherical.

Phenology: July to September

Plate 8: *Crepidotus mollis* (Bull.) Kummer (Scale bar = 5mm)

Plate 9: *Hygrocybe* species (Scale bar = 1cm)

4.1.1.6 PLEUROTACEAE

Nothopanus species

Ecological status: Common

Location: Plots A, B, C, D and E

Family: Pleurotaceae

Substrate: Wet and dry decaying logs

Morphodescription: cap is bracket shaped with subdistant gills lining the undersurface. The upper surface of the pileus is milky in colour and becomes tainted brown with age, sessil or possesses insignificantly small stipe. The texture is leathery and taste is bitter.

Phenology: All year round.

Plate 11: *Pleurotus* species

Ecological status: Rare

Location: D and E,

Family: Pleurotaceae

Substrate: Slightly buried decaying wood and soil

Morphodescription: Fuunel shaped fruit body; Cap is depressed at the center, dry, incurved but smooth margin, coffee brown to deep brown colour, leathery in texture with a slight velvety feeling to touch. Gills are pale brown, subdecurrent to decurrent, crowded, smooth and attached to the stipe. Stipe is tough or hard, central, chocolate brown, feels velvety when touched and equal.

Phenology: August ï September.

Plate 10: *Nothopanus* species (Scale bar = 1cm)

Plate 11: *Pleurotus* species (Scale bar = 1cm)

Plate 12: *Pleurotus squarrosulus* (Fr.) Kummer.
Ecological status: Dominant
Location: All plots sampled
Substrate: Dead decaying wood/logs
Morphodescription: Fruit body is white to milky in colour and crowded with regular, decurrent gills. Cap is has a squamose surface, convex with a central, shallow depression and occasional smooth, almost incurved margin. Stipe is central thick and equal arises directly from a cryptic mycelium or hypogeous sclerotium within the substrate.
Phenology: March ï February.

Pleurotus tuberregium (Fr.) Singer.
Ecological status: Rare
Location: D
Substrate: Dead decaying wood/logs
Morphodescription: Funnel-shaped or trumpet-shaped fruit body, white to milky in colour and may grow singly or in group, often caespitose. Cap is smooth, incurved with regular, decurrent gills. Stipe is central thick and equal arises directly from a cryptic mycelium or hypogeous sclerotium within the substrate.
Phenology: July

Plate 12: *Pleurotus squarrosulus* (Fr.) Kummer (Scale bar = 1.5cm)

4.1.1.7 PLUTACEAE

Plate 13: *Pluteus cervinus* (Schaeff. ex Fr.) Kum.

Ecological status: Rare

Location: C

Substrate: Dead decaying logs

Morphodescription: Fruit body is umbrella shape; pileus is plane; dry to moist, grey in colour with white, close to crowded, soft gills. Margin is almost crisped. The stalk is smooth, grey to white in colour, central, equal, and cartilaginous without annulus or veil and often caespitose.

Phenology: August.

Plate 14: *Volvariella volvaceae* (Fr.) Singer.

Ecological status: Rare

Location: Plots E

Substrate: Forest floor and wood

Morphodescription: Fruit body is broadly parabolic when young to flatten or broadly convex when matured. Gills are neither waxy nor deliquescent, close to crowded, broad with a soft texture. The stalk is typically equal, without annulus. The stalk is also saccate i.e. with volva.

Phenology: July and August.

Plate 13: *Pluteus cervinus* (Schaeff. ex Fr.) Kum. (Scale bar = 1.5 cm)

Plate 14: ***Volvariella volvaceae*** **(Fr.) Singer. (Scale bar = 1 cm)**

4.1.1.8 RUSSULACEAE

Plate 15: *Russula* species

Ecological status: Rare

Location: E

Substrate: Dead decaying litters around the base of a tree

Morphodescription: Cap is convex to plane; dry, pinkish orange in colour with a smooth orange margin. Gills are crowded and yellowish orange. The stalk is smooth, pinkish orange, short equal, central and slightly bulbous at the base.

Phenology: September/November.

4.1.1.9 TRICHOLOMATACEAE

Plate 16: *Clitocybe* species

Ecological status: Occasional

Location: A and B

Substrate: Decomposing forest litter

Morphodescription: Pileus is smooth, dry, umbilicate to shallowly depressed, deep coffee brown and almost leathery or non-brittle in texture. Gill attached, close, slightly decurrent or descending to the stalk. Stalk is central, greyish-brown, and equal without annulus, veil or volva.

Phenology: June ï July.

Plate 15: *Russula* species (Scale bar = 1cm)

Plate 16: *Clitocybe* species (Scale bar = 1.5cm)

Clitocybe dealbata (Sow) Gillet.

Ecological status: Common

Location: Plots A, B and C

Substrate: Decomposing forest litter

Morphodescription: Mature pileus may be flat or slightly concave without umbo, pale to dull white in color. Gill attached and descending the stalk. Stalk is central and tapers downward, non-annulated without veil and volva.

Phenology: June ï September.

Plate 17: *Marasmius graminum* (Libert) Berkeley.

Ecological status: rare

Location: E

Substrate: Twigs and leaflitters

Morphodescription: Fruit body is parabolic, corrugated with evenly wavy margin and pale to cream coloured distant gills. The stipe or stalk is thin, brittle and brown at the base to white in colour at the apex.

Phenology: August to September

Plate 17: ***Marasmius graminum*** **(Libert) Berkeley (Scale bare = 1cm)**

Plate 18: *Marasmius lachnophyllus* Berkeley.

Ecological status: Rare

Location: A

Substrate: Twigs and leaflitters

Morphodescription: Cap is brownish to dark brown, convex to flat or somewhat sunken at the center with smooth margin and dry. Gills are attached, faintly brownish to yellowish pink with gill edge appearing serrated with age. Stipe is equal, central, hard, subcaespitose and dark brown in colour except close to the gill which is faint brown.

Phenology: July to August.

Plate 18: ***Marasmius lachnophyllus*** **Berkeley (Scale bar = 1cm)**

Plate 19: *Marasmius pulcherripes* Peck.

Ecological status: Rare

Location: E

Substrate: Twigs and leaflitters

Morphodescription: Cap is wrinkled or grooved, initially bell-shape to convex with an almost invincible central umbo or nipple; later becomes broadly bell shaped or flaring or convex to nearly flat, pinkish red to brownish orange colour. Gills are adnex or free, brownish pink and close to distant. Stipe is long, less than 1mm thick; equal, dry, wiry, almost uniform pale pinkish to brownish.

Phenology: July to August

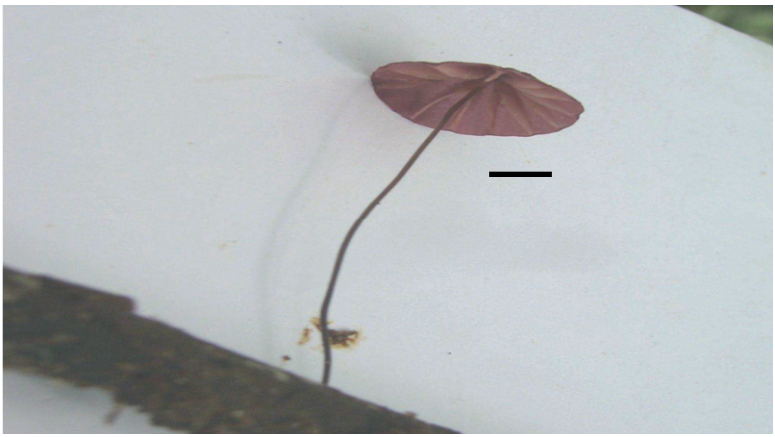


Plate 19: *Marasmius pulcherripes* Peck. (Scale bar = 1cm)

Plate 20: *Marasmius rotula* (Fr.) Scope.

Ecological status: Common

Location: Plots A, B and E

Substrate: Decomposing moist litterfall (kormobiont)

Morphodescription: Cap is convex, totally radially pleated or furrowed margin, dry, dull to velvety to whitish colour and slightly depressed centrally. Gills are attached to the stipe or collar and the stipe is long, central, thick, and fibrous to wiry.

Phenology: Rainy months June ï September.

Plate 21: *Marasmiellus* species

Ecological status: Rare

Location: Plots A and B

Substrate: Twigs, leaflitters and decaying tree bark

Morphodescription: Fruit body is umbilicate to shallowly depressed, wrinkled to striate, greyish purple to pale blue colour. Gill is white, smooth and close. The stipe or stalk is hollow, brittle and purple to bluish colour.

Phenology: August to September.

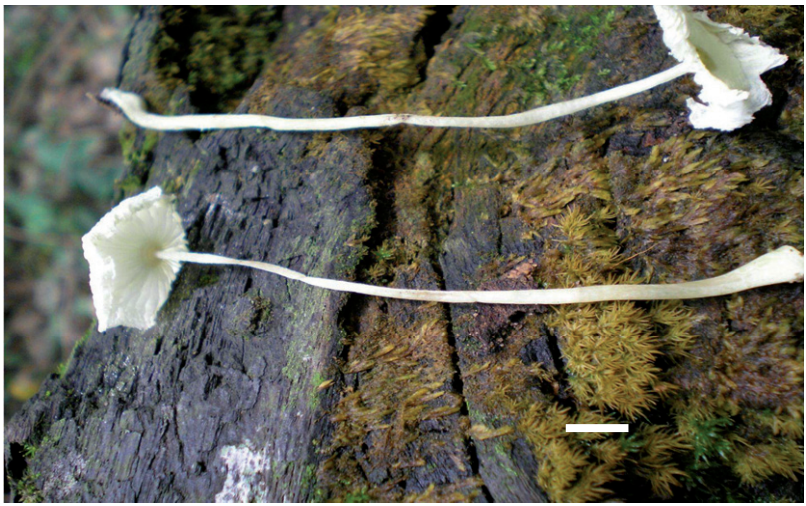


Plate 20: ***Marasmius rotula*** **(Fr.) Scope (Scale bar = 2cm)**

Plate 21: ***Marasmiellus*** **species (Scale bar = 1cm)**

Plate 22: *Megacollybia platyphylla* (Pers.) Kotl. And Pouzar.

Ecological status: Rare

Location: Plots D and E

Substrate: wet logs/trees

Morphodescription: Fruit body is fleshy with cap that is initially convex but becomes lifted with age, smooth and white to cream coloured. Gills are crowded to close, free and narrow. Stipe is central, equal except at the base that is abruptly clavate and cream to whitish pink.

Phenology: August-September.

Plate 23: *Mycena* species

Ecological status: Rare

Location: Plots A and B

Substrate: Twigs and leaflitters

Morphodescription: Fruit body is delicate with a cap that slightly deep brownish umbo which spreads to light brown and to brownish pink towards the margin. Gills are crowded, thin and pinkish brown in colour and adnate. The stipe is slender, long, deep brown colour and easily broken.

Phenology: July to August

Plate 22: *Megacollybia platyphylla* (Pers.) Kotl. And Pouzar. (Scale bar = 1cm)

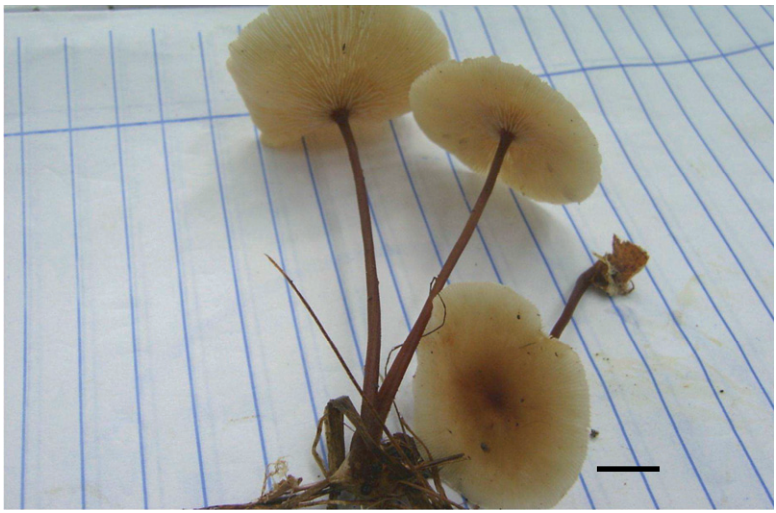


Plate 23: *Mycena* species (Scale bar = 1cm)

Plate 24: *Pleurocybella porrigens* (Pers. ex Fr.) Sing.

Ecological status: Rare

Location: Plots C, D and E

Substrate: Dead decaying logs/trees

Morphodescription: Pileus is broad to flabelliform, or fan or ear shaped, fleshy, dry smooth, white to cream coloured with incurved margin, sessile or with short lateral stalk. Gills are decending to stublike base, crowded, narrow and white in colour.

Phenology: August ï September.

Plate 25: *Panellus* species

Ecological status: Common

Location: Plots A, B and C

Substrate: Dead decaying logs

Morphodescription: Cap is shelf-like to kidney shaped, pale brownish, non-fleshy to dry, papery to leathery in texture and gregarious. Gills are false, crowded to close, narrow, darkish brown to brownish black, descending to a short, lateral, off-centred stalk.

Phenology: September.

Plate 24: ***Pleurocybella porrigens*** **(Pers. ex Fr.) Sing. (Scale bar = 1.5 cm)**

Plate 25: ***Panellus*** **species (Scale bar = 1cm)**

4.1.2 Polypore Mushrooms

4.1.2.1 AURICULARIACEA

Plate 26: *Auricularia auricular* Judae (Bull.) Pat.

Ecological status: Abundant

Location: Plots A, B, C, D and E

Substrate: Dry and wet decaying logs (xylobiont)

Morphodescription: Fruit body is polyporoid, jelly pliant and rubbery, fan or bracket shaped or pinna like, Coffee to deep brown in colour with or without ribbed or veined, non-stipitate or sessil or rudimentary stalked, Gelatinous or slimy in nature.

Phenology: All the year round.

4.1.2.2 CANTHARELLACEAE

Plate 27: *Cantharellus tubaeformis* (Bull.) Fr.

Ecological status: Rare

Location: Plot E

Sustrate: Dead decaying wood and logs

Morphodescription: Fruit body is cream to pale yellowish in colour, rubbery in texture with distant decurrent gills and wavy pileus margin.

Phenology: July to September

Plate 26: ***Auricularia auricular*** **Judae (Bull.) Pat. (Scale bar = 1cm)**

Plate 27: *Cantharellus tubaeformis* (Bull.) Fr. (Scale bar = 1cm)

4.1.2.3 CLAVARIACEAE

Plate 28: *Clavulina* species

Ecological status: Common

Location: Plot C and E

Family: Clavariaceae

Substrate: Decaying logs

Morphodescription: Fruit body is rubbery, greyish white to cream in colour, coral-like, non-gelatinous, branched usually from the base with each branch carrying an apical dichotomous branching or forked. Always in crowded or gregarious to scattered with no typical cap and stipe configuration.

Phenology: September

Plate 29: *Clavulinopsis* species

Ecological status: Rare

Location: Plot E

Substrate: Decaying tree barks.

Morphodescription: The fruit body is white to cream in colour, elastic to cartilagenous in texture, slender to thin clavate forked apex.

Penology: July

Plate 28: *Clavulina* species (Scale bar = 8 mm)

Plate 29: *Clavulinopsis* species (Scale bar = 1 cm)

Plate 30: *Thelephora* species A

Ecological status: Rare

Location: C

Substrate: Dead decaying logs

Morphodescription: Fruit body is ramariod but leathery and tough with a glossy brown base to a creamy to pinkish white irregular branches that flares outward.

Phenology: September.

Plate 31: *Thelephora* species B

Ecological status: Rare

Location: C and D

Substrate: Soil and litters

Morphodescription: Fruit body is smaller sub-microscopic, grey in colour, leathery with regular apical branches that flare outward.

Phenology: October to November.

Plate 30: *Thelephora* species A (Scale bar = 8 mm)

Plate 31: *Thelephora* species B (Scale bar = 5 mm)

4.1.2.4 DACRYMYCETACEAE

Plate 32: *Calocera cornea* (Batsch) Fr.

Ecological status: Rare

Location: Plot C

Substrate: Moist decaying wood

Morphodescription: Fruit body is rubbery, yellowish to yellowish orange, coral-like, gelatinous to wet, clavate with apical dichotomous branching or forked. No typical cap and stipe configuration.

Phenology: July.

4.1.2.5 HYDNACEAE

Hericium ramosum (Bull. ex Mér.) Let.

Ecological status: Common

Location: Plot A and B

Substrate: Decaying wood and logs

Morphodescription: Fruit body is white to cream coloured, appearing more like an afro wig with series of branches on a dead log or wood, flesh soft and dusty when touched. Stalk in indistinct, laterally attached, hairy and stublike.
Phenology: September-October.

Plate 32: ***Calocera cornea*** **(Batsch.) Fr. (Scale bar = 1 cm)**

4.1.2.5 HYMENOCHAETACEAE

Plate 33: *Coltricia perennis* (L.: Fr) Murrill.
Ecological status: Abundant
Location: Plots A, B and E
Substrate: Twigs in forest litters, branches and decaying log/wood
Morphodescription: The fruit body is feels like paper, whitish to creamy exterior while the interior is alternately coloured in reddish brown to deep brown thereby creating a form of colour zonation, funnel shape with a central stalk.
Penology: All the year round.

4.1.2.6 PODOSCYPHACEAE

Plate 34: *Podoscypha* species

Ecological status: Rare

Location: Plot C

Substrate: Dry dead decaying logs (xylobiont)

Morphodescription: Fruit body has dark brown to light coffee brown zones, leathery to papery texture, rosette, sessile with a whitish tiny pored under-surface.

Phenology: June.

Plate 33: *Coltricia perennis* (L.: Fr.) Murr. (Scale bar = 1 cm)

4.1.2.7 POLYPORACEAE

Plate 35: *Bondarzewia* species

Ecological status: Rare

Location: Plot D

Substrate: Moist decaying logs

Morphodescription: Fruit body is fleshy to soft to spongy in texture, cream coloured to creamish pink, cap is convex to funnel shaped with a descending stalk and numerous pore running from cap to stalk in a decurrent manner. May be mistaken for *Grifola* or *Albatrellus* species

Phenology: August.

Plate 34: *Podoscypha* species (Scale bar = 1 cm)

Plate 36: *Daedalia quercina* Fr.
Ecological status: Rare
Location: Plot D
Substrate: Dry decaying logs
Morphodescription: Fruit body is bracket to fan shaped, non-stipitate, greyish brown in colour, leathery, pliant to papery texture with slight semicircular rays marking on the upper surface. Gills are replaced by non-fleshy deadaloid undersurface.
Penology: November

Plate 37: *Formes fomentarius* (Fr.) Kickx.
Ecological status: Common
Location: Plots D and E
Substrate: Dry decaying living and dead logs
Morphodescription: Fruit body is woody, dark greyish brown to greyish black with light grey zones, sessile or stalkless, hoof-shaped with circular light brown pores.
Penology: January to March

Plate 35: ***Bondarzewia*** **species (Scale bar = 1.3 cm)**

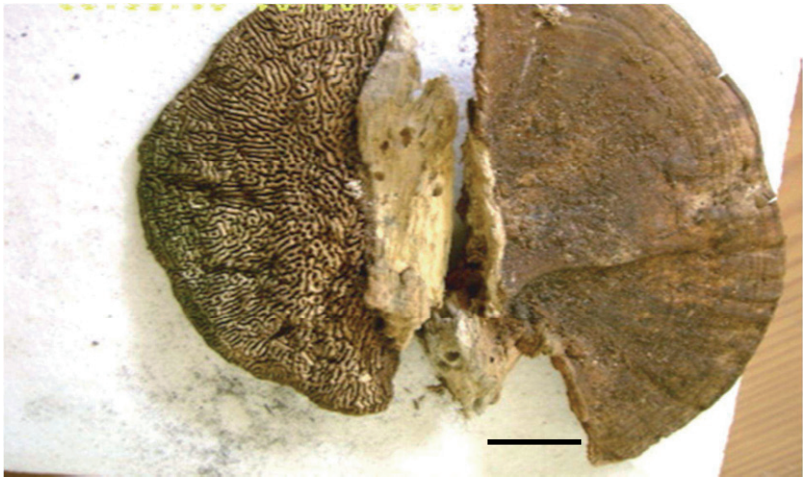


Plate 36: ***Daedalea quercina*** **Fr. (Scale bar = 1 cm)**

Plate 38: *Ganoderma applanatum* (Pers. ex Wall.) Pat.

Ecological status: Rare

Location: Plots B and D

Substrate: Dry and wet dead decaying logs, litter floor or on living trees (xylobiont)

Morphodescription: Fruit body is convex to steeply hoof-shaped, may be sessile or laterally stipitate, large bracket or semicircular shaped, corky or woody or hard with non-glossy dry darkish brown to greyish-black upper surface and grey to yellow lower surface, often warty and zoned or furrowed.

Penology: September to January.

Plate 37: ***Formes fomentarius*** **(Fr.) Kickx (Scale bar = 1 cm)**

Plate 39: *Ganoderma lucidum* (Leyss) P.Karst.

Ecological status: Common

Location: Plots C and D

Substrate: Dry and wet dead decaying logs or on living trees (xylobiont)

Morphodescription: Fruit body may be sessile or laterally stipitate, bracket or semicircular shaped, corky or hard with glossy dry reddish brown upper surface and milky to white lower surface.

Penology: August to November.

Plate 38: *Ganoderma applanatum* (Pers. ex Wall.) Pat. (Scale bar = 1 cm)

Plate 40: *Ganoderma tsugae* Murr.

Ecological status: Rare

Location: Plots B, C and E

Substrate: Dry and wet dead decaying logs, on living trees

Morphodescription: Fruit body is sessile or laterally or sometimes centrally stipitate (if present), kidney or fan or semicircular shaped, corky or hard with non-glossy dry reddish brown to reddish orange upper surface and grey to yellow lower surface, non-warty and zoned or furrowed.

Phenology: July to December.

Plate 39: ***Ganoderma lucidum*** **(Leyss) P.Karst. Dorsal and Ventral Surfaces (Scale bar = 1.5 cm)**

Plate 40: *Ganoderma tsugae* Murr. (Scale bar = 1 cm)

Plate 41: *Pycnoporus cinnabarinus* (Fr.) Kar.
Ecological status: Rare
Location: Plots B
Substrate: Decaying logs
Morphodescription: Fruit body is flat, sessile or laterally stipitate, kidney or fan or bracket or semicircular shaped, leathery to tough texture, plane with slightly visible semicircular ring on the upper surface, orange-red colour with cinnabar to orange-red pores.
Phenology: January.

Plate 42: *Trametes* species
Ecological status: Rare
Location: Plots D and E
Substrate: Dead log or wood
Morphodescription: Basidioma are woody, hard and bracket like without stalk. It is greyish brown in colour with visible circumferential rings or tiny furrow. Grey multipored under surface.

Phenology: January.

Plate 41: *Pycnoporus cinnabarinus* (Fr.) Kar. (Scale bar = 1 cm)

Plate 42: *Trametes* species (Scale bar = 1.8 cm)

4.1.2.8 SCHIZOPHYLLACEAE

Plate 43: *Schizophyllum commune* Fr.

Ecological status: Abundant

Location: Plots A, B, C, D and E

Substrate: Dry and wet decaying logs (xylobiont)

Morphodescription: Fruit body is fan shaped, non-stipitate coarsely fibrillose upper surface and concave i.e. centrally depressed. Stipe may be central or lateral while the fruit body is white. Gill decurrent, crowded and regular. Margin is entire and slightly incurved.

Phenology: All the year round.

4.1.2.9 STERACEAE

Plate 44: *Stereum purpureum* (Pers. ex Fr.) Fr.

Ecological status: common

Location: Plots D and E

Substrate: Dry and wet dead decaying logs (xylobiont)

Morphodescription: Fruit body is sessile or non-stipitate, kidney or fan or bracket or circular shaped, leathery texture with alternate pale and dark brown colour zonation on upper velvety surface. The lower surface is greyish brown and multipored.

Phenology: December to March.

Plate 43: *Schizophyllum commune* Fr. (Scale bar = 1 cm)

Plate 44: *Stereum purpureum* (Pers. ex Fr.) Fr. (Scale bar = 1.5 cm)

4.1.2.10 TREMELLACEAE

Plate 45: *Exidia thuretiana* (Lev.) Fr.
Ecological status: Rare
Location: Plot D
Substrate: Dry decaying logs
Morphodescription: Fruit body is whitish when fresh and milky coloured when dry, slimy to gelatinous to touch, jelly-like and appear as a convoluted or brain mass, stalkless and may be scattered.
Penology: August-September

Plate 46: *Tremella* species
Ecology status: Rare
Location: Plot A
Substrate: Dead decaying tree branch

Morphodescription: Fruit body is sessile or non-stipitate or where present rudimentary, jelly like, slimy and rubbery in texture with no particular shape and lots of aesthetically designed. The fruit body is creamish to whitish and ephemeral.

Phenology: September to December.

Plate 45: *Exidia thuretiana* (Lev.) Fr. (Scale bar = 5 mm)

Plate 46: *Tremella* species (Scale bar = 1 cm)

Plate 47: *Tremella fuciformis* Berk.

Ecology status: Rare

Location: Plots C and D

Substrate: Dead decaying logs.

Morphodescription: Fruit body is sessile or non-stipitate, jelly like, slimy and rubbery in texture with no particular shape. The fruit body is whitish and ephemeral.

Phenology: September to December.

4.1.2.11 XYLARIACEAE

Plate 48: *Daldinia concentrica* (Bolton) Ces and De Not.

Ecological status: common

Location: Plots A, B, C, D and E

Substrate: Tree branches and decayed wood/logs

Morphodescription: Fruit body is round to spherical ball or tuber, dark to light brown in colour, non-stipitate, hard to stony and resupinate.

Phenology: All year round.

Plate 47: *Tremella fuciformis* Berk. (Scale bar = 1 cm)

Plate 48: *Daldinia concentrica* (Bolton) Ces and De Not. (Scale bar = 1.5 cm)

Plate 49: *Xylaria polymorpha* (Pers. ex Mer.) Grev.

Ecological status: Common

Location C, D and E

Substrate: Dry and moist tree logs and stumps

Morphodescription: Fruit body is regularly clavate or finger like club, occurring in groups that may be co-joined at the base, blue black to brownish black colour without pileus and lamellae.

Phenology: January to December.

Plate 50: *Xylaria hypoxylon* (L. ex Hook.) Grev.

Ecological status: Common

Location: C and E

Substrate: Dry logs and stumps

Morphodescription: Fruit body is finger like club, occurring in clusters with series of irregular dichotomous branching almost at the centre, each branch with white apex, charcoal black in colour and daldinoid or tiny tuber-like.

Phenology: September to April.

Plate 49: ***Xylaria polymorpha*** **(Pers. ex Mer.) Grev. (Scale bars = 1 cm). Matured (nutrient-rich substrate) and immatured (nutrient-depleted substrate)**

Plate 50: ***Xylaria hypoxylon*** **(L. ex Hook.) Grev. (Scale bars = 5mm). Matured and young variety**

Plate 51: *Xylaria* species

Ecological status: Common

Location: D and E

Substrate: Dry logs and stumps

Morphodescription: Fruit body is finger like, club or irregularly clavate, apically curved atimes, in scattered group with regular dichotomous branching almost at the centre, each branch with white patches scattered on the fruit body or on apex, charcoal black in colour and daldinoid or tiny tuber-like.

Phenology: September to February.

Plate 51: *Xylaria* species (a = primordia heads, Scale bars = 1cm). Matured and immatured types

4.1.3 BIRD NEST, CUP FUNGI, BOLETS, EARTH STARS, PUFF BALLS AND CORAL MUSHROOMS

4.1.3.1 BOLETACEAE

Plate 52: *Leccinum* species

Ecological status: Rare

Location: Plot B

Substrate: Decomposing moist litterfall and soil

Morphodescription: Cap is convex to broadly, brownish, soft and smooth. Gills are replaced with numerous greyish brown pores. The stalk is thick, enlarge toward the base, greyish brown some distance from the cap and greyish black toward the base and visibly reticulate.

Phenology: September

4.1.3.2 GEASTRACEAE

Plate 53: *Geastrum saccatum* Fr.

Ecological status: Rare

Location: Plot E

Substrate: Decaying litter around the base of a tree

Morphodescription: Fruit body is round to spherical ball encirculed by starlike rays, brownish in colour with a central disc-like sac visible when the rays finally pen.

Phenology: August to September.

4.1.3.3 LEOTIACEAE

Plate 54: *Helotium citrinum* (Hedwig) Fr.

Ecological status: Rare

Location: Plot B

Substrate: Wet dead decaying logs

Morphodescription: Fruit body is lemon-yellow to yellowish pink, sessile or stalkless, cuplike and gregarious.

Phenology: September.

Plate 52: *Leccinum* species (Scale bar = 1cm)

Plate 53: *Geastrum saccatum* Fr. (a = Gleba, Scale bar = 1cm)

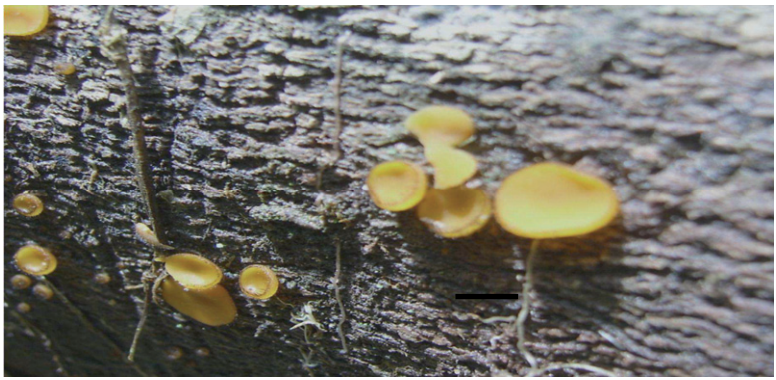


Plate 54: *Helotium citrinum* (Hedwig) Fr. (Scale bar = 1 cm)

4.1.3.4 LYCOPERDACEAE

Plate 55: *Calvatia cyathiformis* (Bosc) Morg.

Ecological status: Rare

Location: Plot D (within a gap and inside a deep created by fallen log)

Substrate: Decomposing litterfall within a gap and fully decomposed logs

Morphodescription: The fruit body is large, deep purple to chocolate brown with a flat base resupinate on ths subtrate and feels like paper to touch, puff to release purple cloud of dust/spores when dry.

Penology: January and February.

Plate 55: *Calvatia cyathiformis* (Bosc) Morg. (Scale bar = 1 cm)

4.1.3.5 NIDULARIALES

Plate 56: *Cyathus striatus* (Huds.) Willd. ex. Pers.

Ecological status: Rare

Location: Plots A, B,C, D and E

Substrate: Twigs tree branches and decayed wood/logs

Morphodescription: Fruit body is conical, that is broadly cup shaped or apex flaring outward, narrowing at the base with lined inner wall containing attached dark egg-like glebae. The fruit body is brownish grey to deep brown and a markedly grooved outer and inner wall.

Phenology: September to January.

4.1.3.6 PYRONEMATACEAE

Tarzetta rosea (Rea.) Dennis

Ecological status: Rare

Location: Plots A, B and D

Substrate: Bark of decayed soft logs/woods

Morphodescription: Reddish pink cluster of cuplike fruit bodies which differ from *Cookeina sulcipes* being smaller in size with short white stalk that is buried within substrates.

Phenology: September.

Plate 56: *Cyathus striatus* (Huds.) Willd. per Pers. (Scale bar = 1cm)

Plate 57: *Cookeina sulcipes* (Berk.) Kunt.

Ecologica status: Common

Location: Plots A, B and E

Substrate: Dead twig, the bark of tree branches and decaying logs

Morphodescription: Pink to pinkish white cluster of cup shaped sessile or short stalked and cartilaginous fruit bodies.

Phenology: July to November.

Plate 57: ***Cookeina sulcipes*** **(Berk.) Kunt. (Scale bar = 7mm)**

4.1.4 UNIDENTIFIED SPECIES

Plate 58: RRIN01

Ecological status: Common

Location: Plots A and B

Substrate: Dead decaying leaf litters

Morphodescription: Fruit body grows singly and scattered, with red coloured cap and an orange stipe. The cap is convex or hemispherical to broadly convex, smooth, and red when young to reddish orange when mature. Gills are adnate, regular distant to close and appear pinkish grey in colour. The stipe is smooth, central, equal, long (Ó4cm) and hollow.

Comment: It is probably a red *Marasmius acicular* or *Marasmiellus* species observed only on leaflitters during the rainy months of June to August with rhizomorphic attachment or mycelium base.

Plate 59: RRIN02
Ecological status: Rare
Location: Plot E
Substrate: Dry dead decaying log
Morphodescription: Fruit body occurred singly. It is deep red to reddish orange in colour, dry, spiky or spiny, shaped like a wine class with almost crispy texture and stipitate. The stalk is spikeless, broad immediately below the cup but tapers down to the base. The cap has a greyish white to interior base or hymenium with uneven margin and no gleba.
Comments: The fungus may be a spiny *Cookeina* of the Family Magnoliaceae or *Microstoma* in the Family Sarcoscyphacea. It was encountered once in the dry month of February with no smell and taste.

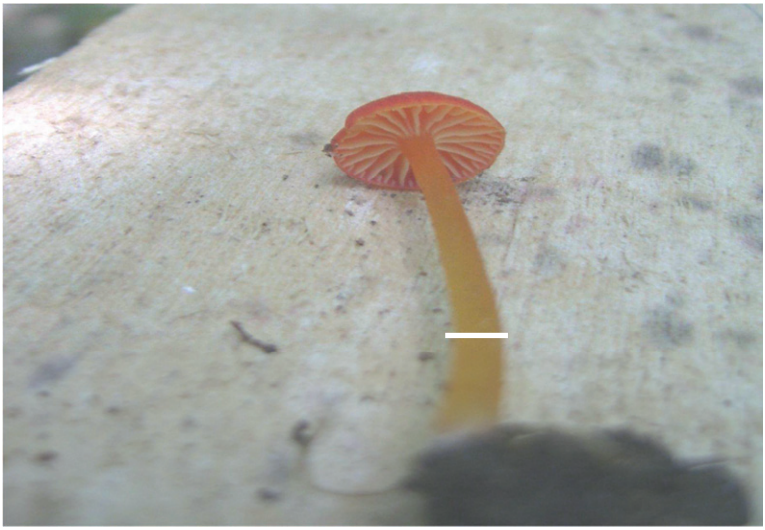


Plate 58: RRIN01 (Scale bar = 5 mm)

Plate 59: RRIN02 (Scale bar = 1 cm)

Plate 60: RRIN03
Ecological status: Rare
Location: Plot D
Substrate: Dead decaying logs
Morphodescription: Fruit body grows in groups with white pileus, conical to convex, smooth, and fleshy. Margin is smooth with attached gills that are regular and close. Stipe is delicate, central to eccentric, hollow, white especially close to the gills and whitish brown towards the base.
Comments: Fungus may be *Leptonia* or *Rhodophyllus*, both in the Family Entolomataceae and occurs during the rainy month of September. They are observed to be infested by insects at times and have not been known to be edible or used for other things.

Plate 62: RRIN04
Ecological status: Rare
Location: Plot B
Substrate: Dry dead decaying log
Morphodescription: Fruit body occurred singly and scattered. It is a white, leathery, hand-fan shaped mushroom (sporocarp) with a short lateral deep brown stipe terminated in a basal

disk. The pileus is flabelliform with a smooth white to cream coloured upper surface and a white multipored lower surface.

Comments: The fungus is colloquially a polypore mushroom (stipitate flabelliform) observed in the month of September only in plot B and may probably be a *Polyporus* species of the Family Polyporaceae.

Plate 60: RRIN03 (Scale bar = 1cm)

Plate 61: RRIN04 (Stipitate flabelliform) (Scale bar = 1cm)

Plate 62: RRIN05

Ecological status: Rare

Location: Plot B

Substrate: Moist dead decaying log

Morphodescription: Fruit body occurred singly and scattered. It is a pale brown mushroom (sporocarp), perhaps almost cup shaped, non-jelly with a rough, wrinkled, spongy, soft, deep chocolate brown, waterlogged, bulbous base or support.

Comments: The fungus may be a *Peziza* of the Family Pezizaceae or *Scutellina* of the Family Pyronemataceae observed infrequently in the month of March.

Plate 63: RRIN06

Ecological status: Common

Location: Plot D

Substrate: Dead decaying leaf litters

Morphodescription: Fruit body is usually numerous, pale yellow, jelly with spongy texture, coral-like with apical trichotomous branching.

Comment: Mushroom may be *Tremellodendron* species of the Family Tremellaceae that occurs within the rainy months of July and August in plot D characterised by layers of undergrowths and fallen logs. It is neither non-edible nor poisonous.

Plate 62: RRIN05 (*Scutellina*) (Scale bar = 1cm)

Plate 63: RRIN06 (False coral) (Scale bar = 5mm)

Plate 64: RRIN07

Ecological status: Rare

Location: Plots A and B

Substrate: Dry dead decaying log

Morphodescription: Fruit bodies are occur singly and are scattered. It is a greyish brown, basally tapering and apically flaring, clavate mushroom (sporocarp) with an apical cream coloured afro-like or brush-like branching that produce white cloud of spores when touched.

Comments: The fungus may be a *Clavaria* species of the Family Clavariaceae ripe for or in the middle of spore discharge. It is observed especially between the months of September and November.

Plate 65: RRIN08

Ecological status: Rare

Location: Plot A

Substrate: Dry dead decaying log

Morphodescription: Fruit body greyish pink with numerous folds or rosette folial arrangement flaring out from one basal short stalk and terminating in tiny mosaic fork.

Comments: The fungus is definitely too small to be edible, lack any smell or taste and observed around March.

Plate 64: RRIN07 Afro fungus (Scale bar = 5mm)

Plate 65: RRIN08 (Scale bar = 1cm)

Plate 66: RRIN09

Ecological status: Rare

Location: Plots A and B

Substrate: Small dead decaying coarse woods

Morphodescription: Fruit body is usually inserted, singly, in groups of twos or threes, whitish grey in colour with a central stipe. The cap is campanulate to broadly parabolic, smooth, greyish white, plicate striate with a smooth margin. Gills are adnexed, distant to close, regular and white to cream coloured. Stipe is fragile, white to greyish white in colour, central, long, slender, equal and inserted.

Comment: It is probably a *Mycena rubromarginata* of the Family Tricholomataceae or *Coprinus* of the Family Coprinaceae species, observed during the rainy months of July to August with know identifiable taste and a mealy smell.

Plate 67: RRIN10

Ecological status: Rare

Location: Plot E

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is inserted, gregarious with golden to brownish gold coloured, pubescent or spiky cap and a central, brown stipe. The cap is uplifted to slightly depressed and indented at the centre. The gills are decurrent, attached, whitish in colour, even and terminates in a smooth margin. The stipe is brown, pubescent, equal and not less than 2mm thick.

Comment: It is pleurotoid, perhaps a *Lentinus* species of the Family Tricholomataceae or a spiky *Pleurotus* species of the Family Pleurotaceae, observed only in the wet season of August to September.

Plate 68: RRIN11

Ecological status: Rare

Location: Plots A and B

Substrate: Dead decaying logs and coarse woods buried in decomposing litterfalls.

Morphodescription: Fruit body is polyporoid, bracket shaped or semicircular shaped, fleshy, gregarious, snow white with rough almost prunoise upper surface and reticulate or hexagonal lower surface comprising the hymenium layer. Stalk is absent or off-centre to lateral stublike in nature.

Comment: It may be *Favolus* or *Polyporus* species (hexagonal polypore) both of the Family Polyporaceae observed infrequently from July to September.

Plate 66: RRIN09 (Scale bar = 6 mm)

Plate 67: RRIN10 (Scale bar = 5mm)

Plate 68: RRIN11 Hexagonal polypore (Scale bar = 1 cm)

Plate 69: RRIN12

Ecological status: Rare

Location: Plot B

Substrate: Dead decaying litterfalls.

Morphodescription: Fruit body made up a cap and thick stalk. The cap is smooth, hemispherical to parabolic, shallowly depressed, almost sulcate striate and pale brown in colour with wavy margin. The gills are close, regular, attached and pale brown in colour. Stipe is long, pale brown to cream coloured, central, equal with or without an apparent sac-like structure or sheathing.

Comment: It is a *Mycena* species of the Family Tricholomataceae and it was observed only in the month August. The stipe as observed in some species may have picked up decomposing material appearing as sac-like structure.

Plate 69: RRIN12 (Scale bars = 7.5mm)

Plate 70: RRIN13

Ecological status: Rare

Location: Plot E

Substrate: Dead decaying decomposing litterfalls or buried coarse woods.

Morphodescription: Cap is smooth, white, striate, convex to campanulate with a slight central depression and wavy margin. Gills are free, regular, close and white. Stalk is frail, brown in colour, long (Ó4cm), central, equal and sometime ending in a visible mycelia pad.

Comment: It is M*ycena* species of the Family Tricholomatacaea with a sweat smell, observed infrequently in July on wet litters

Plate 71: RRIN14
Ecological status: Rare
Location: Plot C
Substrate: Dead decaying trees and logs
Morphodescription: Fruit body is fleshy with a typical brownish grey cap and a cream coloured stipe. The pileus is smooth, broadly convex with a slight central umbo or papilla. Margin is faintly striate. Gills are crowded, attached, smooth, regular and terminated in a smooth margin. Stipe is hollow, smooth, inserted, equal and central.
Comment: Mushroom may be a *Hygrocybe* species of the Family Hygrophoracaea. It occurs in the months of April and March usually at the base of fallen logs and ephemeral as they do not easily preserve. Nibbling of the cap is indication that it might be edible by small animals.

Plate 70: RRIN13 (Scale bar = 1cm)

Plate 71: RRIN14 (Scale bar = 1cm)

Plate 72: RRIN15
Ecological status: Rare
Location: Plot C
Substrate: Dead decaying tree stumps and logs
Morphodescription: Fruit body is inserted, scattered with cap and a central stipe. The cap is parabolic to broadly convex, warty when young to scurfy at maturity, dark brown background with greyish warts and tacky. Gills are attached, snow white in colour, close, smooth and even. Stalk is initially spherical with circumsessile base above which are local glandular dots. At maturity, the stipe stretches to cylindrical shape with the cap becoming less scurfy.
Comment: The agaric only grows on logs with the tendency to differ when mature. It may be an *Amanita* or a *Lepiota* species of the Family Agaricaceae occurring only on a few occasions in the month of March and October.

Plate 73: RRIN16
Ecological status: Rare
Location: Plot E
Substrate: Dead decaying tree stumps and logs
Morphodescription: Fruit bodies are small, gregarious, leathery, non-fleshy and numerous kidney-shaped, cap with not so easily observed lateral stipe. The gills are crowded, regular, darker brown, smooth and terminated in a smooth margin.

Comment: It is observed only in plot E around February though rare and may be a *Crepidotus* species of the Family Crepidotaceae.

Plate 72: RRIN15 (Scale bars = 1cm). Matured and young species.

Plate 73: RRIN16 (Scale bar = 6mm)

Plate 74: RRIN17

Ecological status: Rare

Location: Plots A and B

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is bracket shaped, dry, scattered sessile with a notch, polyporoid, hard to papery in texture, rough surfaced with tiny semicircular rings appearing almost equidistant from each other each with a different shade of brown. The lower surface is whitish grey in colour, made up of wide numerous pentagonal to circular pores or faveolate or honeycomb-like hymenophore.

Comment: It is observed from around January and may be a *Panellus* or *Hexagonia* species.

Plate 75: RRIN18

Ecological status: rare

Location: Plots C and D

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is bracket shaped, leathery, crowded, sessile, polyporoid with concentric colour zonation of beige and brown. The upper surface is smooth while the lower surface is cream in colour.

Comment: It is observed July to August and may be a young *Coltricia* species of the Family Polyporaceae.

Plate 74: RRIN17 (Scale bar = 8 mm)

Plate 75: RRIN18 (Scale bar = 1 cm)

Plate 76: RRIN19

Ecological status: Rare

Location: Plot E

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is funnel-shaped, non-fleshy but rather polyporoid, glossy, smooth, leathery, scattered, stipitate with concentric colour zonation of white and reddish brown. The under surface is shiny white and glossy with no visible pores. The stipe is central, equal, smooth, glassy and terminated in a basal disc.

Comment: It is observed from July to August and may be a young *Coltricia* of the Family Polyporaceae or *Coriolus* species the Family Hymenochaetaceae.

Plate 77: RRIN20

Ecological status: Rare

Location: Plot A

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is initially funnel-shaped and becoming completely flat, whitish marginate, non-fleshy but rather polyporoid, glossy, smooth, leathery, scattered, stipitate with concentric shades of brown colour zonation. The stipe is central to eccentric, equal, smooth, glassy and terminated in a basal disc.

Comment: It is observed from July to August and may be a young *Coltricia* or *Trogia* species.

Plate 78: RRIN21

Ecological status: Rare

Location: Plots A and D

Substrate: Dead decaying tree stumps and logs

Morphodescription: Fruit body is bracket-shaped, whitish marginate, non-fleshy, non-velvety but rather polyporoid, smooth, leathery, gregarious, sessile with concentric colour zonation.

Comment: It is observed at the base of trees from February to March and may be a *Trametes versicolor* (Family Polyporaceae).

Plate 76: RRIN19 (Scale bars = 1 cm)

Plate 77: RRIN20 (Scale bar = 6mm)

Plate 79: RRIN22

Ecological status: Common

Location: Plot C, D and E

Substrate: Buried logs and litterfalls

Morphodescription: Fruit body is whitish grey, gregarious, fleshy agaric with a typical cap and stipe. The cap is white but turns pink to reddish in bruised regions or hygrophanus, broadly convex to plane and smooth. Gills are regular, smooth, attached and crowded. Stalk is thick, central, hygrophanus, caespitose and grows into a mycelium pad.

Comment: It is likely to be *Hygrophorus* species (Family Hygrophoraceae) and were observed in the rainy months.

Plate 78: RRIN21 (Scale bar = 1cm)

Plate 79: RRIN22 (Scale bar = 1cm)

Plate 80: RRIN23

Ecological status: Rare

Location: Plots D and E

Substrate: Decomposing leaf litters

Morphodescription: Fruit body is a fleshy agaric with a typical stipe and cap. The cap is parabolic, dirty brown colour, scurfy to warty, rough with smooth margin. Gills are crowded, regular, adnexed, white and smooth. Stipe is greyish brown except towards the gills, covered with a long sheath which ends in an upturned annulus-like structure, equal with a bulbous base, non-squamulose and rhizoidal.

Comment: It is observed on the plantation/forest floor in March and may be a *Amanita* of the Family Amanitaceae or *Lepiota* of the Family Agaricaceae.

Plate 81: RRIN24

Ecological status: Rare

Location: Plot A

Substrate: Decomposing leaf litters

Morphodescription: Fruit body is a coffee brown, fleshy agaric with a typical stipe and cap. The cap is convex, shallowly depressed at the center, smooth with almost incurved margin. The gills are slightly decurrent, crowded, regular, lighter shade of coffee brown colour. The stipe is long, central, equal, almost velvety to touch and smooth.

Comment: Mushroom is a *Clitocybe* species (Family Tricholomataceae) and occurs during the month of August. The cream patch of deposit on one of the mushrooms in the picture may be as a result of bird droppings and not observed in all others.

Plate 80: RRIN23 (Scale bar = 1cm)

Plate 81: RRIN24 (Scale bars = 7mm)

Plate 82: RRIN25

Ecological status: Rare

Location: Plot D

Substrate: Decaying fallen logs and trees

Morphodescription: Fruit body is pale pink, fleshy agaric with a typical stipe and cap. The cap is parabolic to campanulate, pale pink, smooth with observed trace of wrinkling. The gills

are adnate, close, regular, light pink in colour. The stipe is long, central, equal, dark to pale pink and almost pruinoise.

Comment: Mushroom is a *Mycena* species (Family Tricholomataceae) and was encountered less than 4 times between the months of June and August.

Plate 83: RRIN26

Ecological status: Rare

Location: Plots C and D

Substrate: Dead decaying logs.

Morphodescription: Fruit body is a fleshy, white garic with a typical stipe and cap. The cap is broadly convex to slightly uplifted, whitish with few central rusty brown spots. Gills are distant regular, adnexed, white and smooth. Stipe is whitish brown, pruinoise, non-squamulose and terminated in a basal disc.

Comment: Mushroom was observed in the rainy month of July and could be a *Marasmius* species (Family Tricholomataceae) or *Lepiota* species (Family Agaricaceae).

Plate 82: RRIN25 (Scale bar = 5mm)

Plate 83: RRIN26 (Scale bar = 1cm)

Plate 84: RRIN27
Ecological status: Common
Location: Plots A and B
Substrate: Decomposing leaf litters
Morphodescription: Fruit body is a whitish grey, fleshy with a typical stipe and cap. The cap is convex to plane, grey mammilate or flattened umbo centrally located and margin almost rimose to lacerated. The gills are crowded, regular, adnex and white in colour. The stipe is long, central, equal, smooth, apically annulated and terminated in a mycelial pad.
Comment: It is probably a *Lepiota* species (Family Agaricaceae) or *Agrocybe* (Family Bolbitiaceae) and occurs during the Months of August and September.

Plate 85: RRIN28
Ecological status: Rare
Location: Plot D
Substrate: Dead decaying logs.
Morphodescription: Fruit body is polyporoid, bracket shaped, dry, and leathery in texture, pileat sessile with greyish white upper surface, non-porioid but instead crisped to almost toothlike.

Comment: Mushroom was observed in the dry months of January and February. It is perhaps a Trametes species (Family Polyporaceae).

Plate 84: RRIN27 (Scale bar = 1cm)

Plate 85: RRIN28 (Scale bar = 1cm)

Plate 87: RRIN29

Ecological status: Rare

Location: Plot E

Substrate: Soil and litters.

Morphodescription: Fruit body is polyporoid, dry, leathery in texture, pileat stipitate with brownish cap and a long pubescent stipe which terminated in a bulbous sclerotium. The cap has a white under-surface, porioid and terminated in a smooth margin. The stipe is central, equal and brownish in colour.

Comment: Mushroom was observed in rainy month of August. It is perhaps a *Rigidoporus rhinoceros* or *Polyporus* species (Family Polyporaceae).

Plate 87: RRIN29 (Scale bar = 1cm)

4.2 Composition of mushroom flora

A total of 93 species of mushrooms comprising of 9% Asomycetes and 91% Basidiomycetes were encountered throughout the duration of study out of which 64 species

(10.9% Asomycetes and 89.1 Basidiomycetes) are identified and named. The identified and named genera are distributed into 28 families, 9 orders and 4 classes. The class Hymenomycetes (57%) and family Tricholomataceae (17.19%) recording the highest number of mushroom taxa. The distribution of mushroom floras into various, sampling plots (A ï E), sub-divisions, classes, orders and families, and their composite genera is outlined in Table 1. Plot E recorded the highest number of species (25%) while Plot A registered the least (18%) as shown in Table 2. The variation and differences in the distribution of mushroom taxa into sub-divisions, classes and families are also illustrated in Fig. 1A, Fig. 1B and Fig. 2 respectively. Attempt was also made to categorise all the observed mushroom taxa into five informal life form classes according to Lincoff (2005) which include Clavate/club mushrooms, Cup/tuber mushrooms, Earth stars/puff balls, Gill mushrooms and Polypores as illustrated by Fig. 3B. Phenological information and nature of growth substrate for each taxon are also enumerated in Table 1 and Fig. 3A. Number of species per sampling plots and the total number of exclusive species are outlined in Table 2. A total of 435 fruit bodies (abundance) belonging to 93 species were recorded on a total area of 3125 m^2. *Auricularia auricular*, *Coprinus acuminatus*, *Cyathus striatus*, *Daldinia concentrica*, *Nothopanus* sp., *Pleurotus squarrosulus* and *Schzophyllum commune* were the 8 only species of mushrooms observed to be common to all the sampled plots and persist through out the duration of study hence are described as perennial species. The aforementioned species were also all observed to be strict wood colonizers. Plot E recorded the highest number (16 species) of exclusive (endemic) species some of which include *Cantharellus tubaeformis*, *Chlorophyllum* sp., *Geastrum saccatum*, *Lepiota* sp., *Macrolepiota* sp., *Marasmius graminum*, *M. pulcherripes*, *Russula* sp. and *Volvariella volvceae* while Plot B recorded the least number (5 species) of exclusive species out of which only 2 species are yet to be correctly identified. It was also observed that 20.6% of the unidentified (new) species are exclusive to Plot E when compared with Plots A (10.35%), B (6.9%), C (10.35%) and D (10.35%). The average number of fruit bodies per species per duration of study equals 425/93 = 4.57 according to Straatsma *et al*. (2001) and Straatsma and Krisal-Greilhuber (2003).

Many mushroom taxa (70%) were observed to colonise different woods (dead decaying woods Ó12 cm diameter, coarse woods Ò2 cm, fallen tree branch Ò8 cm, buried wood of various dimensions, tree stump and living trees) as substrate base while only about 7% of the total mushroom encountered grows on soil. With only 19.36% capable of growing on two different kinds of substrates which include any two of wood base, living trees, soil

and decomposing litters respectively (Fig. 3A). *Chlorophyllum* species, *Coprinus atramentarius*, *Hygrocybe* species and *Pleurotus tuberregium* are examples of mushrooms with facultative substrate habit.

Table 1: Checklist of mushrooms species, incidence data per plot, phenology, sociability and nature of substrate.

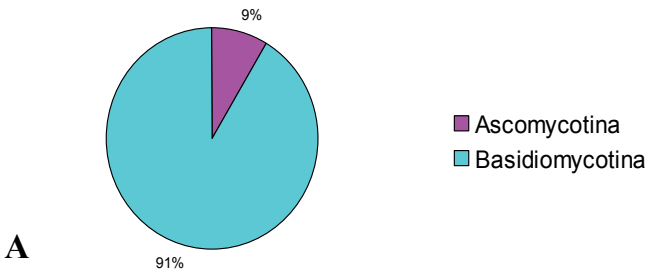
s/n	Species	SAMPLE PLOTS					Phenology	Soc.	Substrate
		A	B	C	D	E			
	ASCOMYCOTINA								
	****DISCOMYCETES**								
	***HELOTIALES**								
	*LEOTIACEAE								
1	*Helotium citrinum* (Hedwig) Fr.	-	+	-	-	-	Sept.	5	DW
	***PEZIZALES**								
	*PYRONEMATACEAE								
2	*Tarzetta rosea* (Rea.) Dennis	+	+	-	+	-	Sept.	4	DW
	*SARCOSCYPHACEAE								
3	*Cookeina sulcipes* (Berk.) Kunt.	+	+	-	-	+	Jul. - Nov.	4	DW
	****PYRENOMYCETES**								
	***SPHAERIALES**								
	*XYLARIACEAE								
4	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	+	+	+	+	+	AYR	2	DW
5	*Xylaria* sp.	-	-	-	+	+	Sept. - Feb.	5	DW
6	*X. hypoxylon* (L. ex Hook) Grev.	-	-	+	-	+	Sept. - April.	5	DW
7	*X. polymorpha* (Pers. ex Mèr.) Grev.	-	-	+	+	+	Jan. - Dec.	4	DW
	**UNIDENTIFIED								
8	RRIN02	-	-	-	-	+	Jun. - Aug.	1	DW
	BASIDIOMYCOTINA								
	****HYMENOMYCETES**								
	***AGARICALES**								
	**AGARIC FUNGI								
	*AGARICACEAE								
9	*Agaricus arvensis* Schaeff.	+	-	-	-	-	Jun.	1	DL
10	*Chlorophyllum* sp.	-	-	-	-	+	Jul.	2	DL, S
11	*Lepiota* sp	-	-	-	-	+	Aug.	1	S
12	*Macrolepiota* sp.	-	-	-	-	+	Sept.	1	S
	*AMANITACEAE								
13	*Amanita phylloides* (Vail.) Secretan.	-	-	-	+	+	Jan, - Aug.	2	DW

	*BOLETACEAE								
14	*Leccinum* sp.	-	+	-	-	+	Sept	1	DL, S
	*COPRINACEAE								
15	*Copinus acuminatus* (Romagn.) P.D. Orton	+	+	+	+	+	Jun.- Aug.	2	DL
16	*Coprinus atramentarius* Ulje and Bas.	+	+	-	-	-	Jul.-Sept.	2	DL, DW
17	*Coprinus disseminatus* (Pers. ex Fr.) S.F.G.	+	+	-	-	-	Jul.-Sept.	2	DL
18	*Omphalina chrysophylla* (Fr.) Murrill	-	-	+	+	-	Sept.	2	DW
19	*Panaeolus foenisecii* Pers:Fr) Kuhner	+	+	-	-	-	Jun-Sept.	2	DW
	*CREPIDOTACEAE								
20	*Crepidotus mollis* (Bull.) Kummer	+	+	+	-	-	Aug.-Nov.	5	DW
	*HYGROPHORACEAE								
21	*Hygrocybe* sp.	-	-	-	+	-	Jul.-Sept.	2	DL, S
	*PLEUROTACEAE								
22	*Nothopanus* sp.	+	+	+	+	+	AYR	2	DW
23	*Pleurotus* sp.	-	-	+	+	-	Jun - Sept.	1	DW, S
24	*P. squarrosulus* (Fr.) Kummer	+	+	+	+	+	AYR	4	DW
25	*P. tuberregium* (Fr.) Singer	-	-	+	+	-	Jul.	2	DW, S
	*PLUTACEAE								
26	*Pluteus cervinus* (Schaeff. ex Fr.) Kummer	-	-	+	-	-	Aug.	4	DW
27	*Volvariella volvaceae* (Bull. ex Fr.) Singer.	-	-	-	-	+	Jul.-Aug.	1	DW
	*RUSSULACEAE								
28	*Russula* sp.	-	-	-	-	+	Sept.- Nov.	4	TB
	*TRICHOLOMATACEAE								
29	*Clitocybe* sp.	+	+	-	-	-	Jun. - Jul.	2	DL
30	*C. dealbata* (Sow.) Gillet.	+	+	+	-	-	Jun.- Sept.	2	DL
31	*Marasmius graminum* (Libert) Berkeley	-	-	-	-	+	Aug. - Sept.	2	CW, DL
32	*M. lachnophyllus* Berkeley	+	-	-	-	-	Jul. - Aug.	2	CW, DL
33	*M. pulcherripes* Peck	-	-	-	-	+	Jul. - Aug.	2	CW, DL
34	*M. rotula* (Fr.) Scope	+	+	-	-	+	Jun. - Sept.	2	CW, DL
35	*Marasmiellus* sp.	+	+	-	-	-	Aug. - Sept.	2	DW
36	*Megacollybia platyphylla* (Pers.) kotl. and Pouzar.	-	-	-	+	+	Aug. - Sept.	1	DW
37	*Mycena* sp.	+	+	-	-	-	Jul. - Aug.	2	CW, DL
38	*Panellus* sp.	+	+	+	-	-	Sept.	1	DW
39	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	-	-	+	+	+	Aug. - Sept.	2	DW
	***APHYLLOPHORALES**								
	**POLYPORE								
	*AURICULARIACEAE								
40	*Auricularia auricula* Judae (Bull.) Pat.	+	+	+	+	+	AYR	2	DW

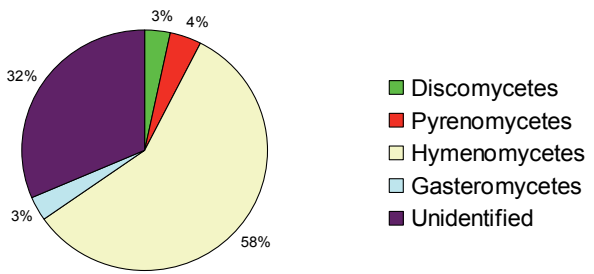
	*CANTHARELLACEAE								
41	*Cantharellus tubaeformis* (Bull.) Fr.	-	-	-	-	+	Jul. - Sept.	4	DW
	*CLAVARIACEAE								
42	*Clavulina* sp.	-	-	-	+	+	Sept.	5	DW
43	*Clavulinopsis* sp.	-	-	-	-	+	Jul.	4	DW
44	*Thelephora* sp. A	-	-	+	-	-	Sept.	1	DW
45	*Thelephora* sp. B	-	-	+	+	-	Oct. - Nov.	1	DW
	*HYDNACEAE								
46	*Hericium ramosum* (Bull. ex Mèr.) Let.	+	+	-	-	-	Sept. - Oct.	1	DW
	*HYMENOCHAETACEAE								
47	*Coltricia perennis* L.: Fr.) Murr.	+	+	-	-	+	AYR	4	DW
	*PODOSCYPHACEAE								
48	*Podoscypha* sp.	-	-	+	-	-	Jun.	4	DW
	*POLYPORACEAE								
49	*Bondarzewia* sp.	-	-	-	+	-	Aug.	2	DW
50	*Daedaelia quercina* Fr.	-	-	-	+	-	Nov.	2	DW
51	*Fomes fomentarius* (Fr.) Kickx.	-	-	-	+	+	Jan. - Mar.	1	DW, T
52	*Ganoderma applanatum* (Pers. ex Wall.) Pat.	-	+	-	+	-	Sept. - Jan.	1	DW, DL
53	*G. lucidum* (Leyss.) P,Karst	-	-	+	+	-	Aug.	2	DW
54	*G. tsugae* Murrill	-	+	+	-	+	Jul.- Dec.	2	DW, T
55	*Pycnoporus cinnabarinus* (Fr.) Kar.	-	+	-	-	-	Jan.	4	DW
56	*Trametes* sp.	-	-	-	+	+	Jan.	2	DW
	*SCHIZOPHYLLACEAE								
57	*Schizophyllum commune* Fr.	+	+	+	+	+	AYR	5	DW
	*STEREACEAE								
58	*Stereum purpureum* (Pers ex Fr.) Fr.	-	-	-	+	+	Dec. - Mar.	5	DW
	*****DACRYMYCETALES**								
	*DACRYMYCETACEAE								
59	*Calocera cornea* (Batsch.).Fr.	-	+	-	-	-	Jul.	5	DW
	*****TREMELLALES**								
	*TREMALLACEAE								
60	*Exidia thurentiana* (Lev.) Fr.	-	-	-	+	-	Aug. - Sept.	2	DW
61	*Tremella* sp	+	-	-	-	-	Sept.- Dec.	2	DW
62	*T. fuciformis* Berkeley	-	-	+	+	-	Sept.- Dec.	2	DW
	******GASTEROMYCETES**								
	*****LYCOPERDALES**								
	**STOMACH FUNGI								
	*GEASTRACEAE								

63	*Geastrum saccatum* Fr.	-	-	-	-	+	Aug. - Sept.	2	DW
	*LYCOPERDACEAE								
64	*Calvatia cyathiformis* (Bosc.) Morg.	-	-	-	+	-	Jan. - Feb.	1	DL
	***NIDULARIALES								
	*NIDULARIACEAE								
65	*Cyathus striatus* (Huds.) Willd.	+	+	+	+	+	Sept. - Jan.	5	CW,DW
	**UNIDENTIFIED								
66	RRIN01	+	+	-	-	-	Jun. - Aug.	1	DL
67	RRIN03	-	-	-	-	+	Feb.	2	DW
68	RRIN04	-	+	-	-	-	Sept.	1	DW
69	RRIN05	-	+	-	-	-	Mar.	1	DW
70	RRIN06	-	-	-	+	-	Jul. - Aug.	2	DW, TB
71	RRIN07	+	+	-	-	-	Sept. - Nov.	1	DW
72	RRIN08	+		-	-	-	Mar.	1	DW
73	RRIN09	+	+	-	-	-	Jul. - Aug.	2	CW
74	RRIN10	-	-	-	-	+	Aug. - Sept.	2	DW
75	RRIN11	+	+	-	-	-	Jul. - Sept.	2	DL
76	RRIN12	-	-	-	-	+	Jul.	1	DL
77	RRIN13	-	-	+	-	-	Apr. - Mar.	2	DW
78	RRIN14	-	-	+	-	-	Mar. - Oct.	2	DW
79	RRIN15	-	-	+	-	-	Mar. - Oct.	4	DW
80	RRIN16	-	-	-	-	+	Feb.	5	DW
81	RRIN17	+	+	-	-	-	Jan.	2	DW
82	RRIN18	-	-	+	+	-	Jul. - Aug.	3	DW
83	RRIN19	-	-	-	-	+	Jul. - Aug.	2	DW
84	RRIN20	+	-	-	-	-	Jul. - Aug.	2	DW
85	RRIN21	+	-	-	+	-	Feb.	2	DW
86	RRIN22	-	-	+	+	+	Mar.- Sept.	3	BW, DL
87	RRIN23	-	-	-	+	+	Mar.	1	DL
88	RRIN24	+	-	-	-	-	Aug.	2	DL
89	RRIN25	-	-	-	+	-	Jun. - Aug.	4	DW
90	RRIN26	-	-	+	+	-	Jul.	2	DW
91	RRIN27	+	+	-	-	-	Aug. - Sept.	1	DL
92	RRIN28	-	-	-	+	-	Jan. - Feb.	2	DW
93	RRIN29	-	-	-	-	+	Aug.	1	DL, S

****Class, ***Order, **Group, *Family, + = Present, - = Absent, AYR = All year round, BW = Burried wood, CW = Coarse wood, DL = Decomposing litters, DW = Dead decaying wood (tree stump and fallen logs), S = Soil, T = Living tree, TB = Tree branch.



A



B

Fig. 3: Mushroom taxa distribution into (A) Sub-division and (B) Classes.

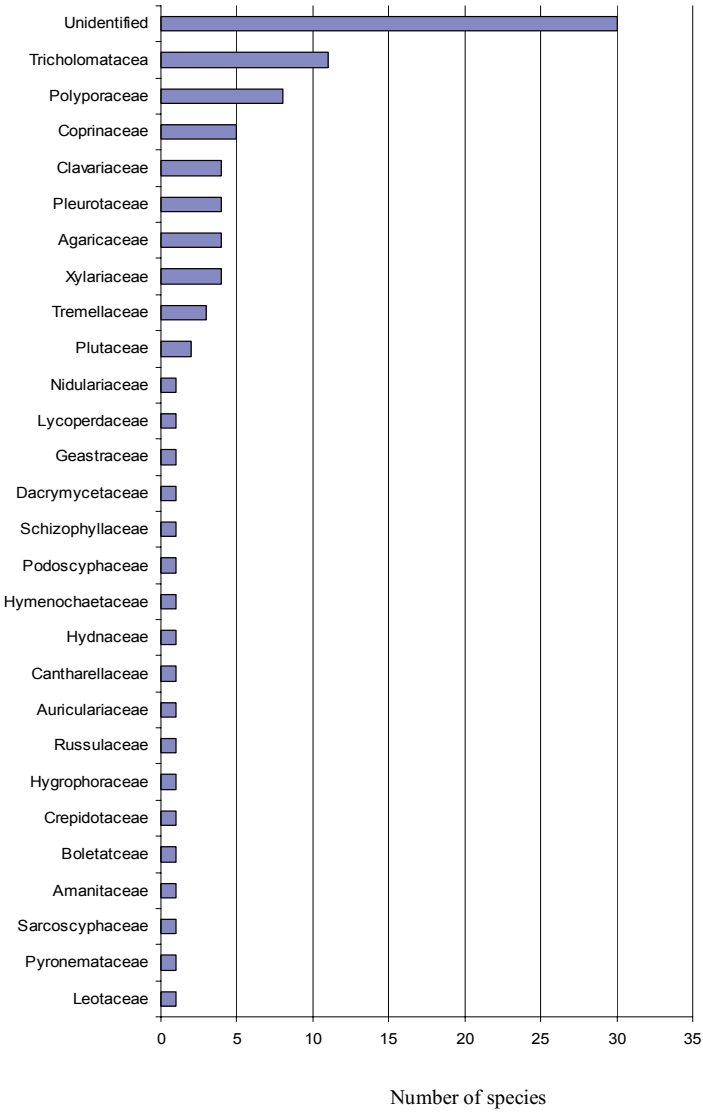


Fig. 4: Illustration of Family distribution of mushroom taxa recorded during the study.

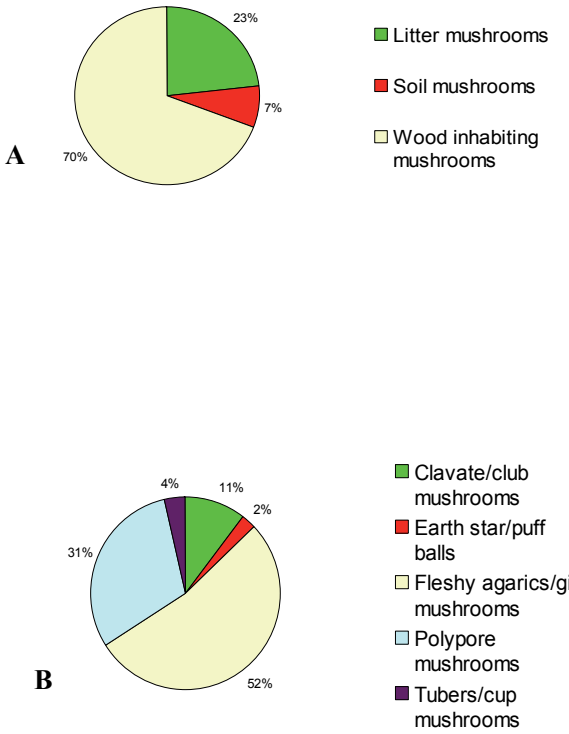


Fig. 5: Mushroom species substrate propensity (A) and mushroom taxa distribution into life-form groups (B).

Table 2: Species distribution, abundance and number of exclusive taxa between sampled plots per duration of study

SAMPLED PLOT	NUMBER OF SPECIES	ABUNDANCE (No of fruit bodies)	NUMBER OF SP. EXCLUSIVE TO PLOT
A	31	83	6
B	32	88	4
C	29	86	6
D	36	78	8
E	40	90	16

Table 3: Abundance (A), density (D), fidelity (F) and relative density (RD) parameters per sample plots of the study area

	Species	PLOT A				PLOT B				PLOT C				PLOT D				PLOT E			
		A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD
	ASCOMYCOTINA																				
	Daldinia concentrica (Bolt. Ex Fr) Ces.																				
1	and DeNot	5	0.008	4	6.024	5	0.008	4	5.682	6	0.010	4	6.977	3	0.005	4	3.846	3	0.005	4	3.333
2	*Cookeina sulcipes* (Berk.) Kunt.	4	0.006	2	4.819	3	0.005	2	3.409	-	-	5	-	-	-	5	-	3	0.005	2	3.333
3	*Helotium citrinum* (Hedwig) Fr.	-	-	5	-	2	0.003	1	2.273	-	-	5	-	-	-	5	-	-	-	5	-
4	*Tarzetta rosea* (Rea.) Dennis	-	-	5	-	4	0.006	2	4.545	-	-	5	-	2	0.003	2	2.564	-	-	5	-
5	*Xylaria* sp.	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	2	2.564	2	0.003	2	2.222
6	*X. hypoxylon* (L. ex Hook) Grev.	-	-	5	-	-	-	5	-	5	0.008	2	5.814	-	-	5	-	4	0.006	2	4.444
7	*X. polymorpha* (Pers. ex Mèr.) Grev.	-	-	5	-	-	-	5	-	1	0.002	3	1.163	2	0.003	3	2.564	2	0.003	3	2.222
8	RRIN02	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.222
	BASIDIOMYCOTINA																				
9	*Agaricus arvensis* Schaeff.	3	0.005	1	3.614	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
10	*Auricularia auricula* Judae (Bull.) Pat.	4	0.006	4	4.819	5	0.008	4	5.682	6	0.010	4	6.977	3	0.005	4	3.846	3	0.005	4	3.333
11	*Amanita phylloides* (Vail.) Secretan.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	2	-	1	0.002	2	1.111
12	*Bondarzewia* sp.	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.564	-	-	5	-
13	*Cantharellus tubaeformis* (Bull.) Fr.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.222
14	*Calocera cornea* (Batsch.).Fr.	-	-	5	-	2	0.003	1	2.273	-	-	5	-	-	-	5	-	-	-	5	-
15	*Calvatia cyathiformis* (Bosc.) Morg.	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.282	-	-	5	-
16	*Chlorophyllum* sp.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	1	3.333
17	*Clavulina* sp.	-	-	5	-	-	-	5	-	2	0.003	3	2.326	-	-	5	-	3	0.005	3	3.333
18	*Clavulinopsis* sp.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.111

Table 3: Abundance (A), density (D), fidelity (F) and relative density (RD) parameters per sample plots of the study area (continued)

	Species	PLOT A				PLOT B				PLOT C				PLOT D				PLOT E			
		A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD
19	*Clitocybe* sp.	2	0.003	2	2.410	3	0.005	2	3.409	-	-	5	-	-	-	5	-	-	-	5	-
20	*C. dealbata* (Sow.) Gillet.	2	0.003	3	2.410	2	0.003	3	2.273	3	0.005	3	3.488	-	-	5	-	-	-	5	-
21	*Coltricia perennis* L.: Fr.) Murr.	3	0.005	4	3.614	3	0.005	4	3.409	-	-	5	-	-	-	5	-	2	0.003	4	2.222
22	*Copinus acuminatus* (Romagn.) P.D. Orton	7	0.011	4	8.434	7	0.011	4	7.955	3	0.005	4	3.488	3	0.005	4	3.846	2	0.003	4	2.222
23	*Coprinus atramentarius* Ulje and Bas.	4	0.006	2	4.819	3	0.005	2	3.409	-	-	5	-	-	-	5	-	-	-	5	-
24	*Coprinus disseminatus* (Pers. ex Fr.) S.F.G.	2	0.003	2	2.410	-	-	2	-	-	-	5	-	-	-	5	-	-	-	5	-
25	*Crepidotus mollis* (Bull.) Kummer	-	-	5	-	1	0.002	2	1.136	3	0.005	2	3.488	-	-	5	-	-	-	5	-
26	*Cyathus striatus* (Huds.) Willd.	-	-	4	-	-	-	4	-	6	0.010	4	6.977	2	0.003	4	2.564	2	0.003	4	2.222
27	*Daedaelia quercina* Fr.	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.282	-	-	5	-
28	*Exidia thurentiana* (Lev.) Fr.	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.564	-	-	5	-
29	*Fomes fomentarius* (Fr.) Kickx.	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	2	2.564	3	0.005	2	3.333
30	*Ganoderma applanatum* (Pers. ex Wall.) Pat.	-	-	5	-	2	0.003	2	2.273	-	-	5	-	-	-	2	-	3	0.005	5	3.333
31	*G. lucidum* (Leyss.) P,Karst	-	-	5	-	-	-	5	-	3	0.005	2	3.488	1	0.002	2	1.282	-	-	5	-
32	*G. tsugae* Murrill	-	-	5	-	-	-	5	-	1	0.002	3	1.163	2	0.003	3	2.564	2	0.003	2	2.222
33	*Geastrum saccatum* Fr.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	1	3.333
34	*Hericium ramosum* (Bull. Ex Mèr.) Let.	3	0.005	2	3.614	1	0.002	2	1.136	-	-	5	-	-	-	5	-	-	-	5	-
35	*Hygrocybe* sp.	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.282	-	-	5	-
36	*Leccinum* sp.	-	-	5	-	2	0.003	1	2.273	-	-	5	-	-	-	5	-	-	-	5	-
37	*Lepiota* sp	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.222

Table 3: Abundance (A), density (D), fidelity (F) and relative density (RD) parameters per sample plots of the study area (continued)

	Species	PLOT A				PLOT B				PLOT C				PLOT D				PLOT E			
		A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD
38	*Macrolepiota* sp.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.111
39	*Marasmius graminum* (Libert) Berkeley	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	1	3.333
40	*M. lachnophyllus* Berkeley	2	0.003	1	2.410	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
41	*M. pulcherripes* Peck	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.111
42	*M. rotula* (Fr.) Scope	4	0.006	3	4.819	5	0.008	2	5.682	-	-	5	-	-	-	5	-	2	0.003	2	2.222
43	*Marasmiellus* sp.	1	0.002	2	1.205	1	0.002	2	1.136	-	-	5	-	-	-	5	-	-	-	5	-
44	*Megacollybia platyphylla* (Pers.) kotl. and Pouzar.	-	-	5	-	-	-	5	-	-	-	5	-	4	0.006	2	5.128	3	0.005	2	3.333
45	*Mycena* sp.	6	0.010	2	7.229	4	0.006	3	4.545	-	-	5	-	-	-	5	-	-	-	5	-
46	*Nothopanus* sp.	3	0.005	4	3.614	2	0.003	4	2.273	3	0.005	4	3.488	3	0.005	4	3.846	2	0.003	4	2.222
47	*Omphalina chrysophylla* (Fr.) Murrill	-	-	5	-	-		5	-	2	0.003	2	2.326	4	0.006	2	5.128	-	-	5	-
48	*Panaeolus foenisecii* (Pers: Fr) Kuhner	3	0.005	3	3.614	4	0.006	3	4.545	-	-	5	-	-	-	5	-	-	-	5	-
49	*Panellus* sp.	2	0.003	3	2.410	2	0.003	3	2.273	1	0.002	3	1.163	-	-	5	-	-	-	5	-
50	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	-	-	5	-	-	-	5	-	3	0.005	2	3.488	1	0.002	2	1.282	1	0.002	2	1.111
51	*Pleurotus* sp.	-	-	5	-	-	-	5	-	1	0.002	2	1.163	1	0.002	2	1.282	-	-	5	-
52	*P. squarrosulus* (Fr.) Kummer	1	0.002	4	1.205	2	0.003	4	2.273	2	0.003	4	2.326	2	0.003	4	2.564	3	0.005	4	3.333
53	*P. tuberregium* (Fr.) Singer	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.282	-	-	5	-
54	*Pluteus cervinus* (Schaeff. ex Fr.) Kummer	-	-	5	-	-	-	5	-	5	0.008	1	5.814	-	-	5	-	-	-	5	-
55	*Podoscypha* sp.	-	-	5	-	-	-	5	-	2	0.003	1	2.326	-	-	5	-	-	-	5	-
56	*Pycnoporus cinnabarinus* (Fr.) Kar.	-	-	5	-	3	0.005	1	3.409	-	-	5	-	-	-	5	-	-	-	5	-

Table 3: Abundance (A), density (D), fidelity (F) and relative density (RD) parameters per sample plots of the study area (continued)

	Species	PLOT A				PLOT B				PLOT C				PLOT D				PLOT E			
		A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD
57	*Russula* sp.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	1	3.333
58	*Schizophyllum commune* Fr.	2	0.003	4	2.410	3	0.005	4	3.409	3	0.005	4	3.488	3	0.005	4	3.846	2	0.003	4	2.222
59	*Stereum purpureum* (Pers ex Fr.) Fr.	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	2	1.282	2	0.003	2	2.222
60	*Thelephora* sp. A	-	-	5	-	-	-	5	-	4	0.006	1	4.651	-	-	5	-	-	-	5	-
61	*Thelephora* sp. B	-	-	5	-	-	-	4	-	4	0.006	2	4.651	2	0.003	2	2.564	-	-	5	-
62	*Trametes* sp.	-	-	5	-	-	-	5	-	-	-	5	-	4	0.006	2	5.128	1	0.002	2	1.111
63	*Tremella* sp	3	0.005	1	3.614	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
64	*T. fuciformis* Berkeley	-	-	5	-	-	-	5	-	3	0.005	2	3.488	4	0.006	2	5.128	-	-	5	-
65	*Volvariella volvaceae* (Bull. ex Fr.) Singer.	-	-	5	-	-	-	5	-	-	-	5	-	-	-	-	-	2	0.003	1	2.222
66	RRIN01	1	0.002	2	1.205	1	0.002	2	1.136	-	-	5	-	-	-	5	-	-	-	5	-
67	RRIN03	-	-	5	-		-	5	-	-	-	5	-	1	0.002	5	1.282	-	-	1	-
68	RRIN04	-	-	5	-	2	0.003	1	2.273	-	-	5	-	-	-	5	-	-	-	5	-
69	RRIN05	-	-	5	-	1	0.002	1	1.136	-	-	5	-	-	-	5	-	-	-	5	-
70	RRIN06	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.564	-	-	5	-
71	RRIN07	2	0.003	2	2.410	2	0.003	2	2.273	-	-	5	-	-	-	5	-	-	-	5	-
72	RRIN08	1	0.002	1	1.205	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
73	RRIN09	3	0.005	2	3.614	3	0.005	2	3.409	-	-	5	-	-	-	5	-	-	-	5	-
74	RRIN10	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.222
75	RRIN11	1	0.002	2	1.205	2	0.003	2	2.273	-	-	5	-	-	-	5	-	-	-	5	-
76	RRIN12	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	5	3.333
77	RRIN13	-	-	5	-	-	-	5	-	2	0.003	1	2.326	-	-	5	-	-	-	5	-

Table 3: Abundance (A), density (D), fidelity (F) and relative density (RD) parameters per sample plots of the study area (continued)

	Species	PLOT A				PLOT B				PLOT C				PLOT D				PLOT E			
		A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD	A	D	F	RD
78	RRIN14	-	-	5	-	-	-	5	-	2	0.003	1	2.326	-	-	5	-	-	-	5	-
79	RRIN15	-	-	5	-	-	-	5	-	2	0.003	1	2.326	-	-	5	-	-	-	5	-
80	RRIN16	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	1	1.111
81	RRIN17	2	0.003	2	2.410	4	0.006	2	4.545	-	-	5	-	-	-	5	-	-	-	5	-
82	RRIN18	-	-	5	-	-	-	5	-	3	0.005	3	3.488	3	0.005	3	3.846	-	-	5	-
83	RRIN19	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	4	0.006	1	4.444
84	RRIN20	1	0.002	1	1.205	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
85	RRIN21	2	0.003	2	2.410	-	-	5	-	-	-	5	-	2	0.003	2	2.564	-	-	5	-
86	RRIN22	-	-	5	-	-	-	5	-	3	0.005	3	3.488	4	0.006	3	5.128	1	0.002	3	1.111
87	RRIN23	-	-	5	-	-	-	5	-	-	-	5	-	1	0.002	2	1.282	3	0.005	2	3.333
88	RRIN24	1	0.002	1	1.205	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-
89	RRIN25	-	-	5	-	-	-	5	-	-	-	5	-	3	0.005	1	3.846	-	-	5	-
90	RRIN26	-	-	5	-	-	-	5	-	2	0.003	2	2.326	1	0.002	2	1.282	-	-	5	-
91	RRIN27	3	0.005	2	3.614	2	0.003	2	2.273	-	-	5	-	-	-	5	-	-	-	5	-
92	RRIN28	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.564	-	-	5	-
93	RRIN29	-	-	5	-	-	-	5	-	-	-	5	-	-	-	5	-	2	0.003	1	2.222
Total		83	0.133	383	99.998	88	0.141	376	100.000	86	0.137	393	100.000	78	0.125	358	100.000	90	0.144	351	100.000

Table 4: Matrix of shared species distribution value of sampled plots presented as mean of 100 randomised sample orders.

PLOT	A	B	C	D	E
A	-	23 (27)	8 (10)	7 (9)	9 (10)
B	23 (27)	-	9 (11)	7 (9)	10 (12)
C	8 (10)	9 (11)	-	18 (18)	13 (12)
D	7 (9)	7 (9)	18 (18)	-	17 (18)
E	9 (10)	10 (12)	13 (12)	17 (18)	-

The values in parenthesis represent number of shared species in a single unrandomized run.

Table 5: Checklist of species abundance value distribution of the study area

		PLOT				
s/n	Species	A	B	C	D	E
1	*Agaricus arvensis* Schaeff.	3	0	0	0	0
2	*Amanita phylloides* (Vail.) Secretan.	0	0	0	0	1
3	*Auricularia auricula* Judae (Bull.) Pat.	4	5	6	3	3
4	*Bondarzewia* sp.	0	0	0	2	0
5	*Cantharellus tubaeformis* (Bull.) Fr.	0	0	0	0	2
6	*Calocera cornea* (Batsch.).Fr.	0	2	0	0	0
7	*Calvatia cyathiformis* (Bosc.) Morg.	0	0	0	1	0
8	*Chlorophyllum* sp.	0	0	0	0	3
9	*Clavulina* sp.	0	0	2	0	3
10	*Clavulinopsis* sp.	0	0	0	0	1
11	*Clitocybe* sp.	2	3	0	0	0
12	*C. dealbata* (Sow.) Gillet.	2	2	3	0	0
13	*Coltricia perennis* L.: Fr.) Murr.	3	3	0	0	2
14	*Cookeina sulcipes* (Berk.) Kunt.	4	3	0	0	3
15	*Copinus acuminatus* (Romagn.) P.D. Orton	7	7	3	3	2
16	*Coprinus atramentarius* Ulje and Bas.	4	3	0	0	0
17	*Coprinus disseminatus* (Pers. ex Fr.) S.F.G.	2	0	0	0	0
18	*Crepidotus mollis* (Bull.) Kummer	0	1	3	0	0

19	*Cyathus striatus* (Huds.) Willd.	0	0	6	2	2
20	*Daedaelia quercina* Fr.	0	0	0	1	0
21	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	5	5	6	3	3
22	*Exidia thurentiana* (Lev.) Fr.	0	0	0	2	0
23	*Fomes fomentarius* (Fr.) Kickx.	0	0	0	2	3
24	*Ganoderma applanatum* (Pers. ex Wall.) Pat.	0	2	0	0	3
25	*G. lucidum* (Leyss.) P,Karst	0	0	3	1	0
26	*G. tsugae* Murrill	0	0	1	2	2
27	*Geastrum saccatum* Fr.	0	0	0	0	3
28	*Helotium citrinum* (Hedwig) Fr.	0	2	0	0	0
29	*Hericium ramosum* (Bull. ex Mèr.) Let.	3	1	0	0	0
30	*Hygrocybe* sp.	0	0	0	1	0
31	*Leccinum* sp.	0	2	0	0	0
32	*Lepiota* sp	0	0	0	0	2
33	*Macrolepiota* sp.	0	0	0	0	1
34	*Marasmius graminum* (Libert) Berkeley	0	0	0	0	3
35	*M. lachnophyllus* Berkeley	2	0	0	0	0
36	*M. pulcherripes* Peck	0	0	0	0	1
37	*M. rotula* (Fr.) Scope	4	5	0	0	2
38	*Marasmiellus* sp.	1	1	0	0	0
39	*Megacollybia platyphylla* (Pers.) kotl. and Pouzar.	0	0	0	4	3
40	*Mycena* sp.	6	4	0	0	0
41	*Nothopanus* sp.	3	2	3	3	2
42	*Omphalina chrysophylla* (Fr.) Murrill	0	0	2	4	0
43	*Panaeolus foenisecii* (Pers: Fr) Kuhner	3	4	0	0	0
44	*Panellus* sp.	2	2	1	0	0
45	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	0	0	3	1	1
46	*Pleurotus* sp.	0	0	1	1	0
47	*P. squarrosulus* (Fr.) Kummer	1	2	2	2	3
48	*P. tuberregium* (Fr.) Singer	0	0	0	1	0
49	*Pluteus cervinus* (Schaeff. ex Fr.) Kummer	0	0	5	0	0
50	*Podoscypha* sp.	0	0	2	0	0
51	*Pycnoporus cinnabarinus* (Fr.) Kar.	0	3	0	0	0
52	*Russula* sp.	0	0	0	0	3
53	*Schizophyllum commune* Fr.	2	3	3	3	2
54	*Stereum purpureum* (Pers ex Fr.) Fr.	0	0	0	1	2
55	*Tarzetta rosea* (Rea.) Dennis	0	4	0	2	0
56	*Trametes* sp.	0	0	0	4	1
57	*Thelephora* sp. A	0	0	4	0	0

58	*Thelephora* sp. B	0	0	4	2	0
59	*Tremella* sp	3	0	0	0	0
60	*T. fuciformis* Berkeley	0	0	3	4	0
61	*Volvariella volvaceae* (Bull. ex Fr.) Singer.	0	0	0	0	2
62	*Xylaria* sp.	0	0	0	2	2
63	*X. hypoxylon* (L. ex Hook) Grev.	0	0	5	0	4
64	*X. polymorpha* (Pers. ex Mèr.) Grev.	0	0	1	2	2
65	RRIN01	1	1	0	0	0
66	RRIN02	0	0	0	0	2
67	RRIN03	0	0	0	1	0
68	RRIN04	0	2	0	0	0
69	RRIN05	0	1	0	0	0
70	RRIN06	0	0	0	2	0
71	RRIN07	2	2	0	0	0
72	RRIN08	1	0	0	0	0
73	RRIN09	3	3	0	0	0
74	RRIN10	0	0	0	0	2
75	RRIN11	1	2	0	0	0
76	RRIN12	0	0	0	0	3
77	RRIN13	0	0	2	0	0
78	RRIN14	0	0	2	0	0
79	RRIN15	0	0	2	0	0
80	RRIN16	0	0	0	0	1
81	RRIN17	2	4	0	0	0
82	RRIN18	0	0	3	3	0
83	RRIN19	0	0	0	0	4
84	RRIN20	1	0	0	0	0
85	RRIN21	2	0	0	2	0
86	RRIN22	0	0	3	4	1
87	RRIN23	0	0	0	1	3
88	RRIN24	1	0	0	0	0
89	RRIN25	0	0	0	3	0
90	RRIN26	0	0	2	1	0
91	RRIN27	3	2	0	0	0
92	RRIN28	0	0	0	2	0
93	RRIN29	0	0	0	0	2

4.3 Mushroom ecological investigations

Abundance, density, fidelity (propensity for plot) and relative density parameters of taxon encountered in each of the sampled plots are tabulated in Table 3 (uncombined version is presented in Appendix i, ii, iii, iv and vi respectively) while sociability of taxon is expressed in Table 4. About 12 mushroom fruit bodies which include *Agaricus arvensis*, *Calvatia cyathiformis*, *Fomes fomentarius*, *Ganoderma applanatum*, *Hericium ramosum*, *Leccinum* sp, *Macrolepiota* sp, *Megacollybia platyphylla*, *Panellus* sp, and *Thelephora* sp are observed to grow singly and in spatially scattered pattern all over their respective substrate.

A matrix table of the number of mushroom species shared between plots is enumerated in Table 4. Each value is a mean estimate of 100 randomization of sample accumulation order. It was observed from the table that the heterogeneous nature the vegetation of Plot E afforded it greater number of species (40) amounting to 90 fruit bodies 77.5% of which is shared with the other sampled plots. Plots A and B registered the highest number (23) amounting to approximately 74.2% of shared species followed by plots C and D, and plots D and E respectively. In addition, Plot D recorded the least number (9) of shared species amounting to approximately 19.4% with Plots A and B respectively. *Coprinus acuminatus* (7), *Mycena* species (8) and *Marasmius rotula* (5) are some of the mushrooms observed to have recorded the highest species abundance (Table 1 and Table 5). Sampled Plot E registered a total species abundance of 90 amounting to 21.18% of 425 fruit bodies within the period of study. Species richness, species diversity and similarity indices were also estimated using estimateS according to Colwell (2005). Species richness estimate such as Mao Tau (Observed species richness), Singleton (number of species with only one individual), Doubletons (number of species with only two individuals), Uniques (number of species occurring in only one sample/plot), Duplicates (number of species that occur only in two samples), Abundance-based coverage estimate per plot (ACE), Incidence-based coverage-estimate per plot (ICE), Chao 1, Chao 2, First order jackknife or Jack 1, Second order jackknife or Jack 2, Bootstrap, and Cole rarefaction (number of species expected in the pooled number of samples assuming individuals distributed at random and plots) are enumerated in Table 6. Also illustrated in Table 6 are diversity index estimate such as Alpha (Fisherôs alpha index), Shannon and Simpson. This was done to remove the prejudice of a single index on the diversity of species (seen and unseen) on community type (finite or infinite), sample size, length of sampling or area sampled. A general look at species richness

indices (except Incidence-based coverage estimator of species richness and Chao 2 which are inverse values) showed a progressive increase and variation in species richness from Plots A to E indicating that the young grooves or plantations (Plots A and B) had lesser species richness and biodiversity when compared with the old plantations (Plots C and D). The forest plot (Plot E) recorded the highest species richness and diversity indices. Since the study is comparative, the result will be incomplete without similarity indexes such as Jaccard, Sorensen (qualitative), Morisita-Horn, Bray-Curtis (Sorensen quantitative), Chao-Jaccard Raw abundance- and incidence-based, Chao-Jaccard Est abundance and incidence-based, Chao-Sorensen Raw abundance- and incidence-based and Chao-Sorensen Est abundance- and incidence-based which are enumerated in Table 7.

The Table of similarity indices showed that Plots A and B are the most similar in species diversity while Plots B and D are the most dissimilar in terms of species richness and diversity. This means that the species composition of Plots A and B are very similar to each other. The species accumulation curve of the study area was plotted (Fig. 4) to assess the effect of sample area on species richness and no asymptote was observed. This showed that asymptote can be reached with extension of period of study and perhaps study area, thus the study area still has species yet to be recognised or missed or overlooked during this study period. Plot E also showed the highest Singletons, doubletons, Uniques and duplicates mean, thus registered the most species with only one individual and two individuals as well as species occurring in only one and two sampled plots.

4.4 Relationship between species abundance, litterfall mass and meteorological parameters.

The meteorological data as supplied by the Rubber Research Meteorological Unit is enumerated in Table 8. Monthly evaporation rate, rainfall, relative humidity (minimum and maximum), temperature (minimum and maximum) and wind speed variations are matched against monthly species abundance of the study area in Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9 respectively.

Table 6: Species richness and biodiversity estimates based on 100 randomization accumulation order ± SD values

Estimates/Measures	Plot A	Plot B	Plot C	Plot D	Plot E
Computed number of individuals	85	170	255	340	425
Mao Tau (Observed species richness)	33.6 ± 2.65	55.1 ± 3.38	71.5 ± 3.9	83.8 ± 4.25	93 ± 4.59
Singletons mean	7.07 ± 2.55	10.81 ± 3.51	13.09 ± 3.23	13.98 ± 2.76	14 ± 0
Doubletons mean	11.67 ± 2.93	16.14 ± 3.14	19.82 ± 1.35	21.78 ± 1.250	23 ± 0
Uniques mean	33.73 ± 4.030	42.69 ± 10.92	49.39 ± 7.56	50.21 ± 4.83	46 ± 0
Duplicates mean	0 ± 0	12.44 ± 4.98	15.05 ± 1.67	23.9 ± 3.47	31 ± 0
ACE mean	37.12± (5.23)	59.96± (8.52)	77.55± (6.99)	90.18± (4.49)	98.58± (0)
ICE mean	481.8 ± 114.1	277.4 ± 133.5)	194.7 ± 48.83	170.9 ± 20.18	151.67 ± 0
Chao 1 mean	36.04± (2.31)	58.88± (3.04)	76.31± (3.35)	89.11± (3.43)	97.26± (3.2)
Chao 2 mean	481.8 ± 155.2	155.6 ± 45.47	157.2 ± 34.1	139.5 ± 20.67	127.1 ± 13.15
Jack 1 mean	33.73 ± 0	76.48 ± 2.89	104.7 ± 7.44	122.01 ± 9.18	129.8 ± 8.33
Jack 2 mean	0 ± (0)	76.48 ± 12.17	118.7 ± 13.26	139.2 ± 10.07	143.5 ± 0
Bootstrap mean	33.73± (4.03)	65.8± (9.5)	86.98± (7.85)	101.75± (4.8)	110.6 ± 0
Cole rarefaction	49.9 ± 4.26	71.21 ± 3.6	82.57 ± 2.74	89.17 ± 1.8	-
Alpha mean	21.19 ± 3.75	28.68 ± 3.49	33.33 ± 3.3	35.91 ± 3.1	36.74 ± 2.86
Shannon mean	3.4 ± 0.14	3.82 ± 0.15	4.03 ± 0.1	4.14 ± 0.05	4.22 ± 0
Simpson mean	41.33 ± 9.94	50.86 ± 9.02	54.59 ± 6.98	56.25 ± 6.98	57.28 ± 0

Table 7: Similarity indices estimates of sampled plots in the study area of 100 randomization accumulation order

First Plot	Second Plot	Sobs First Sample	Sobs Second Sample	Shared Species Observed	ACE First Sample	ACE Second Sample	Chao Shared Esimated	Jaccard Classic	Sorensen Classic	Chao-Jaccard-Raw Abundance-based	Chao-Jaccard-Est Abundance-based	Chao-Sorensen-Raw Abundance-based	Chao-Sorensen-Est Abundance-based	Morisita-Horn	Bray-Curtis
A	B	31	32	23	34.22	34.039	24.2	0.575	0.73	0.668	0.694	0.801	0.819	0.826	0.702
A	C	31	29	8	34.22	30.625	8.952	0.154	0.267	0.186	0.191	0.314	0.321	0.331	0.249
A	D	31	36	7	34.22	41.91	7.261	0.117	0.209	0.152	0.155	0.264	0.268	0.281	0.211
A	E	31	40	9	34.22	43.902	9.381	0.145	0.254	0.178	0.187	0.303	0.315	0.304	0.231
B	C	32	29	9	34.04	30.625	10.2	0.173	0.295	0.204	0.21	0.339	0.347	0.358	0.276
B	D	32	36	7	34.04	41.91	7	0.115	0.206	0.16	0.16	0.276	0.276	0.311	0.217
B	E	32	40	10	34.04	43.902	10	0.161	0.278	0.201	0.201	0.335	0.335	0.34	0.258
C	D	29	36	18	30.63	41.91	20.438	0.383	0.554	0.428	0.466	0.599	0.635	0.549	0.463
C	E	29	40	13	30.63	43.902	15.185	0.232	0.377	0.253	0.268	0.404	0.423	0.392	0.295
D	E	36	40	17	41.91	43.902	20.132	0.288	0.447	0.304	0.32	0.466	0.485	0.412	0.381

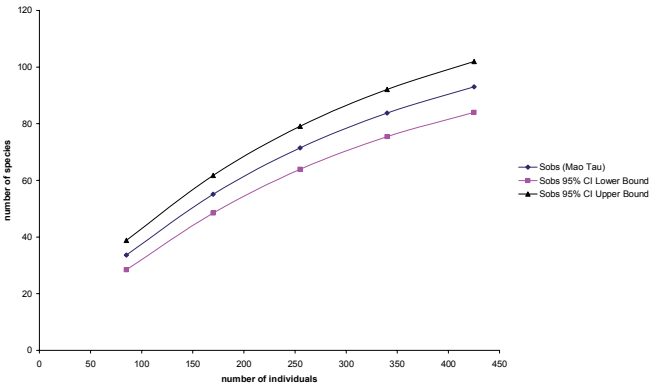


Fig. 6: Species accumulation curve (Observed species richness) of the study area based on the mean of 100 randomized sample orders.

Species abundance was observed to be higher in the months of March to September when the rate of evaporation (2.6 ï 5.1 mm) is lower. Species abundance profile per month is observed to be directly related to rainfall pattern of the study area. That is there is higher abundance (number of fruit bodies) values recorded in the months with high rainfall (ranging from 12.7 ï 17.9 mm) distribution. Abundance of species was also marginally related to wind speed (km / h), minimum temperature and relative humidity values but inversely proportional to maximum temperature and relative humidity values. Fine litter (a mixture of leaf-litter, coarse woods, seeds, flowers and seed pods) dry weight (g / m^2/ month) for each sampled plot was tabulated in Table 9. The fine litter for each plot was also evaluated (% per gram) for Carbon (C), Nitrogen (N) and Phoshorus (P) (Table 9). A quick look at the litter mass profile of the sampled plots showed that the young rubber plantations recorded higher annual litter mass when compared with the old grooves or plantations and the forest. Correlation was estimated using Spss 11 between litter mass, carbon, nitrogen and phosphorus contents of 1g of fine litter and correlation matrix presented in Table 10. The result showed no correlation between litter fall parameters (litter mass, C, N and P contents per 1g of fine litter) and the number of fruit bodies observed per month per sampled plot even though a strong correlation was observed amongst the litter variables with the exception of P-content which did not correlate with litter mass, C- and N-content. There was however a positive significant difference ($P < 0.05$) in the amount of fruit bodies recorded monthly and per sampled plots.

There was a significant difference (Appendix viii) between litter mass per plot (P = 2.42) and per month (P = 1.73) even though the null hypothesis (H_O) was accepted for N and P contents across both months (P = 0.5676, 0.4989) and plots (P = 0.0967, 0.4563). The C-content of the fine litter collected from each sampled plot differ significantly (P = 11.038) but are not significantly different (P = 0.9361) across the various months.

Table 8: Meteorological data from Rubber Research Institute, Iyanomo.

MONTH	RAINFALL (mm)	EVAP. (mm)	WS (km/h)	TEMP/MIN (ºC)	TEMP/ MAX (ºC)	RH/MIN (%)	RH/MAX (%)
Jun-06	17.04	3.77	2.17	25.9	27.1	61.8	82.5
Jul-06	17.9	2.38	2.32	26.03	25.19	61.29	76.09
Aug-06	9.142	2.6	2.048	23.355	24.226	61.839	76.516
Sep-06	12.27	3.02	2.17	25.53	25.067	61.933	77.867
Oct-06	9.4	3.82	2.24	26.48	27	63.516	81.03
Nov-06	0.002	5.89	1.75	26.13	29.2	61.2	93.1
Dec-06	0	4.27	1.73	25.4	29.78	60.5	94.9
Jan-07	0	5	2.3	21.6	29.5	59.7	97.5
Feb-07	1.6	4.9	2.6	26.7	30.6	61	92.9
Mar-07	5.6	5.1	2.6	27.3	30.6	60.3	89.9
Apr-07	7.7	4.8	2.5	27	29.2	60.1	83.2
May-07	12.7	4.8	2.2	26.3	27.9	60.7	82.9
Jun-07	12.7	4.1	2.6	26.5	26.6	61.4	79.8

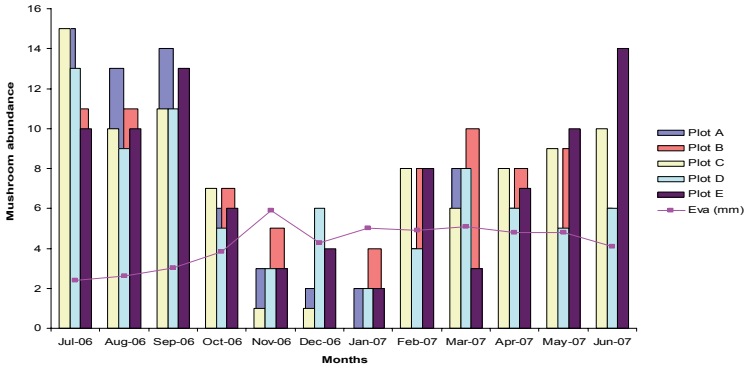


Fig. 7: **Relationship between evaporation rate (mm) and species abundance of sampled plots in the study area.**

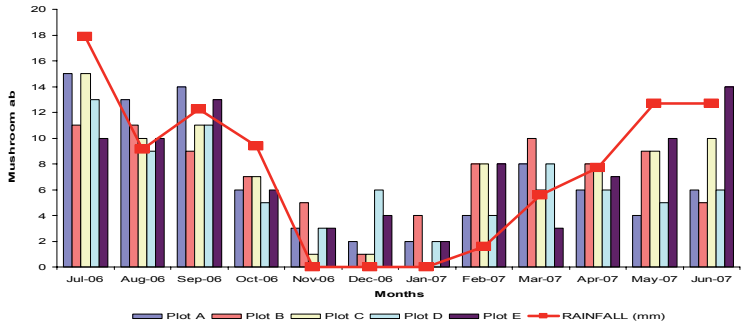


Fig. 8: Relationship between rainfall rate (mm) and species abundance of sampled plots in the study area

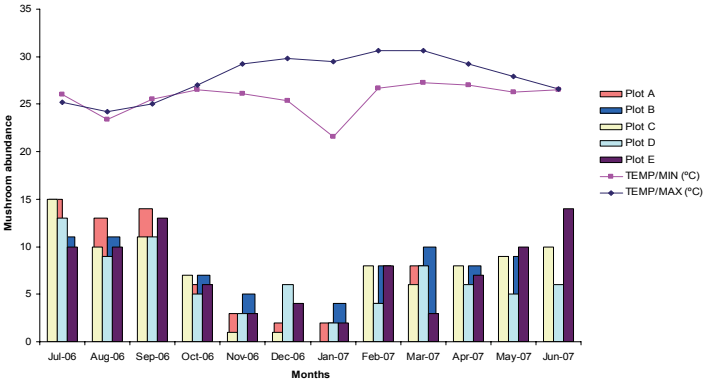


Fig. 9: Relationship between temperature (minimum and maximum in ºC) and species abundance of sampled plots in the study area.

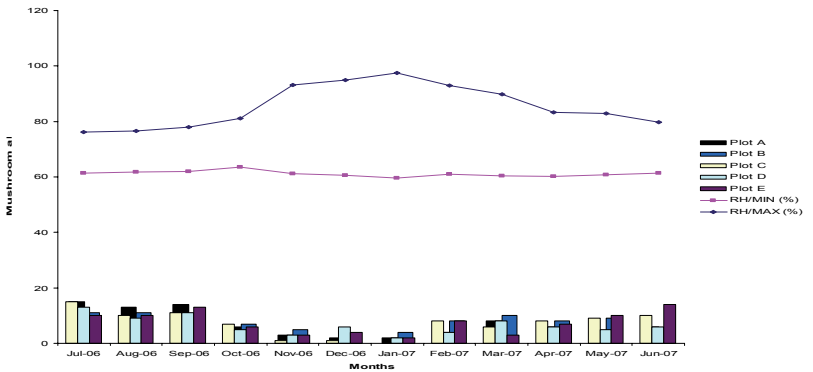


Fig. 10: Relationship between relative humidity (minimum and maximum in %) and species abundance of sampled plots in the study area.

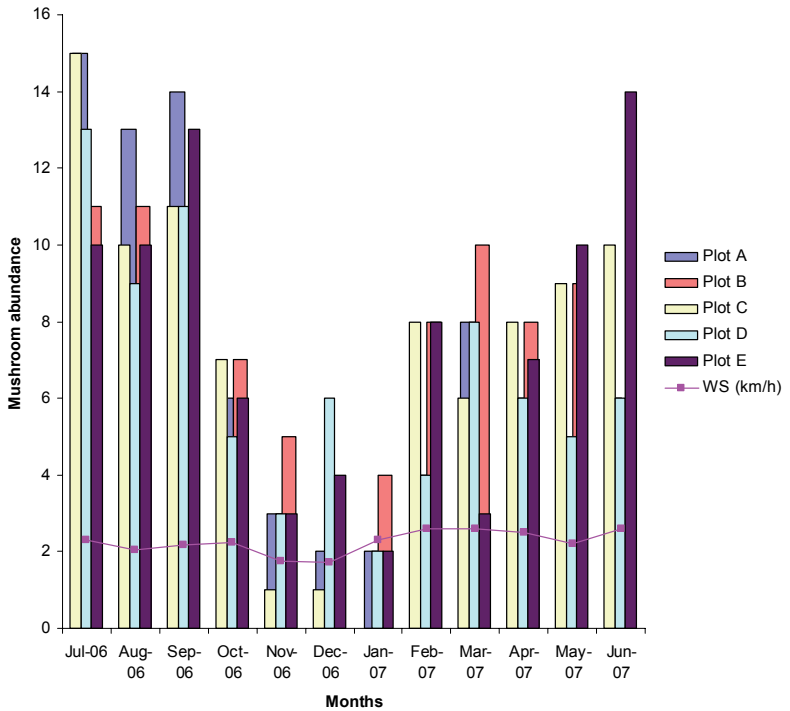


Fig. 11: **Relationship between wind speed (km/h) and species abundance of sampled plots in the study area.**

Table 9: Litter mass, carbon, nitrogen and phosphorus contents of sampled plots in the study area

	2006						2007						
Measure /Month	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	Jun.	Year
PLOT A													
Abundance	15	13	14	6	3	2	2	4	8	6	4	6	83
Litter mass (g / m^2 /month)	28.25±9.7	24.71±5.4	19.6±4.4	21.62±5.1	43±10.1	50.15±9.4	44.71±11.3	45.65±10.8	60.09±12.9	59.45±10.7	30.29±6.5	31.2±8.3	458.7
Carbon content per 1g litter (%)	45.67±5.6	49.87±4.3	52.6±2.3	51.1±3.9	52.9±4.5	53.55±7.9	52.78±11.2	62.65±3.7	69.18±4.9	57.29±9.1	56.29±3.8	56.18±6.2	660.1
Nitrogen content per 1g litter (%)	0.75±0.04	0.747±0.23	0.7±0.11	0.763±0.12	0.81±0.09	0.761±0.16	0.686±0.07	0.75±0.14	0.78±0.10	0.789±0.25	0.819±0.16	0.796±0.33	9.154
Phosphorus content per 1g litter (%)	0.081±0.03	0.082±0.01	0.08±0.02	0.081±2.0	0.1±0.00	0.098±0.04	0.082±0.01	0.154±0.09	0.158±0.12	0.079±0.01	0.1±0.04	0.102±0.02	1.197
PLOT B													
Abundance	11	11	9	7	5	1	4	8	10	8	9	5	88
Litter mass (g / m^2 /month)	22.75±2.3	19.98±4.8	19.7±4.1	20.05±1.9	24±6.8	24.58±4.7	20.86±3.5	24.86±5.3	35.12±8.4	35±3.1	16.4±0.81	20.56±2.7	283.88
Carbon content per 1g litter (%)	48.91±5.7	49.55±2.9	60±3.45	58.32±5.4	60.2±9.1	61.05±3.8	56.75±7.3	66.18±14.4	67.75±5.0	68.05±6.2	62.3±2.4	65.24±5.1	724.34
Nitrogen content per 1g litter (%)	0.688±0.23	0.721±0.17	0.78±0.09	0.879±0.08	0.8±0.03	0.751±1.08	0.7±2.1	0.674±0.26	0.69±0.2	0.679±0.37	0.589±0.10	0.6±0.02	8.551
Phosphorus content per 1g litter (%)	0.105±1.0	0.101±0.02	0.1±0.008	0.128±0.9	0.12±0.06	0.103±0.09	0.089±0.01	0.088±0.00	0.101±0.02	0.105±1.0	0.098±0.04	0.101±0.02	1.234
PLOT C													
Abundance	15	10	11	7	1	1	0	8	6	8	9	10	86
Litter mass (g / m^2 /month)	8.05±4.6	3.856±1.8	6.39±5.1	7.124±3.9	10.9±4.8	14.56±10.4	13.86±7.5	14.06±8.9	28.24±2.1	28.96±15.4	21.05±10.1	22.47±9.8	179.52
Carbon content per 1g litter (%)	50.01±9.2	48.75±19.2	49.5±9.8	54.1±10.2	58.5±11.1	53.89±8.2	51.71±8.50	47.1±6.1	47.7±6.9	46.34±2.3	47.05±13.0	49.01±10.1	603.73
Nitrogen content per 1g litter (%)	0.768±0.4	0.555±0.18	0.58±0.21	0.817±0.13	0.86±0.31	0.901±0.65	0.613±0.15	0.791±0.04	0.802±0.29	0.565±0.51	0.575±0.29	0.557±0.18	8.379
Phosphorus content per 1g litter (%)	0.075±0.02	0.099±0.05	0.09±0.06	0.101±0.02	0.95±0.15	0.601±0.11	0.063±0.02	0.1±0.08	0.11±0.05	0.108±0.08	0.101±0.02	0.098±0.03	2.499
PLOT D													
Abundance	13	9	11	5	3	6	2	4	8	6	5	6	78
Litter mass (g / m^2 /month)	6.798±4.2	22.44±10.9	5.73±1.61	6.734±3.41	20.8±12.6	24.99±14.2	25.44±9.7	24.95±10.9	28.95±13.4	30.01±13.8	19.05±9.1	20.06±6.43	235.92
Carbon content per 1g litter (%)	60.21±20.3	55.98±9.8	59.9±1.02	56.91±9.01	59.2±6.7	59.78±5.2	62.46±12.7	49.66±9.23	51.81±7.1	54.78±9.3	58.61±11.4	60.01±18.3	689.32
Nitrogen content per 1g litter (%)	0.401±0.21	0.399±0.09	0.5±0.19	1.002±0.09	0.99±0.38	0.951±0.41	0.762±0.08	0.775±0.15	0.98±0.39	1±0.06	1.008±0.04	0.99±0.50	9.755
Phosphorus content per 1g litter (%)	0.105±0.06	0.089±0.02	0.1±0.07	0.105±0.06	0.1±0.08	0.101±0.02	0.057±0.01	0.192±0.09	0.101±0.02	0.101±0.02	0.01±0.007	0.08±0.03	1.133
PLOT E													
Abundance	10	10	13	6	3	4	2	8	3	7	10	14	90
Litter mass (g / m^2 /month)	11.9±5.6	12.53±8.3	12.2±8.61	12.99±7.1	15.8±3.41	17.25±10.3	16.53±9.52	17.27±9.91	23.14±12.4	24.88±11.8	14.96±8.32	16.56±6.61	195.98
Carbon content per 1g litter (%)	49.25±4.9	49.73±6.8	50.1±10.3	51.47±9.81	55±4.08	54.73±1.6	47.1±4.9	48.54±6.4	50.01±7.36	46.34±5.71	46.72±9.01	45.96±6.83	594.97
Nitrogen content per 1g litter (%)	0.516±0.21	0.801±0.60	0.7±0.16	0.695±0.09	0.73±0.37	0.712±1.7	0.569±3.0	0.545±0.31	0.594±0.18	0.555±0.22	0.61±0.46	0.85±0.45	7.882
Phosphorus content per 1g litter (%)	0.101±0.051	0.099±0.04	0.11±0.06	0.142±0.08	0.17±1.01	0.19±2.0	0.069±1.4	0.091±0.01	0.102±0.02	0.108±0.05	0.111±0.09	0.107±0.03	1.392

Table 10: Correlation matrix of fine litter variables (litter mass, C-, N-, and P-content) and number of fruit bodies per annum

Correlation	Litter mass	C-content	N-content	P-content	Abundance
Litter mass	1.000	0.302	0.101	-0.221	-0.235
C-content	0.302	1.000	0.079	0.133	-0.230
N-content	0.101	0.079	1.000	0.067	-0.109
P-content	-0.221	0.133	0.067	1.000	-0.148
Abundance	-0.235	-0.230	-0.109	-0.148	1.000

Values closer to 1 have stronger correlation.

CHAPTER 5

DISCUSSION

The discussion of the results obtained from this study is outlined to cover (i) composition of mushrooms and their distribution, (ii) ecological and phenological variability, (iii) relationship between species abundance and litterfall.

5.1 COMPOSITION OF MUSHROOMS AND THEIR DISTRIBUTION

The mushroom species abundance curve of the study area (3125m^2) within the 14 months period of study showed no asymptote, an indication that the study area harbour more mushroom resources yet unrecorded by this study. This justifies the nomination of West Africa as one of the worldôs biodiversity hotspots for conservation priorities by Myers *et al*. (2000) even though the tropical areaôs biodiversity is slowly changing (Sala *et al*., 2000). A total of 93 species of mushrooms amounting to 425 fruit bodies and comprising 9% Ascomycetes and 91% Basidiomycete were recorded from the study (Fig 3A). This according to Straatsma *et al*. (2001) and Straatsma and Krisai-Greilhuber (2003) constitute an average of 4.9 fruit bodies per species per duration of study *stricto lato*. A total of 64 species amounting to approximately 69% of the overall taxa encountered during the study were identified (Table 1). This result compares with similar empirical mushroom biodiversity studies carried out for other tropical woodland ecosystems outside Nigeria (Iwabuchi *et al*., 1994; Shigeki *et al*., 1994; Karadelev, 1998; Lindblad, 2001; Straatsma *et al*., 2001; Straatsma and Krisal-Greilhuber, 2003; Cifuentes and Villarruel-Ordaz, 2006; Gazis and

Romina, 2006; Houseknecht and Weir, 2006; Lynch and Thorn, 2006). For the purpose of this study, woodland ecosystems refer to both or either heteroculture or heterogeneous forest and monoculture or homogeneous plantations. Conversely, the result is an improvement over results from previous scant but old works (regional and local) on mushroom biodiversity in the country even though such works were scattered and carried out over relatively more extended periods (Bond, 1972; Zoberi, 1972; Nicholson, 1989 and 2000; Osemwegie *et al*., 2006). This may be due to a number of factors which include a relatively low level of interest in fungal diversity studies by Nigerian mycologists of the past compared to now, and the cumbersome political and bureaucratic procedures involved in obtaining permission for a place to carry out such empirical studies. The belated evolution of a more standardized, improved, integrated approach now available to present generation of survey and mushroom biodiversity studies is also a contributory factor (Lodge *et al*., 1995; Mueller *et al*., 2004; Mueller *et al*., 2007). The knowledge acquired from available literature especially on studies based outside the continent of Africa on how the network of relationships between fungal biota, community and their physical environment impact on mushroomsô mating systems, dispersal mechanisms, evolution, penology and distribution has also contributed to the improved record on the number of taxa obtained from the study.

The identified species of mushrooms are distributed into 28 Families, 9 Orders and 4 Classes. The Class Hymenomycetes and Family Tricholomataceae recorded higher number of taxa amounting to approximately 57% and 17.2% respectively (Fig. 1 and 2). This agrees with the works of Nicholson (1989), Lodge *et al*. (1995), Lindblad (2001), Cifuentes and Villarruel-Ordaz (2006), Crous *et al*. (2006), Gazis and Romina (2006) and Osemwegie *et al*. (2006). It is believed that the reason for the higher record of members of the Family Tricholomataceae in many tropical woodland ecosystems might be due to the enzyme makeup and dynamics, substrate colonization potential which usually may be non-substrate

specific, reproductive mechanisms and phenology. Many genera of mushrooms such as *Clitocybe*, *Marasmius*, *Marasmiellus* and *Megacollybia* belonging to the Family Tricholomataceae, though ligninolytic, were observed to colonize wood and decomposing litters and this might have also accounted for their high representation as recorded in this study. This is due to their spectrum of enzymes (Laccase, peroxidase, glucosidases, cellulases, hemicellulases, proteases and phosphatases) in addition to the fact that their fruitification coincide with the wet season (Sinsabaugh, 2005; Osono, 2007). This study also recorded some mushrooms that are widely reported in local and international body of literature as medicinal e.g. *Amanita phalloides, Daldinia concentrica, Ganoderma lucidum, Ganoderma tsugae, Nothopanus* sp*., Pleurotus tuberregium, Schizophyllum commune*; edible e.g. *Agaricus arvensis, Auricularia auricula, Cantharellus tubaeformis, Macrolepiota* sp*., Lepiota* sp*., Pleurotus tuberregium, Pleurotus squarrosulus, Russula* sp*., Volvariella volvacea*; and poisonous e.g. *Amanita phylloides*, *Clitocybe dealbata*, *Chlorophyllum* sp., *Panaeolus foenisecii*, *Pluteus cervinus* (Pegler and Pearce, 1980; Morris, 1984; Arora, 1986; Adewusi *et al*., 1993; Stamets, 1993; Chang, 1998; Joshi and Joshi, 1999; Chang, 2000; Chang and Mshigeni, 2001; Akpaja *et al*., 2003; Dijk *et al*., 2003; Sharma, 2003; Yongabi *et al*., 2004; Osemwegie *et al*., 2006). Red coloured *Pycnoporus cinnabarinus* which was observed during the study was reported as a potential source of natural dye by Arora (1986), Chang *et al*. (1993) and Mshigeni (2003). The study has therefore shown that these mushroom resources are found here in Edo State and Nigeria.

The significance of dead wood which according to Lindblad (2001) represents a potentially large pool of carbon is an integral part of understorey deposits in many forested ecosystems. Their role in the forest ecosystem processes such as supporting physical, chemical and biological functions cannot be over-emphasized (Franklin *et al*., 1987; Samuelsson *et al*., 1994; Bunnell *et al*., 2002). This assertion is corroborated by this work

which registered 70% wood inhabiting macrofungi (Fig. 5A) 19.4% of which exhibit overlapping substrate propensity. This may be as a result of the dominance of ligninolytic Basidiomycetes which according to Lynch and Thorn (2006) are the main decomposers of recalcitrant components of various woodland ecosystems like those found in the study area. This consequently explains the observation of Agaric (synonym; gill mushrooms) and Polypores (synonym; poroid mushrooms) as the best represented taxa in the study area respectively, both of which amount to 83% of total mushrooms recorded during the study (Fig. 5B). The observation of agarics *stricto lato* as the dominant (52%) mushroom life form of the study area is explained in the works of Cifuentes and Villarruel-Ordaz (2006) and Osono (2007) to be because the arbitrary group accommodates taxa that grow on a range of both or either wood and leaf litters. Although, the soil type of the study area was not closely studied, it supported the growth of about 7% of the total macroflora encountered during the study. Furthermore, the clavate/club mushroom life form (11%) is observed to be dominated by members of the family Xylariaceae while the earth stars and puffballs were rarely observed. This is in agreement with the observations of Gazis and Romina (2006). Their scarcity may be due to their response or, and sensitivity to the simultaneous effects of both biotic (human disturbance, competitive and antagonistic impact of other understorey organisms) and abiotic variables (climate change, elevation, gradient, log volume, litter depth). At this point, it is also imperative to intensify interest in the ecological impact of understorey animals especially õmacrofungivoresò (animals that exhibit macrophagy or feed on mushrooms) on mushroomôs community structure and composition. This is why Yamashita (2007) proposed that members of the Order Aphyllophorales which in the context of this study include poroid, clavate, club, boletes and puffballs are suitable candidates of environmental indicators that could be used to examine the effect of forest use in every woodland ecosystem.

The distribution of mushrooms between the various studied plots varied numerically in composition and abundance with each having its own distinct group of characteristic endemic species (Table 2). The younger plantations (Plots A and B) recorded low mushroom diversity and abundance due to increase in human activities such as fragmentation through the creation of paths within the expanse of the plantations, invasion for rubber tapping activity, occasional weeding which makes them easily penetrable and exposes them to uncontrolled wood picking for use in cooking by neighbouring settlements. These may have no doubt contributed to the reduced number (6 and 4 species respectively) recorded for endemic or exclusive mushrooms recorded for Plots A and B. These facts agree with the works of Vitousek *et al*. (1997), Tsui *et al*. (1998), Edmonds (2000), Chaverri and Vilchez (2006) and Yamashita *et al*. (2007). Comparatively, Plot E recorded higher number (Table 2) of mushrooms (40 species) which is approximately 21% of the total mushrooms recorded during the study. This may be associated with the heterogeneous trees that characterise the plot.

The relatively diverse trees which were apparently compact or patchy with relatively thick undergrowth characterises Plot E and invariably translates to more diverse host and habitat spectra (breadth), and resource abundance (quality and diverse utilizable litter mass and wood debris) for mushrooms. Consequently, a combination of these factors and there synergy was observed improve fruiting options and opportunities by leading to the appearance of more mushrooms especially mycorrhizal fungi. Also, several literature abound that correlate abundance and diversity of macromycetes with plant diversity hence the use of plants as surrogate in estimating fungi diversity (Hawksworth, 2001; Carey, 2003; Chiarucci *et al*., 2004; Hawksworth, 2004; Jumpponen *et al*., 2004; Laitung and Chauvet, 2005; Carey, 2006; Yamashita *et al*., 2007). This may perhaps be the reason why Osono (2007) reported that fungi especially saprotrophic macromycetes can provide useful information on resource

utilization in forest ecosystems. It should however be noted that the mushrooms recorded during this study included a few mycorrhizae whose distribution and identity were beyond the scope of this study. The understanding of the relationship between tree diversity and density, and wood deposits with mushroom diversity is inadequate especially in West Africa due to low research works in this area. This work therefore recorded a very strong positive correlation between tree diversity and density with mushroom abundance and substrate options. This observation is in line with the works of Samuelsson *et al*. (1994), Lodge *et al*. (1995), Bunnell *et al*. (2002), Ferrrer and Gilbert (2003), Richard *et al*. (2004) and Laitung and Chauvet (2005). The reasons for the relatively low number of mushroom species recorded for Plot C (Table 2) which is one of the old unmanaged plantations used as study site is not fully understood but might be associated with logging activities coupled with the stage of decay of the numerous wood substrate that litter the site. This is however irrespective of the fact that it is an abandoned plot. The result which is in accordance with Lindblad (2001) suggests that the disparity in macrofungal population, species diversity and composition observed between plots within similar age range such as Plots C and D (Table 2) may be attributed to differences in their ecological organization i.e. structure, age, plant species composition within decay stage and undergrowth, substrate condition, level of human disturbances, understorey decomposition rate etc. This observation showed that more work still needs to be done especially in Nigeria to illuminate our full mushroom complement to the world as it also challenged us to kick-start a long-term forest management programs that will conserve our local mushroom resource. In addition, intense ecodiversity study of mushroom would improve careful evaluation of macrofungal diversity and broaden our understanding of the functional roles of macrofungi in sustainable woodland ecosystem management.

5.2 ECOLOGICAL AND PHENOLOGICAL VARIABILITY

Collection of fruit bodies of different species of macrofungi during this study was taken as a good estimate of their respective fruiting time and period in which they are observed as their respective phenology. It is however also important at this stage to point out that the time scale of mushroom succession in any ecosystem is not well known compared to the volume of available information on higher plant succession. This therefore mean that the first observation of some of the mushrooms on site during this study may just be a reflection of there recent migration into the community (O'Dell *et al*., 2004). The study further recorded interesting variations in the pattern of fruiting by individual mushrooms from one sampled plot to another (Table 1). Thus, a particular mushroom taxon may not appear at the same time in all the sampled plots but was observed to conform to a time range or fructification period within the study area. This observation is however fresh to this type of study especially in Nigeria and the West African sub-region. This is perhaps due to the relative differences in the ecosystem elements such as tree diversity, level of competitive organisms, composition of fauna, decomposition rate, microclimate, litterfall quality and quantity etc and the response of species to changes in abundance or deficiencies of particular composite ecosystem elements of the habitat. This time range or phenology defines the first and the last appearances of a fruit body within the area of study. It was also observed that there was interspecific (amongst species) and intergeneric (amongst genera) differences in fructification pattern within plot as well as between plots. It is however not yet known what could have been responsible for the fruiting disparity or variation of mushrooms within plot and between plots (Table 1) but it is believed that a more elaborate and long-term autecological study is required to draw any conclusion on the sporadic spatial occurrence and behaviour of fruit bodies as affected by environmental conditions, nutrient levels, and relationship with other biomes of woodland ecosystem.

The phenological profile of mushrooms in the study area was observed to follow a seasonal pattern with fruit bodies appearing to increase in variety and number with increasing rainfall. Thus, the study recorded more fruit bodies in all the plots surveyed in the raining season (March ï September) more than the dry season. Consequently, this suggests that there is a stronger correlation between mushroom abundance which is a measure of both biodiversity and mushroom density (number of fruit bodies) and rainfall (Fig. 6). It was also observed that temperature (Fig. 7) and relative humidity (Fig. 8) equally correlate with rainfall and mushroom abundance. It is therefore important to sugest that improved fruting activity of mushrooms is due to a combined or synergic effect of all the elements of climate rather than the effect of a single climatic element. Similar works carried out around the world (Shigeki, *et a*l., 1994; Ananda and Sridhar, 2004; Lodge *et al*., 1995; Vellinga, 2004, Munguia *et al*., 2006; Braga-Neto *et al*., 2007; Kauserud *et al*., 2008) are in agreement with these observations. Myers *et al*. (2000), Sala *et al*. (2000), Straatsma *et al*. (2001), Munguia *et al*. (2006), Yamashita *et al*. (2007) and Kauserud *et al*. 2008 recognise rainfall as the most important climatic element that drives mushroom diversity changes. Although rainfall enhances increase in fruiting activity, it is observed from this study that mushrooms vary in their response to different levels of moisture whose effective drainage is usually determined by the topography of the woodland ecosystem under study. A study that examines the level/quantity of moisture in nature that impact on mushroom phenology and fruiting could reveal more concerning the moisture tolerance and ecophysiology of moisture at the mushroom habitat level (Lindblad, 2001; Osono, 2007).

Auricularia auricula Judae, *Coprinus acuminatus*, *Cyathus striatus*, *Daldinia concentrica*, *Nothopanus* sp., *Pleurotus squarrosulus* and *Schizophyllum commune* are the perennial mushroom taxa recorded during the study (Table 1). They were all strictly wood-inhabiting and produce sporocarps that can tolerate a wide range of climatic extremes (dry

and raining season). This may be because they have a broad range of substrates (dead wood) and hosts (living trees) that they are capable of colonizing. In addition, they are reported in literature to invest so much energy in the development of their sporocarp which is the reason why they need large readily utilizable resource base such as woods. Furthermore, it was observed from this study that besides their being lignocellulosic (white rot), these perennial mushrooms also have sporocarps equipped with moisture holding features e.g. pilial surface as represented by jelatinous covering of *Auricularia auricula Judae*, downy-wooly to cottony appearance of *Schizophyllum commune,* squarrose pilial surface of *Pleurotus squarrosulus*. The shape and texture of the sporocarp of *Cyathus striatus* were also observed to be strategic to its phenology due to its ability to conserve moisture in the recesses of its depressed cup. One cannot also overlook the possibility of the roles of the overall organisation of the hymeniun layer, nature of the stipe (mostly sessil) and pattern of attachment to substrate in expanding the range of mushroom phenology. These observations as registered by this study are to a large extent missing in the increasing body of mushroom biodiversity literature. *Cookeina sulcipes* and *Xylaria* species were the few mushrooms with sporocarp that overlap the two distinct seasons with fruit body production starting within the rainy season and disappearing within the dry season. This suggests that the sporocarps of these mushrooms are not limited to a particular season neither is there fruitification tied to rainfall or dryness but rather had fruit bodies that rmains visible for nothing less than 4 months period within the study area (Table 1). This phonological behaviour also suggests that these sporocarps are annual in nature. This is in agreement with the observations recorded in the work of Straatsma *et al*. (2001).

Many studies bordering on mushroom diversity were focused on examining the influence of temperature and precipitation on mushroom density which within the context of this study is synonymous with abundance or number of fruit bodies without taking a position

on the degree of each of these environmental factors that will impact positively on the appearance and disappearance of fruit bodies. The influence of temperature in structuring mushroom communities has been investigated by Munguia *et al*. (2006). He observed that the impact of temperature in structuring community diversity is hardly recognised at a regional scale. This is however in agreement with the observation made from this study. Chaverri and Vilchez (2006), Kauserud *et al*. (2008) and Lodge *et al*. (1995) observed from their own studies that the effect of temperature in shapening the diversity of mushrooms is however more pronounced on a global scale rather than on a local scale without advancing any reason for the phenomenon. The difficulty experienced in the establishment of temperature as the primary driver or stimulator of fructification of mushrooms in the tropics as compared to temperate woodlands may be due to the fact that tropical temperatures flunctuate less, and it characterised by narrower lower and upper temperature limits (Table 8).

There is dearth of information on the relationship between mushroom interspecific and intraspecific gregarity (socialbility) and ecosystem functions. The attempt made in this direction from this study might just be the first contribution to the body of literature on mushroom ecology. This study documented mushroom sociability (Table 3) noting the number of individuals in such group and point of adherence (co-joining). It was observed in the field that smaller groups of mushrooms comprising 1 - 3 species grow separately and in scattered spatial form on substrate even though they originate from the same running mycelium or rhizomorph. About 14% of the total species of mushrooms encountered during the study occurs in large group of 2 - 5 similar species that are co-joined at the base or from the root up to about 0.3 ï 0.7 mm up the stipe. The family Xylariaceae recorded the highest number of gregarious (sociable) species which is agreement with Lodge *et al*. (1995), and Guevara and Dirzo (1999). The reason for this type of growth behaviour involving similar species of mushrooms occurring as groups is not known. One reason for this phenomenon

might be attributed to their survival and efficient resource utilization strategies. Suffice to say that group existence as observed for some mushrooms in this study may be adaptive and a means of maximixing the utilization of available moisture and nutrients, and increasing the number of potential germinating spores that might perhaps possess new genetic vigour to promote their existence and survive diverse challenges posed by the changing environment. More work however still needs to be done in establishing how the sociability of mushrooms with other biota impact on their diversity.

The mushroom monthly abundance profiles (Table 9) for each of the sampled plots were observed to correlate strongly with rainfall perturbation and this is supported by earlier studies (Lodge *et al*., 1995; Sala *et al*., 2000; Staatsma *et al*., 2001; Mueller *et al*., 2007; Kauserud *et al*., 2008). Estimating the species diversity using Alpha, Shannon and Simpson diversity indices showed a progressive increase in the values recorded from Plot A to Plot E. This suggests that Plot A accommodates the least mushroom species composition contrary to Plot E with the highest species diversity. Similarly, species richness (number of species), which forms the basis of many ecological models of community structure and which within the context of this study combines with relative abundance was also estimated using diverse species richness indices to remove as much bias as could have incurred from the method of survey and experimentation. The results also showed that Plot E recorded the best species richness value when compared to the other sampled plots even though the Unique mean value (species that occur in only on sample) of sample runs was lower than what obtains for Plots C and D respectively. This indicates that there is a correlation between abundance and species diversity (Lodge *et al*., 1995). Species richness was also observed to apparently correlate with the number of fructifications suggesting a parallel between rainfalls, species richness, abundance and diversity. The vegetation diversity or heterogeneity that characterises Plot E

coupled with its rich understorey qualifies it as a high energy site that can support mushrooms (Laitung and Chauvet, 2005; Schmit, 2005).

A comparism of compositional assemblage of mushroom taxa of the various sampled plots showed that Plot A and Plot B had the best homogenous assemblage of mushrooms. Thus, they shared relatively more species (23) between them than observed for other plots as reflected in the similarity indices (Jaccard, Sorensen, Morisita-Horn and Bray-Curtis) enumerated in Table 7. This may be attributed to both their habitat and climatological similarities coupled with homogenous tree composition. It is not however empirically examined if these factors affect individual assemblage of mushrooms in each plot as it varies with seasons. The least number of shared species recorded for 100 randomised sample runs during the study was observed between Plots A and D, and Plots B and D. This is as a result of the differences in their relative tree stand age and the volume of littering woods in the sampled plots considering the fact that Plots A and B are more accessible to human interference. It is however important to state that although the effect of age on community diversity of mushrooms was not one of the objectives of this study, we however observed interestingly a correlation between the age of the various sampled plots or stands and their mushroom abundance and diversity as well as with their species richness (Table 3, Table 5, Table 6). This view is supported by the works of Lodge *et al*. (1995), Laitung and Chauvet (2005), Schmit (2005) and Lindner *et al*. (2006).

5.3 Relationship between species abundance and litterfall

In recent times, many workers have attempted to quantify the rate of litterfall and its nutrient content in Nigeria and elsewhere in the world because of its recognitions as an

important pathway for transfer of organic matter and chemical elements from vegetation to the soil surface in tropical forest ecological systems (Egunjobi and Onweluzo, 1979; Swift *et al*., 1981; Proctor *et al*., 1983; Zarin *et al*., 2001; Chaverri and Vilchez, 2006; Vasconcelos *et al*., 2007). Literfalls combined with other forest measurements of biomass, standing crop and fluxes provide information on production, decomposition (disappearance) and nutrient cycling of many terestial ecosystems. The contributions of macrofungi to these processes can not however be overempasized (Lodge and Cantrell 1995). Works have equally been carried out outside Nigeria on the role and/or association of fungi especially higher fungi in forest litter decomposition (Cooke and Rayner, 1984; Frankland *et al*., 1982; Dix and Webster, 1995; Osono, 2007; Braga-Neto *et al*., 2007). There is however very little information on how litterfall decomposition influences mushroom species composition (assemblage), spatial and temporal distribution, and species richness in woodland ecosystems especially in Nigeria. Hence we decided on this premise to include in the scope of this study an evaluation of litterfall mass (g/m^2) of each sampled plot to test the logical hypothesis that litterfalls promote mushroom species assemblage and abundance.

A record of monthly abundance obtained from the study showed an inverse correlation to litterfall mass which peaks in the dry season (Table 9). This result agrees with the works of Egunjobi and Onweluzo (1979), Swift *et al.* (1981) and Dantas and Phillipson (1989) on tropical forests. The native vegetation of the study area was more dominated by deciduous species (rubber trees). The low mushroom abundance recorded at the peak of litterfall mass is a direct reflection of negligible level of decomposition process which according to Swift *et al*. (1981), Bernhard-Reversat (1982), Muoghalu *et al*. (1994) and Vasconcelos *et al*. (2007) is moisture driven and hence more pronounced in the rainy season. Further more, the litterfalls trapped during the study were not separated into its numerous constituents (seeds, flower, twigs, coarse woods, leaves etc.) and weighed separately but field

observation reveals an increase in leaf litter against other litterfall constituents in the dry season period. This may perhaps explain the low mushroom abundance recorded as leaf litter lignin was reported by Berg *et al*. (1997), Berg and McClaugherty (2003) and Osono (2007) to negatively correlate with decomposition rate despite the fact that it is also the major regulating factor of decomposition in woodland ecosystems. Consequenly, the ratio of leaf litter mass to other litter constituents might impact positively on abundance and this was earlier reported by Osono (2007) to have a parallel correlation with mushroom species richness and diversity. At this point and based on the results gathered as well as field observations, one can infer that litter quality (amount and types of organic carbon compounds, ratio of leaf litter to other litter components, nutrient concentrations in each component, and ratios between carbon compounds and total nutrients in litter), and resource (substratum and the source of organic nutrient) distribution in time and space in addition to their durability influences the activities of fungi and their longevity in decomposition processes (Braga-Neto *et al*., 2007). This is due to the fact that mushrooms, most of which are saprotrophic litter fungi and of different species have different degrees of resource selectivity and optimum resource requirement for both mycelia and sporocarp formation (Hedger, 1985; Rayner *et al*., 1985). Therefore, an in-depth study of the role of fungi in litter decomposition is required to provide useful insights and clarify conjectures into the mechanisms of decomposition and ecosystem processes in tropical woodland ecosystems especially in Nigeria.

Dunham (1989) and Osono (2007) observed a parallel relationship between litter nutrient and litter mass. This agrees with the high carbon content values recorded by this study for litters trapped during the dry season as compared to rainy season (Table 9). It was also observed form the study that there was a variation in litter mass per plot per duration of study with Plots A and B recording the highest litter mass of 458.7 and 283.9 g/m^2/ 14 mo

respectively as compared to Plot E which recorded the least litter mass value (195.98 g/m^2/14 mo) but the highest mushroom abundance value. This can be attributed to the clonal property of the deciduous monoculture nature in the rubber stands in Plots A and B, and the mixture of evergreen and deciduous tree plants that characterise Plot E. The low incidence of fruiting bodies (abundance) in the dry season despite the huge record of litter mass might be due to the slow accessibillty of the litters to the litter decomposing mushrooms. This accoding to Aerts (1997) is attributable to unfavourable understorey climate. In addition, the nature of canopy cover and lack of moisture may have also accounted to this observation (Osono, 2007). Although no definite seasonal pattern was observed for nitrogen (N) and phoshorus (P) contents unlike carbon content whose pattern showed a parallel relationship with litterfall, their effect on mushroom diversity, distribution and abundance remains blurred. The reason for this can be associated with the method adopted for the study which fails to monitor decomposition dynamics in woodlands understorey communities despite references in literature that reported decomposition process as the major link between mushrooms and litterfalls. Compared to higher plants, little is known on the effect of nutrients turnover and utilization (decomposition), spatial distribution and richness of mushrooms in both tropical and temperate woodland ecosystems. However, this study recorded a high number of litter inhabiting fungi (23%) over 60% of which are agaric fungi (Fig 5A). This suggests that the role of moisture in addition to a complex array of interactive factors (e.g. relationship with other litter-dependent organisms, temperature and humidity, ecosystem and community structure, collective efficiency of nutrient utilization, ecosystem functional groups etc.) in the relative appearance and disappearance of mushroom fruit bodies, and in the accessibility of leaf litters by mushrooms can not be overemphasized (Proctor, 1983; Vogt *et al*., 1986 and 1992; Loranger *et al.*, 2002).

The study showed that litter distribution, ratios in which litter constituents are mixed, and nature and distribution of organic matter in litters most of which according to Stevens (1997) reside in mostly coarse woods and other wood debris rather than litter mass in the presence of favourable climatic conditions impact more positively on mushroom fructification and species richness. Furthermore, the study agrees with observations from earlier studies that litter can only be associated to mushroom community structuring through decomposition processes and dynamics.

5.5 CONCLUSION

This study recognises that the sampled plantations and forest are still promisingly rich in mushroom bioresource and therefore recommend a more extensive and frequent survey of the study area. In addition, the study has contributed more mushroom taxa to the already existing inventory of mushroom resource in Nigeria especially Edo state while clearly establishing the relationships between their diversity, climatic factors, tree diversity, litterfall and litter content. It also documented various mushrooms that are reported in several literature as industrially and agriculturally valuable while distinctively corroborating the medicinal, edible and poisonous ones. The study has clearly shown that mushrooms have varying phonological pattern which correlates with rainfall rather than litter mass while establishing wood debris as better determinant of mushroom diversity and species richness above leaflitters. It will be important to state that this study touches salient area of biodiversity and ñMycoecologyò that are hardly reported in the body of literature both in Nigeria and the West African subregion. Therefore I have no doubt that this work will constitute the baseline reference for further biodiversity and taxonomic investigation of mushroom taxa in different range of plantations and vegetations in Edo State and Nigeria at large. Questions on how human activities such as tapping, hunting, farming and lumbering can influence mushroom species range and phenology were also addressed by the study.

Mshigeni (2005) wrote and I quote ñ*when we read publications on wildlife in Africa, mushrooms are seldom mentioned. When we undertake literature surveys on Africa's agricultural crops, mushrooms featured nowhere. When we thumb through the pages in documents presenting accounts on cultivated vegetables in Africa, mushrooms never appear in the table of contents. And when we read inventories of Africa's medicinal biota, mushrooms are rarely listed in those publications*ò unquote. It is therefore challenging for students and researchers of mycology (including my humble self) to consider mushroom ecology as a research option and explore further studies especially in agroforests stands across the country. Rigorous fungal survey data especially as it concerns forest nutrient relationship with mushroom cummnity structure e.g. appearance and disappearance of fruit bodies, can help answer various fundamental scientific and environmental questions especially in Nigeria.

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APENDICES

SPECIES DISTRIBUTION AND ECOLOGICAL PARAMETERS FOR PLOT A

	Species	PLOT A			
		A	D	F	RD
	ASCOMYCOTINA				
1	*Cookeina sulcipes* (Berk.) Kunt.	4	0.0063898	2	4.8191993
2	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	5	0.0079872	4	6.0239991
	BASIDIOMYCOTINA				
3	*Agaricus arvensis* Schaeff.	3	0.0047923	1	3.6143995
4	*Auricularia auricula* Judae (Bull.) Pat.	4	0.0063898	4	4.8191993
5	*Clitocybe* sp.	2	0.0031949	2	2.4095997
6	*C. dealbata* (Sow.) Gillet.	2	0.0031949	3	2.4095997
7	*Coltricia perennis* L.: Fr.) Murr.	3	0.0047923	4	3.6143995
8	*Copinus acuminatus* (Romagn.) P.D. Orton	7	0.0111821	4	8.4335988
9	*Coprinus atramentarius* Ulje and Bas.	4	0.0063898	2	4.8191993
10	*Coprinus disseminatus* (Pers. ex Fr.) S.F.G.	2	0.0031949	2	2.4095997
11	*Hericium ramosum* (Bull. ex Mèr.) Let.	3	0.0047923	2	3.6143995
12	*M. lachnophyllus* Berkeley	2	0.0031949	1	2.4095997
13	*M. rotula* (Fr.) Scope	4	0.0063898	3	4.8191993
14	*Marasmiellus* sp.	1	0.0015974	2	1.2047998
15	*Mycena* sp.	6	0.0095847	2	7.228799
16	*Nothopanus* sp.	3	0.0047923	4	3.6143995
17	*Panaeolus foenisecii* (Pers: Fr) Kuhner	3	0.0047923	3	3.6143995
18	*Panellus* sp.	2	0.0031949	3	2.4095997
19	*P. squarrosulus* (Fr.) Kummer	1	0.0015974	4	1.2047998
20	*Schizophyllum commune* Fr.	2	0.0031949	4	2.4095997
21	*Tremella* sp	3	0.0047923	1	3.6143995
22	RRIN01	1	0.0015974	2	1.2047998
23	RRIN07	2	0.0031949	2	2.4095997
24	RRIN08	1	0.0015974	1	1.2047998
25	RRIN09	3	0.0047923	2	3.6143995
26	RRIN11	1	0.0015974	2	1.2047998
27	RRIN17	2	0.0031949	2	2.4095997
28	RRIN20	1	0.0015974	1	1.2047998
29	RRIN21	2	0.0031949	2	2.4095997
30	RRIN24	1	0.0015974	1	1.2047998
31	RRIN27	3	0.0047923	2	3.6143995
		83	0.1325879		

SPECIES DISTRIBUTION AND ECOLOGICAL PARAMETERS FOR PLOT B

	Species	PLOT B			
		A	D	F	RD
	ASCOMYCOTINA				
1	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	5	0.0079872	4	5.6818214
2	*Cookeina sulcipes* (Berk.) Kunt.	3	0.0047923	2	3.4090928
3	*Helotium citrinum* (Hedwig) Fr.	2	0.0031949	1	2.2727286
4	*Tarzetta rosea* (Rea.) Dennis	4	0.0063898	2	4.5454571
	BASIDIOMYCOTINA				
5	*Auricularia auricula* Judae (Bull.) Pat.	5	0.0079872	4	5.6818214
6	*Calocera cornea* (Batsch.).Fr.	2	0.0031949	1	2.2727286
7	*Clitocybe* sp.	3	0.0047923	2	3.4090928
8	*C. dealbata* (Sow.) Gillet.	2	0.0031949	3	2.2727286
9	*Coltricia perennis* L.: Fr.) Murr.	3	0.0047923	4	3.4090928
10	*Copinus acuminatus* (Romagn.) P.D. Orton	7	0.0111821	4	7.95455
11	*Coprinus atramentarius* Ulje and Bas.	3	0.0047923	2	3.4090928
12	*Crepidotus mollis* (Bull.) Kummer	1	0.0015974	2	1.1363643
13	*Ganoderma applanatum* (Pers. ex Wall.) Pat.	2	0.0031949	2	2.2727286
14	*Hericium ramosum* (Bull. ex Mèr.) Let.	1	0.0015974	2	1.1363643
15	*Leccinum* sp.	2	0.0031949	1	2.2727286
16	*M. rotula* (Fr.) Scope	5	0.0079872	2	5.6818214
17	*Marasmiellus* sp.	1	0.0015974	2	1.1363643
18	*Mycena* sp.	4	0.0063898	3	4.5454571
19	*Nothopanus* sp.	2	0.0031949	4	2.2727286
20	*Panaeolus foenisecii* (Pers: Fr) Kuhner	4	0.0063898	3	4.5454571
21	*Panellus* sp.	2	0.0031949	3	2.2727286
22	*P. squarrosulus* (Fr.) Kummer	2	0.0031949	4	2.2727286
23	*Pycnoporus cinnabarinus* (Fr.) Kar.	3	0.0047923	1	3.4090928
24	*Schizophyllum commune* Fr.	3	0.0047923	4	3.4090928
25	RRIN01	1	0.0015974	2	1.1363643
26	RRIN04	2	0.0031949	1	2.2727286
27	RRIN05	1	0.0015974	1	1.1363643
28	RRIN07	2	0.0031949	2	2.2727286
29	RRIN09	3	0.0047923	2	3.4090928
30	RRIN11	2	0.0031949	2	2.2727286
31	RRIN17	4	0.0063898	2	4.5454571
32	RRIN27	2	0.0031949	2	2.2727286
		88	0.1405751		

SPECIES DISTRIBUTION AND ECOLOGICAL PARAMETERS FOR PLOT C

	Species	PLOT C			
		A	D	F	RD
	ASCOMYCOTINA				
1	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	6	0.0095847	4	6.9767438
2	*X. hypoxylon* (L. ex Hook) Grev.	5	0.0079872	2	5.8139531
3	*X. polymorpha* (Pers. ex Mèr.) Grev.	1	0.0015974	3	1.1627906
	BASIDIOMYCOTINA				
4	*Auricularia auricula* Judae (Bull.) Pat.	6	0.0095847	4	6.9767438
5	*Clavulina* sp.	2	0.0031949	3	2.3255813
6	*C. dealbata* (Sow.) Gillet.	3	0.0047923	3	3.4883719
7	*Copinus acuminatus* (Romagn.) P.D. Orton	3	0.0047923	4	3.4883719
8	*Crepidotus mollis* (Bull.) Kummer	3	0.0047923	2	3.4883719
9	*Cyathus striatus* (Huds.) Willd.	6	0.0095847	4	6.9767438
10	*G. lucidum* (Leyss.) P,Karst	3	0.0047923	2	3.4883719
11	*G. tsugae* Murrill	1	0.0015974	3	1.1627906
12	*Nothopanus* sp.	3	0.0047923	4	3.4883719
13	*Omphalina chrysophylla* (Fr.) Murrill	2	0.0031949	2	2.3255813
14	*Panellus* sp.	1	0.0015974	3	1.1627906
15	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	3	0.0047923	2	3.4883719
16	*Pleurotus* sp.	1	0.0015974	2	1.1627906
17	*P. squarrosulus* (Fr.) Kummer	2	0.0031949	4	2.3255813
18	*Pluteus cervinus* (Schaeff. ex Fr.) Kummer	5	0.0079872	1	5.8139531
19	*Podoscypha* sp.	2	0.0031949	1	2.3255813
20	*Schizophyllum commune* Fr.	3	0.0047923	4	3.4883719
21	*Thelephora* sp. A	4	0.0063898	1	4.6511625
22	*Thelephora* sp. B	4	0.0063898	2	4.6511625
23	*T. fuciformis* Berkeley	3	0.0047923	2	3.4883719
24	RRIN13	2	0.0031949	1	2.3255813
25	RRIN14	2	0.0031949	1	2.3255813
26	RRIN15	2	0.0031949	1	2.3255813
27	RRIN18	3	0.0047923	3	3.4883719
28	RRIN22	3	0.0047923	3	3.4883719
29	RRIN26	2	0.0031949	2	2.3255813
		86	0.1373802		

SPECIES DISTRIBUTION AND ECOLOGICAL PARAMETERS FOR PLOT D

	Species	PLOT D			
		A	D	F	RD
	ASCOMYCOTINA				
1	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	3	0.0047923	4	3.846155
2	*Tarzetta rosea* (Rea.) Dennis	2	0.0031949	2	2.5641034
3	*Xylaria* sp.	2	0.0031949	2	2.5641034
4	*X. polymorpha* (Pers. ex Mèr.) Grev.	2	0.0031949	3	2.5641034
	BASIDIOMYCOTINA				
5	*Auricularia auricula* Judae (Bull.) Pat.	3	0.0047923	4	3.846155
6	*Bondarzewia* sp.	2	0.0031949	1	2.5641034
7	*Calvatia cyathiformis* (Bosc.) Morg.	1	0.0015974	1	1.2820517
8	*Copinus acuminatus* (Romagn.) P.D. Orton	3	0.0047923	4	3.846155
9	*Cyathus striatus* (Huds.) Willd.	2	0.0031949	4	2.5641034
10	*Daedaelia quercina* Fr.	1	0.0015974	1	1.2820517
11	*Exidia thurentiana* (Lev.) Fr.	2	0.0031949	1	2.5641034
12	*Fomes fomentarius* (Fr.) Kickx.	2	0.0031949	2	2.5641034
13	*G. lucidum* (Leyss.) P,Karst	1	0.0015974	2	1.2820517
14	*G. tsugae* Murrill	2	0.0031949	3	2.5641034
15	*Hygrocybe* sp.	1	0.0015974	1	1.2820517
16	*Megacollybia platyphylla* (Pers.) kotl. and Pouzar.	4	0.0063898	2	5.1282067
17	*Nothopanus* sp.	3	0.0047923	4	3.846155
18	*Omphalina chrysophylla* (Fr.) Murrill	4	0.0063898	2	5.1282067
19	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	1	0.0015974	2	1.2820517
20	*Pleurotus* sp.	1	0.0015974	2	1.2820517
21	*P. squarrosulus* (Fr.) Kummer	2	0.0031949	4	2.5641034
22	*P. tuberregium* (Fr.) Singer	1	0.0015974	1	1.2820517
23	*Schizophyllum commune* Fr.	3	0.0047923	4	3.846155
24	*Stereum purpureum* (Pers ex Fr.) Fr.	1	0.0015974	2	1.2820517
25	*Thelephora* sp. B	2	0.0031949	2	2.5641034
26	*Trametes* sp.	4	0.0063898	2	5.1282067
27	*T. fuciformis* Berkeley	4	0.0063898	2	5.1282067
28	RRIN03	1	0.0015974	5	1.2820517
29	RRIN06	2	0.0031949	1	2.5641034
30	RRIN18	3	0.0047923	3	3.846155
31	RRIN21	2	0.0031949	2	2.5641034
32	RRIN22	4	0.0063898	3	5.1282067
33	RRIN23	1	0.0015974	2	1.2820517
34	RRIN25	3	0.0047923	1	3.846155
35	RRIN26	1	0.0015974	2	1.2820517

36	RRIN28	2	0.0031949	1	2.5641034
		78	0.1246006		

SPECIES DISTRIBUTION AND ECOLOGICAL PARAMETERS FOR PLOT E

	Species	PLOT E			
		A	D	F	RD
	ASCOMYCOTINA				
1	*Daldinia concentrica* (Bolt. Ex Fr) Ces. And DeNot	3	0.0047923	4	3.3333326
2	*Cookeina sulcipes* (Berk.) Kunt.	3	0.0047923	2	3.3333326
3	*Xylaria* sp.	2	0.0031949	2	2.2222217
4	*X. hypoxylon* (L. ex Hook) Grev.	4	0.0063898	2	4.4444435
5	*X. polymorpha* (Pers. ex Mèr.) Grev.	2	0.0031949	3	2.2222217
6	RRIN02	2	0.0031949	1	2.2222217
	BASIDIOMYCOTINA				
7	*Auricularia auricula* Judae (Bull.) Pat.	3	0.0047923	4	3.3333326
8	*Amanita phylloides* (Vail.) Secretan.	1	0.0015974	2	1.1111109
9	*Cantharellus tubaeformis* (Bull.) Fr.	2	0.0031949	1	2.2222217
10	*Chlorophyllum* sp.	3	0.0047923	1	3.3333326
11	*Clavulina* sp.	3	0.0047923	3	3.3333326
12	*Clavulinopsis* sp.	1	0.0015974	1	1.1111109
13	*Coltricia perennis* L.: Fr.) Murr.	2	0.0031949	4	2.2222217
14	*Copinus acuminatus* (Romagn.) P.D. Orton	2	0.0031949	4	2.2222217
15	*Cyathus striatus* (Huds.) Willd.	2	0.0031949	4	2.2222217
16	*Fomes fomentarius* (Fr.) Kickx.	3	0.0047923	2	3.3333326
17	*Ganoderma applanatum* (Pers. ex Wall.) Pat.	3	0.0047923	5	3.3333326
18	*G. tsugae* Murrill	2	0.0031949	2	2.2222217
19	*Geastrum saccatum* Fr.	3	0.0047923	1	3.3333326
20	*Lepiota* sp	2	0.0031949	1	2.2222217
21	*Macrolepiota* sp.	1	0.0015974	1	1.1111109
22	*Marasmius graminum* (Libert) Berkeley	3	0.0047923	1	3.3333326
23	*M. pulcherripes* Peck	1	0.0015974	1	1.1111109
24	*M. rotula* (Fr.) Scope	2	0.0031949	2	2.2222217
25	*Megacollybia platyphylla* (Pers.) kotl. and Pouzar.	3	0.0047923	2	3.3333326
26	*Nothopanus* sp.	2	0.0031949	4	2.2222217
27	*Pleurocybella porrigens* (Pers. ex Fr.) Sing.	1	0.0015974	2	1.1111109
28	*P. squarrosulus* (Fr.) Kummer	3	0.0047923	4	3.3333326
29	*Russula* sp.	3	0.0047923	1	3.3333326
30	*Schizophyllum commune* Fr.	2	0.0031949	4	2.2222217
31	*Stereum purpureum* (Pers ex Fr.) Fr.	2	0.0031949	2	2.2222217
32	*Trametes* sp.	1	0.0015974	2	1.1111109

33	*Volvariella volvaceae* (Bull. ex Fr.) Singer.	2	0.0031949	1	2.2222217
34	RRIN10	2	0.0031949	1	2.2222217
35	RRIN12	3	0.0047923	5	3.3333326
36	RRIN16	1	0.0015974	1	1.1111109
37	RRIN19	4	0.0063898	1	4.4444435
38	RRIN22	1	0.0015974	3	1.1111109
39	RRIN23	3	0.0047923	2	3.3333326
40	RRIN29	2	0.0031949	1	2.2222217
		90	0.14377		